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CONTROL OF AGROPYRON REPENS BY HERBICIDES AND CROP ROTATION IN A ZERO-TILLAGE SYSTEM

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Summary: In 2 field experiments with direct-drilled w. wheat, s.barley and maize the combined effect of a competitive green manure crop and different sequences of small, repeated herbicide applications on A. repens has been tested. Initial infestation level was 5 g rhizome d.m./25 m^2, planted in April into a cereal crop. Complete control was achieved by sowing Raphanus sativus (fodder radish) in autumn, treated with dalapon (preemergence), paraquat (preemergence) and dalapon (postemergence), and by following maize treated with paraquat (preemergence) and atrazine (postemergence). Incomplete control, but no increase in A. repens infestation resulted from sequences with aminotriazole, TCA and paraquat and following culture of maize. In combination with w.wheat or s.barley culture none of the tested herbicide treatments effected satisfactory control.

In a second series of 2 field experiments with repeated culture of direct-drilled wheat the effect of time of application and dose of glyphosate and dalapon, respectively, on a natural infestation of A. repens has been tested. Application of 1.4 kg/ha a.i. of glyphosate and 12.8 kg/ha a.i. of dalapon to the cereal stubble resulted in sufficient control of A. repens, and did not negatively affect the growth of wheat.

INTRODUCTION

The most extreme form of minimum cultivation is known as zero-tillage. In this system mechanical soil manipulation is reduced to traffic and seedbed preparation only. Weed control cannot be effected by soil cultivation but has to be achieved entirely by good crop husbandry and chemical means. Relevant experimental results and the practical experience gained during the last decade have shown that cereal crops can be grown successfully by zero-tillage methods, if only one essential requirement is fulfilled: satisfactory weed control, especially of persistent grass weed (Baeumer and Bakermans 1973).

In Germany, several long-term zero-tillage experiments have been discontinued due to the increase in grass weeds. A. repens is the most difficult and intractable weed problem, if

- cereals are grown continuosly without a "break" crop,
- fallow periods between cereal crops are not used for soil cultivations, and
- paraquat - even with repeated application - is used as the only herbicide for A. repens control.

In this situation very high doses of grass-killing herbicides like TCA, dalapon and aminotriazole have been applied to A. repens infested stubble fields (Schwerdtle 1971, Bakermans and ten Holte 1972). Though the existing A. repens populations were not eradicated completely, a satisfactory level of control was achieved.

Yet, TCA, dalapon and aminotriazole are relatively persistent herbicides. This can create considerable risks for the following cereal crop, especially, if high doses are applied and soil and climatic conditions do not allow for sufficient dissipation of the toxic residue. In this situation a compromise has to be reached; the herbicide dose has to be lowered to a level which can be tolerated by the following cereal crop, but which is high enough to give the required control of A. repens.

With regard to the latter, additional measures should be taken to reinforce the herbicide effect. Split application of residual selective herbicides, especially in combination with competitive green manure crops which tolerate these herbicides, i.e. suitable sequences of herbicides and crop rotation may be useful in this respect. To test the potential of such systems 2 field experiments have been carried out at Goettingen (series A).

Another approach became feasible with the introduction of glyphosate, a broad spectrum, nonresidual herbicide which probably lacks the apparent weakness of paraquat in A. repens control (Evans 1972). To test its applicability in a zero-tillage system with repeated growing of winter wheat a second series of field experiments have been carried out (series B).

With these investigations an attempt was made to get information on the potential of the system or herbicide tested for controlling A. repens and on its compatability with growth and production of the following crop.

METHOD AND MATERIALS

1. General

The field experiments were carried out during 1970-1974 on silt loam soils (grey brown podsolic soils) near Goettingen, F.R.G. In each case the soil cultivation was omitted and sowing was done by a triple-disc drilling machine. Seed rates, fertilization, application of growth regulator herbicides, and of chlormequat to wheat followed the usual local pattern. Medium volume rates were used for spray applications of herbicides. Crop performance was assessed by taking data on emerged seedlings, final stand density and yield.

2. Series A, on land free from natural A. repens infestation

One experimental site was situated on a level plain sloping slightly to Northwest, the other site on a hillside, with up to 10 % slope facing North. Here, sowing and other cultural manipulation were delayed by about 2 weeks. In each case a 3-factorial split-plot design was used, with 4 replicates and the following independent factors (dates of application in brackets):

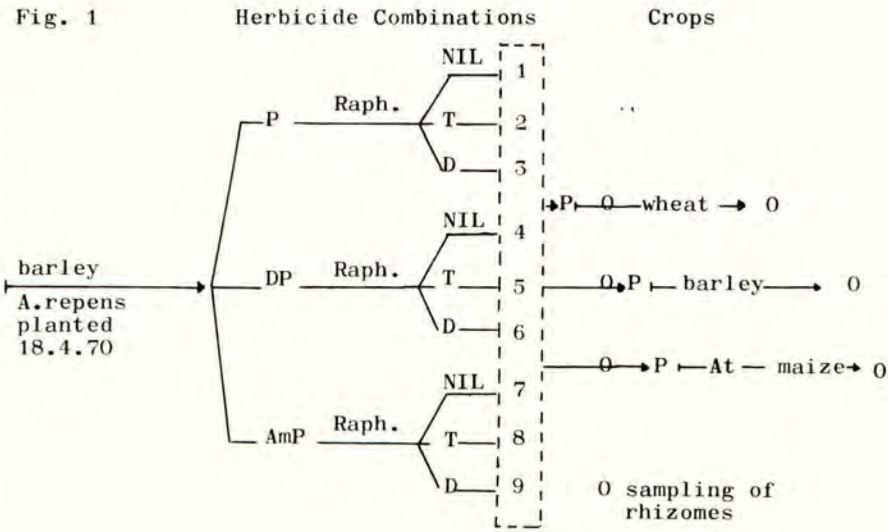
a) test crops, following spring barley (15.4.70) and *Raphanus sativus* (17.8.70): I. winter wheat (20.11.70); II. spring barley (24.3.71); III. maize grown for silage (20.4.71).

b) preemergence application of herbicides to *Raphanus s.*:
I. paraquat (P: 0.6 kg/ha a.i., 26.8.70); II. dalapon (D: 8.5 kg/ha a.i., 17.8.70) and paraquat (P: 0.6 kg/ha a.i., 26.8.70); III. aminotriazole + ammonium thiocyanate (Am: 3.5 kg/ha a.i., 17.8.70) and paraquat (0.6 kg/ha a.i., 26.8.70).

c) postemergence application of herbicides to *Raphanus s.*
I. no herbicides; II. TCA (T: 12.5 kg/ha a.i., 18.9.70); III. dalapon (D: 4.25 kg/ha a.i., 18.9.70).

The combination of factors is shown in fig. 1.

Fig. 1



Prior to sowing of w.wheat, s.barley and maize, paraquat (P: 0.6 kg/ha a.i.) was sprayed. The maize was treated with atrazine (At: 0.8 kg/ha a.i., 8.6.71). Size of treatment plots was 5 x 20 m.

A. repens rhizomes (5 g d.m.) of about 15 cm length, each section with a viable terminal bud, were planted at the centre of assesment plots, 5 x 5 m in size, 3 per treatment plot. Sampling dates were 15.3.71, 25.8. - 20.9.71 and 15.3.72. At each date the rhizome material was excavated as completely as possible and assessed as sand-free weight (105° C).

3. Series B, on land with natural A. repens infestation

The 2 experiments - one started in 1972, the other in 1973 - were laid out in a field, where w.wheat had been grown continuously for 4 years. In each case a randomized block design was used, with 3 replicates, and plot size of 15 m^2. 2 herbicides were applied to the wheat stubble at the following rates (kg/ha a.i.): dalapon 4.3, 8.5 and 12.8; glyphosate 1.4, 2.2 and 2.8; and at the following dates: 8 weeks and 4 weeks prior to sowing of wheat (2.11.72 and 26.10.73). Effects on growth of A. repens were assessed by rating visually the percent cover of A. repens top growth and by excavating the total rhizome material of 0.5 m^2 per plot after wheat harvest.

Differences between treatment means are calles "significant" in the following text when they exceed the least significant difference of the P = 0.05 level (LSD 0.05).

RESULTS

1. Series A experiments

a) Vegetative propagation of A. repens

The response of A. repens to the herbicide treatments applied to the green manure crop was first assessed in spring 1971. Significant effects on rhizome dry matter per plot were observed. As compared to the amount of the initially planted rhizome matter, the relative increase in rhizome matter (propagation factor F = present matter divided by initial matter) ranged between 1.9 (treatment 1) and 0.7 (treatment 7).

With respect to the main effects of the preemergence treatments, the application of aminotriazole/paraquat had the best effect (F: 0.8), followed by dalapon/paraquat (F: 1.2) and paraquat alone (F: 1.3). Among the main effects of the postemergence treatments no difference was observed between TCA and dalapon (F: 0.9 and 1.0 respectively), but without any postemergence application F amounts to 1.5. The increased couch-suppressing effect of postemergence application was observed only when paraquat or dalapon/paraquat had been applied preemergence.

Table 1 contains the results of the second sampling in autumn 1971, after the harvest of the main crops. Again, significant treatment effects were observed. It is evident that only the culture of maize suppressed the existing A. repens population satisfactorily and even completely in case of treatment 6. The data show further that the 2 cereal crops tested did not check the vegetative propagation of A. repens.

With regard to the residual effects of the herbicide combinations applied to the green manure crop the differences between the observed general means (table 1) follow the same pattern as found with the first assessment. Yet, the differences are more pronounced and even more in favour of the preemergence application of aminotriazole/paraquat and of the postemergence application of dalapon.

Table 1

Effect of herbicides and crops on rhizome propagation of A. repens (mean of 2 experiments, g/plot d.m., F: propagation factor, see text).

Crops	Wheat	Barley	Maize	Mean	F
herbicide combinations					
1	61.9	37.8	5.9	35.2	7.0
2	17.5	12.5	2.8	10.9	2.2
3	25.6	14.9	1.3	13.9	2.8
4	37.5	44.1	4.1	28.5	5.7
5	12.1	16.4	1.2	9.9	2.0
6	14.7	8.7	0.0	7.8	1.6
7	30.3	32.7	1.8	21.6	4.3
8	10.5	25.4	1.3	12.4	2.5
9	4.9	8.8	0.3	4.7	0.9
mean	23.9	22.4	2.1		
LSD 0.05	18.0	12.3	1.5	14.3	
F	4.8	4.5	0.4		

b) crop growth

Since TCA, dalapon and aminotriazole are toxic to all gramineous species, phytotoxic effects of their application late in autumn could be expected on the germination and growth of the following test crops - w.wheat, s.barley and maize.

Significant, but slight effects on seedling density per m^2 were observed in w.wheat only, in the sense that the late (postemergence) application of dalapon and, even more, TCA reduced the seedling stand. Yet, this reduction was of no consequence for the final stand (number of ears per m^2) and the grain yield of wheat.

No phytotoxic effect of herbicide treatments on seedling emergence and final yield could be observed in s.barley and maize. The differences in treatment means on final yield are mainly related to the differences in suppression of A. repens. The more effective it was, the higher the yield.

2. Series B experiments

a) Vegetative propagation of A. repens

The effect of early and late applications of dalapon and glyphosate, respectively, on the growth of A. repens was assessed by repeated visual rating of % cover of A. repens tops and by measuring the rhizome dry matter per m^2 (the latter data are not yet available for 1974). Due to technical reasons the initial A. repens infestation had not been assessed.

Treatment effects are significant both for percent cover and rhizome mass. Yet, in consequence of the lacking homogeneity in initial dispersal of A. repens over the plots, the LSD 0.05 values are very high.

The data in table 2 show that with increasing amounts of herbicides applied the suppression of the vegetative propagation of A. repens was increased. With respect to the time of application, dalapon had a slightly better effect when applied early and glyphosate, when applied late. None of applied treatments suppressed the existing A. repens population completely.

Table 2

Effect of herbicide dose and time of application on vegetative propagation of A. repens and seedling stand of w. wheat (means of 2 experiments, except rhizome matter).

application prior to sowing weeks		A. repens % cover in April 8	4	rhizomes g/m^2 d.m. 8	4	wheat seedlings/m^2 in January 8	4
no herbicide		38.9	38.9	240	240	338	338
dalapon							
kg/ha	4.25	12.5	18.6	47	193	343	290
a.i.	8.5	18.8	8.4	167	85	311	312
	12.75	5.6	7.1	12	41	322	339
glyphosate							
kg/ha	1.4	7.0	5.2	45	23	365	266
a.i.	2.2	6.6	5.1	75	34	324	316
	2.8	3.3	4.8	34	15	339	310
LSD	0.05	23.3		141		128	

b) Crop growth

As shown in table 2, none of the herbicides applied significantly impeded the germination of w.wheat. Consequently, the final stand and the grain yield was affected only by the competitive growth of A. repens. Omitting every measure of control resulted in a yield reduction of about 1.2 t/ha grain d.m. (about 32 %).

DISCUSSION

Since A. repens is able to build up high population levels during the course of one year, even with conventional tillage methods and competitive crops (Cussans 1968, 1972), the objective of every control system should be complete eradication of A. repens. In contrast to the failure of previous attempts to reach this worthy goal by herbicide treatments only (Schwerdtle 1971, Bakermans and ten Holte 1972, van Hiele and de Boer 1972), our treatment No. 6 did succeed in complete eradication.

This could be explained by the combined effect of repeated chemical treatments on vigourously growing A. repens and of the additional counter competition of crops which tolerate the applied herbicides, i.e. Raphanus sativus with respect to dalapon and TCA, and maize with respect to atrazine. A central point of this system seems to be the time of herbicide application. The postemergence treatment in autumn attacks A. repens during the regrowth phase after the initial stubble treatment. The preemergence application of paraquat in spring represses the growth of A. repens when the stored reserves are almost exhausted by spring regrowth. Finally, the postemergence application of atrazine, which could be repeated once if necessary, kills the last regrowth of A. repens.

Apparently, this system of small steps is not effective enough in the culture of winter or spring cereals. Atrazine, as selective herbicide, cannot be applied. The presowing application of paraquat does not affect the build up of rhizome reserves. The counter competition of cereals to A. repens does not last long enough. Thus, in a cereal system it maybe regarded as a success, if the A. repens population can be restricted to a level which does not result in uneconomically high yield losses.

With respect to this objective, a single application of dalapon (13 kg/ha a.i.) 3 weeks after harvest to the stubble field or of glyphosate (1.4 kg/ha a.i.) 7 weeks after harvest may suffice to control A. repens satisfactorily, without being a risk to the growth of the following w.wheat crop. Aminotriazole applied early could be useful as well, but has been withdrawn from the list of approved herbicides in W. Germany.

Evans (1972) observed 100 % kill of A. repens in some of his experiments, when glyphosate (1.1 kg/ha a.i.) had been applied in autumn on stubble fields. Such complete control has not yet been achieved in our experiments, perhaps due to the omission of any soil cultivation. Yet, glyphosate may become quite useful in zero-tillage, since it makes the presowing application of paraquat unecessary.

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REDUCED CULTIVATIONS : AN ECONOMIC ASSESSMENT OF TWO EXAMPLES OF THE "SPRING CLEANING" TECHNIQUE IN FRANCE

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Summary The use of paraquat allows the elimination of/or the reduction in cultivations in the drilling of a number of crops. This leads to saving in time which allows either the rotation to be altered or to reduce the amount of manpower required and brings about an improvement in the gross margin from a given farming enterprise.

From the two case studies presented, it has been shown that the systematic use of paraquat for spring cleaning is justified from the economic point of view in all cases where the area of spring crops on the farm is above 37-62 acres per unit of manpower and in some cases when it is below this level. This corresponds to about 87 acres of total arable land per unit of manpower.

Resume L'emploi du paraquat permet la suppression ou la simplification des facons culturales pour le semis des cultures. Il en resulte un gain de temps qui permet soit de modifier l'assolement, soit de reduire le niveau de main d'oeuvre dans le sens d'une amelioration de la marge brute de l'exploitation.

Dans l'etude de deux exemples, il a pu etre mis en evidence que l'emploi systematique du paraquat sur les labours reverdis au printemps se justifie economiquement, de facon systematique au dela du seuil de 15-25 ha de cultures de printemps par unite de main d'oeuvre et de facon occasionnelle en deca de ce seuil. Ceci correspond a environ 35 ha de surface arable par unite de main d'oeuvre.

INTRODUCTION

With the advent of paraquat, a number of cultivation methods have been evolved that are quicker and simpler than the conventional ones. The most widely known is undoubtedly direct drilling, whose development reached more than 1.5 million hectares (3.75 million acres) in the USA and 100,000 hectares (250,000 acres) in the UK in 1973.

In the Gers area in the south west of France, a technique is used which, after autumn-ploughed fields have greened-up in spring, consists in killing the weeds with paraquat, then in preparing the seed bed and drilling with the minimum of soil working.

The main advantage of this method lies in avoiding the need to cultivate the land again in the spring, but in addition at the end of winter, the soil structure is good and it is advantageous to limit the number of spring cultivations to preserve this good structure.

Too often, the full potential of a product or a technique is not fully shown up in trials or demonstrations and it is only when the product or technique is used on a practical scale that results, sometimes partially shown up in trials, are really seen. This is true for the spring cleaning technique. The purpose of the paper was to study whether the time saved when drilling spring crops would allow the farmer to modify the rotation of the farm and/or cut down manpower needs.

The paper reports on two studies carried out in order to study the technique of spring cleaning on the whole farm and its consequences at the economic level. The data was obtained in 1971 and 1972.

METHOD

For each farm information was collected on the time taken for various farm tasks, especially those necessary for sowing the crops, the season when these tasks were executed, the climatic conditions over those periods and the gross margin per hectare and per crop. These figures were then used in a linear programming calculation to study the importance of some factors:

The extent to which paraquat could usefully be used for spring cleaning.
The possibility of introducing new crops into the rotation.
The possibility of reducing manpower.

The criterion chosen in order to assess the optimal use of the area under consideration has been the gross margin of the farm less the manpower costs.

MATERIAL

Farm No 1 has 120 ha (300 acres) of arable land, of which 43 ha (106 acres) are at present in lucerne and the remainder in cash crops. Two people are employed but one of them will, in the future, only work for 30% of his time on the farm. The cost of manpower is estimated to be 18.900 FF (£1,700) per year per man.

Farm No 2 covers 53 ha (132 acres) all in arable cropping. The farmer spends 85% of his time on the farm and is helped by one man who is paid 7 FF (63p) per hour and who is available for as long as required. It is possible to introduce irrigation on 20 ha (50 acres) of this farm for maize growing.

RESULTS

These are summarised in Table 1 (Farm No 1) and Table 2 (Farm No 2).

Farm No 1

The principal points studied were the effect of spring cleaning on:

The ability to introduce new crops.
Overcoming the reduction in manpower.

The results of the present rotation without spring cleaning are shown in Column A. The gross margin is shown to be 117.000 FF (£10,540) and the limitations are lack of time at the spring drilling period and too much of the less profitable lucerne.

The introduction of new, more profitable crops always improves the gross margin (see comparisons B and C, D and F, E and G). It is the same for the reduction of manpower (see comparisons A and D, B and E, C and G). But what is more interesting is that in all cases, the possibility of using the spring cleaning technique gives a substantial increase in the gross margin, even though this gross margin has already been increased by means of other factors. This technique is therefore to be recommended throughout (see comparisons A and B, D and E, F and G). The best gross margin, less manpower cost, is given where manpower is reduced and the cropping is optimised within this constraint (G).

Farm No 2

The main factors studied were the effect of spring cleaning on:

The ability to introduce maize.
The ability to introduce other new crops.

The results of the present rotation are shown in Column A. It will be noted that all the farm area has not been used due to lack of time for spring drilling.

The introduction of the spring cleaning technique (Column B) removes almost entirely the limiting factor, i e lack of time for spring drilling.

If maize is introduced into the rotation, the gross margin is maximum when the area down to maize is maximum. There is no bottleneck in the early spring and the introduction of the spring cleaning technique brings no improvement (see comparison C and D).

It is the same when introducing other new crops. The gross margin becomes 156.000 FF (14,050). The use of the spring cleaning technique only improves the gross margin slightly (see comparison E and F).

The last case which includes the use of spring cleaning, a return to maize and a completely new set of crops, maximises the gross margin (less manpower costs) but does not produce as dramatic an improvement in gross margin as in Farm No 1.

DISCUSSION

The interpretation of these results shows that the spring cleaning technique can be of benefit to the farmer particularly under certain situations, i e where:

The rotation includes a high proportion of spring crops.
The soils dry out badly and must be ploughed in autumn.
The farm is a large one.
The manpower is below a certain level or can with benefit be reduced.

In the two case studies, there is a relationship between the manpower requirements, the area of the farm and the area down to spring crops, as far as the profitability of the spring cleaning technique is concerned. In a given area of the country, there is a certain amount of time available in the spring. If the times for cultivations, etc and the manpower level are known, the area which can be drilled to spring cereals can be determined. In the south west of France, in the Gers, where the rotation often is a five-course one, the spring cropping area that can be worked and drilled per unit of manpower has been estimated to be about 15 to 25 ha (37 to 62 acres) and the total arable acreage that can be handled by one man is about 35 ha (87 acres).

The above mentioned examples show that the systematic application of the spring cleaning technique is very profitable when the farm area is above 35 ha (87 acres) per unit of manpower and only occasionally profitable when it is below the figure (see the comparisons 1.3 man for 120 ha (300 acres) to 2 men for 53 ha (132 acres)).

The method of study used here is not new. It is, however, suggested that it should be used more widely for the evaluation and development of new herbicides and new techniques.

Acknowledgements

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Table 1 - Farm No 1 : The financial effect of using spring cleaning to reduce manpower and improve the cropping

Total Area : 120 ha (297 acres)			2 Men			1.3 Men			
	Gross margin per ha/acre	Crop	1 A	2 B	3 C	4 D	5 E	6 F	7 G
Existing Crops	1,458 FF (£131)	Oil seed rape	24.0 ha (60 acres)	24.0 ha (60 acres)	24.0 ha (60 acres)	24.0 ha (60 acres)	24.0 ha (60 acres)	24.0 ha (60 acres)	24.0 ha (60 acres)
	1,447 FF (£130)	Soft wheat	31.5 ha 79 acres)	41.3 ha (103 acres)	48.0 ha (120 acres)	33.0 ha (82 acres)	41.2 ha (103 acres)	38.5 ha (96 acres)	48.0 ha (120 acres)
	1,350 FF (£122)	Barley	13.5 ha (34 acres	2.7 ha (7 acres)		9.0 ha (22 acres)	2.0 ha (5 acres)	2.8 ha (7 acres)	
	1,290 FF (£116)	Barley		24.3 ha (61 acres)			16.0 ha (40 acres)		
	1,559 FF (£140)	Sunflower	7.5 ha (19 acres)	17.3 ha (43 acres)	17.3 ha (43 acres)	9.0 ha (22 acres)	4.9 ha (12 acres)	12.3 ha (31 acres)	9.0 ha (22 acres)
	1,499 FF (£135)	Sunflower					12.4 ha (31 acres)		6.0 ha (15 acres)
	1,030 FF (£93)	Lucerne 1st year	10.8 ha (27 acres)	2.5 ha (6 acres)		9.0 ha (22 acres)	5.0 ha (12 acres)	7.0 ha (17 acres)	
	1,030 FF (£93)	Lucerne 2nd & following years	32.5 ha (81 acres)	7.5 ha (18 acres)		27.0 ha (67 acres)	15.0 ha (37 acres)	21.0 ha (52 acres)	
Possible New Crops	1,476 FF (£133)	Hard wheat			12.8 ha (32 acres)			12.0 ha (30 acres)	2.0 ha (5 acres)
	1,416 FF (£128)	Hard wheat			11.2 ha (28 acres)				22.0 (55 acres)
	1,515 FF (£136)	Flax			6.7 ha (17 acres)			2.2 ha (5.5 acres)	9.1 ha (23 acres)
	Whole farm gross margin per ha/acre less manpower cost		117,000 FF (£10,540)	129,000 FF (£11,620)	138,000 FF (£12,430)	126,000 FF (£11,350)	145,000 FF (£13,060)	144,000 FF (£12,970)	156,000 FF (£14,050)

1 Existing crops - conventional methods
2 Existing crops - improved cropping as a result of spring cleaning
3 Including possible new crops introduced as a result of spring cleaning
4 Existing crops - conventional methods
5 Existing crops - improved cropping as a result of spring cleaning
6 Including possible new crops - conventional methods
7 Including possible new crops - spring cleaning

Table 2 - Farm No 2 : The financial effect of using spring cleaning to improve the cropping

Total Area : 52 ha (131 acres)

	Gross margin per ha/acre	Crop	1 A	2 B	3 C	4 D	5 E	6 F	7 G
Existing Crops	1,214 FF (£109)	Oil seed rape	13.15 ha (33 acres)	13.15 ha (33 acres)	12.20 ha (30 acres)	12.20 ha (30 acres)	4.00 ha (10 acres)	4.00 ha (10 acres)	
	1,212 FF (£109)	Soft wheat	13.15 ha (33 acres)	13.15 ha (33 acres)	10.40 ha (26 acres)	10.40 ha (26 acres)	12.50 ha (31 acres)		
	1,281 FF (£115)	Barley	13.00 ha (32 acres)	2.90 ha (7 acres)	10.40 ha (26 acres)	10.40 ha (26 acres)			
	1,221 FF (£110)	Barley		23.60 ha (59 acres)					
		Fallow	13.50 ha (34 acres)						
Possible New Crops	1,476 FF (£133)	Hard wheat					14.00 ha (35 acres)	26.40 ha (66 acres)	9.60 ha (24 acres)
	1,416 FF (£128)	Hard wheat							10.40 ha (26 acres)
	1,515 FF (£136)	Flax					13.10 ha (33 acres)	6.00 ha (15 acres)	13.15 ha (33 acres)
	1,455 FF (£131)	Flax						7.00 ha (17 acres)	
	1,324 FF (£119)	Sunflower					9.40 ha (23 acres)	9.25 ha (23 acres)	
	1,594 FF (£144)	Maize			20.00 ha (50 acres)	20.00 ha (50 acres)			20.00 ha (50 acres)
	Whole farm gross margin per ha/acre less manpower cost		133,000 FF (£11,980)	148,000 FF (£13,330)	161,000 FF (£14,500)	161,000 FF (£14,500)	156,000 FF (£14,050)	157,900 FF (£14,230)	167,800 FF (£15,120)

1 Existing crops - conventional methods
2 Existing crops - improved cropping as a result of spring cleaning
3 Possible maize - conventional methods
4 Possible maize - with spring cleaning
5 Possible new crops - conventional methods
6 Possible new crops - possible cropping as a result of spring cleaning
7 Combination of new crops and spring cleaning

NEW TECHNIQUES FOR SEED BED PREPARATION FOR BREAK CROPS

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Summary Ten field trials have been carried out in the clay soils of Central Italy during 1973/74, on spring/summer break crops (maize, sorghum, sugar beet, sunflower and soya), comparing two systems of seed bed preparation: the traditional system, involving cultivations up until drilling, and minimum tillage aimed at improving the winter seed bed by removing all the weeds present with a paraquat spray at least four to five weeks before drilling, followed by drilling into an undisturbed seed bed.

In eight fields out of ten, minimum tillage gave better crop growth as measured by plants numbers and evenness of plant distribution.

In some cases, in the traditional system plots, weed infestation was much greater than in the minimum tillage plots.

INTRODUCTION

Where the soil is predominantly clay, compact and difficult to cultivate, the preparation of a good seed bed at the end of winter or in early spring is generally a difficult operation, particularly for break crops with small and delicate seeds, e g sugar beet, sorghum, tomatoes, etc, which also germinate with difficulty.

Cultivations, including ploughing and subsequent operations, when carried out at the right time allow natural weathering conditions (rain, frost and thaw) to complete the preparation of a fine tilth.

With traditional methods of seed bed preparation, a final cultivation is often necessary mainly to destroy emerged weeds which hinder drilling. This unnecessary movement of the soil can destroy the naturally produced tilth and often produces conditions favourable to a new weed germination. Such a cultivation also leads to moisture loss from the soil surface layer.

MATERIALS AND METHODS

Trials were carried out in Umbria, Central Italy, in 1973 and 1974 at two locations, one upland and one in the plain, covering different soil types. The three 1973 trials were at a) S Apollinare, upland, with grain sorghum (Sorghum vulgare), b) Papiano, on the plain, with maize (Zea mays L), and c) Papian, on the plain with grain sorghum.

In 1974 trials were extended to seven sites (four on the plain and three upland) and included, in addition to sorghum, other traditional or recently introduced break crops, e g sugar beet (Beta vulgaris ssp saccarifera), sunflower (Helianthus annuus) and soya (Glycine max).

The soils on the plain contained 33% clay and the upland soils 40% to 45% clay.

In order to be able to use standard farm machinery fields of over 0.5 ha (1 acre) were chosen, with an individual plot size greater than 600-700 m^2 (717-837 yd^2).

A four replicate randomised block experimental design was used. The treatments compared were:

Traditional cultivations.
Minimum tillage.

Traditional cultivation consisted of a) a summer ploughing after the cereal harvest, b) one to three cultivations 20 to 25 cm (8 to 10 in) deep during the winter in order to break up big clods and/or to destroy emerged weeds, c) cultivation at drilling time at 15 to 20 cm (6 to 8 in) followed by light (5 to 10 cm (2 to 4 in)) harrowing with a rigid tined harrow.

For minimum tillage the operations were: a) winter ploughing (as above), b) a number of deep cultivations (as above), c) final seed bed preparation, with a harrowing four to five weeks prior to drilling, d) a spray with paraquat at 0.5 kg a i/ha (8 oz a i/acre) in 500 l water/ha (45 gal/acre) plus 0.5% wetter, either just before or just after drilling depending on whether the weeds would impede drilling.

Minimum tillage thus allows drilling to take place into soil which has been undisturbed for four to five weeks and has had the benefit of weathering.

The details of the various cultivations are shown in Table 1.

Emergence counts were made on 8 to 10 rows/plots in 10 m (33 ft) lengths.

In some of the 1974 trials, in order to check on plant spacing in the rows, the average distance between plants was measured, thus giving a variability coefficient. Also, in the 1974 trials weed infestation was important in some of the trials and in two out of the seven sites considerable differences in levels of infestation were noted between the two treatments.

The Braun-Blanquet method was used to measure the importance of the weed flora and Table 2 shows this converted into a ground area cover index.

Each plot was harvested separately in order to measure yield.

Emergence counts in the form of paired comparisons were analysed using students' "t" test. An analysis of variance was carried out on the yield data.

RESULTS

The experimental results are shown in Tables 2 and 3. On the plain, fields drilled with soya (Table 2) showed a higher degree of weed infestation following traditional cultivations than those drilled after minimum tillage. The ground area cover indices were respectively 221% and 14%.

It is clear that harrowing just before drilling with the traditional method brought a large quantity of weed seeds to the surface or favoured their germination. This did not occur with the minimum tillage technique.

The same result, although to a lesser degree, occurred in the sugar beet trial, where the ground area cover indices were 72% and 34% respectively.

Other trials carried out showed no difference between the two techniques.

Other data reported in Table 3 shows that in seven trials out of ten there was a higher plant population per square metre following minimum tillage as compared with the traditional method.

With plants having comparatively larger seeds, e g maize and soya, or that establish themselves vigorously, e g sunflower, differences are small; on the other hand differences are very marked for plants with small seeds or delicate seedlings, especially for sorghum, which because of late drilling is most likely to suffer from lack of moisture in the soil surface layer.

The variability coefficient, which is always greater in the traditionally cultivated plots, shows that in these plots, not only is the plant population lower but its distribution is also more irregular.

Yields for 1973 showed no difference between treatments for maize, but for sorghum were significantly higher with the minimum tillage technique.

With spring sown break crops which have difficulty in germinating because of a clay soil, poor soil structure or lack of moisture in the soil surface layer altering the method of seed bed preparation can give better results. Under these conditions, cultivating just before drilling should be avoided.

With the minimum cultivation technique, with the final cultivation made some weeks before drilling and with the use of a herbicide to kill the weeds that are present, farmers have the possibility of drilling into a soil with a good structure and sufficient moisture. In this situation there are often less weeds. Drilling can also take place quickly, avoiding the delays occasioned by numerous, expensive cultivations necessary with the traditional system.

Table 1 - Calendar for Seed Bed Preparation

1973	Maize		Grain Sorghum	
	Traditional system	Minimum tillage	Traditional system	Minimum tillage
Ploughing	Summer 72	Summer 72	Summer 72	Summer 72
Deep cultivations (15 - 20 cm) 1	Autumn 72	Autumn 72	Autumn 72	Autumn 72
2	Feb 73	Feb 73	Feb 73	Feb 73
3	26/3	-	26/3	-
4	15/4	-	16/5	-
Seed bed preparation (harrowing)	15/4	11/3	16/5	15/4
Date of drilling	15/4	15/4	16/4	16/5
Herbicide spray	-	16/4	-	14/5

1974	Sugar beet		Sunflower		Soya		Sorghum	
	Traditional system	Minimum tillage	Traditional system	Minimum tillage	Traditional system	Minimum tillage	Traditional system	Minimum tillage
Ploughing	Summer 73	Summer 73	Summer 73	Summer 73	Summer 73	Summer 73	Summer 73	Summer 73
Deep cultivations (15 - 20 cm)	Winter	Winter	Winter	Winter	Winter	Winter	Winter	Winter
Seed bed preparation (harrowing)	9/3	15/2	2/4	15/3	16/5	10/4	15/5	9/4
Date of drilling	9/3	9/3	2/4	2/4	16/5	16/5	15/5	15/5
Herbicide spray	-	10/3	-	4/4	-	16/5	-	16/5

Table 2 - Ground Area Cover (1)

Weeds	Plain					Upland	
	Soya		Sugar beet		Sunflower (2)	Soya (2)	Sugar beet (2)
	Traditional system	Minimum tillage	Traditional system	Minimum tillage			
Ajuga chamaepitys	-	-	-	-	-	-	17.5
Amaranthus albus	5.0	0.1	-	-	-	5.0	0.1
Amaranthus retraflexus	31.9	3.8	21.2	21.2	37.5	0.1	0.1
Anagallis arvensis	0.1	0.1	5.0	0.1	-	-	0.1
Brassica arvensis	-	-	-	-	-	0.1	37.5
Chenopodium album	0.1	0.1	11.5	2.5	37.5	0.1	5.0
Convolvulus arvensis	6.9	0.1	2.5	2.5	-	0.1	0.1
Convolvulus sepium	25.6	3.8	-	-	-	-	-
Diplotaxis erucoides	10.1	0.1	-	-	-	-	-
Echinochloa crusgalli	15.6	0.1	-	-	-	0.1	-
Helminthia echioides	-	-	-	-	-	5.0	0.1
Linaria spuria	0.1	-	11.5	2.5	0.1	0.1	5.0
Lolium multiflorum	0.1	0.1	2.5	0.1	-	-	-
Matricaria chamomilla	0.1	0.1	5.0	2.5	0.1	-	-
Papaver rhoeas	8.7	0.1	0.1	0.1	-	-	0.1
Polygonum aviculare	0.1	0.1	-	-	5.0	-	-
Polygonum convolvulus	65.6	1.4	5.0	0.1	5.0	0.1	0.1
Portulaca olevacea	18.7	3.8	0.1	0.1	-	-	-
Raphanus raphanistrum	31.9	0.1	-	-	0.1	-	-
Setaria verticillata	0.1	0.1	2.5	2.5	5.0	-	-
Setaria viridis	0.1	-	-	-	-	0.1	5.0
Solanum nigrum	0.1	0.1	0.1	0.1	0.1	5.0	-
Stachys annua	0.1	0.1	5.0	0.1	0.1	0.1	17.5
Verbena officinalis	0.1	0.1	-	-	5.0	-	-
Total cover %	221.1	14.3	72.0	34.4	95.5	15.9	88.2

(1) Calculated on the basis of the Braun-Blanquet index.

(2) Traditional and minimum tillage assessments grouped together.

Table 2 (continued)

Species occasionally occurring included:

Plain	Soya	Digitaria sanguinalis
		Ammi majus
		Alopecurus myosuroides
		Avena sterilis
		Mercurialis annua
		Sonchus sp
	Sugar beet	Avena sterilis
		Sonchus sp
		Rumex crispus
	Sunflower	Ammi majus
Upland	Soya	Ammi majus
		Ammi visnada
		Phalaris paradoxa
		Alopecurus myosuroides
		Rumex crispus
	Sugar beet	Ammi majus
		Ammi visnada
		Phalaris paradoxa
		Avena sterilis
		Alopecurus myosuroides
		Euphorbia sp

Table 3 - Other Data

Year	Crop and Variety	Location	Emergence count/m2		Increase of minimum tillage over traditional system			Variability coefficient of average distance between plants		Grain yield q/ha		
			TS	MT	A/m2	SD	R%	TS	MT	TS	MT	SD
1973	Maize (Etruria 285)	Plain	3.5	4.3	0.8	ns	22	-	-	37	38	ns
	Sorghum (Mini-Milo 54/Br)	Plain	13.3	28.8	15.5	++	119	-	-	19	35	+
	Sorghum (Mini-Milo 54/Br)	Upland	2.1	7.1	5.0	++	238	-	-	55	64	+
1974	Sorghum (Funk's G 516/Br)	Plain	25.7	44.5	18.8	++	73	-	-			
	Sorghum (Funk's G 516/Br)	Upland	16.6	20.0	3.4	++	20	113	105			
	Sunflower (Uniflor 70)	PPlain	3.3	3.6	0.3	ns	9	38	31			
	Sugar beet (Kawemono)	Plain	7.0	8.0	1.0	+	14	-	-			
	Sugar beet (Kawemono)	Upland	5.4	7.9	2.5	++	18	78	73			
	Soya (Chippewa 64)	Plain	12.3	13.1	0.8	ns	6.5	-	-			
	Soya (Chippewa 64)	Upland	10.4	12.3	1.9	++	18	129	103			

TS = Traditional system
MT = Minimum tillage
A = Absolute

SD = Significant difference
R = Relative

NOTES

THE EFFECT OF DIQUAT AND PARAQUAT APPLIED TO SEEDS

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Summary In laboratory experiments in a Jacobsen apparatus the effects of diquat and paraquat on the germination of eight species were studied. The herbicides as a rule reduced the germination capacity and the number of surviving seedlings. The seedlings developed abnormally, with reduced length of roots and shoots. There were no differences in the phytotoxic effect when the germination analyses were carried out immediately after the treatment of the seeds or when they were carried out one month after the treatment.

Résumé Lors d'expériences faites en laboratoire, les effets du diquat et du paraquat sur la germination de huit espèces ont été étudiés. De manière générale, les herbicides ont réduit la capacité de germination et le nombre des jeunes plants proissant. Ceux-ci se sont développés anormalement, avec une longueur de racines et de pousses réduite. Lors des analyses de germination effectuées immédiatement après les traitements des semences et celles effectuées un mois après ces traitements, il ne fut constaté aucune différence en ce qui concerne l'effet phytotoxique.

INTRODUCTION

The effect of diquat and paraquat on plants in different developmental stages is well known. However, the influence of these herbicides on non-germinated seeds has only been studied to a small extent. For pre-emergence weed control in certain crops or for "chemical ploughing" the bipyridylium herbicides often come into contact with ripe, non-germinated seeds. Hierholzer (1966) found that paraquat applied to seeds reduced the germination capacity of wheat and meadow fescue but it had no influence on lettuce and *Galium aparine*. An improved germination of lucerne was found by Gimesi (1966) when diquat was used as defoliant. Steckő (1974) showed that diquat and paraquat reduced the emergence of some weed species that were treated on the soil surface. When seeds were placed 0.5 cm below the treated surface the effect of herbicides was small.

This report briefly refers to laboratory experiments carried out at the Department of Plant Husbandry in 1974. The aim was to study the influence of diquat and paraquat on the germinating processes, and the development of seedlings of some dicotyledonous and monocotyledonous species.

METHODS AND MATERIALS

Seeds of Anthemis tinctoria, Chenopodium album, Delphinium consolida, Galinsoga parviflora, Lactuca serriola, Phleum pratense, Poa pratensis and Senecio vulgaris that had been stored indoors for 2-3 years were treated with 0.5 and 2 kg per hectare a.i. of diquat and paraquat respectively. Immediately after this 2x25 seeds in each treatment were placed in a Jacobsen apparatus (Bell-jar germinator). The germination bed was illuminated daily for 24 hours with about 1000 lux. The testing period lasted for 20 days at an average temperature of 20° C. The following analyses were recorded: germination speed, germination capacity, number of survived seedlings, length of roots and length of shoots.

Similar germination experiments were carried out one month after the treatment. At the same time treated seeds washed in water for 2 minutes were also germinated in the Jacobsen apparatus.

RESULTS

There were no large difference in germination when the analyses were carried out immediately after the treatment or one month after the treatment; the average results are summarized in Table 1. In most cases diquat and paraquat reduced the speed of germination by some days. The influence on the germination capacity varied. The herbicides increased the number of germinated seeds of Delphinum consolida and decreased it for seeds of Galinsoga parviflora, Phleum pratense, Poa pratensis and Senecio vulgaris. However, most of the seedlings in the treated plots were abnormal and without the ability to develop into normal plants. The growth of the roots and the shoots was inhibited, and the cotyledons often lacked chlorophyll.

The monocotyledonous species and Delphinium consolida and Senecio vulgaris were found to be more sensitive to paraquat while the other species were more sensitive to diquat. When the treated seeds were washed with water the phytotoxicity of diquat and paraquat were somewhat reduced on Chenopodium album and Lactuca serriola. On the other species washing did not influence the action of the herbicides.

DISCUSSION

The results presented in this paper show that diquat and paraquat applied on non-germinated seeds had a considerable effect on the germination processes. It is suggested that the herbicides are adsorbed onto the seed coats, and consequently, the phytotoxic residues are retained. Experiments of Watkin and Sagar (1971) and Steckő and Svensson (1974) also show that the bipyridylium herbicides applied to the soil surface persist for a considerable time.

Thus, it can be assumed that diquat and paraquat applied on the soil surface influence the germination processes, partly through direct contact with the seed and partly via the soil at germination. In a field experiment Steckő (1974) found inhibited germination of Avena fatua when 1 kg/ha paraquat was used on barley stubble infected with this weed. However, a reduced germination is also possible when the bipyridyl herbicides are applied to plants at milk-ripeness (Svensson 1971).

Table 1

Influence of diquat and paraquat on the germination and the development of seedlings of eight species

	Treatment				
	Control	Diquat, kg/ha 0.5	2	Paraquat, kg/ha 0.5	2
Chenopodium album					
Germinated seeds after 7 days, %	88	89	94	93	93
Germinated seeds after 20 days, %	98	94	96	94	94
Living seedlings after 20 days, %	97	65	5	77	76
Length of roots after 20 days, mm	24	5	7	6	5
Length of shoots after 20 days, mm	25	17	-	13	12
Anthemis tinctoria					
Germinated seeds after 7 days, %	82	79	69	76	69
Germinated seeds after 20 days, %	90	93	74	88	81
Living seedlings after 20 days, %	89	24	0	43	12
Length of roots after 20 days, mm	56	3	-	7	3
Length of shoots after 20 days, mm	-	-	-	-	-
Delphinium consolida					
Germinated seeds after 7 days, %	35	31	2	36	27
Germinated seeds after 20 days, %	63	82	47	72	74
Living seedlings after 20 days, %	62	28	0	3	0
Length of roots after 20 days, mm	29	3	-	-	-
Length of shoots after 20 days, mm	27	9	-	-	-
Galinsoga parviflora					
Germinated seeds after 7 days, %	40	43	18	27	21
Germinated seeds after 20 days, %	86	62	40	66	51
Living seedlings after 20 days, %	86	10	0	45	0
Length of roots after 20 days, mm	39	-	-	5	-
Length of shoots after 20 days, mm	9	-	-	7	-
Lactuca serriola					
Germinated seeds after 7 days, %	89	91	67	92	91
Germinated seeds after 20 days, %	93	95	84	92	93
Living seedlings after 20 days, %	91	6	0	27	0
Length of roots after 20 days, mm	91	-	-	10	-
Length of shoots after 20 days, mm	-	-	-	-	-
Phleum pratense					
Germinated seeds after 7 days, %	96	84	70	76	71
Germinated seeds after 20 days, %	96	84	71	76	71
Living seedlings after 20 days, %	96	10	0	0	0
Length of roots after 20 days, mm	52	-	-	-	-
Length of shoots after 20 days, mm	58	3	-	-	-

Table 1 (Cont.)

	Treatment				
	Control	Diquat, kg/ha 0.5	2	Paraquat, kg/ha 0.5	2
Poa pratensis					
Germinated seeds after 7 days, %	3	0	0	0	0
Germinated seeds after 20 days, %	60	48	27	39	27
Living seedlings after 20 days, %	60	17	5	1	0
Length of roots after 20 days, mm	28	-	-	-	-
Length of shoots after 20 days, mm	33	5	-	-	-
Senecio vulgaris					
Germinated seeds after 7 days, %	17	25	16	31	23
Germinated seeds after 20 days, %	70	69	42	55	48
Living seedlings after 20 days, %	70	31	0	8	0
Length of roots after 20 days, mm	37	4	-	-	-
Length of shoots after 20 days, mm	13	8	-	-	-

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THE RESULTS FROM 7 YEARS RESEARCH INTO MINIMAL AND ZERO TILLAGE TECHNIQUES FOR MAIZE IN ROMANIA

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Summary This paper presents the results obtained from research into minimal and zero tillage techniques for maize cultivated in chernozem soils containing 3.5% humus and 34% clay. Maize has been grown continuously for 7 years on the same site. Grain yields obtained from minimal and zero tillage plots were found to be of the same level as those obtained on plots subjected to conventional cultivation techniques.

On the basis of the results obtained, the conclusion was drawn that minimum and zero tillage techniques could be used generally for the cultivation of maize in areas not infested with perennial weeds such as Sorghum halepense.

INTRODUCTION

The use of minimum and zero tillage techniques for the cultivation of maize represents a true revolution in agriculture. In order to obtain good results from growing maize without ploughing the soil, two conditions must be respected; the use of a suitable sowing machine and the use of herbicides to destroy all weed growth present.

Because of the technical and economic advantages of zero and minimum tillage, research has been carried out in many countries. On the basis of research Brown (1968), Jeater (1968) and Millou and Marmion (1970), the use of paraquat pre-planting followed by direct sowing with the Howard Rotaseeder machine gave good results for a variety of crops including wheat, barley and flax. Also Elenov (1974) has shown that the area of cereals direct drilled in the U K increased from 6,500 ha in 1968 to 54,000 ha in 1973, and that this area will have increased to 200,000 ha by 1980.

Maize cultivation using minimal and zero tillage techniques is the theme of much research work in the U S A. Philips and Young (1973) quote that, in the state of Kentucky alone, the area of maize cultivated by minimal and zero tillage methods increased from 150,000 ac in 1969 to 420,000 ac in 1971. In 12 states the area increased from 262,000 ac in 1969 to 1,012,000 ac in 1971.

Minimum tillage methods for maize cultivation have been studied in Romania since 1962 (Sarpe 1966, 1967, 1969) using atrazine for weed control and machinery commonly available on Romanian farms. Many state farms used this system of cultivation on a practical scale. The zero tillage method was investigated for the first time in 1967 and initial results for the period 1968 - 1970 have been reported by Sarpe and Arghir (1970). This paper extends the results up to 1973.

METHODS AND MATERIALS

3 methods of maize cultivation were studied at Fundulea, conventional, minimal and zero tillage on a degraded medium chernozem soil containing 3.5% humus and 34% clay. Maize was cultivated on the same plots continuously for 7 years beginning in 1967. These plots were arranged on a latin square design with a four-fold replication. Each plot was 250 m^2.

Weed control on plots cultivated by conventional means was achieved using mechanical and manual methods. Herbicides were not used.

Plots intended for minimal and zero tillage treatments were divided into three, each sub-plot receiving 5, 10 or 20 kg of atrazine per ha (see Table 1).

Table 1

Conventional technology	Minimum tillage			Zero tillage		
-	Atrazine			Atrazine		
-	5 kg	10 kg	20 kg	5 kg	10 kg	20 kg

The mechanical and manual operations carried out for each method are shown in Table 3.

Atrazine was applied during the autumn, October - November, to ensure the efficient action of the product through distribution and winter precipitations.

Fertilizer was applied at the rate of 100 kg nitrogen and 50 kg phosphorus per ha in order to maintain the maize production at a high level.

Maize hybrid seed was sown with Romanian seed drills, the SPC-6 on plots cultivated by conventional means. The MFSU-4 seed drill, slightly modified for sowing into uncultivated soil was used for the zero tillage plots. Plant populations on all plots varied between 40,000 and 45,000 per ha.

Weed evaluation was made during the growing seasons and the results were expressed in EWRC scale units. Weed weights were determined before harvesting the maize crop.

The following weeds were present on the trial plots : Echinochloa crus-galli, Setaria glauca, Amaranthus retroflexus, Chenopodium album, Sinapis arvensis, Digitaria sanguinalis and Convolvulus arvensis.

Moisture content of the soil was determined at depths 0 - 100 cms at 10 day intervals between sowing and harvest. Results are shown in Table 2.

After harvest, maize grain production was determined at 15% moisture content.

Results obtained from the analysis of the physical chemical and microbiological properties of the soil during the relevant period are the subject of a separate report.

RESULTS

Objections, based mainly on traditional ideas have obstructed the more general use of minimum and zero tillage techniques. It has been widely suggested that the use of minimal tillage techniques could result in considerable water loss from the soil. This objection is made even stronger when applied to zero tillage where neither ploughing nor any other cultivation is carried out. In order to investigate this aspect of the problem, soil moisture was recorded at depths between 0 and 100 cms. The quantity of information recorded was so great that it could not all be issued with this paper. Some of the results are shown in table 2 including results for those months with minimal atmospheric precipitation only.

The results indicated that soil moisture content of zero tilled plots was equal to that obtained where conventional cultivations were carried out.

It was also shown that all the cultivations, including mechanical and manual tillage, were carried out in order to destroy weeds and in fact contributed very little (negligible as far as maize production is concerned) to water conservation. Water loss depends to a greater extent on environmental temperature and wind speed. Hoeing of the upper layer of soil and destruction of capillary pores does not contribute to the retention of water by the soil.

Weed control data shown in Table 3 indicates that in the first 4 years of the experiments, weeds not killed by atrazine (Digitaria sanguinalis and Convolvulus arvensis) did not adversely effect maize growth or grain production per ha.

Where plots were treated with atrazine at 5 kg/ha, a radical change in weed spectrum was noted. Sinapis arvensis, Amaranthus retroflexus, Chenopodium album, Echinochloa crus-galli and Setaria glauca were killed, but the density of other weed species such as Digitaria sanguinalis and Convolvulus arvensis increased considerably.

Plots treated with atrazine 10 kg/ha showed a decrease in the density of Digitaria sanguinalis and Convolvulus arvensis and were absent following 7 years of this treatment.

Of great importance was the situation prevalent on plots treated with atrazine 20 kg/ha, where a complete absence of weed growth was recorded

It can be stated, therefore, that the susceptability of different species of weeds to atrazine treatment depends on the treatment rate. Moreover Digitaria sanguinalis is resistant to atrazine at a rate of 5 kg/ha (for the chernozem soil at Fundulea) but was susceptible at higher rates.

Table 2

Relationship between soil moisture content (%) and cultivation method used at Fundulea

Month	CONVENTIONAL		MINIMUM TILLAGE		ZERO TILLAGE	
	Depth		Depth		Depth	
	0-50 cm	50-100 cm	0-50 cm	50-100 cm	0-50 cm	50-100 cm
Year 1967						
20 V	20.5	22.4	20.3	23.0	20.6	22.9
10 VI	24.3	23.1	24.1	23.4	23.8	22.8
10 VII	19.8	20.6	19.6	21.0	19.2	21.3
20 VIII	18.6	19.3	18.8	19.6	18.4	19.0
10 IX	17.2	18.0	17.8	18.1	17.1	18.4
Year 1969						
22 V	19.9	20.0	20.0	20.1	20.1	20.9
12 VI	23.9	22.3	22.3	21.5	23.4	21.4
3 VII	23.7	23.2	23.0	22.3	22.9	22.9
24 VII	19.6	19.7	20.4	20.1	19.2	19.7
14 VIII	21.3	18.2	21.4	17.1	21.1	18.4
3 IX	17.6	17.5	17.6	17.3	17.3	16.8
Year 1971						
24 V	21.1	19.0	23.5	22.3	22.1	21.4
22 VI	19.4	19.3	18.9	20.4	18.6	19.2
19 VII	16.6	19.2	18.4	20.3	16.3	17.8
9 VIII	12.4	16.6	13.0	15.5	10.5	15.2
20 IX	13.9	17.0	15.1	16.2	14.4	15.0
Year 1972						
20 IV	20.2	20.9	21.3	21.1	21.8	20.9
16 V	22.8	21.0	23.1	20.8	22.7	20.3
5 VI	20.3	19.9	19.8	20.0	19.8	19.0
25 VII	20.4	19.7	20.0	19.6	18.8	19.2
12 VIII	22.5	19.3	21.4	18.3	18.6	19.5
14 IX	19.5	17.4	18.7	17.3	18.0	18.2
Year 1973						
21 V	21.7	19.7	20.5	19.8	20.2	19.8
11 VI	17.9	20.7	18.6	19.7	18.5	20.8
3 VII	19.8	20.8	18.2	19.3	19.1	19.2
13 VIII	16.7	20.2	18.3	18.9	16.6	19.1
4 IX	12.4	14.6	11.1	13.8	14.3	16.8

Table 3

Weed dry weight in relation to the cultivation method and rate of atrazine

CONVENTIONAL METHOD (Without herbicides)	MINIMUM TILLAGE (With atrazine)	ZERO TILLAGE (With atrazine)
1 Fertilizing	1 Fertilizing	1 Fertilizing
2 Fall ploughing + harrowing	2 Fall ploughing + harrowing	2 -
3 Spring harrowing	3 Treated with atrazine	3 Treated with atrazine
4 Discing + harrowing	4 Discing + harrowing	4 -
5 Discing + harrowing	5 -	5 -
6 Sowing with S.P.C.-6	6 Sowing with S.P.C.-6	6 Sowing with M.F.S.U.-4
7 Harrowing	7 -	7 -
8 Rotary hoeing	8 -	8 -
9 Mechanical hoeing I	9 -	9 -
10 Manual hoeing I	10 -	10 -
11 Mechanical hoeing II	11 -	11 -
12 Manual hoeing II	12 -	12 -
13 Mechanical hoeing III	13 -	13 -
14 Manual hoeing III	14 -	14 -
15 Mechanical harvest	15 Mechanical harvest	15 Mechanical harvest

Years	Without manual and mechanical hoeing		With manual and mechanical hoeing		Atrazine 5 kg/ha		Atrazine 10 kg/ha		Atrazine 20 kg/ha		Atrazine 5 kg/ha		Atrazine 10 kg/ha		Atrazine 20 kg/ha	
	Weeds dry weight		Weeds dry weight		Weeds dry weight		Weeds dry weight		Weeds dry weight		Weeds dry weight		Weeds dry weight		Weeds dry weight	
	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%
1967	46.0	100	8.2	18	4.6	10	0	0	0	0	3.9	8	0	0	0	0
1968	30.0	100	6.7	22	3.2	11	0	0	0	0	3.6	12	0	0	0	0
1969	40.5	100	18.0	44	[illegible].0	12	0	0	0	0	6.8	17	0	0	0	0
1970	35.0	100	6.5	18	6.7	19	2.2	6	0	0	10.2	29	4.8	14	0	0
1971	39.0	100	7.0	18	7.7	20	1.6	4	0	0	9.9	25	2.5	6	0	0
1972	60.0	100	10.6	18	8.0	13	2.7	4	0	0	10.8	18	5.3	9	0	0
1973	40.4	100	19.1	47	10.2	25	3.9	10	0	0	22.0	54	8.8	22	0	0

The data presented in Table 3 shows that the quantity of weeds obtained from zero tilled plots was greater than that obtained from minimal tilled plots i.e. ploughing contributed to some extent to the decrease in infestation of weeds resistant to atrazine.

Table 4 compares grain production obtained from the use of the three tillage methods.

The average grain production from conventional plots was 49.6 centner per ha over the 7 year period. The minimal cultivation method produced 54.8 - 58.9 centner per ha, the increase in production resulting from the better control of weeds by atrazine over the majority of years than that obtained by using conventional mechanical or manual tillage. It was observed that, after 3 mechanical or manual operations, the crop was again infested with weeds, especially during rainy summers.

Zero cultivation plots provided grain yields of 48.1 - 57.2 centner per ha (production from sub-plots treated with atrazine at 10 and 20 kg per ha was practically equal to that obtained from minimum tillage plots).

During the last 3 - 4 years, grain production on both minimum and zero tillage plots treated with atrazine 5 kg per ha was lower than that obtained by conventional methods. This was caused by the extent of the infestation of *Digitaria sanguinalis* (60 - 80% of weed growth) and *Convolvulus arvensis*.

DISCUSSION

The use of atrazine has been shown to allow the modern techniques of minimum and zero tillage to be applied to the cultivation of maize for grain production.

Soil moisture at depths between 0 and 100 cms determined on minimal and zero tillage plots was shown to be equal to that obtained on conventionally cultivated plots. It was also demonstrated that the main benefit of manual and mechanical tillage was the control of weed growth and that their contribution towards conserving soil moisture was only marginal.

On the degraded medium chernozem soil at Fundulea, it was shown that, when atrazine was applied annually at 5 kg per ha, the quantity of *Digitaria sanguinalis* increased considerably and no control of *Convolvulus arvensis* was obtained. An increased rate of atrazine was necessary to control these species.

Maize grain production from minimal and zero tillage plots was greater than that obtained from conventional plots. This increase was due to the efficient weed control obtained by the use of appropriate herbicides.

It is considered that the use of minimum and zero tillage techniques could be extended to other soil types provided they are not infested with perennial weed species such as *Sorghum halepense*.

Table 4

Relationship between grain yield and cultivation method, Fundulea

	CONVENTIONAL METHOD (Without herbicides)	MINIMUM TILLAGE (With atrazine)	ZERO TILLAGE (With atrazine)
1	Fertilizing	Fertilizing	Fertilizing
2	Fall ploughing + harrowing	Fall ploughing + harrowing	-
3	Spring harrowing	Treated with atrazine	Treated with atrazine
4	Discing + harrowing	Discing + harrowing	-
5	Discing + harrowing	-	-
6	Sowing with S.P.C.-6	Sowing with S.P.C.-6	Sowing with M.F.S.U.-4
7	Harrowing	-	-
8	Rotary hoeing	-	-
9	Mechanical hoeing I	-	-
10	Manual hoeing I	-	-
11	Mechanical hoeing II	-	-
12	Manual hoeing II	-	-
13	Mechanical hoeing III	-	-
14	Manual hoeing III	-	-
15	Mechanical harvest	Mechanical harvest	Mechanical harvest

Years	Without herbicides		Atrazine 5 kg/ha		Atrazine 10 kg/ha		Atrazine 20 kg/ha		Atrazine 5 kg/ha		Atrazine 10 kg/ha		Atrazine 20 kg/ha	
	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%	Q/ha	%
1967	52.1	100	55.8	107	55.1	106	55.9	107	54.3	104	55.7	107	55.3	106
1968	40.5	100	40.2	100	42.0	104	43.0	106	40.1	99	42.4	105	42.8	106
1969	57.1	100	76.3	133	80.3	140	75.2	141	71.8	125	78.1	136	75.1	131
1970	54.2	100	54.2	100	60.8	112	61.5	113	38.2	94	50.1	124	51.7	128
1971	40.7	100	43.0	105	53.3	133	55.6	137	41.3	101	56.8	139	57.7	142
1972	60.9	100	65.0	107	69.8	115	70.2	115	61.2	100	64.1	105	64.2	105
1973	42.1	100	49.7	118	54.8	130	51.0	121	30.0	71	43.6	103	53.7	127
Average	49.6	100	54.8	110	59.4	119	58.9	118	48.1	96	55.8	112	57.2	115

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THE EFFECT OF METHOD OF SEED BED PREPARATION ON MAIZE (ZEA MAYS L) AND BARLEY (HORDEUM SATIVUM JESS) YIELDS

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Summary   Grain yields from maize and barley sown in seed beds prepared by a range of cultivation techniques were measured.

With both crops, late cultivation resulting in a one to two week fallow period, without either a pre cultivation application of 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat, or a post sowing application of nitrogenous fertiliser gave significantly lower yields. Early cultivation resulting in a four week fallow period gave higher grain yields which were not increased by either a pre cultivation application of paraquat or a post sowing application of nitrogenous fertiliser. The pre cultivation application of 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat prior to late cultivation caused highly significant yield increase up to that obtained from early cultivation. A post sowing application of nitrogenous fertiliser only partially overcame the yield depression caused by late cultivation.

INTRODUCTION

The nature of the intensive farming practised in several lowland districts of New Zealand is such that the demands of livestock for scarce spring pasture is high, forcing farmers to delay ploughing. This problem, coupled with labour and contractor shortages, together with delays due to wet weather frequently results (if planting dates are to be met) in farmers ploughing and planting without the "traditional" four to six week fallow period.

Some work on the application of 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat to pasture four to ten days prior to ploughing has been reported by Blackmore (1967) who demonstrated yield increases, and pointed out that pre cultivation spraying enabled "fallowing" to proceed under wet conditions when it would be impossible to cultivate.

During the late 1960s several maize and barley growers in the Manawatu and Waikato districts were applying paraquat to pasture, predominantly perennial ryegrass (Lolium perenne L) and white clover (Trifolium repens), prior to commencing normal cultivations for spring sowing. This practice, it was claimed, led to increased yields particularly when the fallow period was short, i e one to two weeks.

It was considered that further work was necessary to quantify the conditions under which a benefit from pre cultivation spraying might be expected.

This paper reports results obtained from three years' experimental work carried out on spring sown maize and barley in the Waikato and Manawatu districts. In the "1970 Hamilton Maize Trial" and the "1971 Manawatu Barley Trial" the objective was to measure the effect of such factors as type of cultivation, length of fallow, pre cultivation spraying with paraquat 0.50 lb ai per acre (0.56 kg ai per hectare) and the application of nitrogenous fertiliser. The use of nitrogen fertiliser is not recommended for use on spring cereals sown after ryegrass/white clover pasture. The "1973 Manawatu Barley Trial" investigated the need for a time interval following paraquat application and ploughing to allow the pasture to desiccate, as well as further evaluating the substitution of other methods of cultivation for ploughing as the initial cultivation.

METHODS AND MATERIALS

1970 Hamilton Maize Trial

This field trial was laid down on a 30 year old pasture which was predominantly perennial ryegrass and white clover. The soil was a Maeroa volcanic ash. The treatments were

1 "Early ploughing" without paraquat - ploughed 28th September.

2 "Early ploughing" with paraquat - 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat applied 22nd September, ploughed 28th September.

3 "Late ploughing" without paraquat - ploughed 16th October.

4 "Late ploughing" with paraquat - 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat applied 8th October, ploughed 16th October.

5 Rotary hoed without paraquat - rotary hoed 15th October.

6 Rotary hoed with paraquat - 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat applied 8th October, rotary hoed 15th October.

On 16th October all treated areas were disced, rolled and harrowed prior to precision planting the hybrid maize PX610 in 30 in (75 cm) rows on 23rd October. The trial design was a randomised block with four replications. The plot size was 20 ft x 59 ft (6 m x 18 m), four rows at 30 in (75 cm) spacing. Rotary hoeing consisted of two cuts to a depth of 5 in to 6 in (12.5 cm to 15 cm).

Plant numbers were assessed on 7th December by counting plants in the two centre rows of each plot. Grain was harvested on 24th April 1971 and yields were determined by harvesting a random 30 ft (9 m) length of two rows. Grain yields were calculated at 14% moisture.

1971 Manawatu Barley Trial

This trial was located on a drained Kairanga silt loam soil. The area had been in pasture for about four years and, at the time of treatment, was a predominantly ryegrass/white clover sward.

The trial was a randomised block design with four replications. Nitrogen was broadcast post sowing on a random split plot basis. The plots were large - 33 ft (10 m) wide by 59 ft (18 m) long - to facilitate combine harvesting. The treatments were

1 "Early ploughing" with paraquat ± 20 lb per acre (22.5 kg per hectare) nitrogen - 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat applied 2nd October, ploughed 14th October.

2 "Early ploughing" without paraquat ± 20 lb per acre (22.5 kg per hectare) nitrogen - ploughed 14th October.

3 "Late ploughing" with paraquat ± 20 lb per acre (22.5 kg per hectare) nitrogen - 0.50 lb ai per acre (0.56 kg ai per hectare) paraquat applied 27th October, ploughed 3rd November.

4 "Late ploughing" without paraquat ± 20 lb per acre (22.5 kg per hectare) nitrogen - ploughed 3rd November.

From 10th November all treatments received the same management, viz one rolling on 10th November, three discings and harrowings on 13th November, followed by planting on 14th November with barley c v Zephyr at 178 lb per acre (200 kg per hectare). The barley was sown with 223 lb per acre (250 kg per hectare) of a 6:6:4 NPK fertiliser using a conventional hoe coulter drill. Additional nitrogen at 20 lb per acre (22.5 kg per hectare) was broadcast on 17th November as sulphate of ammonia.

On 20th December, four sites within each plot were chosen at random and the number of plants in the rows on either side of a 3 ft (1 m) marker counted. On 24th December, within a 131 ft (40 m) area in the centre of the trial, five plants per plot were chosen at random and their height measured. The crop was harvested 1st March 1972 using a combine harvester which took a 14 ft (4.3 m) swath down the length of each sub-plot. Barley grain yields were subsequently adjusted to a 14.5% moisture level.

1973 Manawatu Barley Trial

This trial was located on a 2½ year old predominantly perennial ryegrass/white clover pasture in the Manawatu district on a Te Arakura sandy loam soil. The treatments were

1 Plough day 1.

2 Paraquat 0.50 lb ai per acre (0.56 kg ai per hectare) day 1 - plough day 2.

3 Paraquat 0.50 lb ai per acre (0.56 kg ai per hectare) day 1 - plough day 4.

4 Paraquat 0.50 lb ai per acre (0.56 kg ai per hectare) day 1 - plough day 8.

5 Cultivate with roller-tiller day 1.

6 Paraquat 0.50 lb ai per acre (0.56 kg ai per hectare) day 1 - roller-tiller day 8.

All spray treatments were applied on 10th October, in 25 gal water per acre (275 l per hectare). At the time of spraying the pasture height was from 2 in to 3 in (5 cm to 7.5 cm).

Ploughing was with a conventional, three furrow mould-board plough to a depth of 7 in (17.5 cm). The roller-tiller used was fitted with three rows of staggered 0.78 in (2 cm) wide tines; three passes each way were required to achieve cultivation to a depth of 6 in (15 cm).

Following the completion of the initial cultivation treatments (ploughing and roller-tillering) the total trial area was subjected to the same management, i e tandem disced once on 23rd October, followed by planting on 26th October with Reka barley at 150 lb per acre (168 kg per hectare). The barley was sown in 6 in (15 cm) rows with 112 lb per acre (125 kg per hectare) 4:7:5 NPK fertiliser. The trial was a randomised block design with four replications. The plots were large, 138 ft x 20 ft (42 m x 6 m), to facilitate combine harvesting.

Plant counts were made on 19th November by selecting 10 x 3 ft (1 m) rows per plot at random and counting the number of plants therein.

The crop was harvested on 12th February 1974, the combine harvester taking a 14 ft (4.3 m) swath down the length of each plot. Barley grain yields were subsequently adjusted to a 14% moisture level.

RESULTS

Plant Counts

1970 Hamilton Maize Trial

The results of the plant counts made on 7th December are shown in Table I.

Table I - Number of Maize Plants

Treatment	Number of plants per hectare Without paraquat	With paraquat
Early ploughing	65,900 aA*	65,700 aAB
Late ploughing	52,360 cC	60,520 abABC
Rotary-hoed	53,350 bcBC	57,800 abcABC

* Duncan's Multiple Range Test A = 1% level, a = 5% level

The late ploughing and rotary hoed treatments without paraquat were similar, and both had highly significantly fewer plants than did early ploughing. Paraquat significantly increased the number of plants in late ploughing, but not in early ploughing or rotary hoed.

1971 Manawatu Barley Trial

Plant counts and height measurements are shown in Table II.

Table II - Plant Counts and Height Measurements

Treatment	Number of plants per m row 20th December		Plant height (cm) 24th December (main treatment mean)
	n_0	n_1	
Early ploughing			
with paraquat	51	52	210 aA
without paraquat	53	46	207 aA
Late ploughing			
with paraquat	53	48	179 bB
without paraqwat	49	49	145ccC

There were no differences in plant counts between treatments. With regard to height, analysis of the data showed there were no significant differences due to nitrogen. Late ploughing with and without paraquat had highly significantly shorter plants than did early ploughing. Paraquat did not affect height with early ploughing but caused a highly significant increase with late ploughing.

1973 Manawatu Barley Trial

Plant counts made on 19th November are shown in Table III.

Table III - Number of Barley Plants

Treatments	Number of plants per m row (Mean of 10 rows per plot x 4 replicates)
Plough day 1	41
Paraquat - plough day 2	39
Paraquat - plough day 4	43
Paraquat - plough day 8	39
Cultivate with roller-tiller day 1	30
Paraquat - roller-tiller day 8	34

There were no differences in plant counts between any of the ploughed treatments. There were however fewer plants on the roller-tiller treatments particularly in the absence of paraquat.

YIELDS

1970 Hamilton Maize Trial

The grain yields from this trial are shown in Table IV.

Table IV - Grain Yields

Treatment	Yield kg/ha
Early ploughing	
without paraquat	12,770 aA
with paraquat	13,300 aA
Late ploughing	
without paraquat	11,020 bcAB
with paraquat	12,040 aA
Rotary-hoed	
without paraquat	9,880 cB
with paraquat	12,430 abA

In the absence of paraquat, the late ploughing and rotary-hoed treatments gave significantly lower yields than did early ploughing either with or without paraquat. The lowest yielding was the rotary-hoed without paraquat treatment. Paraquat increased yields up to those obtained from early ploughing. No yield increase was obtained from paraquat when it was applied prior to early ploughing.

1971 Manawatu Barley Trial

The grain yields from this trial are given in Table V.

Table V - Barley Yields

Treatment	Yield kg/ha	
	n_0	n_1
Early ploughing		
with paraquat	4,850	4,940
without paraquat	4,900	4,940
Late ploughing		
with paraquat	4,690	4,690
without paraquat	3,190	3,860

C V main plots 5.3%
C V sub plots 3.1%

The grain from the late ploughing without paraquat treatments was graded poor quality, due to pinching and shortness of grain. Grain from all other treatments was acceptable. The significance of the main effects was as follows

Paraquat	kg/ha
Early ploughing n_0	- 406
Early ploughing n_1	0
	NS
Late ploughing n_0	+ 1,500**
Late ploughing n_1	+ 820**

Paraquat had no significant effect either with or without nitrogen with early ploughing, but had a highly significant effect especially without nitrogen with late ploughing. Paraqwat almost brought the yields from late ploughing up to those obtained from early ploughing.

Nitrogen	kg/ha
Early ploughing	
with paraquat	+ 80
without paraquat	+ 40
Late ploughing	
with paraquat	- 10
without paraquat	+ 670**

Nitrogen had a significant effect only when applied to the late ploughing no paraquat treatment.

Time of Ploughing

The main effect of time of ploughing was highly significant. Late ploughing seriously depressed yield. This was partly overcome by applying paraquat, and to a lesser extent by applying nitrogen. No additional benefit was obtained from nitrogen where paraquat had been applied.

1973 Manawatu Barley Trial

The grain yields from this trial are given in Table VI.

Table VI - Barley Yields (14% moisture)

Treatment	Yield kg/ha	Yield as a percentage of plough day 1
Plough day 1	4599 bcD	100
Paraquat day 1 - plough day 2	5146 aAB	112
Paraquat day 1 - plough day 4	5292 aA	115
Paraquat day 1 - plough day 8	5217 aA	113
Cultivate with roller-tiller day 1	4167 cD	91
Paraquat day 1 - roller-tiller day 8	4689 bBC	102

In the case of the ploughed treatments, paraquat caused a highly significant increase in yield. This increase was similar for the plough day 2, 4 and 8 post spraying treatments. Paraquat caused a highly significant increase in yield on the roller-tiller treatment.

DISCUSSION

Significant despressions in grain yields were recorded on the 1970 Hamilton Maize and 1971 Manawatu Barley trials, by reducing the fallow period from approximately four weeks to one week. In both trials however a precultivation application of 0.50 lb per acre (0.56 kg per hectare) paraquat significantly increased yields from late ploughing and rotary-hoeing. The yields resulting from precultivation spraying and late ploughing or rotary-hoeing were nearly equivalent to those obtained from early ploughing. Yield responses from paraquat applied prior to a two week fallow period were recorded on the 1973 Manawatu Barley trial, which also showed similar yield increases can occur when ploughing commences from one to seven days after paraquat application.

In the Manawatu barley trials the yield responses to paraquat were due to higher yielding individual plants. There was no significant relationship between yields and plant counts. In the Hamilton maize trial an increase in plant numbers was recorded as a result of precultivation spraying prior to late ploughing or rotary-hoeing. These were similar to early ploughing treatments.

The results from these trials support the view that yield responses can be obtained from precultivation spraying if ploughing is late and the fallowing period is reduced to seven to fourteen days. The application of nitrogen at 20 lb per acre (22.5 kg per hectare) with late ploughing whilst causing a significant yield increase in the absence of paraquat, did not compensate for the yield loss caused by a reduction in the fallow period.

The nature of the biological processes involved could make an interesting study, but meanwhile the use of paraquat at 0.50 lb ai per acre (0.56 kg ai per hectare) appears to have some practical value to growers unable to commence ploughing sufficiently early to allow a four week fallow. Under these conditions the use of a precultivation spraying treatment offers the prospect of obtaining yields very similar to those obtained from longer fallows, and of avoiding the significant yield depressions of the kind recorded in these trials. The conflicting demands from livestock and cropping on intensive downland farms during the spring can to some extent be reconciled by techniques of this sort and prespraying followed by a one week fallow may become the "norm". During the 1974 spring it is estimated that in the Manawatu, Hawkes Bay and Waikato districts alone some 61,775 acres (25,000 hectares) will be treated in this way.

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EVALUATION OF AC 92,553 FOR WEED CONTROL IN VEGETABLE CROPS

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Summary In field experiments on a sandy loam with AC 92,553 (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine) carrot, parsley and parsnip were tolerant and pea, dwarf bean, runner bean and broad bean fairly tolerant to both pre-emergence and incorporated pre-drilling applications of 0.5-2.0 lb/ac a.i. Onion and leek were fairly tolerant pre-emergence, but less so when AC 92,553 was incorporated; in contrast, lettuce cabbage, radish and turnip were susceptible pre-emergence whereas injury was much less if the herbicide was incorporated. Red beet and spinach were the most susceptible crops. A range of important annual weeds was controlled, but Compositae were relatively tolerant and Poa annua was only partially killed by pre-emergence treatment. AC 92,553 appears potentially useful as part of a herbicide programme for umbelliferous crops and possibly legumes. At 1.0 lb/ac it successfully improved the performance of propachlor as a pre-emergence treatment for both spring-sown and overwintered bulb onions.

INTRODUCTION

AC 92,553 (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine) is an experimental soil-acting herbicide developed by Cyanamid International which has been examined as a pre-planting incorporated or pre-emergence treatment on a wide range of crops (Anon., 1973; 1974). This herbicide was evaluated for possible selectivity in drilled vegetable crops at the National Vegetable Research Station in 1973 and 1974 and promising indications were further examined in particular crops. The results obtained are summarized in this report.

METHODS AND MATERIALS

The formulation of AC 92,553 used was an e.c. containing 330 g/1., all doses are given as lb/ac a.i. and the sprays were applied in a volume of 100 gal/ac. The soil was a sandy loam with approximately 2% o.m. To determine relative crop tolerance to pre-emergence application, single rows of fifteen crops (Table 1) were drilled at appropriate depths and the herbicide applied across them immediately afterwards. To determine tolerance to incorporated applications, the weathered furrow was ring-rolled, the sprays applied and then a single pass made with a Lely Roterra rotary power harrow which prepared the seedbed and incorporated the herbicide to a depth of 1.5-2.0 in. Treatments in individual tests were not replicated but two separate tests under differing weather conditions were made in each year. Crop injury and overall weed control were assessed visually on two occasions, using a scale of 0 (no effect) to 10 (complete kill), and the response of individual species in the naturally-occurring weed population was determined.

The experiments with individual crops were of randomized block design with three or four replicates and a plot size of 5-8 yd^2. Weed kill was determined by counting survivors in a number of random quadrats, by visual scoring, or by recording the fresh weight of weed vegetation at harvest. The treated plots were not weeded and comparisons were made with hand-weeded controls. Yields are expressed as percentages of the values for these controls, and those significantly less are indicated by single ($P = 0.05$) and double ($P = 0.01$) asterisks.

RESULTS

Crop tolerance

Two tests were made in 1973 to determine the tolerance of drilled vegetable crops to AC 92,553 applied after drilling at 0.5, 1.0 and 2.0 lb/ac. The first was drilled on 1 May and was followed by 1.6 in. rainfall in the next 3 weeks. The second, drilled on 1 June, received only 1.1 in. and most of this fell in the third week; 0.3 in. irrigation was given 5 days after drilling.

Crop injury, especially with 0.5 lb/ac, was generally less in the second test but otherwise the results of the two tests were very similar (Table 1). The most susceptible crops were lettuce, spinach and red beet while the three cruciferous crops were almost as susceptible. The large-seeded legumes were relatively tolerant, although with all four in both tests there was some stunting or chlorosis with 2.0 lb/ac. Onion, and especially leek, were also relatively tolerant; 2.0 lb/ac caused some damage to onion in the first test, but otherwise there were negligible effects. Carrot, parsley and parsnip were the most tolerant of the crops examined.

Table 1

Response of vegetable crops to pre-emergence applications of AC 92,553

	Injury 0-10					
	First test lb/ac			Second test lb/ac		
	0.5	1.0	2.0	0.5	1.0	2.0
Cabbage	2	6	9	0	6	9
Radish	4	6	10	0	6	8
Turnip	5	8	10	0	6	9
Leek	0	0	1	0	0	0
Onion	0	2	5	0	0	0
Carrot	0	0	2	0	0	0
Parsley	0	0	2	0	0	0
Parsnip	0	0	0	0	0	0
Red beet	7	8	9	4	7	8
Spinach	7	9	10	3	8	9
Lettuce	7	9	10	6	8	9
Pea	2	3	3	0	2	4
Dwarf bean	0	2	5	0	2	4
Runner bean	0	1	2	0	3	4
Broad bean	1	3	5	0	0	3
Weeds - initial	7	8	9	8	9	9
- final	6	7	9	7	8	9

The overall weed control was commercially acceptable with 1.0 lb/ac in both tests, but there were pronounced differences between species. Complete or almost complete kill was achieved of Lamium amplexicaule, L. purpureum, Polygonum aviculare, P. convolvulus, Capsella bursa-pastoris, Thlaspi arvense, Urtica urens, Stellaria media, Veronica persica and Solanum nigrum. Matricaria matricarioides, M. recutita and Tripleurospermum maritimum ssp. inodorum were scarcely affected by 0.5 lb/ac, partially killed by 1.0 lb and killed by 2.0 lb/ac. Poa annua was also relatively tolerant, and some plants survived all doses in both tests. The most tolerant species was Senecio vulgaris which was not killed even by 2.0 lb/ac, although there was some check to growth.

In 1974 two tests were made of crop responses to AC 92,553 applied pre-emergence or incorporated pre-drilling. The first test was drilled on 15 May; only 0.4 in. of rain fell in the first 3 weeks, and three irrigations of 0.3 in. were given. The second was drilled on 5 June, with 0.6 in. rain and four irrigations during the first 3 weeks. The results for comparative crop tolerance with the surface-applied treatments closely resembled those obtained in 1973. Injury was more severe in the second test which received more water (Table 2).

Table 2

Response of vegetable crops to incorporated pre-drilling (I) and pre-emergence surface (S) applications of AC 92,553

Crop	Injury 0-10 First test I lb/ac 1.0	2.0	S lb/ac 1.0	2.0	Second test I lb/ac 1.0	2.0	S lb/ac 1.0	2.0
Cabbage	0	0	2	7	2	4	10	10
Radish	4	4	7	7	0	5	7	9
Turnip	0	3	7	8	3	6	9	10
Leek	8	9	0	4	0	4	4	5
Onion	3	7	0	4	6	9	5	6
Carrot	0	0	0	0	0	0	0	0
Parsley	0	0	0	0	0	0	0	0
Parsnip	0	0	0	0	0	0	0	0
Red beet	9	9	8	9	9	10	9	10
Spinach	9	10	7	10	9	10	10	10
Lettuce	0	0	7	8	2	4	10	10
Pea	0	0	0	3	0	0	2	3
Dwarf bean	0	1	0	0	0	0	0	4
Runner bean	0	2	0	0	0	0	2	5
Broad bean	0	3	0	0	0	2	0	4
Weeds - initial	8	9	7	8	9	9	9	9
- final	8	9	6	7	8	9	8	9
Poa annua % kill	99	99	48	68	98	100	92	98
Dicots % kill	69	88	79	83	61	88	81	98

The results from the incorporated treatments were similar in that spinach and red beet remained highly susceptible, while the umbelliferous and leguminous crops were relatively tolerant. Incorporation, however, tended to increase the injury to onion and leek whereas the three cruciferous crops and lettuce were affected less when the herbicide was incorporated than when it was applied to the soil surface. This was particularly striking with lettuce which was killed or severely damaged by surface applications yet showed no or only slight injury where the herbicide had been incorporated.

Both doses applied to the surface killed all Stellaria media, Veronica persica, Chenopodium album, Lamium amplexicaule, Urtica urens, Capsella bursa-pastoris and Solanum nigrum; when incorporated there was greater survival of C. bursa-pastoris, but an improved kill of Poa annua. This difference was most apparent in the first test (Table 2). Senecio vulgaris was not killed by any treatment, though checked by 2.0 lb/ac applied to the surface.

Carrots

AC 92,553 was included as a pre-emergence treatment in two experiments with carrots cv. Chantenay Supreme, one drilled in April the other in June 1973. In the first, 0.75 and 1.50 lb/ac both killed Urtica urens, Polygonum aviculare and Chenopodium album but Senecio vulgaris and Poa annua remained and plants of Tripleurospermum maritimum ssp. inodorum grew vigorously. At the low dose, total fresh weight of weed vegetation at harvest differed little from that of the unweeded control (Table 3); with 1.50 lb/ac there was still an appreciable weed cover but no significant yield reduction.

Table 3

Response of weeds and carrots to pre-emergence applications of AC 92,553

lb/ac	Experiment 1 Weeds kill %	Weeds reduction in wt %	Crop no. %	Crop wt %	Experiment 2 Weeds kill %	Weeds reduction in wt %	Crop no. %	Crop wt %
AC 92,553 0.75	75	16	81	53**	78	90	111	102
AC 92,553 1.50	87	54	99	80	91	99	100	106
Control, unweeded	($28/ft^2$)		50**	11**	($14/ft^2$)		98	49**

In the second experiment both doses killed the main weeds, Veronica persica, Chenopodium album, Lamium amplexicaule and L. purpureum. The survivors, Senecio vulgaris, T. maritimum ssp. inodorum, Thlaspi arvense and some Poa annua were suppressed by the crop, and the yield did not differ significantly from that of the weeded control. In neither experiment was there any evidence of injury to the crop.

Runner beans

The same treatments were included in two experiments with runner beans cv. Kelvedon Marvel grown as a pinched crop. In the first, AC 92,553 killed Polygonum aviculare, Lamium purpureum, Stellaria media and Chenopodium album, with partial kill of Solanum nigrum and Poa annua. The main survivors were Tripleurospermum maritimum ssp. inodorum and Senecio vulgaris, the former accounting for most of the weed vegetation present at harvest. Both pod and haulm weights were significantly reduced (Table 4), probably mainly as a result of competition; there was, however, slight stunting of crop growth with 0.75 lb/ac and more pronounced stunting with 1.50 lb/ac.

Table 4

Response of weeds and runner beans to pre-emergence applications of AC 92,553

lb/ac	Experiment 1: Weeds kill %	Experiment 1: Weeds reduction in wt %	Experiment 1: Crop pods %	Experiment 1: Crop haulm %	Experiment 2: Weeds kill %	Experiment 2: Weeds reduction in wt %	Experiment 2: Crop pods %	Experiment 2: Crop haulm %
AC 92,553 0.75	93	53	77**	74**	62	99	95	96
AC 92,553 1.50	96	63	77**	68**	76	100	101	85
Control, unweeded	($39/ft^2$)		27**	31**	($9/ft^2$)		45**	54**

The main weeds in the second experiment were Chenopodium album and Solanum nigrum, with smaller numbers of Thlaspi arvense, Poa annua, Senecio vulgaris and Capsella bursa-pastoris. Those plants which survived treatment were suppressed by the crop, and the pod and haulm weights did not differ significantly from those of the weeded control. In this experiment also, 1.5 lb/ac caused some stunting of the crop during the early growth stages.

Onions

AC 92,553 was included in two experiments with spring-sown onions cv. Bola in 1974. The first was drilled on 29 March, the treatments applied with paraquat on 18 April, and 0.3 in. irrigation given 6 days later followed by three further irrigations during the next month. During this very dry period few weeds emerged, but it is evident from Table 5 that AC 92,553 alone did not perform as well as propachlor, mainly because of the survival of Poa annua and Senecio vulgaris. The combined treatments all gave better weed control than propachlor alone (Table 5), with some Poa annua and Solanum nigrum the main survivors. There was no visible injury to the crop; the significant effect on stand of 1.0 lb with propachlor 3.9 lb/ac was probably fortuitous, since there was no adverse effect from the higher dose of 1.5 lb/ac in combination with propachlor.

Table 5

Effects of AC 92,553 on the numbers of weeds and of spring-sown onions

Experiment 1: AC 92,553 lb/ac	Weeds/ft^2	Onions/ft^2	Experiment 2: AC 92,553 lb/ac	Weeds/ft^2	Onions/ft^2
1.0	1.4	7.4	1.0	7.7	6.2
2.0	1.0	6.6	2.0	2.7	5.0*
1.0 + propachlor 3.9	0.2	5.6*	1.0 incorporated	6.9	5.7
1.5 + propachlor 3.9	0.1	6.9	2.0 incorporated	3.2	4.2**
1.5 + propachlor 3.0	0.1	7.3	1.0 +propachlor 3.9	2.5	6.8
			1.0 +propachlor 3.9 inc.	1.9	4.1**
0.0 + propachlor 3.9	0.6	7.8	0.0 +propachlor 3.9	5.6	6.8

In the second experiment, drilled on 24 April, surface and incorporated treatments were compared. The weather was still mainly dry, with less than 0.5 in. rainfall in the first 3 weeks, and three irrigations of approximately 0.3 in. were given. AC 92,553 alone killed Polygonum aviculare and Chenopodium album more effectively than did propachlor, and when incorporated also killed Poa annua. Incorporation, however, reduced the control of Capsella bursa-pastoris and Urtica urens and also of Solanum nigrum, which was only slightly affected by incorporated treatments yet partially killed and severely retarded by AC 92,553 applied to the surface. Overall, therefore, there was little difference in the numbers of weeds surviving (Table 5). The combinations with propachlor gave the best weed control. The crop was more severely affected when AC 92,553 was incorporated as compared with application to the soil surface after drilling. There were significant reductions in stand with 2.0 lb/ac applied in both ways and by 1.0 lb/ac incorporated with propachlor.

The effect of adding AC 92,553 to propachlor to enhance the range of weeds killed and the persistence of control was examined in three crops of onions cv. Presto drilled at fortnightly intervals (Table 6) in summer 1973 and harvested in July 1974. All plots received paraquat just before crop emergence, and methazole was applied in February. These plots were not weeded; plots which received propachlor + paraquat and were then hand-weeded served as controls.

Table 6

Effect of AC 92,553 added to propachlor and applied pre-emergence for weed control in overwintered bulb onions

Treatment (lb/ac) Pre-em.	February	Weeds $/ft^2$ autumn	Weed control 0-10 Feb	Weed control 0-10 Apr	Marketable bulbs $/ft^2$	Marketable bulbs ton/ac	Bolters %
First sowing, 31 July 1973							
Propachlor 3.9 + AC 92,553 1.0	methazole 1.87	0.5	9.3	9.3	5.1	8.4	52
Propachlor 3.9	methazole 1.87	1.1	7.0	7.8	5.1	9.0	50
Propachlor 3.9	weeded	2.0	-	-	5.0	7.6	54
Second sowing, 14 August 1973							
Propachlor 3.9 + AC 92,553 1.0	methazole 1.87	0.2	9.2	9.1	4.5	9.0	41
Propachlor 3.9	methazole 1.87	4.4	8.3	8.3	4.7	7.8**	48
Propachlor 3.9	weeded	5.8	-	-	5.3	9.9	42
Third sowing, 29 August 1973							
Propachlor 3.9 + AC 92,553 1.0	methazole 1.87	0.5	9.4	9.5	10.2	17.8	6
Propachlor 3.9	methazole 1.87	13.7	5.8	7.5	11.6	16.4	10
Propachlor 3.9	weeded	12.4	-	-	10.4	17.2	8

Major weed species in these experiments included Veronica persica, Stellaria media, Poa annua, Capsella bursa-pastoris and Senecio vulgaris, with smaller numbers of Urtica urens, Chenopodium album, Thlaspi arvense and various others. Counts made in autumn (Table 6) showed that when AC 92,553 had been added to propachlor the numbers of surviving weeds were considerably less than where propachlor had been applied alone. Besides improving the control of species such as C. album which emerged rapidly, it appeared that AC 92,553 prevented establishment of seedlings of Stellaria media, Poa annua and Veronica persica during autumn, so that the plots remained very clean throughout the winter. Treatment with methazole effectively suppressed weeds which germinated in Spring, such as Polygonum aviculare and P. convolvulus, and at harvest the only survivors were isolated plants of Senecio vulgaris, Tripleurospermum maritimum ssp. inodorum and Matricaria matricarioides.

Where propachlor was the only residual pre-emergence herbicide applied, a mixed weed flora was present during winter composed of plants which had germinated at different times in autumn. Methazole was effective against most of these, and on these plots the main survivor was Veronica persica together with some large plants of Poa annua. In these experiments, all of which were irrigated to secure crop establishment, AC 92,553 caused no visible crop injury and there was no significant difference compared with the weeded plots in respect of numbers or weights of marketable bulbs or in the percentage of bolters; this was high for all treatments in the first two sowings.

DISCUSSION

The results obtained in these preliminary tests indicate that on a light soil AC 92,553 at a dose of 1.0 lb/ac controls a number of important annual weeds of vegetable crops, including Capsella bursa-pastoris, Chenopodium album, Lamium amplexicaule, L. purpureum, Polygonum aviculare, P. convolvulus, Stellaria media, Thlaspi arvense, Urtica urens and Veronica persica. Certain other species, among them Solanum nigrum and Fumaria officinalis, appeared to be somewhat less susceptible. Senecio vulgaris and Tripleurospermum and Matricaria spp., however, were appreciably more tolerant and whether or not adequate overall weed control was obtained depended on the extent to which these were present (Tables 3,4). The results obtained with Poa annua are of particular interest. This species has been classed as 'susceptible' (Anon., 1973; 1974), yet in the initial tests in 1973 with pre-emergence applications it was not killed completely by 2.0 lb/ac and appeared to be one of the more tolerant species. Control was found to be improved, however, if the herbicide was incorporated into the soil rather than applied to the surface although when irrigation was followed by rainfall (Table 2, second test) the difference was slight. On the contrary, incorporation tended to reduce the degree of control of dicotyledonous species such as Capsella bursa-pastoris and Solanum nigrum.

The most tolerant of the crops examined were carrot, parsley and parsnip; there was no or only very slight injury with 2.0 lb/ac in 1973 and no injury from either incorporated or surface-applied treatments in 1974. The four large-seeded legumes were comparatively tolerant, but there was sometimes a check during the early stages of growth which was also observed in the two experiments with runner beans (Table 4). There was no consistent difference between incorporated and surface applications.

Onion and leek were also relatively tolerant to pre-emergence application but appeared to be generally more susceptible when the herbicide was incorporated. In contrast, the three cruciferous crops were severely damaged by AC 92,553 applied to the surface, but the degree of injury was less when it was incorporated. This was also true of lettuce, which was killed by surface pre-emergence applications but only slightly affected when the herbicide was incorporated. These differences presumably reflect interactions between herbicide concentration and the relative importance of shoot and root uptake in the different species. The most susceptible of the crops examined were spinach and red beet; these were consistently killed or very severely damaged by 1.0 lb/ac in all four tests, whether incorporated or not.

These results suggest several potential uses for AC 92,553 in vegetable crops which would seem worth pursuing. As already indicated (Anon., 1974), it is likely that it will need to be combined with some other herbicide in order to secure control of a wide spectrum of weeds. The high tolerance of carrots and related crops suggest that it could well prove useful as part of a programme where Polygonum aviculare is a problem on mineral soils. It is also possible that it could be used in this way on large-seeded legumes, although these suffered slight stunting even with 1.0 lb/ac. The apparent tolerance of lettuce to incorporated treatments does not seem promising since survival of weeds in the Compositae confers no advantage over existing treatments.

The susceptibility of P. aviculare and certain other species together with the relative tolerance of onions to pre-emergence application observed in 1973 immediately suggested the possibility of combination with propachlor, and this was followed up in five replicated experiments. The control of weeds was greatly improved by adding 1.0 lb/ac to the standard pre-emergence propachlor treatment, and there were no adverse effects on the crops (Tables 5, 6). It is clear, however, that soil moisture and soil type (Anon., 1974) both affect the activity of AC 92,553 and more evidence of the possible value of the propachlor/AC 92,553 combination under differing soil and weather conditions is required. The fact that crop injury was more severe when the herbicide was incorporated suggests that if heavy rainfall shortly after application caused the herbicide to move downwards into the root zone, then injury could occur. There was some evidence of this (Table 2, second test), and there was also consistently some degree of injury when 2.0 lb/ac was applied pre-emergence. Although the initial results are promising, therefore, it remains to be seen whether the margin of safety to the crop will prove adequate.

Acknowledgements

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WEED CONTROL PROGRAMMES FOR CANNING CARROTS

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Summary A range of weed control programmes was tested in a series of experiments with carrots grown on the mini-bed system for canning. Linuron, prometryne and chlorbromuron were used both pre- and post-emergence. Trifluralin was incorporated pre-sowing and metoxuron was applied as a post-emergence treatment. No single pre-emergence herbicide gave adequate weed control, and supplementary treatment was necessary at the 2-rough leaf stage of the crop to avoid severe loss ofyield. The effectiveness of any programme rested on its ability to control both Fumaria officinalis and Polygonum aviculare. Failure on one or other species resulted in yield depression. In these circumstances the most effective programmes were those involving trifluralin followed by either metoxuron or prometryne.

INTRODUCTION

When canning carrots are grown at high populations in wide beds or in mini-beds, supplementary cultivation is limited to the gaps between beds. Weed control in the beds is therefore totally dependent on herbicides. Dry weather after sowing, together with the presence of resistant weed species, frequently results in poor performance by pre-emergence residual herbicides. By the time the crop is sufficiently large for safe post-emergence treatment, usually at the 2-rough leaf stage of the crop, weeds may be too large for effective control. The reliability of weed control in spring-sown brassica crops in the United Kingdom has been considerably improved in recent years by the inclusion of the soil-incorporated herbicide trifluralin in weed control programmes. Successful results with this herbicide in carrots have been reported from several other countries (Denisevic 1969, Menges & Hubbard 1966). Metoxuron has also been reported (MacNaeidhe, 1970) to give promising results as a post-emergence treatment in carrots in Ireland. Both these materials were included in a preliminary experiment in 1971, in which the three principal carrot herbicides in use in the United Kingdom were evaluated as single and split-treatment applications. This was followed by two experiments comparing all possible combinations of four pre- and four post-emergence treatments.

METHOD AND MATERIALS

Three experiments were carried out at Invergowrie on sandy loam soils with organic matter contents (as determined by loss on ignition) of between 6 and 8%. The carrots were drilled in beds 25 cm wide with 46 cm between beds. Plots consisted of two beds plus shared guard beds. Total plot length was 7.6 m and the harvested area was 4.34 m^2. A stump-rooted selection of Chantenay Red-cored carrot was sown with a Stanhay drill to give an estimated plant density of 500 plants per m^2. All three experiments were laid out as randomised blocks with four replicates. The land was ploughed and harrowed, the beds were marked out by tractor wheels, and the trifluralin was applied to appropriate plots. The whole experimental area was then rotary cultivated to 10 cm depth to preserve uniformity of sowing conditions. After the beds were again marked out and rolled, the crop was drilled.

Herbicide application was made by Oxford Precision Sprayer in 730 l water/ha. The herbicide formulations used in these experiments were as follows:

Chemical	Formulation
chlorbromuron	50% wettable powder
linuron	50% wettable powder
metoxuron	80% wettable powder
prometryne	50% wettable powder
trifluralin	48% w/v emulsifiable concentrate

Pre-emergence residual herbicides were applied as soon as possible after sowing and post-emergence treatments as soon as the crop reached the 2-rough leaf stage. Ground cover by weeds was scored visually at regular intervals throughout the experiments and weed numbers per 2 m^2 were counted after the second herbicide treatments had had their effect.

The carrot and weed foliage was removed by flail prior to harvest. Carrot roots were graded into sizes according to diameter. Canning size was taken as 19-32 mm. There was no indication in any of the experiments of direct herbicide toxicity to the crop.

RESULTS

Expt. I - 1971

Trifluralin was applied and incorporated on April 27, the crop was drilled on April 28 and the other pre-emergence treatments were applied on April 29. Post-emergence herbicides were applied on June 9. Metoxuron was further applied on July 7. Experimental treatments were as follows:

Treatment	kg a.i./ha	Timing
Weedfree control	-	-
Unweeded control	-	-
Linuron	1.12	Pre-em.
Linuron	1.12 + 1.12	Pre-em. and at 2 rough leaf
Prometryne	1.12	Pre-em.
Prometryne	1.12 + 1.12	Pre-em. and at 2 rough leaf
Chlorbromuron	1.12	Pre-em.
Chlorbromuron	1.12 + 1.12	Pre-em. and at 2 rough leaf
Metoxuron	2.69	Weeds above crop (July 7)
Metoxuron	2.69 + 2.69	2-rough leaf and July 7
Trifluralin	1.12	Pre-plant
Trifluralin	1.12	Pre-plant (hand-weeded)

The pre-emergence treatment with prometryne reduced weed cover very little compared with the unweeded control (Table 1). Linuron delayed the spread of weeds in the early growth stages of the crop but failed to give adequate weed control beyond the

Table 1
Expt.I - Crop & weed records 1971

Treatment	Root yield $kg/4.3m^2$ Size grades (mm) 0-19	19-32	32-51	Total	% in canning grade 1.9-3.2	% Ground cover by weeds Jun. 3	Jun. 24	Jul. 14	Aug. 10
Weedfree	4.3	21.3	7.3	32.9	65.0				
Unweeded	2.4*	2.9***	0.4***	5.7***	18.7***	8	32	58	74
S.E. mean ±	0.51	2.13	1.19	3.25	5.48				
L	3.6	6.5***	1.6**	11.7***	37.4**	5	16	46	69
L + L	4.7	21.1	6.7	32.5	65.7		2	1	1
P	2.8	10.9**	2.9*	16.6**	40.9**	7	25	54	73
P + P	4.2	18.3	3.0	27.5	67.1		2	1	1
C	5.1	9.2**	2.6*	16.9**	46.3*	2	11	19	54
C + C	4.6	22.4	8.8	35.8	63.9		2	2	2
M	4.3	7.9***	1.9**	14.1**	54.1	8	26	57+	14
M + M	4.4	17.6	3.1	27.1	64.4		1	1+	2
T	5.8	11.3**	2.8*	19.9*	54.9	4	11	14	17
T (WF)	4.0	21.7	7.6	33.3	66.1		-	-	-
S.E. mean ± a)	0.59	2.77	1.17	3.93	5.84				
S.E. mean ± b)	0.66	2.89	1.45	4.28	6.86				

a) for comparisons within herbicides
b) for comparisons across herbicides

L - linuron
P - prometryne
C - chlorbromuron
M - metoxuron
T - trifluralin

* significantly different from Weedfree at the 5% level
** significantly different from Weedfree at the 1% level
*** significantly different from Weedfree at the 0.1% level
\+ treated on July 7.

first few weeks. Chlorbromuron was the best of the pre-emergence treatments, permitting only 19% ground cover by weeds by July 14, compared with 46% cover with linuron, 54% with prometryne plots and 58% on untreated plots. Even this treatment, however, permitted severe weed competition later in the season. The major weed on these treatments and on hitherto untreated plots was Chenopodium album which germinated in late May and caused severe shading of crop foliage from July onwards. Fumaria officinalis and Polygonum aviculare were the major weeds on plots where C. album was controlled, but were suppressed by it on other plots.

Metoxuron applied on June 9 gave excellent kill of C. album and most other species. Repeat treatment virtually eliminated all weeds. The application of metoxuron on July 13 to untreated plots with a dense stand of C. album, reduced weed cover from 57% before treatment to not more than 13% thereafter.

Repeat treatment with prometryne, linuron or chlorbromuron eliminated most of the weeds which had escaped pre-emergence treatment.

Trifluralin gave excellent control of all species except F. officinalis, Capsella bursa-pastoris and Matricaria spp. These weeds spread to give 17% ground cover by mid-August.

Total yields on plots treated with trifluralin and kept weedfree were equivalent to those on untreated weedfree plots (Table 1). Repeat applications of linuron and chlorbromuron produced similar results. Reduced total yields on plots treated with single rates of linuron, prometryne, chlorbromuron and metoxuron are attributed to severe competition from weeds.

On weedfree plots 65% of the crop weight fell into the canning size (19-32 mm). Treatments with similar percentages included the repeat applications of prometryne, linuron, chlorbromuron and metoxuron, and weedfree plots treated with trifluralin. The unweeded treatment had only 19% of roots in the canning grade, and weedy herbicide-treated plots had intermediate percentages.

Expt. II - 1972

The crop was drilled on April 25. Trifluralin was applied and incorporated just prior to drilling and the other pre-emergence herbicides were applied on April 28. Post-emergence herbicides were applied on June 6.

Treatments kg a.i./ha

Pre-emergence		Post-emergence	
Linuron	0.84	Linuron	0.84
Prometryne	1.12	Prometryne	1.12
Chlorbromuron	1.12	Chlorbromuron	1.12
Trifluralin	1.12	Metoxuron	3.58

These were applied in all combinations to give 16 herbicide programmes. In addition there were two extra treatments - weedfree and unweeded controls.

A very dense stand of weeds emerged on unweeded plots in mid-May. This expanded to cover 32% of the ground area by June 6 and reached 90% in early July (Table 2). The major species were Stellaria media and P. aviculare. F. officinalis, C. album and Polygonum aviculare were also of importance. All pre-emergence herbicide treatments controlled virtually all species except P. aviculare and F. officinalis which together produced 8-15% weed cover on treated plots by June 6. Subsequent differences in weed control depended on the efficiency of the post-emergence materials in controlling these two species, especially P. aviculare.

Table 2
Expt.II - Crop & weed records 1972

Treatment	Root yield kg/4.3 m^2 Size grades (mm) 0-19	19-32	32-51	Total	% in canning grade (19-32)	% Ground cover by weeds Jun. 6 +	Jun. 14	Jul. 13	Aug. 10
Weedfree	11.1	11.0	0.1	22.2	54.0				
Unweeded	0.3***	0**	0	0.3***	0***	32	64	91	95
L + L	5.0*	0.6**	0	5.6**	7.7***		15	51	73
L + P	5.6*	3.0*	0.1	8.7**	19.5**	13	9	46	59
L + C	13.0	4.5	0	17.5	24.5*		4	20	39
L + M	13.7	6.6	0.1	20.4	31.9		3	7	22
P + L	6.4	1.2**	0	7.6**	13.0***		10	45	65
P + P	9.1	5.4	0.3	14.8	25.1*	15	7	34	45
P + C	7.9	2.9*	0	10.8*	22.0**		8	34	43
P + M	12.5	7.1	0.1	19.7	34.0		4	13	35
C + L	11.9	4.8	0	16.7	26.4*		5	26	21
C + P	10.1	7.6	0.2	17.9	30.1*	8	6	28	26
C + C	9.5	5.0	0.1	14.6	25.8*		5	23	35
C + M	13.0	5.9	0.2	19.1	27.4*		3	19	25
T + L	11.5	7.5	0.2	19.2	31.3*		5	21	29
T + P	9.9	7.4	0.4	17.7	33.4	12	10	27	40
T + C	12.6	8.3	0.2	21.1	34.3		5	13	27
T + M	11.7	7.7	0.4	19.8	36.4		5	10	15
S.E. mean ±	1.66	2.33	0.14	3.51	7.89				
Pre-em.									
All L	9.3	3.7	0.1	13.1	20.9		8	31	48
P	9.0	4.1	0.1	13.2	23.5		7	32	48
C	11.1	5.8	0.1	17.0	27.4		3	24	27
T	11.4	7.7	0.3	19.4	33.8		6	18	28
Post-em.									
All L	8.7	3.5	0.1	12.3	19.6		8	36	47
P	8.7	5.8	0.2	14.7	27.0		8	34	43
C	10.8	5.2	0.1	16.1	26.6		5	22	37
M	12.8	6.8	0.2	19.8	32.4		4	12	24
S.E. mean ±	0.83	1.16	0.07	1.75	3.94				

L - linuron
P - prometryne
C - chlorbromuron
M - metoxuron
T - trifluralin

* significantly different from Weedfree at the 5% level
** significantly different from Weedfree at the 1% level
*** significantly different from Weedfree at the 0.1% level

\+ Date of post-emergence treatment

By the time the carrots had reached the 2-rough leaf stage, weeds resistant to pre-emergence treatments were already past the seedling stage. Metoxuron gave best control of P. aviculare, regardless of original treatment, followed by chlorbromuron. Linuron and prometryne were equally unable to control this species. Both linuron and chlorbromuron also failed to control F. officinalis. Prometryne eliminated this weed from most plots, but metoxuron was only partly successful. In terms of overall weed control, trifluralin and chlorbromuron were the most effective pre-emergence treatments and the particular post-emergence treatment used did not change this situation. The best overall post-emergence herbicide was metoxuron followed by chlorbromuron. The poorest overall programmes were those in which linuron and prometryne were used post-emergence following either of them used pre-emergence. The best individual programmes were trifluralin or linuron followed by metoxuron. Other treatments considered as giving acceptable levels of overall weed control were prometryne or chlorbromuron followed by metoxuron, and trifluralin followed by chlorbromuron.

Early crop growth was slow, probably due to shortage of rain during the late spring and summer. By the time the crop reached the 2-rough leaf stage, P. aviculare was beginning to cause shading on many herbicide-treated plots. Untreated plots were already suffering from crop shading by this species and by S. media. Some degree of weed competition is likely to have occurred on most treatments, particularly on plots originally treated with linuron and prometryne. The crop was lifted on Sept. 21 and, as yield results show (Table 2), only 54% of the roots on weedfree plots were in the canning size with the remainder virtually all smaller. Competition from weeds significantly reduced the percentage in the canning grade on most other treatments. Totally unweeded plots produced virtually nothing. Only plots treated with metoxuron post-emergence and those treated with trifluralin pre-emergence (except where followed by prometryne) produced crops with less than 15% loss of total yield. Weeds resistant to the herbicide programmes very severely reduced the percentage of the crop falling into the canning grade, with poorest results being where linuron was followed by linuron (under 8%).

Expt. III - 1973

Treatments were identical to those in Expt. II. Trifluralin was applied and incorporated on April 4, the crop was drilled on April 5, and the other pre-emergence herbicides were applied on April 13. A dense stand of weeds emerged within a few weeks of sowing the crop. By the date of post-emergence treatment (May 31), cover by weeds on unweeded plots was 16% (Table 3). F. officinalis, S. media and Spergula arvensis were the major weeds on untreated plots. P. aviculare, P. convolvulus and C. album were of lesser importance. At this time, ground cover was 12% on plots treated with prometryne and 5-7% on the other treatments. On unweeded plots ground cover had risen to 68% by mid-June and to 84% by the end of the month. The best herbicide programmes (all involving trifluralin) held the weeds to 4-9% ground cover throughout. Pre-emergence treatment with linuron, prometryne and chlorbromuron eliminated most species leaving the post-emergence herbicides to control a mixture of F. officinalis and P. aviculare. The order of importance of these two species in this experiment was reversed compared with the previous trial. Trifluralin gave very good control of P. aviculare but was only partly effective on F. officinalis. Post-emergence treatments with linuron, chlorbromuron or metoxuron had little effect on P. aviculare, but this was hidden on most plots by their even less effective control of F. officinalis, which remained dominant. Prometryne, however, eliminated F. officinalis, leaving P. aviculare to spread unhampered on these plots. Despite this, prometryne was the best overall post-emergence treatment. There was nothing to choose between the others.

Overall, the most effective herbicide programme was trifluralin plus prometryne but all treatments involving trifluralin gave very acceptable weed control. The more effective control of F. officinalis by linuron and metoxuron on these plots was probably linked with the partial kill and stunting of this species by trifluralin, but chlorbromuron was unable to prevent its eventual spread to cover a substantial

Table 3
Expt.III - Crop & weed records 1973

Treatment	Root yield kg/4.3 m² Size grades (mm) 0-19	19-32	32-51	Total	% in canning grade (19-32)	% Ground cover by weeds May 31+	Jun. 15	Jul. 13	Aug. 7
Weedfree	1.6	16.6	12.7	30.9	53.8				
Unweeded	1.9	1.2***	0.1***	3.2***	47.4	16	68	95	94
L + L	1.2	9.1***	5.6**	15.9***	60.1		10	59	43
L + P	1.6	8.7***	5.5**	15.8***	58.4	7	7	29	36
L + C	1.3	7.8***	3.5***	12.6***	61.6		16	70	55
L + M	1.4	5.5***	3.7***	10.6***	49.5		10	71	63
P + L	1.3	9.0***	5.8**	16.2***	57.6		11	42	42
P + P	1.6	11.1**	6.3**	19.0***	59.5	12	6	25	30
P + C	1.4	8.0***	5.0***	14.4***	56.1		18	71	51
P + M	1.6	9.2***	5.3**	16.1***	57.1		15	49	36
C + L	1.3	7.3***	4.1***	12.7***	58.1		15	69	54
C + P	1.6	9.6***	4.4***	15.6***	63.1	7	6	20	38
C + C	1.3	7.8***	5.3**	14.4***	53.1		10	60	55
C + M	1.4	7.0***	5.2**	13.6***	53.0		11	56	49
T + L	1.8	13.8	10.1	25.7	54.1		4	7	8
T + P	1.6	14.8	12.2	28.6	51.7	5	1	3	3
T + C	1.7	11.9**	9.3	22.9*	54.3		3	31	18
T + M	1.7	14.3	8.8	24.8	59.5		4	6	7
S.E. mean ±	0.31	1.15	1.54	2.44	5.40				
Pre-em.									
All L	1.4	7.8	4.5	13.7	57.4		11	57	49
P	1.5	9.3	5.6	16.4	57.6		13	47	40
C	1.4	7.9	4.8	14.1	56.8		11	51	49
T	1.7	13.7	10.1	25.5	54.9		3	12	9
Post-em.									
All L	1.4	9.8	6.4	17.6	57.5		10	44	37
P	1.6	11.1	7.1	19.8	58.2		5	19	27
C	1.4	8.9	5.8	16.1	56.3		12	58	45
M	1.5	9.0	5.8	16.3	54.8		10	46	39
S.E. mean ±	0.16	0.58	0.77	1.22	2.70				

L - linuron
P - prometryne
C - chlorbromuron
M - metoxuron
T - trifluralin

* 5%
** significantly different from Weedfree at the 1% level
*** 0.1%

+ Date of post-emergence treatment

area of the plots. No other programme gave an acceptable level of weed control. The crop was harvested on Oct. 18. 54% of the yield on weedfree plots fell within the canning size, with 41% of greater size (Table 3). Unweeded plots produced only 11% of the total yield on weedfree plots; the poorest herbicide programme produced 34% and the best produced 93% of this yield. In the canning grade, only the three successful treatments involving trifluralin were not significantly poorer than the weedfree control. Post-emergence treatment with prometryne, although highly effective on weeds in early summer, did not prevent loss of crop later in the season, caused by the spread of surviving plants of P. aviculare.

DISCUSSION

The high level of vulnerability of this crop to competition from weeds throughout most of its growing season was clearly shown in these experiments. Although many major weed species were encountered, three species, C. album, P. aviculare and F. officinalis, determined the success or failure of the herbicide programmes tested. They caused severe competition with the crop by their ability to exploit space left by the removal of other weed species. Post-emergence treatments readily controlled C. album, but few pre- or post-emergence treatments were able to control both other species. Effective weed control depended therefore on choosing an appropriate combination of pre- and post-emergence treatment. No single pre-emergence herbicide treatment was able to prevent severe reduction in crop yield, and it was necessary to apply both pre- and post-emergence treatments in order to achieve yields equivalent to those on weedfree plots. Choice of the correct combination of herbicides was, however, critical. Because of resistance by two species in 1972 and 1973, very few of the combined pre- and post-emergence treatments were able to give effective overall control and avoid loss of crop yield. Repeat application with the same herbicide was successful in Expt. I, since the first treatments had failed to control a normally susceptible species (C. album) possibly due to dry soil conditions after application. However, this type of programme was unsuccessful in the later experiments where inherently resistant species were a major problem. Since other post-emergence herbicides can extend the range of weeds controlled, it is desirable in most situations to avoid repeat applications of the same herbicide.

The most reliable of the pre-emergence treatments was trifluralin, which is made independent of soil moisture conditions by incorporation. Control of resistant weeds on these plots was readily achieved with metoxuron or prometryne. Differences in soil types, seed bed conditions and basic weed flora will affect the choice of pre-emergence herbicide at other locations. The correct choice of post-emergence herbicide should be determined by an assessment of the relative competitive ability of the weed species which escape residual herbicide treatment.

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THE EVALUATION OF BENTAZONE FOR WEED CONTROL IN PROCESSING LEGUMES

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Summary The results are presented of experiments to evaluate bentazone MCPB mixtures as post-emergence treatments in peas and bentazone as a post-emergence treatment in dwarf beans, either used alone or as part of a spray programme with pre-sowing trifluralin or pre-emergence dinoseb-acetate plus monolinuron.

The bentazone MCPB mixture, at the rate of 1.5 + 1.5 kg a.i./ha, proved to be a reliable treatment for peas, effective against a wide range of important weeds and safe to the crop, even under adverse weather conditions, when compared to the standard dinoseb-amine treatment.

Bentazone as a post-emergence treatment in dwarf beans did not control two common weeds Veronica spp and Polygonum aviculare, and gave variable control of Chenopodium album, Tripleurospermum maritimum ssp inodorum and Polygonum convolvulus, particularly when applications were made at an advanced stage of weed development. When bentazone was used following trifluralin a wide range of weeds were controlled and it also proved a useful emergency treatment against a more restricted weed range when used after pre-emergence applications of dinoseb-acetate plus monolinuron.

INTRODUCTION

The need for new post-emergence herbicides for both peas (Pisum sativum) and dwarf beans (Phaseolus vulgaris)was reported by King & Handley (1972), and the results now presented are of continued work to establish the effectiveness of a bentazone MCPB mixture in peas and bentazone alone, or as part of a programme with pre-sowing trifluralin or pre-emergence dinoseb-acetate plus monolinuron in dwarf beans.

In peas residual herbicides have been accepted as standard treatments on approximately 60% of the total UK acreage, because of their convenience of application and effectiveness against problem weeds such as Polygonum aviculare, Tripleurospermum maritimum ssp inodorum, Papaver rhoeas, and Chenopodium album. Control of other species such as Fumaria officinalis, Sinapis arvenis and Polygonum convolvulus, is more variable according to the material used, but none of the residual herbicides used in the pea crop are particularly effective against Galium aparine. It is estimated that approximately 10% of the acreage treated with residual herbicides requires a follow-up post-emergence treatment, due to the presence of resistant weeds or variable control caused by dry or cloddy seedbeds. The remaining acreage is basically grown on soils unsuitable for residual herbicides, those with a high percentage of organic matter, coarse sand or clay fraction.

The most widely used post-emergence herbicides, dinoseb-amine and dinoseb-acetate, are toxic materials listed as Part II substances under the British Poisons

Act of 1972; they require to be applied at medium to high volume and the weather should be dry and warm at the time of treatment and shortly afterwards. The leaf wax on the crop must be sound and the control of certain weeds such as Urtica urens, Polygonum aviculare, Aethusa cynapium, Polygonum convolvulus, Papaver rhoeas, Polygonum persicaria and Matricaria sp. can only be achieved if the application is made before they reach the 2-3 true leaf stage. The more recently introduced material cyanazine also has a rather restricted weed range and is weak against P. aviculare, G. aparine, F. officinalis and Matricaria sp.

There is therefore a very real need for a safe post-emergence herbicide capable of giving good control of a wide range of annual weeds and which is not unduly affected by weather conditions.

The range of herbicides available for use in dwarf beans is limited and the two most commonly used residual materials, both contain monolinuron. Certain of the newer varieties are susceptible to this material while the dry conditions experienced during May and June when the crop is sown reduce the effectiveness of these herbicides. Late germinating weeds such as Solanum nigrum and C. album can be particularly troublesome in this crop.

Early work by PGRO with pre-sowing applications of trifluralin indicated that because of its restricted weed range it was not suitable as a herbicide for dwarf beans without supplementary treatment to remove the resistant weeds. When the evaluation of bentazone showed that this was suitable as a post-emergence treatment it was decided to carry out spray programmes using these materials and also the pre-emergence dinoseb-acetate plus monolinuron.

METHOD AND MATERIALS

All experiments were of randomised block design with three replications in 1973 and four in 1974, the plots being 0.001 hectares in area, and were carried out in commercial crops with the exception of those on the Thornhaugh trial ground.

Applications were made with a van der Weij sprayer fitted with cone nozzles at either 225 l/ha (low volume) or 560 l/ha (medium volume), in the pea experiments and medium volume was used in the bean experiments. All doses are presented in kg/ha of active ingredient. In the 1973 work both wettable powder and liquid formulations of bentazone were used, while for the bentazone MCPB mixture both tank and formulated mixes were tested. In 1974 liquid formulations of bentazone and bentazone MCPB were used throughout the work. Assessments for effects on the crop, control of individual weed species and overall control were made at all sites, while in addition weed counts were also made at some sites. The scoring system used was on a 0-10 scale where 10 was no visible crop damage or complete weed control. At harvest the peas were cut by hand and then put through a plot viner. Yields of shelled peas were recorded and the relative maturity measured by means of a tenderometer. The dwarf bean experiments were harvested by hand picking the produce from the centre one or two rows, the outer rows being discarded. Samples from both crops were taken and processed for taint testing.

Table 1

Site details

Year	Code	Location	Soil type	Variety	Stage of growth at application (no. of leaves) Crop*	Weed✝	Date of application	Temp. at application
Peas								
1973	A	Thornhaugh	Zy.L.	Scout	5	2-4	14/5	7°C
	B	Benwick	Peaty L.	Freezer 69	4-5	S.-Est.	7/5	13°C
	C	Holbeach	Zy.L.	Puget	5	2	6/6	20°C
1974	D	Thornhaugh	F.S.L.	H.G. Shaft	4-6	2-4	30/5	18°C
	E	Marston	C.S.L.	Hurst Beagle	4-5	1-6	7/5	16°C
	F	Grimston	Org.C.S.L.	Sprite	4-5	2-8	8/5	13°C
	G	Holbeach	Zy.L	Puget	7-8	Est.	20/6	16°C
Dwarf beans								
1973	A	Thornhaugh	Z.L.	Cascade	1½	Est.	27/6	13°C
	B	Holbeach	F.S.L.	Tendercrop	1½-2	S.	9/7	20°C
	C	Fosdyke	Zy.L.	Cascade	3-4	6-Est.	24/7	18°C
1974	D	Thornhaugh	F.S.L.	Cascade	3-4	6-Est.	17/7	18°C
	E	Holbeach	Zy.L.	Provider	2	6-8	1/8	18°C
	F	Fosdyke	Zy.L.	Cascade	2½	6-8	5/8	16°C

✝ Weed stage S = Seedling
EST = Established

* Crop stage dwarf beans - no. of tri-foliate leaves.

RESULTS

Peas

The results of assessments made for the effects of the treatments on the crop appear in Table 2. In 1973 both wettable powder and emulsifiable concentrate formulations of bentazone were tested as tank mixes with MCPB and compared to the liquid formulated product. No observable differences in the degree of effect on the crop from these various mixtures was recorded and only the results for the formulated mixture are presented for both years. A reduced rate of MCPB (1.0 kg/ha) in mixture with 1.5 kg/ha of bentazone was tested in 1973, but did not show any significant advantage in terms of reduced effect on the crop and the results are not presented. Several assessments were carried out at each site, but only the results of the assessment made shortly after the treatments had been applied are presented and these show the maximum effects recorded on the crop before they were outgrown. The effects of the bentazone MCPB were distortion, a reduction is leaflet size and a slight change in foliage colour; the plants had a 'bluish' hue. The effects recorded from the 1.0 + 1.0 kg/ha and 1.5 + 1.5 kg/ha rates were not pronounced and were outgrown by harvest, but those from the 3.0 + 3.0 kg/ha were more persistent and resulted in slight stunting. Crops which were treated early in the season in cool conditions and where growth was slow, eg sites B & F had more damage than those treated where growing conditions were better. Leaf necrosis was recorded on the bentazone MCPB treated plots at some sites, but this was generally very slight and was always less than that recorded from dinoseb-amine, which caused quite appreciable leaf and stem necrosis at some sites.

Table 2

Crop assessments - Vining peas 1973-74

Material[†]	Rate kg/ha	Volume 1973	1974	Crop damage (0-10) Site A	B	C	D	E	F	G
B + MCPB	1.0+1.0	-	M	-	-	-	7.3	9.6	7.8	9.9
B + MCPB	1.5+1.5	L	M	8.3	7.3	7.7	7.3	9.0	6.8	9.8
B + MCPB	3.0+3.0	L	M	5.0	5.0	6.0	6.3	5.3	6.5	7.5
D.-A.	1.9	M	M	5.0	5.0	8.0	10.0	8.3	8.5	9.0
Untreated	-	-	-	10.0	10.0	10.0	10.0	10.0	10.0	10.0

† B. Bentazone D.-A. Dinoseb-amine

While bentazone MCPB at 1.5 + 1.5 kg/ha affected the crop to a certain extent at all sites it did not at any site cause such severe effects as those recorded from dinoseb-amine at sites A and B.

The results of the overall weed assessments are presented in table 3, while those for individual species appear in table 4.

Table 3

Weed assessments - Vining peas 1973-74

Material[†]	Rate kg/ha	Volume 1973	1974	Weed control (0-10) Site A	B	C	D*	E	F	G
B + MCPB	1.0+1.0	-	M	-	-	-	4.3	6.3	7.1	8.3
B + MCPB	1.5+1.5	L	M	9.3	7.7	10.0	6.0	6.9	8.0	8.8
B + MCPB	3.0+3.0	L	M	9.3	8.3	10.0	7.3	7.8	8.4	9.0
D.-A.	1.9	-	-	8.7	8.7	8.3	2.0	6.0	5.3	6.5
Untreated	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0

† B. Bentazone D.-A. Dinoseb-amine
* *Polygonum aviculare* only

It will be seen that bentazone MCPB at 1.5 + 1.5 kg/ha gave better overall control than dinoseb-amine at all but one site and while the rate of 1.0 + 1.0 kg/ha was not as effective as the higher rate it was superior to dinoseb-amine at all four sites in 1974.

In table 4 it can be seen that bentazone MCPB gave superior control to dinoseb-amine of eight important weed species and was only inferior against *Veronica spp*. Of particular interest are the results for *P. aviculare*, *T. maritimum*, *S. nigrum* and *U. urens*, all species which are difficult to control with dinoseb-amine. Results of assessments (not presented) for control of *Viola arvensis* indicated that dinoseb-amine gave slightly better control than bentazone MCPB, but the latter material gave good control of *Descurainia sophia* and *Silene alba*, which were not controlled by dinoseb-amine.

Table 4

Control of individual weed species

Weed species	No. of sites 1973	1974	Bentazone MCPB (1.5+1.5 kg/ha) 1973	1974	Dinoseb-amine (1.9 kg/ha) 1973	1974
Stellaria media	2	3	10.0	9.7	9.7	7.1
Polygonum convolvulus	3	3	9.1	9.6	9.6	7.8
Polygonum aviculare	3	2	9.1	6.8	7.3	3.1
Polygonum persicaria	2	1	8.9	8.3	7.7	8.8
Tripleurospermum maritimum	2	2	9.5	9.8	9.9	7.4
Veronica spp.	2	2	8.2	5.7	9.7	7.3
Solanum nigrum	1	1	7.8	10.0	6.6	10.0
Urtica urens	-	2	-	9.2	-	7.0
Chenopodium album	1	3	10.0	8.8	10.0	7.8

Score: 0 = No control. 10 = Complete control

The yield data is presented in table 5.

Table 5

Yield data - Vining peas 1973-74

Material†	Rate kg/ha	Volume 1973	1974	Yield (% of untreated control) Site A	C	D	E	F	G
B + MCPB	1.0+1.0	-	M	-	-	89	105	93	122
B + MCPB	1.5+1.5	L	M	104	116	96	97	100	139
B + MCPB	3.0+3.0	L	M	89*	111	96	73*	92	115
D.-A.	1.9	M	M	93	111	100	115	101	134
Untreated	-	-	-	100	100	100	100	100	100
Yield of untreated t/ha				10.2	2.7	8.3	5.2	3.7	3.5
Sig. at P = 0.05%				Sig.	N.S.	N.S.	Sig.	N.S.	N.S.
S.E. as % of gen. mean				5.4	15.4	16.6	14.4	14.5	16.1

† B. Bentazone D.-A. Dinoseb-amine

The effects of the treatments observed on the crop are reflected in the yield results. Dinoseb-amine caused appreciable scorch at site A and the final yield was low, and this also applies to bentazone MCPB at 1.5+1.5 kg/ha at sites D and E. The high rate of bentazone MCPB tended to give lower yields, those at sites A and E being significantly below the untreated. While the bentazone MCPB at 1.0+1.0 kg/ha did not cause serious damage the moderate weed control resulted in rather low yields at three sites compared to the more effective treatments. The bentazone MCPB treatments appeared to have a more persistant effect on the crop when applied during cool dry conditions, when growth was slow, for example sites A, D and E.

The maturity data appears in table 6.

Table 6

Maturity data - Vining peas 1973-74

Material[†]	Rate kg/ha	Volume 1973	Volume 1974	Tenderometer reading Site A	C	D	E	F	G
B + MCPB	1.0+1.0	-	M	-	-	115	102	100	101*
B + MCPB	1.5+1.5	L	M	105	86	113	101	101	100*
B + MCPB	3.0+3.0	L	M	101	85	110	99	100	103*
D.-A.	1.9	M	M	111	87	116	102	100	94
Untreated	-	-	-	112	84	122	102	101	95
Sig. at P = 0.05				N.S.	N.S.	N.S.	N.S.	N.S.	Sig.
S.E. as % of gen. mean				5.9	2.1	5.7	2.8	3.0	2.6

B. Bentazone D.-A. Dinoseb-amine

There was an indication that the bentazone MCPB treatments, particularly the 3.0+3.0 kg/ha rate, caused a slight delay in maturity at some sites, compared to the untreated control. However, comparisons between dinoseb-amine and the 1.5 + 1.5 kg/ha rate of bentazone MCPB showed only very slight differences; on two occasions the dinoseb-amine treatments were slightly more mature while on another they were less mature. At site G the bentazone MCPB treatments were significantly more mature than either dinoseb-amine or the untreated, which could have been delayed by weed competition.

No taints were detected in any of the samples of produce treated with bentazone MCPB.

Dwarf beans

The results of assessments carried out shortly after the post-emergence applications had been made, for effects on crop development are presented in table 7.

In 1973 the post-emergence bentazone applications caused a moderate, but acceptable level of leaf necrosis and in general the effects were rapidly outgrown. In 1974 the applications were made at a later stage of crop development and the effects on the crop were slight. The effects recorded from bentazone applications made after the 0.8 kg/ha rate of trifluralin were comparable to those where bentazone alone had been used, but where bentazone was used at 2.0 kg/ha following trifluralin at 1.6 kg/ha, quite marked necrosis occurred and the effects were more persistent. Although some slight stunting was initially recorded on the plots treated with trifluralin at 0.5 and 0.8 kg/ha this was later outgrown and generally at these rates the crop tolerance was satisfactory. The high rate of trifluralin caused marked stunting at four of the six sites with up to 30% loss of plant at some sites and the effects were not always outgrown by harvest. At sites A and E the loose seedbed conditions probably resulted in the material being incorporated deeper than at the other sites. Conditions were generally dry following the dinoseb-acetate + monolinuron applications and no marked effects were recorded on crop development from these treatments.

The assessments for overall weed control and crop assessments are presented in table 7. Weed assessments were made just prior to harvest while the crop assessments were made approximately seven days after the post-emergence treatments had been applied.

Table 7

Weed & crop assessments - Dwarf beans 1973-74

Material†	Rate kg/ha	Assessments§ Site A W	A C	B W	B C	C W	C C	D W	D C	E W	E C	F W	F C
T	0.8	-	-	-	-	-	-	6.0	9.5	5.5	8.3	4.0	9.8
T & B	0.5+1.0	9.0	8.7	8.3	10.0	8.7	8.7	-	-	-	-	-	-
T & B	0.8+1.0	9.3	7.7	8.8	9.7	8.7	8.3	9.5	9.5	8.1	9.3	9.5	9.0
T & B	1.6+2.0	9.0	4.7	9.0	9.0	9.3	6.3	9.8	6.0	9.5	3.8	10.0	7.0
D + M	2.8	5.7	9.0	-	-	-	-	5.8	10.0	3.3	10.0	5.5	10.0
D + M & B	2.8+1.0	-	-	-	-	-	-	8.3	9.8	5.8	10.0	9.5	8.8
B	1.4	7.0	7.3	8.8	9.0	5.7	8.0	5.5	9.5	6.0	10.0	7.8	9.3
Untreated	-	0.0	10.0	0.0	10.0	0.0	10.0	0.0	10.0	0.0	10.0	0.0	10.0
Weeds per $10m^2$		7	-	25	-	47	-	36	-	49	-	69	-

† T Trifluralin
B Bentazone
D + M Dinoseb-amine + monolinuron

§ W Weeds 0 = no control
C Crop 10 = no damage

Trifluralin did not give acceptable overall control, even at the rate of 1.6 kg/ha, due mainly to poor control of Capsella bursa pastoris, S. arvensis, Senecio vulgaris, T. maritimum ssp inodorum, & S. media. Control of U. urens was variable, but good control was achieved of P. aviculare, P. convolvulus, C. album and Veronica spp. Control from dinoseb- acetate plus monolinuron was poor and at none of the sites was the level of control acceptable, Veronica spp and P. aviculare were the main weeds left, but control of P. convolvulus, S. vulgaris, U. urens and S. media was also variable. Bentazone on its own gave variable control depending on the weed spectrum present. Veronica spp and P. aviculare were not controlled while control of C. album, U. urens and C. bursa-pastoris was also somewhat variable. Bentazone following the use of trifuluralin generally gave excellent control of the remaining species, but since the two main weeds which were not controlled by dinoseb-acetate plus monolinuron were P. aviculare and Veronica spp., bentazone gave less satisfactory results when used after the pre-emergence treatment. The combination of trifluralin plus bentazone gave particularly effective control of C. album and Polygonum sp.; important species in this crop.

The yield data appears in table 8. Weed competition was low in 1973 and yield differences at all sites were small. In 1974 weed populations were higher and yield differences were greater. Although dinoseb-acetate plus monolinuron gave poor weed control the species left were not tall vigorous weeds and apparently did not seriously compete with the crop. This treatment gave the highest yields in 1974 and because bentazone also failed to control the weeds left after the pre-emergence treatment, and affected the crop to some extent, yields from the combination were a little lower. Yields from the trifluralin treatment were quite good and again the remaining species apparently did not compete strongly with the crop since the use of bentazone failed to give increased yields in spite of giving excellent control.

DISCUSSION

The results of the work with the bentazone MCPB mixture in peas indicate that it is capable of giving excellent control of a wide range of weed species, including some of the most important ones likely to affect the growing, harvesting or processing of the crop. Weed control was generally better and more reliable than with the standard dinoseb-amine treatment, and although the effects of the treatment on the crop tended to be more persistent under slow-growing conditions it did not appear to be as likely to cause such severe effects as dinoseb-amine did under unfavourable conditions.

Table 8
Yield data - Dwarf beans 1973-74

Material ǂ	Rate Kg/ha	Yield (% of untreated) Site					
		A	B	C	D	E	F
T	0.8	-	-	-	109*	112	91
T & B	0.5+1.0	107	94	95	-	-	-
T & B	0.8+1.0	101	99	100	106	112	95
T & B	1.6+2.0	110	106	96	87*	92	42
D + M	2.8	93	-	-	114*	120*	107
D + M & B	2.8+1.0	-	-	-	105	112	91
B	1.4	108	96	93	106	108	96
Untreated	-	100	100	100	100	100	100
Yield of untreated (tonnes/ha)		17.8	14.3	17.2	14.4	10.0	9.8
Sig. at P = 0.05		N.S.	N.S.	N.S.	Sig.	Sig.	N.S.
S.E. as % of gen. mean		11.4	13.3	11.8	10.5	16.8	14.1

ǂ T Trifluralin
B Bentazone
D + M Dinoseb-acetate + monolinuron

The low mammalian toxicity, the lack of a need to apply it at high volume and the greater reliability against weeds, even when applied at relatively advanced stages of growth, are likely to make bentazone MCPB a valuable herbicide for use in the pea crop. Farmer-usage trials (results not presented) carried out in 1974, confirmed the usefulness of the material under commercial conditions. Bentazone as a post-emergence treatment in dwarf beans also appears to be a valuable addition to the range of materials available for this crop. Although its weed spectrum is not wide enough to provide satisfactory control without supplementary treatment, it would still be a valuable 'emergency' treatment capable of controlling the most important weed species found in beans. When used following the pre-sowing use of trifluralin excellent results have been obtained and these two materials are complementary in terms of the species controlled. Control following the use of dinoseb-acetate plus monolinuron is not always as successful due to the type of weeds resistant to the pre-emergence treatment.

Trifluralin does not appear to possess sufficient selectivity to be used at rates above 0.8 kg/ha and care will be required in its use. It will, however, provide more reliable control under dry conditions than the standard pre-emergence materials at present in use.

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EXPERIMENTS WITH BENTAZONE FOR CONTROL OF WEEDS IN DWARF BEANS

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Summary Experiments carried out since 1971 have indicated that applications of bentazone 1.5 l. a.i./ha can be made to emerged dwarf beans without causing permanent injury. Some necrosis of the older leaves occurred on most varieties, but young leaves and subsequent emerging leaves were not affected.

Assessments have shown no adverse effect on crop yield or maturity when compared to untreated or dinoseb-acetate + monolinuron treated plots. It appears, however, that applications made before the 2 trifoliate leaf stage or in temperatures of over 21°C have a greater effect on the crop and may cause prolonged crop injury with a subsequent adverse effect on yield.

Trials have also shown that bentazone may be safely applied following a pre-sowing application of trifluralin or a pre-emergence application of dinoseb-acetate + monolinuron. These sequential treatments have given very good weed control. Sequential treatments of trifluralin/bentazone were particularly effective as the weed spectrums of these two chemicals are complementary. Activity was not critically dependent on weather conditions.

Sommaire Les expériences faites depuis 1971 ont indiqué que les applications de bentazone 1,5 l. a.i./ha peuvent se faire aux haricots nains sans occasioner aucun dommage permanent. Quelque nécrose s'est produite parmi les plus vieilles feuilles de la plupart des variétés, mais les jeunes feuilles et celles qui sont subséquemment émergées n'ont pas été atteintes.

Les évaluations n'ont montré aucunes conséquences nuisibles pour le rapport ou la maturité de la récolte en comparaison avec les terrains non-traités ou traités de dinoseb-acetate + monolinuron. Il paraît, cependant, que les applications faites avant la phase de 2 trifoliées, ou à des te mperatures de plus de 21 degrés, produisent un plus grand effet sur la récolte et peuvent occasioner du dommage prolongé à la recolte et ensuite un effet adverse sur le rapport.

Les essais ont montré aussi qu'on peut appliquer le bentazone sans risque à la suite d'une application de dinoseb-acetate + monolinuron faite avant l 'émergence. Ces traitements consécutifs ont effectué un très bon contrôle de mauvaises herbes. Les traitements consécutifs de trifluralin/bentazone ont été particulièrement éfficaces car les spectres à mauvaises herbes de ces deux produits chimiques sont complémentaires. L'activité n'était pas critiquement dépendante des conditions météorologiques.

INTRODUCTION

Bentazone is a thiadiazinone derivative of low mammalian toxicity. It is essentially a contact herbicide for control of broad leaved weeds, and has a wide range of selectivity in gramineae and leguminous crops.

The chemical is very effective against many important arable weeds, e.g. Chenopodium album, Matricaria spp., Sinapis arvensis, Stellaria media, Solanum nigrum and Polygonum persicaria although some important weed species, i.e. Polygonum aviculare, Veronica spp., Lamium spp. and Galeopsis tetrahit are resistant.

Screening trials carried out at the Weed Research Organisation in 1970, Richardson and Dean (1973), followed by field trials at the National Vegetable Research Station and the Processors and Growers Research Organisation, Roberts and Bond (1971 & 1972) and King (1971), indicated that Phaseolus vulgaris (dwarf french and navy beans) and Phaseolus coccineus (runner beans) were tolerant to post-emergence applications of bentazone.

In order to fully evaluate these results four replicated field trials were carried out on dwarf beans in 1971 comparing single and double rates of bentazone with dinoseb-acetate + monolinuron. Although no trials were carried out by BASF U.K. Limited in 1972 work was continued at the Processors and Growers Research Organisation. Further trials were carried out in 1973 to compare sequential treatments of trifluralin followed by bentazone and dinoseb-acetate + monolinuron followed by bentazone. Also in 1973, several farmer usage trials were carried out to confirm the results obtained in the small plot replicated trials.

METHOD AND MATERIALS

All small plot trials were of a randomised block design, with four replicates of each treatment. Each plot measured 2 x 6.25 metres. Treatments were applied with a Van der Weij knapsack sprayer fitted with cone nozzles. Spray pressure was maintained at 2.5 kg/m^2 and spray volume at 250 l./ha of water, except for dinoseb-acetate + monolinuron and trifluralin which were applied in 450 l./ha.

Farmer usage trial plots usually measured 1 acre, were unreplicated, and applications were made using the farmers' own equipment. All dose rates are presented in kg a.i./ha.

Trifluralin was applied pre-sowing of the crop and incorporated with a rotary cultivator and dinoseb-acetate + monolinuron was applied to the soil surface pre-emergence of the crop.

Weed control and crop tolerance scores were made according to the E.W.R.C. method of herbicide and crop assessment and all treatments were assessed approximately 14 days after the post-emergence applications.

Crop yields were determined by taking 4 x 1.5 metres of row per plot and recording the weight of the pods produced.

Maturity was assessed by taking the largest pod from ten randomly selected plants in each plot and measuring the length of the largest seed in each pod.

Taint tests were carried out by the Campden Food Preservation Research Association.

Formulations

a) Bentazone was formulated as a wettable powder (BAS 3510H) containing 50% w/w active ingredient in 1971 and as an aqueous solution (BAS 3517H) containing 50% w/v active ingredient in 1973.

b) Dinoseb-acetate + monolinuron is a wettable powder containing 50% active ingredient.

c) Trifluralin is an emulsifiable concentrate containing 48% w/v active ingredient.

Table 1

Trial site details for bentazone applications

Cultivar	Crop stage (No. of trifoliate leaves)	Soil type	Weather conditions	Weed stages
1971				
1 Cascade	1	sandy loam	15°C overcast	*U. urens* - 4 leaves *C. album* - 4-6 leaves *S. vulgaris* - 4-6 leaves
2 Processor	2	fine sandy loam	27°C overcast	*P. aviculare* - 4-6 leaves *C. album* - 2 leaves *S. media* - young plants *S. nigrum* - 2 leaves *C. bursa-pastoris* - 4-6 leaves
3 Processor	3-4	fine sandy loam	27°C sunny	No weeds present
4 Valiant	2-3	dry sandy loam	21°C overcast	*P. persicaria* - 12 in. high *C. album* - 5-12 in. high *S. media* - flowering *U. urens* - 3-4 in. high
1973				
5 Tendercrop	2	sandy loam	17°C sunny	No weeds present
6 Bush Blue Lake	2	very fine sandy loam	17°C overcast	*C. album* - 2-6 leaves *V. spp.* - small plant *S. arvensis* - 2-4 leaves *A. arvensis* - 2-6 leaves
7 Provider	2	very fine sandy loam	25°C sunny	No weeds present

Table 2

Overall weed control and crop tolerance assessments - 1971

Treatments	kg a.i./ha	1 Cascade Weed	1 Cascade Crop	2 Processor Weed	2 Processor Crop	3 Processor Weed*	3 Processor Crop	4 Valiant Weed	4 Valiant Crop
Untreated	-	9.0	1.0	9.0	1.0	-	1.0	9.0	1.0
Bentazone	2.0	4.0	3.0	2.0	1.1	-	2.0	6.0	1.0
Bentazone	4.0	4.0	3.0	2.0	1.8	-	4.0	5.3	1.0
Dinoseb-acetate + monolinuron	2.5	3.0	1.0	1.8	1.5	-	1.0	9.0	1.0

* weed control could not be assessed owing to the very low levels of weed in the trials area.

Table 3

Yield of beans (1971) expressed as a percentage of the dinoseb-acetate + monolinuron treatment

Treatments	kg a.i./ha	1 Cascade	2 Processor	3 Processor	4 Valiant
Untreated	-	94	52	106	98
Bentazone	2.0	111	106	104	87
Bentazone	4.0	110	96	104	100
Dinoseb-acetate + monolinuron	2.5	100 (15.8 t/ha)	100 (14.2 t/ha)	100 (16.8 t/ha)	100 (14.3 t/ha)

The figures in brackets show the actual yield of the dinoseb-acetate + monolinuron plots in tonnes/hectare.

Trials 1, 3 and 4 - differences between treatments not significant when P = 0.05. Untreated in trial 2 was significantly different when P = 0.01. The other treatments were not significantly different from each other when P = 0.05.

Table 4

Weed control and crop tolerance assessments (1973)

Treatments	kg a.i./ha	5 Tendercrop Weed*	5 Tendercrop Crop	6 Bush Blue Lake Weed	6 Bush Blue Lake Crop	7 Provider Weed*	7 Provider Crop
Untreated	-	-	1.0	9.0	1.0	-	1.0
Dinoseb-acetate + monolinuron	2.5	-	1.0	5.5	1.0	-	1.5
Bentazone	1.5	-	1.0	2.0	1.0	-	2.0
Dinoseb-acetate + monolinuron + bentazone	2.5 + 1.5	-	1.5	1.8	1.0	-	2.5
Trifluralin + bentazone	1.0 + 1.5	-	1.5	1.5	1.0	-	2.5

* weed control could not be assessed owing to very low levels of weed in the trials area.

Table 5

Yield of beans (1973) expressed as a percentage of the dinoseb-acetate + monolinuron plots

Treatments	kg a.i./ha	5 Tendercrop	6 Bush Blue Lake	7 Provider
Untreated	-	106	99	102
Bentazone	1.5	109	113	88
Dinoseb-acetate + monolinuron + bentazone	2.5 + 1.5	111	105	105
Trifluralin + bentazone	1.0 + 1.5	112	113	99
Dinoseb-acetate + monolinuron	2.5	100 (22.4 t/ha)	100 (23.0 t/ha)	100 (19.1 t/ha)
Differences not significant where P = 0.05				

Figures in brackets show the actual yield of bean pods for the dinoseb-acetate + monolinuron plots.

Table 6

Farmer-usage applications (1973)

	Application details						
Cultivar	Temp. (°C)	Crop stage (No. of trifoliate leaves)	Weed control A	Weed control B	Crop vigour A	Crop vigour B	Main weeds at application
Tendercrop	18	2-3	9.0	4.0	2.0	4.5	Euphorbia, Matricaria spp., Lamium spp.
Cascade	20	4	9.0	3.0	1.0	3.0	Matricaria spp., P. persicaria
Tendercrop	20	2-3	9.0	4.0	6.0	3.0	C. album, P. persicaria
Tendercrop	18	2-3	9.0	3.0	1.0	3.5	Veronica spp., S. media
			C	C+B	C	C+B	
Bush Blue Lake	22	2	6.0	2.0	1.0	4.0	C. album
Waverow	19	2	4.0	3.0	1.0	2.0	P. persicaria, P. convolvulus
Processor	16	2-3	6.0	4.0	1.0	2.0	Veronica spp., P. aviculare
Bush Blue Lake	16	4-5	4.0	1.5	1.0	1.0	Matricaria spp., U. urens
			D	D+B	D	D+B	
Harvester	10	5-6	7.0	4.0	1.0	3.0	S. vulgaris

A = untreated, B = bentazone, C = dinoseb-acetate + monolinuron, D = paraquat + monolinuron

DISCUSSION

1971 trials

On three of the four trials carried out necrosis of the older leaves occurred following applications of bentazone 2.0 kg a.i./ha and 4.0 kg a.i./ha. However, young leaves and subsequent emerging leaves were not affected, and all plants grew away without permanent injury. Applications made at temperatures above 21°C and before the 2 trifoliate leaf stage appeared to increase the amount of damage caused.

Yield assessments showed that the bentazone treatments had no adverse effect when compared to untreated or dinoseb-acetate + monolinuron treated plots.

Although weed control was generally good, the resistance of some weeds, e.g. *P. aviculare*, and the advanced growth of others (trial 4) prevented 100% weed control. Other work being carried out with bentazone in 1971 on arable legumes indicated that the optimum rate for good weed control and maximum crop safety was 1.5 kg a.i./ha. It was decided therefore to reduce the rate of bentazone in future dwarf bean trials in order to obtain a greater margin of crop safety and also to compare programmes of trifluralin followed by bentazone and dinoseb-acetate + monolinuron followed by bentazone to achieve better overall weed control.

1973 trials

Weed growth in these trials was very poor owing to the very dry soil conditions. Assessments could only be carried out on one trial and results showed that trifluralin + bentazone gave almost 100% weed control, being slightly better than dinoseb-acetate + monolinuron followed by bentazone or bentazone alone. As there were very few weeds present to cause competition any adverse effect on crop vigour could be easily detected and assessments indicated that none of the treatments had any adverse effect except for a slight leaf necrosis of the older leaves following bentazone applications.

None of the treatments significantly affected yield, and applications of bentazone after trifluralin or dinoseb-acetate + monolinuron did not reduce yield compared to these chemicals applied alone.

Maturity assessments were carried out on all replicated trials and no significant differences were recorded. Three years' tests on processed crops have shown no taint.

A series of farmer-usage trials on six different varieties gave similar results to the replicated trials. None of the trials carried out to date have suggested particular varietal susceptibility to bentazone.

The results obtained indicate that bentazone can be safely applied post-emergence to dwarf beans at the 2-3 trifoliate leaf stage. Although good weed control can be achieved using bentazone alone, it appears that it would be best used in a programme with a pre-sowing or pre-emergence herbicide. Trifluralin appears ideally suitable as its weed spectrum is complementary to that of bentazone.

Extension work carried out on runner beans and navy beans has indicated that bentazone can be applied to these crops using similar recommendations.

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E.A. Brown of BASF United Kingdom Limited for implementing these trials.

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THE CONTROL OF WEEDS IN GREEN BEANS (PHASEOLUS VULGARIS)

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Summary In replicated trials, carried out from 1971 to 1974, cyanazine, linuron, and N - sec - butyl - 4 - tert - butyl - 2, 6 dinitro aniline, and cyanatryn were applied in various combinations to a range of green bean varieties for processing, and in 1974, the experiments were extended to include navy beans.

Cyanazine at 1.40 kg.ai/ha, 1.75 kg.ai/ha and 2.10 kg.ai/ha whilst giving improved weed control over the commercial standard lacked selectivity on the lighter soils.

The dinitro aniline product in combination with linuron and cyanatryn gave good weed control and pod yield with significantly higher selectivity margins under conditions of high rainfall on light soils, but with reduced selectivity on a sandy clay loam soil. Maturity was unaffected by chemical treatments, and crop height was marginally increased in two years' trials.

A candidate treatment of 2.20 kg.ai/ha of the nitroaniline compound combined with 0.56 kg.ai/ha of linuron is tentatively recommended with future development aimed at modifying the linuron component.

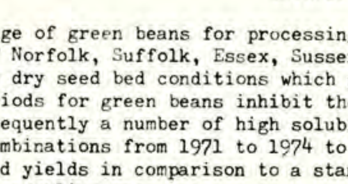
INTRODUCTION

Much of the acreage of green beans for processing tend to be concentrated in the drier counties of Norfolk, Suffolk, Essex, Sussex and Cambridgeshire. This fact, combined with the dry seed bed conditions which prevail in the late May/early June drilling periods for green beans inhibit the effectiveness of pre-emergence herbicides. Consequently a number of high solubility materials were tested alone and in various combinations from 1971 to 1974 to investigate their effects on weed, crop and pod yields in comparison to a standard pre-emergence treatment dinoseb-acetate + monolinuron

METHOD AND MATERIALS

The Shell triazines which were evaluated up to 1973 were cyanazine 2-(4 chloro-6-ethylamino-s-triazin-2-ylamino)-2-methyl proprionitrile introduced by Chapman T.,'et al' 1968. Its use in peas were fully described by Sandford H.,'et al' (1970) and Morris R.O., (1972) and in Brassicas by Haddow B.C., 'et al' (1970) and cyanatryn, evaluated in aquatic situations and reported on by Crossland N.O & Elgar K.E. (1974).

Cyanatryn 2-(4-ethylamino-6-methylthio-s-triazin-2-y)amino-2-methyl propionitrile (WL 63611) has the structural formula.



A-820* (N-sec-butyl-4-tert-butyl-2, 6 dinitro aniline) was evaluated alone and in combination with cyanazine, cyanatryn and linuron.
Cyanazine was formulated as a 50% suspension concentrate, cyanatryn, linuron and dinoseb-acetate+monolinuron as 50% wettable powders. In the 1974 series the linuron used was formulated as a 15% emulsifiable concentrate. All dose rates are given in kg.ai/ha and details of site location, varieties, drilling, spraying and harvest dates are presented in table 1 and soil analysis in table 2.

Table 1

Details of experimental sites

Year	Site	Location	Soil type	Variety	Date drilled	Depth (cm)	Sprayed	Date harvested
1971	1	Threeholes (Cambs)	L	Cascade	May 12	6	May 17	Aug 12
	2	Stalham (Nfk)	SL	Valiant	May 20	5	June 8	Aug 23
1972	3	Stanninghall (Nfk)	LS	Tendercrop	June 1	10	June 2	Sept 5
	4	Stalham (Nfk)	SL	Tendercrop	May 27	9	June 6	Aug 29
1973	5	Stalham (Nfk)	SL	Cascade	June 25	6	July 5	Sept 17
1974	6	Clacton (Essex)	SCL	Purley King	May 25	4	May 29	NA
	7	Gt.Bently (Essex)	SL	Cascade	May 24	4	May 29	Aug 20
	8	Maldon (Essex)	CL	Cascade	June 6	4	June 14	Aug 29
	9	Chichester (Essex)	SCL	Provider	June 8	8	June 12	NA

Table 2

Mechanical analysis of soils

Site No.	Sand(%)	Silt(%)	Clay(%)	OM(%)	Ph
2,4 & 5	68	22	10	2.0	7.1
3	77	17	6	2.2	6.3
6	66	13	21	2.3	NA
7	70	17	13	2.5	6.8
8	42	24	34	3.2	7.5
9	51	25	24	NA	5.6

All treatments were replicated four times in a randomised block design where plots measured 9.9 m^2 with the exception of the 1974 navy bean site which measured $53m^2$ to allow for combine harvesting.

Chemicals were applied, with the exception of the navy bean trial, with an Oxford Precision Sprayer in 280 litres of water per ha (Sites 7 and 8 at 562 litres per ha) at a pressure of 2.1 kg/cm^2 using Allman "oo" gauge brass jets.

Weed control was assessed as percentage ground cover of the surviving weeds 4, 8 and 12 weeks after crop emergence, the data from the final assessment being presented in this report. Crop effects were assessed on the basis of the E.W.R.C. Scale and crop counts were undertaken at harvest, these being expressed as number per sq metre.

At harvest, 10 plants were removed at random from each plot, and the mean seed length determined in the most mature pod to provide comparison of relative maturity. The two innermost rows were harvested, all useable pods (>5 cm) stripped off by hand and weighed, yield being expressed in tonnes per ha.

*Butralin is accepted common name by W.S.S.A.

Samples of beans from the various chemical combinations were quick frozen for taint evaluation at the Fruit and Vegetable Preservation Association at Chipping Campden.

RESULTS

Results from the 1971 trials are presented in Table 3.

Table 3

Effects of pre-emergence herbicides on crop and weeds - 1971

Treatment	Dose (kg./ha)	Plant Survival* Site 1	Plant Survival* Site 2	Pod yield (tonnes/ha) 1	Pod yield (tonnes/ha) 2	Maturity Index (mm) 1	Maturity Index (mm) 2	Weed cover (%) 1	Weed cover (%) 2
Cyanazine	1.40	84(2.5)	63(6.3)	4.3	5.5	8.7	7.2	34	0
Cyanazine	1.75	96(3.0)	46(7.3)	4.1	4.6	9.1	7.7	33	0
Cyanazine	2.10	82(5.0)	36(8.3)	4.6	3.6	9.1	7.9	17	0
A-820	2.24	92(2.8)	81(3.5)	4.3	5.9	9.7	6.9	58	22
Dinoseb-acetate + Monolinuron	2.25	78(2.5)	85(2.8)	4.4	7.5	8.7	7.4	51	3
UTC	-	90(1.0)	80(1.0)	3.6	4.4	10.0	7.6	80	63
L.S.D (P = 0.05)		18(2.0)	18	1.1	1.4	2.8	1.2	23	-

* Figures in brackets denote crop health on E.W.R.C. Scale. Survival = No/M^2

Dominant Weed Species

Site 1. *Polygonum aviculare*, *Polygonum convolvulus*, *Matricaria matricarioides*, *Lamium purpureum*, *Euphorbia helioscopia*.

Site 2. *Chenopodium album*, *Matricaria matricarioides*.

On the loam site (1) no treatment significantly effected plant stands (table 3). However, cyanazine at 2.10kg./ha caused most crop effect (E.W.R.C. score 5.0). On the sandy loam site (2) cyanazine at 1.75 and 2.10 kg/ha significantly reduced plant stands with high scores earlier in the season. These effects were reflected in pod yield with all treatments being significantly lower than the commercial standard. The A-820 treatment yielded significantly more pods than the cyanazine treatment but there were no significant changes in maturity from any chemical treatment.

With the exception of A-820 all treatments significantly reduced the weed cover, the surviving weeds in the cyanazine treatments and the commercial control being *Polygonum convolvulus* and *Polygonum aviculare*.

A-820 controlled *Lamium purpureum* better than the commercial standard, but was ineffective against *Matricaria matricarioides*.

Dinoseb-acetate + monolinuron at 2.25 kg./ha completely controlled *Matricaria matricarioides* and left 3% *Chenopodium album* whereas A-820 left 15% *Chenopodium album* and 7% *Matricaria matricarioides*.

Pre-emergence application 1972

On the loamy sand site (3) A-820 alone and in combination with linuron and cyanatryn resulted in marginally higher crop survival than the standard commercial control whereas the addition of cyanazine led to increased phytotoxicity and lower survival at both sites. There were no significant crop effects at site 4 (Table 4).

At site 4, pod yields were significantly higher than the untreated control, the highest increments being recorded in the dinoseb-acetate + monolinuron, A-820/cyanatryn and the A-820 linuron treatments. There were no significant changes in crop maturity.

Table 4

Effects of pre-emergence herbicides on crop and weeds - 1972

Treatment	Dose (kg./ha)	Plant stand (No/M^2) Site 3	Site 4	Pod yield (tonnes/ha) Site 3	Site 4	Maturity Index (mm) Site 3	Site 4	Weed cover (%) Site 3	Site 4
A-820 + cyanazine	2.20 + 0.87	46(6.0)*	62(6.8)	6.1	7.4	15.5	9.3	<1	0
A-820 + cyanatryn	2.20 + 0.87	65(2.5)	78(4.8)	7.4	10.0	14.5	9.9	7	<1
A-820 + Linuron	2.20 + 0.56	63(3.2)	73(2.2)	6.6	9.8	13.8	10.3	1	3
A-820	3.36	60(2.7)	85(3.8)	6.3	9.3	13.9	10.2	14	4
Dinoseb-acetate + monolinuron	3.36	57(3.2)	82(3.0)	6.2	10.8	14.0	10.3	7	<1
U.T.C.	-	64(1.5)	83(1.0)	3.6	4.6	13.0	9.9	57	27
L.S.D (P=0.05)		NA	22	NA	1.9	NA	1.2		1

*Figures in brackets denote crop health on E.W.R.C. Scale.

Dominant weed species

Site 3 and 4 — Viola tricolor, Polygonum aviculare, Chenopodium album, Matricaria matricarioides.

Site 3 only — Poa annua, Veronica hederifolia.

At site 3, all treatments resulted in acceptable levels of weed control. A-820 at 3.36kg./ha left 10% Viola tricolor, A-820 + cyanaztryn left 6% Viola tricolor and occasional Poa annua whilst the commercial standard partially controlled Veronica hederifolia.

On the sandy loam site (4) all treatments were highly effective, A-820 and A-820 + linuron left occasional Polygonum aviculare, but the control of Viola tricolor and Chenopodium album was excellent.

Pre-emergence application 1973

Shortly after applying the treatments, more than 50 mm. of rain fell on site 5 (table 5) as a result of which both dinoseb-acetate+monolinuron and A-820+linuron treatments affected the crop, the scores for crop health being 5.5 & 5.3 respectively.

There were no significant losses in plant stand. Pod yields from the commercial standard were significantly lower than the other treatments including the 2 x normal rate of A-820+Linuron (4.40 kg./ha + 1.12 kg./ha).

There were no significant differences in maturity, but plants in the A-820/linuron treatments were significantly taller than in the commercial control.

All treatments controlled a high potential weed infestation, however Tripleurospermum maritimum ssp inodorum developed late in the low A-820+linuron treatment.

Table 5

Effects of pre-emergence herbicides on crop and weeds - 1973 (Site 5)

Treatment	Dose (kg./ha)	Plant survival (plants/m^2)	Pod yield (tonnes/ha)	Crop ht (cms)	Maturity (mm)	Weed Cover %
A-820+cyanatryn	2.20+0.56	83(5.3)*	5.8	44.0	11.0	0
A-820+linuron	1.96+0.56	81(3.8)	5.7	43.4	12.4	4
A-820+linuron	2.20+0.56	94(2.8)	6.8	43.4	11.5	0
A-820+linuron	4.40+1.12	92(3.8)	5.3	43.2	11.5	0
Dinoseb-acetate+ monolinuron	2.25	86(5.5)	4.8	40.1	11.3	0
U.T.C.		87(1.0)	5.3	42.2	12.1	92
L.S.D. (P = 0.05)		12(1.5)	0.7	2.9	1.7	

*Figures in brackets denote crop health on E.W.R.C. Scale.

Weed Spectrum

Tripleurospermum maritimum SSP. inodorum	35% ground cover	Spergula arvensis	1% ground cover
Chenopodium album	10% ground cover	Myosotis arvensis	1% ground cover
Poa annua	16% ground cover	Veronica persica	1% ground cover
Scleranthus annuus	21% ground cover	Polygonum aviculare	1% ground cover
Aphanes arvensis	5% ground cover	Cirsium spp	1% ground cover

Pre-emergence applications in 1974

The data available to the time of writing is presented in Tables 6,7 and 8.

Table 6

Effects of pre-emergence herbicides on crop and weeds 1974 (Site 7.)

Treatment	Dose (kg./ha)	Plant stand (No/m^2)	Pod yield (tonnes/ha)	Crop ht (cm)	Maturity (mm)	Weeds (% cover)
A-820 + linuron	1.96+0.56	78 (1)*	8.2	29.2	11.8	6
A-820 + linuron	2.20+0.56	73 (2)	6.6	28.0	10.4	7
A-820 + linuron	4.40+1.12	68 (5)	5.6	28.3	11.1	3
Dinoseb-acetate + monolinuron	2.25	87 (2)	7.5	27.3	12.3	4
U.T.C.		79 (1)	8.6	29.5	10.5	24
L.S.D. (P= 0.05)		19	2.8	3.7	3.8	2

*Figures in brackets denote crop effects on E.W.R.C. Scale.

Predominant Weed Species Matricaria matricarioides, Viola arvensis, Raphanus raphanistrum, Poa annua, Chenopodium album.

In 1974 dinoseb-acetate + monolinuron on a sandy loam (site 7) caused negligable phytotoxicity in common with the optimum and sub optimum rate of A-820/linuron. The 2X normal rate of A-820/linuron mixture, however, scored 5 on the E.W.R.C. scale, and this treatment had the lowest plant stand which was reflected in yield of pods.

The highest yield of pods was obtained in the untreated control (U.T.C.) and the low A-820/linuron combination, with marginal differences in crop height, none of which were significant. All treatments significantly reduced the weed population. Dinoseb-acetate + monolinuron and A-820 + linuron at the high rate were significantly more effective than A-820 + linuron at 1.96 kg/ha + 0.56 kg/ha and 2.20 kg/ha + 0.56 kg/ha.

Table 7

Effects of pre-emergence herbicide on crop and weeds 1974 (Site 8)

Treatment	Dose (kg/ha)	Plant stand (plants/m^2)	Pod yield (tonnes/ha)	Maturity index (mm)	Crop ht (cm)	Weeds (% cover)
A-820+linuron	1.96+0.56	85	3.8	8.9	33.5	17 •(13)
A-820+linuron	2.20+0.56	84	3.0	7.2	35.0	11 (7)
A-820+linuron	4.40+1.12	78	4.6	7.7	31.9	3 (2)
Dinoseb-acetate + monolinuron	2.25	74	3.8	9.2	32.6	67 (56)
U.T.C.		81	2.9	7.8	32.1	72 (60)
L.S.D.(P = 0.05)		15	2.0	2.5	2.5	2 (2)

Predominant weed •Veronica persica ( )

There were no significant differences in the plant stands, however, there appeared to be a dose response to increasing rates of A-820 and the lowest plant stands were recorded in the dinoseb-acetate + monolinuron treatment. There were no significant differences in pod yield, but the plants in the A-820 + linuron at 2.20 kg/ha + 0.56 kg/ha were significantly taller than in the untreated control.

All combinations of A-820+linuron gave significantly higher levels of weed control than dinoseb-acetate + monolinuron, the weed population in this treatment and the untreated control visibly reducing pod production. The other weed species in this series were *Polygonum aviculare* and *Polygonum convolvulus* the control of which can be guaged by deduction. A-820 + linuron at the high rate virtually eliminated these weeds.

Table 8
Field observation at sites 6 and 9

Treatment	Dose kg/ha	Site 6 Plant stand	Site 6 Weed cover (%)	Site 9 Crop health	Weed Cover(%)
A-820+linuron	3.00+0.84	45 (1.0)[1]	7.5 (25)[2]	7.5	0
A-820+linuron	3.36+0.84	46 (1.0)	7.9 (23)	6.8	0
A-820+linuron	6.72+1.68	50 (1.0)	4.1 (15)	8.0	0
Dinoseb-acetate + monolinuron	3.35	47 (1.0)	10.0 (43)	5.0	0
U.T.C.		47 (1.0)	13.0 (68)	1.0	55
L.S.D.		14 NA	1.6 (1.3)		

Dominant weeds at site 6: *Polygonum convolvulus*, *Chenopodium album*

Dominant weeds at site 9: *Poa annua*, *Matricaria matricarioides*, *Stellaria media*, *Senecio vulgaris*

[1]( ) E.W.R.C. scale
[2]( ) 4 x 5 m^2 quadrats

At site 6, on navy beans all products exhibited, excellent selectivity up to 6.7 kg/ha A-820 + 1.68 kg/ha linuron. On the sandy clay loam soil (site 9) all rates of A-820 + linuron caused unacceptable crop effects following 14 mm rain on June 26 and 17 mm rain on June 27, with total weed control. All rates of A-820 + linuron gave significantly higher levels of weed control than the commercial standard at site 6, but on August 7 only the high A-820 + linuron treatment was considered acceptable. No taint has been detected in processed samples submitted up to 1974.

DISCUSSION

Two years trials showed that Phaseolus vulgaris plants were unable to tolerate cyanazine on the lighter soil types, but on heavier soils, both crop health and weed control were satisfactory.

Cyanatryn , however, used as an ancillary component often gave excellent weed control (sites 3,4, and 5), high pod yield (sites 3 and 4) and only marginally decreased the selectivity in combination with A-820. Uptake of cyanatryn in contrast to cyanazine led to interveinal chlorosis without substantial loss in vigour or plant stand.

Chenopodium album and Matricaria matricarioides were not well controlled by A-820 alone at 2.20 kg/ha and 3.36 kg/ha, but in combination with linuron at 0.56 kg/ha control of these weeds and Viola tricolor, Poa annua and Sclerenthus annuus was highly effective.

In terms of selectivity (vigour and establishment) both dinoseb-acetate + monolinuron and A-820/linuron caused unacceptable crop effects when heavy rain followed application, A-820/linuron combinations being safer in 1973 on a sandy loam following 50 mm of rainfall. Although the differences in crop vigour were significant in this series there were no significant reductions in plant numbers in any treatment. Dinoseb-acetate + monolinuron had a better selectivity margin on a sandy clay loam after 31 mm of rain, particularly when seed beds were not consolidated (site 9 1974). Here sub-surface 'panning' had occurred at 9 - 12 cm which accentuated uptake, as well as the fact the variety Provider tends to be more suscept ble than most to linuron.

No chemical treatment significantly altered the date of maturity as indicated by seed size in any of the varieties tested. Yields, however, generally reflected crop damage scores and plant population with A-820/linuron (2.20 kg./ha + 0.56 kg./ha) significantly outyielding the commercial control in 1973, and with no significant depressions in 1972 and 1974. Loss in selectivity at the double rate (4.40 kg.ai/ha + 1.12 kg.ai/ha) may be attributed to the linuron component since A-820 has low mobility in the soil and exhibits good slectivity up to 3.36 kg.ai/ha)

Increases in plant height were detected from the A-820 + linuron treatments at 2.20 kg/ha + 0.56 kg/ha although these were not always significant. In some circumstances, such as direct combining of a navy bean crop, this could be advantageous since picking efficiency is frequently related to crop habit.

The experiments indicate that A-820 at rates below 2.20 kg/ha in combination with linuron may be a useful alternative for weed control on lighter soil type but further development should be directed at modifying the linuron component particularly on sandy clay loams and heavier.

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WEED CONTROL IN RUNNER AND DWARF BEANS WITH TRIFLURALIN AND BENTAZONE

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Summary The possibility of using sequential treatments of trifluralin and bentazone for weed control in runner and dwarf beans was examined in eight field experiments on a sandy loam in 1972-73. Most species that survived trifluralin incorporated pre-drilling at 0.5 lb/ac, notably Capsella bursa-pastoris, Thlaspi arvense, Matricaria and Tripleurospermum spp., Senecio vulgaris and Solanum nigrum, were killed by bentazone applied post-emergence at 0.75 or 1.50 lb/ac. Species not killed by bentazone alone, such as Poa annua, Polygonum aviculare and Veronica persica, were killed by trifluralin. There was no crop injury with trifluralin at 0.5 lb/ac and bentazone usually caused only slight leaf scorch; when more severe scorch occurred, it was associated with hot, humid weather. The results indicate that trifluralin at 0.5 lb/ac pre-drilling followed by bentazone when the crop has 1 or 2 trifoliate leaves could be a useful sequence for broad-spectrum control of annual weeds in runner and dwarf beans.

INTRODUCTION

In 1969 it was found in glasshouse tests at the A.R.C. Weed Research Organisation that Phaseolus beans were tolerant to post-emergence applications of bentazone at doses which were sufficient to kill weeds. This indication was followed up in field experiments at the Processors' and Growers' Research Organisation (King & Handley, 1972) and at the National Vegetable Research Station (Roberts & Bond, 1972), and the initial finding was confirmed.

It was apparent from the results obtained in 1970 and 1971 that bentazone does not control a sufficiently wide range of the common annual weeds to be effective on its own, but a comparison of the species controlled by bentazone and by trifluralin suggested that these two herbicides are to a large extent complementary. Experiments were therefore made in 1972 and 1973 to examine the possibility of using an incorporated pre-drilling application of trifluralin followed by a post-emergence spray of bentazone for weed control in both runner and dwarf beans.

METHODS AND MATERIALS

There were eight experiments, four with runner bean (cv. Kelvedon Wonder or Kelvedon Marvel) grown as a pinched crop and four with dwarf bean (cv. Processor) on a sandy loam with about 2% o.m. They were of randomized block design with three replicates and a plot size of 8 yd^2. The weathered furrow was ring-rolled and trifluralin (Treflan, 48% e.c.) applied to appropriate plots. The whole area then received a single pass of a Lely Roterra rotary power harrow which prepared the seedbed and incorporated the trifluralin to a depth of 1.5 - 2 in. The crop was then sown and the treatment of dinoseb-acetate + monolinuron (Ivorin), which was included in each experiment, was applied shortly after. The sprays were applied in a volume of 100 gal/ac except where stated, and all doses are given as lb/ac a.i. Bentazone was applied when the beans were in the unifoliate leaf stage or had one or two expanded trifoliate leaves. In 1972 a wettable powder formulation was used (BAS 3510H, 50%) but comparisons with a liquid formulation (BAS 3517H, 480 g/l.) showed that this was no more damaging to the crop, and in 1973 the liquid formulation only was used. Survivors from the naturally-occurring weed population were not removed from the treated plots, except where stated, but both hand-weeded and unweeded controls were included in all experiments.

Weed kill was assessed by counting survivors in a number of random quadrats, by visual scoring, and by the fresh weight of weed vegetation present at harvest; data from this last assessment only are presented. The runner beans were picked on four occasions and the weight of marketable pods recorded; on the final occasion haulm weights were also determined. The dwarf beans were picked on a single occasion. The pod and haulm weights are expressed as percentages of the values for the hand-weeded controls, and those which were significantly less are indicated by single ($P = 0.05$) or double ($P = 0.01$) asterisks.

RESULTS

Runner beans

In Experiment 1, trifluralin alone killed Polygonum aviculare, Chenopodium album, Poa annua and Veronica persica, but competition from surviving plants of Capsella bursa-pastoris in particular reduced yield compared with that from the weeded controls (Table 1). There was little difference in the overall performance of 0.5 and 1.0 lb/ac, except that at the lower dose some Stellaria media survived whereas this species was killed by 1.0 lb/ac. The crop grew very slowly at first because of cold weather in May and early June, and by the time the bentazone treatments were applied the weeds had become large. None of the bentazone treatments caused more than slight scorch of the crop foliage, but 0.75 lb/ac did not control the weeds adequately and yield was reduced by competition. There was no significant reduction where 1.5 lb/ac followed trifluralin; this dose killed surviving Stellaria media, Thlaspi arvense, Matricaria matricarioides and Senecio vulgaris, and all except the largest plants of Capsella bursa-pastoris. Where bentazone was applied alone, some competition took place before the plots were weeded.

The main weed species in Experiment 2 were Stellaria media, Poa annua and Polygonum aviculare. Trifluralin gave excellent control, again with little difference between the two doses, and the yields did not differ significantly from that of the weeded controls (Table 1). Bentazone killed Capsella bursa-pastoris, Thlaspi arvense and Senecio vulgaris, but plants of Trifolium repens survived on plots which received both herbicides. At 0.75 lb/ac, bentazone caused only slight crop injury, and had no adverse effect on yield. With 1.5 lb/ac at the first trifoliate leaf stage, scorch was more severe and there was a significant yield reduction where this dose followed trifluralin.

In Experiment 3, trifluralin at 1.0 lb/ac killed all or almost all plants of Poa annua, Lamium purpureum, Chenopodium album, Polygonum aviculare and Stellaria media, and the main surviving species was Tripleurospermum maritimum ssp. inodorum. The degree of control achieved was sufficient to ensure that yield did not differ significantly from that of the hand-weeded plots (Table 2). Bentazone caused only slight crop injury, but although there was complete kill of Tripleurospermum maritimum ssp. inodorum and Capsella bursa-pastoris, plants of Trifolium repens,

Table 1

Effects of trifluralin and bentazone on runner beans in 1972

lb/ac a.i.	Experiment 1 Red. in weed wt %	Experiment 1 Pods wt %	Experiment 1 Haulm wt %	Experiment 2 Red. in weed wt %	Experiment 2 Pods wt %	Experiment 2 Haulm wt %
Trifluralin 0.5	78	29**	29**	98	102	102
Trifluralin 1.0	82	32**	32**	98	89	94
Trifluralin 0.5 + bentazone 0.75 unifol.	89	66**	69**	99	96	108
Trifluralin 0.5 + bentazone 0.75 1 trifol.	91	61**	72**	100	94	98
Trifluralin 0.5 + bentazone 1.50 1 trifol.	95	91	88	100	83*	102
Bentazone 0.75 1 trifol. weeded	-	84	93	-	94	109
Bentazone 1.50 1 trifol. weeded	-	76*	90	-	95	101
Dinoseb-acetate 1.5 + monolinuron 0.5 pre	69	66**	63**	73	71**	85
Unweeded control	0	9**	8**	0	45**	57**
Weed density on unweeded control (plants/ft^2)		9			8	

Table 2

Effects of trifluralin and bentazone on runner beans in 1973

lb/ac a.i.	Experiment 3 Red. in weed wt %	Experiment 3 Pods wt %	Experiment 3 Haulm wt %	Experiment 4 Red. in weed wt %	Experiment 4 Pods wt %	Experiment 4 Haulm wt %
Trifluralin 1.0	78	94	92	80	88	92
Trifluralin 0.5 + bentazone 0.75 unifol.	80	73**	72**	93	68**	87
Trifluralin 0.5 + bentazone 0.75 1 trifol.	94	86	80*	89	89	94
Trifluralin 0.5 + bentazone 1.50 1 trifol.	85	87	89	82	88	82
Tr. 0.5 + bentazone 0.75 unifol. weeded	-	105	111	-	65**	77**
Tr. 0.5 + bentazone 0.75 1 trifol. weeded	-	91	87	-	103	104
Tr. 0.5 + bentazone 1.50 1 trifol. weeded	-	90	93	-	90	101
Dinoseb-acetate 1.5 + monolinuron 0.5 pre	69	72**	71**	42	63**	70**
Unweeded control	0	27**	31**	0	45**	54**
Weed density on unweeded control (plants/ft^2)		39			9	

Atriplex patula and Viola arvensis survived, and were distributed irregularly over the experimental area. The significant yield depression with 0.75 lb/ac at the unifoliate leaf stage appears to have resulted from competition; this treatment had no adverse effect when the plots were subsequently weeded.

The dominant weed in Experiment 4 was Chenopodium album, and this was killed by trifluralin to the extent that competition with the crop was eliminated (Table 2). Where bentazone was applied, there was additional control of Solanum nigrum, Thlaspi arvense, Senecio vulgaris and Capsella bursa-pastoris. Application at the 1-trifoliate leaf stage caused no crop injury, but at the time the bentazone was applied to plants at the unifoliate stage the weather was hot (max. 23°C) and humid. Severe scorch ensued, with the loss of one leaf in some plants. Although subsequent leaves were not affected, the check was sufficiently severe to cause a reduction in yield of about one-third, even on plots which were weeded.

Dwarf beans

Trifluralin alone gave excellent control of Polygonum aviculare, the main weed species in Experiment 1. With 1 lb/ac, however, there was a pronounced check to crop growth which led to a significant reduction in haulm weight compared with the weeded control (Table 3). This was not apparent with 0.5 lb/ac. Where bentazone was applied, there was only slight temporary injury and no adverse effect on yield whether the plots were subsequently weeded or not.

The main weeds in Experiment 2 were Polygonum aviculare, Chenopodium album and Fumaria officinalis, and trifluralin again gave excellent control. Although with 1 lb/ac there was a temporary check to the crop, in this experiment neither pod yield nor haulm weight was adversely affected (Table 3). Application of bentazone at the unifoliate leaf stage coincided with a hot period (max. air temp. 25°C), and resulted in considerable leaf scorch with a check to growth from which the crop did not fully recover. Application at the 1-trifoliate stage, when the temperature was somewhat lower, caused less scorch and there was no depression of yield with either dose.

In Experiment 3, trifluralin alone killed the main weeds, Chenopodium album and Lamium purpureum, and there was no adverse effect on yield (Table 4). When applied at the 1-trifoliate leaf stage, bentazone caused only slight scorch; injury was rather greater at the 2-trifoliate stage, again when temperatures were high, but the yield of pods was not significantly affected. There was little difference in the results obtained from application at 30 gal/ac compared with 100 gal/ac, either in weed control or in damage to the crop foliage.

In Experiment 4, the main weed on the unweeded plots was Chenopodium album, but its presence did not result in any significant yield depression from that of the weeded control (Table 4). All treatments, except for trifluralin alone at 0.5 lb/ac, gave virtually complete weed kill without adverse effects on yield. There was again no detectable difference between application volumes of 30 and 100 gal/ac.

DISCUSSION

As found previously, on this light soil there was little difference in the weed control obtained with trifluralin incorporated at 0.5 lb/ac compared with the normal dose of 1.0 lb/ac. Both were adequate to kill those species regarded as susceptible to trifluralin, although there was a tendency for some Stellaria media to survive with the lower dose. There was no evidence of any injury to runner beans, a crop for which trifluralin is now recommended, but on one occasion (Table 3) the normal dose checked the growth and reduced the yield of dwarf beans, though this did not occur with 0.5 lb/ac. In seven of the eight experiments, application of trifluralin on its

Table 3

Effects of trifluralin and bentazone on dwarf beans in 1972

lb/ac a.i.	Experiment 1 Red. in weed wt %	Experiment 1 Pods wt %	Experiment 1 Haulm wt %	Experiment 2 Red. in weed wt %	Experiment 2 Pods wt %	Experiment 2 Haulm wt %
Trifluralin 0.5	98	118	105	98	114	109
Trifluralin 1.0	98	82	77**	98	100	99
Trifluralin 0.5 + bentazone 0.75 unifol.	100	96	97	98	80**	79**
Trifluralin 0.5 + bentazone 0.75 1 trifol.	100	104	99	100	97	86*
Trifluralin 0.5 + bentazone 1.50 1 trifol.	100	100	88	100	105	95
Bentazone 0.75 1 trifol. weeded	-	109	98	-	96	93
Bentazone 1.50 1 trifol. weeded	-	104	99	-	101	96
Dinoseb-acetate 1.5 + monolinuron 0.5 pre	97	106	110	98	104	105
Unweeded control	0	74*	84*	0	80**	95
Weed density on unweeded control (plants/ft^2)		9			9	

Table 4

Effects of trifluralin and bentazone on dwarf beans in 1973

	Experiment 3 Red. in weed wt %	Experiment 3 Pods wt %	Experiment 3 Haulm wt %	Experiment 4 Red. in weed wt %	Experiment 4 Pods wt %	Experiment 4 Haulm wt %
Trifluralin 0.5	95	107	102	58	80*	93
Trifluralin 1.0	98	100	103	85	104	109
Trifluralin 0.5 + bentazone 0.75 1 trifol.	99	97	103	99	101	96
Trifluralin 0.5 + bentazone 1.50 1 trifol.	100	96	96	100	107	96
Trifluralin 0.5 + bentazone 0.75 2 trifol.	99	96	90*	99	106	97
Trifluralin 0.5 + bentazone 1.50 2 trifol.	100	101	97	100	99	101
Trifluralin 0.5 + bentazone 0.75 2 trif.+	100	95	101	97	114	106
Trifluralin 0.5 + bentazone 1.50 2 trif.+	100	91	89*	100	104	95
Dinoseb-acetate 1.5 + monolinuron 0.5 pre	87	96	98	88	106	107
Unweeded control	0	91	97	0	83	100
Weed density on unweeded control (plants/ft^2)		9			11	

+ Applied at 30 gal/ac.

own reduced weed competition to an extent such that yields did not differ significantly from those of the weeded controls. Experiment 1 on runner beans, however, exemplifies the problem that can arise when tolerant species are present (Table 1).

Dinoseb-acetate + monolinuron, the herbicide treatment most widely used in dwarf beans, was applied as a pre-emergence spray in all the experiments. In dwarf beans, good weed control was obtained and the yields were no different from those of the weeded controls; the crop itself, however, suppressed weeds to a large extent and in neither of the 1973 experiments was there any yield reduction on the unweeded control plots (Table 4). Although with runner beans there was only slight leaf necrosis in a few plants, the degree of weed control obtained was not sufficient to prevent yield loss and in three out of the four experiments trifluralin alone gave superior results.

The results confirmed that bentazone applied alone does not control a wide enough range of weeds; the main survivors were Polygonum aviculare, Poa annua and Veronica persica, while the effects on Fumaria officinalis were inconsistent. Bentazone did control those species which are the most common survivors where trifluralin is used, namely Capsella bursa-pastoris, Thlaspi arvense, Matricaria matricarioides, M. recutita, Tripleurospermum maritimum ssp. inodorum, Senecio vulgaris and Solanum nigrum, except when the plants had reached a large size at the time of application.

Crop injury from bentazone was generally slight and limited to some scorching of the most recently expanded leaf, with no adverse effects on subsequent leaf development. On the occasions when injury was more severe than this, it appeared to be associated with hot, humid weather and the results indicate that spraying under these conditions should be avoided. Damage to both runner beans (Table 2) and dwarf beans (Table 3) from bentazone applied at the unifoliate leaf stage caused significant yield reduction. Partial loss of leaf area has been shown in dwarf beans to affect later growth more severely when it occurs just after the unifoliate leaves have completed their expansion than if it occurs after the first trifoliate leaf has expanded (Green, 1963). It appears, therefore, that spraying should be delayed until at least one trifoliate leaf has fully expanded, but not delayed so long that the weeds become too large for effective control.

Where comparisons of 0.75 and 1.50 lb/ac were made at the same growth stage, the higher dose gave little increase in weed control unless the weeds were very large. Visible scorch of the crop foliage was slightly greater with 1.50 as compared with 0.75 lb/ac, but there was usually no difference in yield. The limited comparisons of application at 30 and 100 gal/ac revealed no differences in either weed kill or crop injury. A small supplementary trial with nine cultivars of dwarf beans in which bentazone was applied at two doses and at two stages of growth suggested that there are likely to be differences in response; of those examined, cv. Tendercrop appeared to be the most susceptible.

The advantages of trifluralin in terms of reliability of performance against susceptible weed species are well known, and when tolerant species are present in small numbers only this herbicide may well prove effective on its own. Bentazone, however, appears to offer promise as a follow-up treatment for application in those instances when it is evident that plants of trifluralin-tolerant species are present in numbers sufficient to affect yield or interfere with harvesting.

Acknowledgement

We are grateful to BASF United Kingdom Ltd for supplying samples of bentazone.

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NOTES

HERBICIDES FOR USE IN CHICORY

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Summary Trials on 6 sites in the years 1971 to 1974 proved that propyzamide is an effective and very selective herbicide for use in chicory. It appeared rather safer to the crop than chlorpropham with an equivalent degree of weed control. Propyzamide did not control Compositae and a mixture of this material with chlorpropham showed promise for controlling a wider spectrum of weeds than either herbicide used alone. Carbetamide and mixtures of carbetamide and chlorpropham were only included in the last 2 years of trials and appeared marginally inferior to propyzamide and propyzamide/chlorpropham mixtures.

A sulfallate chlorpropham mixture used pre-emergence of the crop and phenmedipham used post-emergence proved unsuitable for use in chicory.

All the pre-emergence materials proved ineffective under very dry seedbed conditions, and of these only chlorpropham was at all effective on high organic matter soils.

INTRODUCTION

Chicory for the root processing industry has been grown on some 3,000 acres in the area north of Cambridge for several years, mainly on the high organic matter "Black Fens" but also, more recently, on mineral soils.

Labour for hand weeding is now scarce and chlorpropham, the only herbicide available, is not completely effective. These trials were carried out to examine materials or mixtures that would be more effective for weed control than chlorpropham with an equal or improved degree of selectivity.

METHOD AND MATERIALS

The trials were laid down at 6 sites in the years 1971 to 1974, four on mineral soils and two in the Black Fen. All were in farm crops of chicory and were in the form of randomised blocks with three replications. The individual plot size was 6 ft x 30 ft and the herbicides were applied with a Van der Weij sprayer fitted with the boom of an Oxford Precision Sprayer. All were applied through 00 jets at 32 psi, at a volume of 20 gal/acre. All doses are given as lb/ac a.i.

Chlorpropham was used as the standard treatment with two rates on each soil type, 1.5 and 3.0 lb per acre on the mineral soil and 3.0 and 6.0 lb per acre on the high OM Black Fen. In the second year, only the low rate was used on the sole mineral soil site, and in 1973 the rate was raised to 2.0 lb per acre.

In 1974, there were again trials on 2 sites - mineral and Black Fen - and the rates were 2.0 and 3.0 per acre.

Propyzamide was used at 1.0 and 1.5 lb per acre in all the trials and a mixture of 1.0 lb of propyzamide and 1.0 lb of chlorpropham was used from the second year (1972) onwards. In 1973 and 1974 mixtures of 0.5 lb of propyzamide and 1.0 lb of chlorpropham were also used.

Carbetamide at 0.7 and 1.4 lb per acre was used in 1973 and 1974 and a mixture of chlorpropham at 1.0 lb per acre and carbetamide at 0.7 lb per acre was also used. Sulfallate-chlorpropham at 1.5 and 0.2 lb and 2.5 and 0.4 lb was applied pre-emergence and phenmedipham at 0.7 and 1.0 lb per acre post-emergence in the first year of the trials only. In 1971 higher rate of phenmedipham was applied either 'early' on 17 April or 'late' on 24 April. Combinations of chlorpropham, propyzamide and carbetamide were in fact applied separately to avoid problems of incompatibility.

RESULTS

In 1971 neither rate of sulfallate-chlorpropham mixture was effective as a herbicide, and phenmedipham was too dangerous to the crop, and no further work was carried out with these materials.

As only chlorpropham at the highest rate was effective on the high OM Black Fen, it did not appear that propyzamide was worth further investigation on this soil type. On the mineral soil, however, propyzamide gave weed control equivalent to chlorpropham, but with a greater degree of crop safety.

Propyzamide did not control _Senecio vulgaris_, _Anthemis cotula_, or _Chenopodium album_ at the high rate and was weak on _Viola arvensis_ and _Lamium_ spp at the lower rate.

These results were repeated on a mineral soil in the following year 1972. A mixture of chlorpropham and propyzamide was introduced as a means of improving weed control and reducing the costs and this gave the highest degree of weed control.

This mixture again gave the best control in 1973, though propyzamide alone was very satisfactory. Weed numbers were very low in this season and it was impossible to obtain reliable counts, but it did appear that carbetamide gave inferior control to propyzamide at the rates used in the trials.

In 1974 treatments were repeated on mineral and high OM soils, but seedbed conditions were very dry and the rain forecast failed to materialise. Under these conditions, none of the materials produced anything approaching a satisfactory degree of weed control and the trials were abandoned.

The results in the tables refer to a single trial on a mineral soil in each year.

Table 1

Population of chicory plants in thousands/acre

Treatment lb/ac a.i.	1971	1972	1973
Control	26.1	68.7	62.1
Chlorpropham 3.0	23.8	-	-
Chlorpropham 2.0	-	-	67.2
Chlorpropham 1.5	28.2	68.7	-
Propyzamide 1.0	28.2	69.3	65.7
Propyzamide 1.5	26.7	67.0	61.8
Chlorpropham 1.0 + pronamide 0.5	-	-	61.8
Chlorpropham 1.0 + pronamide 1.0	-	68.6	70.0
Carbetamide 0.7	-	-	67.3
Carbetamide 1.4	-	-	65.3
Chlorpropham 1.0 + carbetamide 0.7	-	-	61.8
Phenmedipham 1.0 (early)	0.7	-	-
Phenmedipham 0.7 (early)	6.5	-	-
Phenmedipham 0.7 (late)	18.4	-	-
Sulfallate-chlorpropham 1.5 + 2.0	28.5	-	-
Sulfallate-chlorpropham 2.5 + 0.4	29.5	-	-

Table 2

Weed control

Treatment lb/ac a.i.	% control of all weeds 1971 (est.)	1972	1973
Chlorpropham 3.0	70	-	-
Chlorpropham 2.0	-	-	94
Chlorpropham 1.5	60	77	r
Propyzamide 1.0	60	77	94
Propyzamide 1.5	90	87	94
Chlorpropham 1.0 + pronamide 0.5	-	-	85
Chlorpropham 1.0 + pronamide 1.0	-	89	99
Carbetamide 0.7	-	-	52
Carbetamide 1.4	-	-	74
Chlorpropham 1.0 + carbetamide 0.7	-	-	81
Phenmedipham 1.0 (early)	90	-	-
Phenmedipham 0.7 (early)	90	-	-
Phenmedipham 0.7 (late)	80	-	-
Sulfallate-chlorpropham 1.5 + 2.0	20	-	-
Sulfallate-chlorpropham 2.5 + 0.4	60	-	-

Table 3

Control of individual weed species (number per ft^2)

Treatments lb/ac a.i.	1972 Ann. Gr.	Lam. spp.	Poly. A.	Ver. spp.	Stell. m.	Mat. spp.	Cap. b.p.	Sen. v.	Others	1973 Ver. spp.	Mat. spp.	Lam. spp.	Others
Chlorpropham 3.0													
Chlorpropham 2.0										0	1.3	0	0.3
Chlorpropham 1.5	0.8	0.7	0.2	0.1	0.1	0.3	0.1	0.1	0.1				
Propyzamide 1.0	0.4	0.3	0.5	0	0.3	0.6	0.1	0.2	0.1	0	1.3	0	0.3
Propyzamide 1.5	0.1	0.2	0.3	0	0.2	0.3	0.1	0.1	0.1	0	0.7	0.3	0.7
Chlorpropham 1.0) Propyzamide 0.5)										0.3	3.0	0	1.0
Chlorpropham 1.0 Propyzamide 1.0	0.2	0.2	0.3	0	0	0.4	0.1	0	0	0	0.3	0	0
Carbetamide 0.7										1.0	11.0	1.0	0.7
Carbetamide 1.4										1.0	5.7	0	0.7
Chlorpropham 1.0) Carbetamide 0.7)										0	3.3	0.7	1.3
Control	3.1	2.2	1.6	1.3	1.2	0.5	0.5	0.4	0.2	9.2	15.6	1.7	2.0

Ann. gr. = Annual grasses
Lam. spp. = Lamium spp.
Poly. A. = Polygonum Aviculare
Ver. spp. = Veronica spp.
Stell. m. = Stellaria media
Mat. spp. = Matricaria spp.
Cap. b.p. = Capsella bursa-pastoris
Sen. v. = Senecio vulgaris

DISCUSSION

The trials showed that propyzamide was very selective when used for weed control in chicory: no evidence was seen of a check to the crop in any of the trials. There was insufficient weed growth in these trials to obtain a very clear idea of the herbicide weed spectrum, though it was clear that Compositae, i.e. Senecio vulgaris and Matricaria spp. were not controlled by propyzamide.

This material shares the defects common to most soil-applied residual herbicides; it is ineffective on soils with a high organic matter and depends on some rainfall to render it active on other soils.

Mixtures of propyzamide and chlorpropham appeared to give promise of weed control slightly better than either material used alone: probably at a cheaper cost than propyzamide used alone and with greater crop safety than chlorpropham used alone.

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THE EVALUATION OF A COMBINATION, CHLORTHALMETHYL + METHAZOLE, (S 1445) FOR WEED CONTROL IN ARABLE AND LEGUMINOUS CROPS

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Summary S 1445 (Dimethyl-tetrachloro-terephtalate + 2-(3-4-Dichlorophenyl)-4-methyl 1.2.4-oxydiazolidine-3-5-dione) is a promising herbicide for weed control in arable and leguminous crops. S 1445 can be applied either pre- or post-emergence. The product proved to be well tolerated by a wide range of crops. It is possible to control a large number of mono- and dicotyledonous weeds.

Résumé Le S 1445 (Dimethyl-tetrachloro-terephtalate + 2-(3-4-Dichlorophenyl)-4-methyl 1.2.4-oxydiazolidine-3-5-dione) est un herbicide qui laisse entrevoir de nombreuses possibilités dans la lutte contre les mauvaises herbes en cultures sarclées et maraîchères. Il peut être utilisé aussi bien en pré-émergence qu'en post-émergence. Ce produit a fait preuve d'une très bonne tolérence envers bon nombre de plantes cultivées. Le rayon d'efficacité du S 1445 s'étend à un grand nombre de plantes adventices monocotylédonées et dicotylédonées.

INTRODUCTION

In Switzerland, chlorthalmethyl has been used successfully for a number of years to control weeds in seeded onions. It has been found, that the efficacy of chlorthalmethyl is highly dependant on the soil type and the climatic conditions. Due to these factors, chlorthalmethyl can be used only on a relatively small area for weed control in seeded onions in warm sandy soils. The crop tolerance of chlorthalmethyl has proved to be very good. Applied under favourable weather conditions and on the right soil type a large number of weeds can be controlled.

To overcome these problems, Siegfried decided to combine chlorthalmethyl with another herbicide. In the laboratory and in the field a number of chemicals have been tested in tank mixtures with chlorthalmethyl.

From all these chemicals the most suitable compound was found to be methazole. Methazole is a chemical developed by Velsicol. It is known under the code number VCS 438 and is sold in Great Britain for weed control in onions as a post-emergence herbicide.

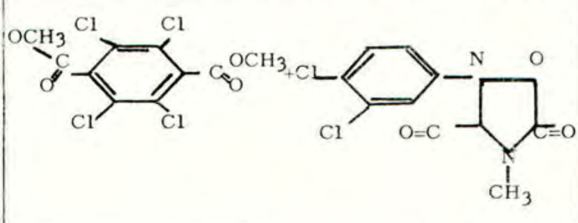
Due to the results achieved in the laboratory and in field tests with the tank mixture a product was formulated. With the mixture, coded S 1445, further investigations in the laboratory and in field were carried out. In these trials it has been found, that with this mixture the activity of chlorthalmethyl was considerably increased even though the amount of chlorthalmethyl used per ha is reduced by about 50 %. Methazole used pre- or post-emergence has a rather specific and narrow crop selectivity. In the mixture the methazole content can be kept very low without loss of activity and thus has a good tolerance to a large number of crops. In general S 1445 applied pre-emergence prevents mono- and dicotyledonous weeds from germinating. Weeds which germinate and emerge after a short time turn a reddish colour and die.

S 1445 applied post-emergence controls a number of weeds. Besides this contact activity a residual action is observed.

Depending on the crop, the following applications and rates can be used:

- pre-emergence immediately after sowing	6 - 8 kg/ha	formulated product
- post emergence cotyledon to two leaf stage of the weeds	5 - 8 kg/ha	
- split application pre-emergence after sowing	5 - 6 kg/ha	
post emergence two leaf stage of the weeds	6 kg/ha	

CHEMICAL PROPERTIES

Common names	Chlorthalmethyl + Methazole
Code number during development	S 1445
Chemical names	Dimethyl-tetrachloro-terephtalate 2-(3,4-Dichlorophenyl)-4-methyl 1, 2, 4-oxydiazolidine - 3,5 - dione
Structural formulas	
Empirical formulas	$C_6 H_6 Cl_4 O_4 + C_9 H_6 Cl_2 N_2 O_3$
Active ingredients:	66 % chlorthalmethyl + 9 % methazole
Formulation	75 % w.p.

METHOD AND MATERIALS

Field studies were conducted on a program basis during the 1972/73/74 growing seasons. These tests were carried out in a number of crops all over Switzerland. The plot size consisted of 10 m^2 and were replicated three times in randomized blocks. Application equipment was a propane powered field plot sprayer. The nozzles were of the Tee-Jet type. Applications were made with about 3 atü pressure using 1'000 l of water per ha.

Observations were made on crop stand, phytotoxicity, percent and nature of weed control, usually eight weeks after treatment.

During the trial seasons 1972 - 74 it was found that the efficacy of chlorthalmethyl was considerably increased in mixture with methazole.

The trials were conducted on a range of soil types. In heavy and rather cold mineral soils considerably better weed control was achieved than with chlorthalmethyl applied alone. The following weeds were controlled better with S. 1445 than with chlorthalmethyl:

Capsella bursa pastoris, Chenopodium polyspermum, Galinsoga parviflora, Lamium purpureum, Senecio vulgaris, Solanum nigrum, Sinapis arvensis.

The weed control spectrum is listed in table 1 while table 2 illustrates the crop tolerance of S 1445, chlorthalmethyl and methazole. The results of field trials with S 1445 in a few major crops grown in Switzerland are shown in tables 3 - 7.

Table 1

Weed control spectrum

Weeds	pre-emergence treatment 6 kg/ha a.i.	post-emergence treatment 2 leaf stage of the weeds 6 kg/ha a.i.
Atriplex patula	XXX	XX
Amaranthus retroflexus	XX	XX
Anagallis arvensis	XX	XX
Capsella bursa pastoris	XXX	XXX
Chenopodium album	XXX	XX
Chenopodium polyspermum	XXX	XXX
Cirsium arvense	X	X
Convolvulus arvensis	X	X
Euphorbia helioscopia	XX	XX
Fumaria officinalis	X	XX
Galium aparine	XX	X
Galinsoga parviflora	XX	XX
Galeopsis tetrahit	XX	XX
Lamium purpureum	XXX	XXX
Matricaria chamomilla	XXX	X

Table 1 Weed control spectrum (continuation)

Weeds	pre-emergence treatment 6 kg/ha a.i.	post-emergence treatment 2 leaf stage of the weeds 6 kg/ha a.i.
Papaver rhoeas	XX	X
Plantago spp.	XXX	X
Polygonum aviculare	XX	XX
Polygonum convolvulus	XX	XXX
Polygonum persicaria	X	X
Rumex obtusifolius (seedlings)	XXX	X
Senecio vulgaris	XX	XX
Sinapis arvensis	X	XXX
Sonchus arvensis	XXX	XX
Solanum nigrum	XXX	XX
Stellaria media	XXX	XXX
Taraxacum officinale	X	X
Thlaspi arvense	XX	XXX
Veronica filiformis	XX	X
Veronica hederaefolia	XX	X
Agropyron repens	X	X
Digitaria sanguinalis	XX	XX
Echinochloa crus galli	XX	XX
Poa annua	XXX	XX
Panicum capillare	XX	X

XXX) very susceptible
XX) susceptible
X) resistant

Table 2

Crop tolerance

Crop	Compound and score 1 - 9 (EWRC)						
	Chlorthalmethyl 11,25 kg/ha a.i.	Methazole 2,25 kg/ha a. i.		S 1445 4,5 kg/ha a.i.		S 1445 6 kg/ha a.i.	
	pre	pre	post	pre	post	pre	post
Broad beans (Vicia faba)	1	3	1	1	3	1	3
Soyabeans (Glycine hispida)	1	6	6	1	1	1	1
Dwarf beans*) (Phaseolus vulg.)	3	9	9	3	-	3	-
Peas	1	1	-	1	1	1	1
Potatoes	1	1	-	1	1	1	1
Tomatoes	1	9	9	-	4	-	6
Brassica crops (incl. Cauliflowers)	1	9	9	1	1	1	1

Table 2 Crop tolerance (continuation)

Crop	Compound and score 1 - 9 (EWRC)						
	Chlorthalmethyl 11,25 kg/ha a.i.	Methazole 2,25 kg/ha a.i.		S 1445 4,5 kg/ha a.i.		S 1445 6 kg/ha a.i.	
	pre	pre	post	pre	post	pre	post
Onions	1	9	3	1	1	1	1
Maize	7	1	9	5	-	8	-
Wheat*)	1	1	9	1	-	1	-
Barley*)	1	1	9	1	-	1	-

*) depending on the variety

Table 3

Results in dwarf beans

(Average results of 8 trials)

Compound	Treatment	Dose kg/ha a.i.	Predominant weed species Percent weed control 8 weeks after treatment						
			Sonchus arvensis	Chenopodium album	Stellaria media	Galinsoga parviflora	Plantago major	Poa annua	Crop tolerance 1-9 (EWRC)
S 1445	pre-em.	6.7.5	100	100	100	100	100	100	4
Chlorthal	pre-em.	11.25	85	82	92	0	85	95	2
Methazole	pre-em.	2.25	100	100	98	100	67	100	8
Monolinuron	pre-em.	0.75	100	100	64	88	98	0	1

Table 4

Results in broad beans

(Average results of 4 trials)

Compound	Treatment	Dose kg/ha a.i.	Predominant weed species. Percent weed control 8 weeks after treatment: Chenopodium album	Anagallis arvensis	Lamium purpureum	Stellaria media	Thlaspi arvense	Fumaria officinalis	Crop tolerance 1-9 (EWRC)
S 1445	pre-em.	6	100	94	89	100	100	74	1
S 1445	pre-em.	6.75	100	97	100	100	100	88	1
Chlorthal	pre-em.	11.25	88	96	100	100	62	50	1
Methazole	pre-em.	2.25	100	82	79	100	57	83	4
Monolinuron	pre-em.	0.75	100	98	85	100	88	100	6

Table 5

Results in peas

(Average results of 7 trials)

Compound	Treatment	Dose kg/ha a.i.	Predominant weed species. Percent weed control 6 weeks after treatment: Thlaspi arvense	Veronica hederaefolia	Capsella bursa pastoris	Stellaria media	Matricaria chamomilla	Lamium purpureum	Chenopodium album	Galium aparine	Crop tolerance 1-9 (EWRC)
S 1445	pre-em.	6	92	85	98	89	100	100	100	75	1
S 1445	pre-em.	6.75	93	98	97	100	100	100	100	78	1
Chlorthal	pre-em.	11.25	66	100	78	100	83	100	89	72	1
Methazole	pre-em.	2.25	53	0	63	100	72	100	100	84	6
Methabenz-thiazuron	pre-em.	3	89	67	92	100	87	100	91	68	1

Table 6

Results in soyabeans

(Average results of 4 trials)

Compound	Treatment	Dose kg/ha a.i.	Predominant weed species. Weed control 8 weeks after treatment/scores 1-9 EWRC								
			Galinsoga parviflora	Solanum nigrum	Capsella bursa pastoris	Sonchus arvensis	Stellaria media	Lamium purpureum	Polygonum persicaria	Chenopodium album	Crop tolerance 1-9 (EWRC)
S 1445	pre-em.	6	2	1	4	1	2	1	7	2	1
Chlorthal	pre-em.	11.25	9	6	7	1	1	4	8	1	3
Methazole	pre-em.	2.25	1	7	3	1	1	2	9	4	6
Linuron	pre-em.	1	4	5	1	1	1	1	7	3	4

Table 7

Results in onions

(Average results of 10 trials)

Compound	Treatment	Dose kg/ha a.i.	Predominant weed species. Weed control 8 weeks after treatment/score 1-9 EWRC								
			Chenopodium album	Chenopodium polyspermum	Papaver rhoeas	Stellaria media	Veronica spp.	Capsella bursa pastoris	Galium aparine	Galeopsis tetrahit	Crop tolerance 1-9 (EWRC)
S 1445	pre-em.	6	3	1	1	1	1	1	4	1	1
S 1445	post-em.*	6	3	1	9	1	7	1	9	3	1
Methazole	pre-em.	2.25	5	4	3	1	9	4	3	1	9
Methazole	post-em.**	2.25	1	1	4	1	9	1	4	1	2
Chlorthal	pre-em.	11.25	8	7	6	1	3	9	9	4	1
Aziprotryne	pre-em.		4	3	3	1	1	5	9	6	4
Diphenoxuron	post-em.*		5	1	9	1	1	1	9	5	1

*) treatment when crop has reached 1 leaf stage and weed 2 - 4 leaf stage

**) treatment when crop has reached 3 true leaves

All these results Tables 1 - 7 were obtained from trials carried out on mineral soils.

Summarising the trials conducted in Switzerland and other European countries it has been found that the efficacy of S 1445 is closely related to the moisture content of the soil. In areas with long dry periods it is necessary to irrigate. The best weed control is achieved if the product is applied to a moist soil surface.

In transplanted crops, S 1445 should be applied 7 - 10 days after planting, before the weeds have emerged. In treatments made before planting the efficacy of S 1445 is considerably decreased.

Soil residue trials with S 1445 showed that the product breaks down very rapidly in the soil. Four months after application all test plants showed no symptoms of herbicide damage and developed absolutely normally.

DISCUSSION

S 1445 is a herbicide, specially designed for weed control in arable and leguminous crops. With this compound, applied pre-emergence, a large number of mono- and dicotyledonous weeds can be controlled. In some crops applications can also be made when the weeds have reached not more than two true leaves. In field trials it has been found that S 1445 possesses a very good crop tolerance, applied either pre- or post-emergence in a range of crops.

With this combination it has become possible to enlarge the weed spectrum of chlorthalmethyl especially when applied on medium to heavy mineral soils. With this mixture it has become possible to use methazole in a much larger range of crops.

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ORYZALIN + LINURON, A NEW HERBICIDE COMBINATION FOR PRE-EMERGENCE WEED CONTROL IN SOYBEANS

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Summary The herbicide combination oryzalin + linuron has been tested as a surface applied, pre-emergence herbicide for weed control in soybeans in Romania. At rates between 1.0 + 1.0 and 1.4 + 1.4 kg a.i./ha according to soil type and organic matter content, oryzalin + linuron provided good control of the grass weeds *Setaria* spp., *Echinochloa crusgalli*, *Digitaria sanguinalis*, and the broadleaf weeds *Amaranthus* spp., *Chenopodium album*, *Polygonum* spp., *Sinapis arvensis*, *Raphanus raphanistrum* and *Thlaspi arvense*. Oryzalin + linuron was safe to soybeans at the above rates. A minimum of 12.5 mm precipitation was required to activate the herbicide mixture. An early cultivation was found to be an alternative way of activating the herbicide combination.

Résumé Le mélange oryzalin + linuron a été étudié en Roumanie, pour le désherbage du soja en préémergence. A des doses variant de 1.0 + 1.0 a 1.4 + 1.4 kg de matières actives par hectare, selon le type de sol et sa richesse en matière organique, le mélange oryzalin + linuron s'est avéré très eificace contre les graminées *Setaria* spp., *Echinochloa crusgalli*, *Digitaria sanguinalis* et les dicotylédones *Amaranthus* spp., *Chenopodium album*, *Polygonum* spp., *Sinapis arvensis*, *Raphanus raphanistrum* et *Thlaspi arvense*, sans montrer de phytotoxicité sur le soja aux doses ci-dessus. Des précipitations supérieures à 12.5 mm sont nécessaires à l'efficacité du mélange. Une façon culturale superficielle peu après l'application du produit est une autre façon d'en assurer l'activité.

INTRODUCTION

Oryzalin, 3,5-dinitro-N^4-N^4-dipropylsufanilamide, is a new selective pre-emergence herbicide for the control of annual grasses and certain broadleaf weeds in soybeans.

Pure oryzalin is a yellowish orange crystalline solid. It is soluble in water to the extent of 2.5 ppm at 25°C, and has a vapour pressure of <1 x 10^{-7} mm Hg at 30°C. (Snel et. al. 1974)

This relatively high water solubility of oryzalin, when compared to other herbicides of the dinitroaniline group, combined with the low vapour pressure, makes it a suitable compound for pre-emergence surface application. In laboratory leaching studies, oryzalin applied to a soil surface remained primarily in the top 5 cm when 15 cm of water was passed through a 23 cm soil column. In field studies, at least 12.5 mm of either rainfall or overhead irrigation water was necessary to position oryzalin in the soil. Excessive rainfall or irrigation did not leach oryzalin out of the weed germination zone. (Snel et. al. 1974)

Oryzalin was first field tested by Eli Lilly and Company in the U.S.A., under the code EL-119, as a pre-emergence weed control chemical for soybeans in 1970. In addition, a large-scale demonstration programme was conducted in 1973 under an experimental permit. Commercial use of oryzalin in the U.S.A. for weed control in soybeans under the trade name SURFLAN® started in the spring of 1974.

In an attempt to extend the broadleaf weed control spectrum of oryzalin, the herbicide was also applied in tankmix combinations with metribuzin, linuron and dinoseb. These compounds have been shown to be herbicidally active against a variety of broadleaf weeds, but they often fail to provide adequate control of annual grasses. Summaries of these results have been published in two recent reports. (Rogers et. al. 1974 and Watson et. al. 1974)

In Europe, tests with the combination oryzalin + linuron for pre-emergence weed control in soybeans were started in 1972 in Romania, the major soybean producing country in Europe. The two active ingredients were formulated in a ratio of 1:1 as a combination 40% + 40% wettable powder (w.p.) formulation. Since this ratio of active ingredients was suitable for use under a wide range of soil conditions and for different weed spectra, the ready-mixed formulation provided definite advantages over a tankmix combination of the two components. The formulated product was easier to handle for distribution and application and possible sources of error were avoided when preparing the tank mixture.

The research reported here is a summary of small plot replicated experiments conducted in Romania in 1973 to determine the herbicidal efficacy, weed control spectrum and crop tolerance of this combination product when applied pre-emergence to soybeans at various rates. Following results from these experiments, a large-scale demonstration programme was established in the spring of 1974, where the combination product was further evaluated under the trade name DIRIMAL EXTRA.

METHOD AND MATERIALS

The small-scale experiments consisted of $25m^2$ plots, four replications, and were established at five different locations. All applications were to the soil surface, pre-emergence to the crop and weeds, immediately after seeding. Spray volume was 1,000 litres of water per hectare.

Soil conditions and weed spectra at the various locations are given in Tables 1 and 2, respectively. In addition to the annual grass and broadleaf weeds listed, some perennial weeds not controlled by the herbicide mixture were present at two locations. Dosage rates of oryzalin + linuron were 0.5 + 0.5, 0.75 + 0.75, and 1.0 + 1.0 kg a.i./ha.

Herbicide treatments were compared to control I, which was weeded mechanically between rows and manually within rows three times each, and control II, which was not weeded. No mechanical or manual weed control practices were carried out in plots treated with herbicides.

Total weed control was evaluated according to the EWRC scale at 30, 60, and 90 days after seeding. Crop safety was also evaluated according to the EWRC scale early in the growing period. Soybean yields were recorded for each trial. Yields of all treatments were compared on a percentage basis. Yield for the mechanically weeded control treatment was set at 100%.

Table 1
Soil conditions in replicated experiments

Location	Soil type	% organic matter
Fundulea	chernozem	3.5
Podul Iloaiei	chernozem	3.7
Turda	chernozem	5.7
Valul Traian	chernozem	3.4
Livada	podzol	1.4

Table 2
Weed spectra in replicated experiments

	Location				
	Fundulea	Podul Iloaiei	Turda	Valul Traian	Livada
Grasses					
Setaria glauca	+	+	+	+	+
Setaria viridis	+	+	+	+	+
Echinochloa crusgalli	+		+		+
Digitaria sanguinalis	+				
Broadleaf weeds					
Amaranthus spp.	+	+	+	+	
Chenopodium album	+	+	+	+	
Polygonum spp.			+		+
Sinapis arvensis	+		+	+	
Raphanus raphanistrum					+
Thlaspi arvense	+				
Hibiscus ternatus	+				

Table 3
Recommended rates of DIRIMAL EXTRA* used in large-scale demonstrations

Soil texture	Dosage kg/ha Active ingredient	Formulated product, kg
light soils and/or soils with low organic matter content	1.0 + 1.0	2.5
medium soils and/or soils with medium organic matter content	1.2 + 1.2	3.0
heavy soils and/or soils with high organic matter content	1.4 + 1.4	3.5

* Wettable powder formulation containing 40% oryzalin and 40% linuron.

The large-scale demonstration programme in 1974 was carried out at various state farms on a total surface of approximately 80 ha. Applications of the herbicide were made with conventional field spraying equipment. Treated plots of 5-10 ha were compared to small check strips. The 40 + 40 w.p. of DIRIMAL® EXTRA was used in this programme at the recommended rates given in Table 3.

RESULTS

a. Herbicidal efficacy

A summary of the results obtained in the 1973 replicated experiments is given in Table 4.

The 1.0 + 1.0 kg a.i./ha rate was found to be the lowest dosage to give adequate weed control under the soil and climatic conditions in Romania, and only results obtained with this dosage are reported here.

At Fundulea, total weed control with the 1.0 + 1.0 dosage was considered acceptable ninety days after planting. Soybean yield from this treatment, however, reached only 68% of the mechanically weeded control. It is believed that failure to control *Hibiscus ternatus* was responsible for this adverse effect on crop yield. These results confirm reports from the U.S.A., where control of *Hibiscus* spp. by the mixture of oryzalin + linuron has been less than commercially acceptable.

At Podul Iloaiei late-season development of the perennial weeds *Sonchus arvensis* and *Convolvulus arvensis* also had an adverse effect on crop yield.

At Turda and Valul Traian total weed control was good to excellent and crop yields reached the level of the mechanically weeded control.

Table 4
Efficacy and crop safety data from replicated experiments

Location/treatment	Weed control rating 30 (days)	60	90	Crop safety rating	Yield kg/ha	Yield % of Control
Fundulea						
Control I	1	1	2	1	2220	100
Control II	9	9	9	1	970	44
Oryzalin + linuron	2	3	4	1	1510	68
Podul Iloaiei						
Control I	2	1	2	1	2502	100
Control II	9	9	9	1	1507	60
Oryzalin + linuron	2	2	5	1	2000	80
Turda						
Control I	1	1	1	1	2518	100
Control II	9	9	9	1	1178	47
Oryzalin + linuron	3	3	3	1	2573	102
Valul Traian						
Control I	1	1	1	1	3200	100
Control II	9	9	9	1	2300	72
Oryzalin + linuron	1	1	1	1	3320	104
Livada						
Control I	1	2	2	1	2627	100
Control II	9	9	9	1	1100	42
Oryzalin + linuron	3	4	4	2	2402	91

Control I: 3 times mechanically weeded between rows + 3 times manually weeded in the rows.

Control II: No weeding

No mechanical or manual weeding in plots treated with herbicides.

At Livada as at Podul Iloaiei the perennial weeds Sonchus arvensis and Convolvulus arvensis were responsible for the small yield reduction in the plots treated with oryzalin + linuron as compared to the mechanically weeded control.

These results showed that the mixture provided good control of a large spectrum of weeds commonly found in soybean fields in Romania. Results from all experiments conducted in 1973 showed that 1.0 kg a.i. of each component is the lowest rate to give consistent weed control, especially on heavier soils and soils with organic matter content of more than 4%. The recommended rates for the 1974 demonstration programme were therefore increased as shown in Table 3, and these confirmed in practice the results of the replicated experiments conducted in 1973.

At the recommended rates (Table 3), oryzalin + linuron provided commercially acceptable control of the grass weeds Setaria spp., Echinochloa crusgalli, Digitaria sanguinalis, and the broadleaf weeds Amaranthus spp., Chenopodium album, Polygonum spp., Sinapis arvensis, Raphanus raphanistrum and Thlaspi arvense. As mentioned earlier, the herbicide mixture had to be activated by at least 12.5 mm of rainfall or irrigation to give consistent weed control. Results from U.S. field experiments (Rogers et. al., Watson et. al.) have shown that where insufficient precipitation occurred within 7-10 days after application of the herbicide mixture, an early cultivation served to activate the herbicide and at the same time removed any tolerant weeds that were present.

b. Crop safety

Except for one trial, on a very light soil in Livada, where very slight early crop injury was reported, crop safety in herbicide treated plots was rated equal to that of control plots in 1973 replicated experiments (Table 4). At the higher rates recommended in the 1974 demonstration programme (Table 3), no cases of injury were reported. The mixture of oryzalin + linuron at the dosages listed in Table 3 is therefore considered safe to soybean varieties commonly grown in Romania.

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WEED CONTROL PROGRAMMES FOR VINING PEAS

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Summary In experiments on vining peas, cyanazine gave the best and prometryne the poorest overall weed control of four residual herbicides tested. Trietazine/simazine and terbutryne/terbuthylazine were intermediate in effectiveness. Increasing the recommended dosage by 20% was unnecessary with cyanazine and gave no worthwhile improvement with prometryne, but the performance of the other two herbicides was enhanced. Better results were obtained where bentazone/MCPB at 1.68 kg a.i./ha was applied post-emergence to plots treated with the standard rates of prometryne, trietazine/simazine and terbutryne/terbuthylazine. Bentazone/MCPB by itself at 3.36 kg a.i./ha was more effective than dinoseb amine at 1 kg a.i./ha in two out of three experiments and controlled weeds as well as or better than the standard rates of all the residual herbicides except cyanazine.

Weeds, other than those on untreated plots or where control was virtually ineffective, had little effect on crop yield but in several cases they reduced the efficiency of vining. None of the individual herbicides directly affected crop yields but there was evidence that the use of bentazone/MCPB at 3.36 kg a.i./ha following a residual herbicide treatment could depress yields.

INTRODUCTION

Until very recently residual herbicides were not widely used by pea growers in Eastern Scotland and they relied mainly on dinoseb for effective weed control. Experiments over a number of years and situations (Lawson & Rubens, 1970) confirmed the greater reliability of dinoseb particularly in comparison with prometryne, while most alternative materials were found to be either insufficiently effective or else potentially injurious to the crop. Of the new herbicides examined in 1972 at SHRI, the most promising was cyanazine (DW 3418). Since then two further residual herbicide mixtures and a new post-emergence herbicide formulation have been introduced. The experiments reported in this paper compared these herbicides against each other and against prometryne and dinoseb amine.

It has been suggested that soil-applied residual herbicides may perform less effectively in E. Scotland because of the higher organic matter content of the soils relative to those of arable Eastern England (Batey, 1974). The effects on weeds and crops of either increasing the residual herbicide dosage recommended by the manufacturer by 20% or applying an additional post-emergence treatment of bentazone/MCPB were therefore examined.

METHOD AND MATERIALS

The experiments were carried out at Invergowrie on sandy loam soils with organic matter contents (as determined by loss on ignition) of between 6 and 8%.

Plots consisted of single beds 1.5 m wide by 9 m in length and the harvested area was 13 m^2. The cultivar Sprite was sown with a Nordsten drill in rows 10 cm apart to give an estimated population of 54 plants/m^2. All three experiments were laid out as randomised blocks. In 1972, a split-plot design was used, but the other experiments had a factorial design with additional control plots.

Herbicide application was made by Oxford Precision sprayer, in 730 l water/ha. The herbicide formulations used in these experiments were as follows:

Chemical	Formulation
cyanazine	50% w/v suspension concentrate
dinoseb amine	18.5% w/v emulsifiable concentrate
prometryne	50% wettable powder
bentazone/MCPB	48% w/v aqueous solution (24/24)
terbutryne/terbuthylazine	50% wettable powder (35/15)
trietazine/simazine	50% wettable powder (43.75/6.25)

Ground cover by weeds was visually assessed at regular intervals until harvest and weeds were counted after the post-emergence herbicides had had their effect. At harvest, plots were scythed, weed vegetation separated from pea vine and the latter put through a small plot viner. Tenderometer assessments were made on the vined peas.

RESULTS

Expt. I - 1973

The crop was drilled on March 27. Plant stand counts showed that the mean population actually achieved was 69 plants/m^2. Pre-emergence herbicides were applied on April 3 and post-emergence herbicides on May 28. The crop was harvested on July 16.

Treatments kg a.i./ha

Main (pre-emergence)			Split	
Z	No residual herbicide		1	No further treatment
G	Prometryne	1.68	2	20% extra dosage of residual herbicide applied pre-emergence*
R	Trietazine/simazine	1.40	3	Bentazone/MCPB 1.68 post-emergence (half rate)
O	Terbutryne/terbuthylazine	1.40		
F	Cyanazine	1.75	4	Bentazone/MCPB 3.36 post-emergence (full rate)

*Dinoseb 1.01 post-emergence on Z2 plots

Weeds emerged after the crop, and weed numbers were low. As a result ground cover by weeds on untreated plots was only 8% at the time of application of the post-emergence herbicides, reaching a maximum of 25-30% by mid-July. At standard rates, prometryne had little effect on ground cover by weeds compared with the untreated control, while terbutryne/terbuthylazine gave better initial control but resistant weeds spread rapidly later in the season. Trietazine/simazine reduced weed cover by some 50% compared with the untreated plots throughout the experiment, but by far the best control was given by cyanazine, which prevented weed cover from rising above 6% at any time until harvest. It was therefore not possible to measure any benefit from supplementary treatment with this herbicide. Increasing

Table 1

Crop & weed records 1973

Treatment	Expt.I Yield kg/plot Vine	Peas	Weeds	% peas in vine + weeds
Z	51.3	10.9	7.7	18.4
Z + D	53.7	12.8	0	23.9
Z + ½B	51.5	11.4	1.3	21.7
Z + B	52.3	11.9	0.8	22.4
GS	44.2	9.9	7.4	19.1
G + 20%	44.2	10.0	6.7	19.6
G + ½B	53.6	13.0	0.9	23.7
G + B	51.5	11.6	0	22.5
RS	51.1	12.3	3.0	22.7
R + 20%	54.7	12.4	0.8	22.3
R + ½B	55.7	13.6	0	24.6
R + B	52.9	12.8	0.5	24.0
OS	49.4	11.8	6.3	21.2
O + 20%	53.3	12.0	1.5	21.9
O + ½B	53.1	12.5	0	23.6
O + B	44.9	9.6	1.5	20.9
FS	54.5	12.7	0.7	23.0
F + 20%	52.2	10.9	1.1	20.4
F + ½B	53.2	11.9	0.8	22.0
F + B	48.9	11.2	1.4	22.3
S.E. mean ± a)	2.79	0.76	1.32	1.21
S.E. mean ± b)	2.95	0.79	1.51	1.13
All S*	49.8	11.7	4.4	21.5
All + 20%*	51.1	11.3	2.5	21.0
All + ½B*	53.9	12.8	0.4	23.5
All + B*	49.6	11.3	0.8	22.4
S.E. mean ± c)	1.39	0.38	0.66	0.60

Key:
Z = No residual herbicide
D = Dinoseb amine
B = Bentazone/MCPB
G = Prometryne
R = Trietazine/simazine
O = Terbutryne/terbuthylazine
F = Cyanazine

a) for comparison within main treatments
b) for comparisons across main treatments
c) for comparisons between supplementary treatments

* excluding Z treatments
S = standard rate
½ = 50% of standard rate
20% = 20% above standard rate

dosage by 20% enhanced weed control by terbutryne/terbuthylazine and trietazine/simazine but had little effect on weed cover on plots treated with prometryne. Much better results were obtained on weedy plots by supplementary treatment with the half rate of bentazone/MCPB. Supplementary treatment with the full rate of bentazone/MCPB gave no better results than did the half-rate. Both dinoseb and the full rate of bentazone/MCPB alone kept weed cover at or below 5% throughout the experiment. The half-rate of bentazone/MCPB allowed weeds to reach a maximum of 15% cover, but this was better than the performance of all the standard rates of pre-emergence herbicides except cyanazine.

Weed counts showed that dinoseb controlled everything except Poa annua. This was the main species left by the full rate of bentazone/MCPB, which also failed to control Polygonum aviculare and Euphorbia spp. The half-rate of bentazone/MCPB was also not sufficiently effective on these species or on Chenopodium album and Fumaria officinalis. Since Euphorbia spp. were not controlled by any of the residual herbicide treatments, these and P. aviculare were the main surviving weeds on plots given supplementary treatment with bentazone/MCPB. They were also the predominant weeds on plots treated with cyanazine.

Prometryne at either rate had little effect on the numbers or species of weeds present. Terbutryne/terbuthylazine at the standard rate gave only partial control of F. officinalis, Stellaria media and C. album. Increasing the dosage by 20% gave a marked improvement on all three species. Trietazine/simazine also failed to give complete control of F. officinalis and S. media but increasing the dosage showed relatively little improvement.

The weights of weeds cut with the vine at harvest illustrate the efficacy of the herbicide treatments (Table 1). All except both rates of prometryne and the standard rate of terbutryne/terbuthylazine significantly reduced weed growth in comparison with untreated plots. Most of them also significantly improved the yield of peas per unit weight of vegetation cut. However, since the weight of weeds even on untreated plots was relatively low, there was little evidence of reduction in weights of vine or of peas and no significant increases over yields on untreated plots were recorded. Overall, the addition of 20% to residual herbicide dosages did not significantly improve crop yields but additional treatment with the half-rate of bentazone/MCPB did boost yields. There was, however, evidence that the full rate of this herbicide when added to residual herbicide treatments reduced yields slightly compared with supplementary treatment with the half-rate.

There was no visible evidence of adverse effect of any pre-emergence treatment on the early growth of the crop and differences in populations were not significant. Slight scorch by dinoseb was the only visible evidence of reaction to post-emergence treatment; bentazone/MCPB caused neither hormone distortion nor scorch.

Tenderometer readings were not affected by herbicide treatment.

Expt. II - 1974

The crop was drilled on April 11, pre-emergence herbicides were applied on April 15 and post-emergence ones on May 30. The mean plant population achieved was 51 plants/m^2. The crop was harvested on July 23.

Pre-emergence treatment was followed by a long dry spell, but soil moisture at sowing was sufficient to allow most residual herbicide treatments to give acceptable weed control, preventing the ground cover by weeds from rising above 15% during the experiment.

Treatments kg a.i./ha

Basic		Additional
Z No residual herbicide		1 No further treatment
G Prometryne	1.68	2 20% extra dosage of residual herbicide applied pre-emergence*
R Trietazine/simazine	1.40	3 Bentazone/MCPB 1.68 post-emergence (half rate)
O Terbutryne/terbuthylazine	1.40	
F Cyanazine	1.75	

*dinoseb 1.01 post-emergence on Z2 plots

Extra treatment on Z plots - bentazone/MCPB 3.36 post-emergence (full rate)

Prometryne was again relatively ineffective, the extra dosage reducing weed cover even less than the standard dosage. Weeds on both treatments reached 8% ground cover by the date of post-emergence treatment compared with 12% on untreated plots and 4% or less on other treatments. The initial development of the weeds was slow but between late June and harvest the weed cover on untreated plots rose sharply from 16% to a peak of 66%. Dinoseb and both rates of bentazone/MCPB were successful in preventing this expansion of weed growth.

P. annua accounted for half the weed flora on most plots. None of the post-emergence treatments had any effect on this species, so that plots without residual herbicides and those treated with prometryne had a dense matt of grass by harvest time. Of the broad-leaved weeds, untreated plots had high populations of S. media, C. album and Matricaria spp., with lesser amounts of P. aviculare and Veronica spp. Apart from Matricaria spp these were also the main weeds present on plots treated with either rate of prometryne.

Of the other residual herbicides, cyanazine gave virtually complete weed control at both rates, while trietazine/simazine was superior to terbutryne/terbuthylazine at both the standard and extra rates, the difference between them being mainly in the degree of control of S. media. This was also the main surviving broad-leaved species on plots treated with dinoseb. Both rates of bentazone/MCPB eliminated this species, but the half-rate was not very effective on C. album.

In terms of supplementary treatment, cyanazine required none and the level of weed control by the standard rates of the other residual herbicides was augmented more by bentazone/MCPB than by increased dosage.

Harvest records (Table 2) show the weight of weeds harvested with the crop. Over 40% of the total weight of vegetation cut from untreated plots was weed. The poor level of weed control with prometryne at either rate is clearly shown. All other treatments significantly reduced the weight of weeds relative to the untreated plots. The half-rate of bentazone/MCPB by itself and dinoseb were the least successful treatments (other than prometryne) in reducing weed weights but bentazone/MCPB as a supplementary treatment reduced weeds more effectively than increasing the dosage of residual herbicide treatment. Overall this improvement was significant. Weeds on the untreated plots contributed to significantly lower pea yields per unit weight of vegetation cut than were achieved on all treatments other than the higher rate of prometryne. Weeds also caused a significantly lower pea : vegetation ratio on plots treated with dinoseb than on plots treated with the full

Table 2

Crop & weed records 1974

Treatment	Expt.II Yield kg/plot Vine	Peas	Weeds	% peas in vine + weeds	Expt. III Yield kg/plot Vine	Peas	Weeds	% peas in vine + weeds
Z	41.4	6.6	29.1	9.4	15.0	2.0	30.3	4.2
Z + D	51.9	7.6	10.2	12.2	25.8	3.4	17.5	8.1
Z + ½B	48.5	8.1	10.0	13.8	29.5	4.1	7.3	11.2
Z + B	51.0	8.7	4.8	15.7	29.8	4.3	4.3	12.8
GS	48.2	8.0	16.1	12.4	36.0	4.2	5.1	10.4
G + 20%	45.0	7.0	22.2	10.3	36.1	4.7	3.7	11.8
G + ½B	51.0	7.9	5.5	13.8	35.6	5.1	2.4	13.4
RS	55.4	7.7	8.2	12.2	34.6	4.3	3.8	11.4
R + 20%	51.5	8.4	6.7	14.4	34.3	4.0	3.2	10.8
R + ½B	58.1	9.1	0.5	15.5	35.7	4.2	0.6	11.6
OS	61.1	9.7	4.2	14.9	35.1	4.3	3.2	11.3
O + 20%	60.9	9.6	1.8	15.3	36.4	4.3	2.1	11.2
O + ½B	57.6	9.7	0.3	16.7	36.8	4.6	0.3	12.4
FS	58.6	9.2	0.3	15.7	35.9	4.5	3.8	11.8
F + 20%	56.2	8.9	0.1	15.8	37.2	4.5	2.1	11.6
F + ½B	58.1	9.0	0.2	15.5	37.7	4.4	0.6	11.5
S.E. mean ±	4.10	0.75	3.08	0.85	1.86	0.40	1.19	0.95
All S*	55.8	8.7	7.2	13.8	35.4	4.3	3.9	11.2
All + 20%*	53.4	8.5	7.7	13.9	36.0	4.4	2.8	11.3
All + ½B*	56.2	8.9	1.6	15.4	36.5	4.6	1.0	12.2
S.E. mean ±	2.05	0.38	1.54	0.42	0.93	0.20	0.60	0.48

Key:
Z = No residual herbicide
D = Dinoseb amine
B = Bentazone/MCPB
G = Prometryne
R = Trietazine/simazine
O = Terbutryne/terbuthylazine
F = Cyanazine

* excluding Z treatments
S = standard rate
½ = 50% of standard rate
20% = 20% above standard rate

rate of bentazone/MCPB. Supplementary treatment with bentazone/MCPB gave significantly better pea : vegetation ratios overall than either rate of the residual herbicides. Weight of vine was significantly higher with many herbicide treatments than on untreated plots, the exceptions being all prometryne treatments and trietazine/simazine at the higher rate. Yield of peas was similarly affected, being up to 50% higher on the cleanest plots than on untreated plots. Differences between herbicide treatments were not significant. No visible crop injury from herbicide treatments was noted, nor were there any significant differences between them in plant stand counts, yields of vine and peas, or in tenderometer readings.

Expt. III - 1974

Treatments were exactly the same as in Expt. II. The crop was drilled on May 8, plant emergence was poor and the final population averaged only 37 plants/m^2. Pre-emergence herbicides were applied on May 17 and the post-emergence ones on June 24. Pre-emergence treatment was followed by heavy rain and some yellowing of crop foliage on all treated plots was noted. Wind and rain delayed post-emergence treatment beyond the optimum stage for weed control. On untreated plots weeds reached 24% ground cover by June 24. S. media on plots sprayed with dinoseb recovered to give a ground cover averaging 65% at harvest compared with 83% on untreated plots. Both rates of bentazone/MCPB reduced weed cover to just under 20% by July 2 and it remained constant thereafter. All residual herbicide treatments gave excellent weed control, ground cover never rising above 12% even on the weediest plots. Poa annua was present in large numbers on plots treated with dinoseb and the two rates of bentazone/MCPB. Untreated plots had a dense population of S. media, with Matricaria spp., C. album and P. aviculare also of importance. Bentazone/MCPB at the half-rate again failed to control C. album effectively and the full rate and dinoseb were only partially successful. All three treatments failed to control P. aviculare. Dinoseb reduced the S. media population by only 50%, whereas both rates of bentazone/MCPB eliminated this species. Prometryne left sufficient numbers of several species to make it the poorest of the residual herbicide treatments. There was little to choose between the other three residual treatments but cyanazine reduced weed numbers slightly more than did the others. Bentazone/MCPB at the full rate gave as satisfactory control of broad-leaved species as did the residual treatments. The addition of 20% to residual herbicide dosages reduced weed populations slightly, but supplementary treatment with bentazone/MCPB made a greater difference, particularly by eliminating S. media.

The crop was harvested on August 5. Harvest records (Table 2) show that the freshweight of weeds on untreated plots was twice the weight of vine. Dinoseb also produced a weedy crop, due mainly to S. media, while C. album was the major weed in crops treated with the half rate of bentazone/MCPB. Untreated and dinoseb-treated crops were significantly weedier than all others. Bentazone/MCPB at the half-rate produced significantly weedier crops than all residual herbicide treatments except prometryne at the standard rate. Other differences were not significant, but overall supplementary treatment with bentazone/MCPB gave significantly less weed at harvest than either the standard or extra rates of residual herbicides. Pea : vegetation ratio in untreated crops was extremely low, while in crops treated with dinoseb the ratio was significantly poorer than with all other herbicide treatments except the standard rate of prometryne. Untreated plots yielded significantly less vine than all others, while those treated with dinoseb and both rates of bentazone/MCPB had significantly lower yields than with most other treatments. Differences between residual herbicides were minimal. Yields of peas from plots treated with bentazone/MCPB at either rate were as high as with most other treatments. Untreated plots yielded less than half the peas harvested from any treatment other than dinoseb. Overall weed control by all treatments except dinoseb was sufficient to protect crop yields from weed competition. As a result there was no boost to yield from supplementary treatment of either type. Weather conditions after pre-emergence treatment were conducive to crop injury. Despite some initial yellowing of foliage on all treated plots, no significant reductions in plant stand or in yield of vine or peas attributable to residual herbicide injury were recorded. Both rates of bentazone/MCPB caused temporary foliage distortion, which was soon outgrown. However, although yield of peas was unaffected on these plots, the weight of vine was lower than on all residual herbicide treatments. This may possibly be related to the initial effect on crop foliage. None of the treatments had any effect on tenderometer values at harvest. There was no indication that supplementary treatment, either by increased dosaged or with bentazone/MCPB, had any injurious effect on crop yields.

DISCUSSION

Plant populations at the lower end of the range found in commercial practice were chosen so that the weed flora had a chance to develop. It is therefore interesting to note the relatively small effect on yield of peas which resulted from anything less than severe smothering by weeds. However, the presence of weeds at harvest frequently reduced the pea : vegetation ratio and would therefore have impaired the speed and efficiency of vining. This factor and the risk of contamination by weed particles during processing necessitates a high level of weed control.

Cyanazine gave the best overall weed control of any of the residual herbicides. At all three sites, trietazine/simazine and terbutryne/terbuthylazine were more effective than prometryne, which failed to give reliable weed control. Evaluation of rates 20% higher than those recommended by manufacturers suggested that this would not be sufficient to improve the performance of prometryne. However, further evaluation of higher rates in Scotland would be worthwhile for trietazine/simazine and terbutryne/terbuthylazine. The high level of weed control by cyanazine at the standard rate did not indicate any need for increased dosage and the margin of crop safety may not permit any increase (Lawson & Rubens, 1970). Bentazone/MCPB at 3.36 kg a.i./ac gave better weed control than dinoseb in 1974 and equivalent control in 1973, although the speed of kill was much slower. It was also as effective as any of the standard rates of residual herbicide treatments (apart from cyanazine). The half-rate was not sufficiently effective on its own, but was highly successful when used as a supplementary treatment following a residual herbicide. The full rate gave little if any better supplementary weed control in 1973 but did give an indication of adverse crop reaction. King & Handley (1972) also found bentazone/MCPB to be a most useful post-emergence treatment for peas. Being foliar-applied, it is largely independent of the variations in soil type and seed-bed conditions which affect the performance of soil-applied herbicides. This herbicide should therefore be of particular interest in Scotland both as an alternative to residual herbicides and as a remedial treatment in situations where residual herbicides have failed to give effective weed control.

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