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THE TOLERANCE OF FENUGREEK (Trigonella foenumgraecum, L.) TO VARIOUS HERBICIDES

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SUMMARY

In a series of outdoor pot experiments the tolerance of fenugreek to numerous herbicide treatments was examined pre- and post-emergence. Pea, dwarf and field bean were included as reference species and were treated with some of the herbicides which are already approved for use in these crops. Herbicides to which fenugreek showed good post-emergence tolerance included: bentazon and MCPB alone or in mixture, bifenox, metamitron, diphenamid, chlorthal-dimethyl, propyzamide, barban, dichlofop-methyl and alloxydim-sodium. In a follow-up post-emergence experiment, fenugreek showed some degree of tolerance to methazole and metamitron but this was lost with the latter when an adjuvant, Actipron, was added. (Bifenox was safe when applied as a wettable powder formulation but not as an emulsion.) Tolerance pre-emergence was found with an even greater range of herbicides, notably nitrofen, methazole, chlortoluron, aziprotryne, chlorthal-dimethyl, propyzamide, butam, propachlor, alloxydim-sodium and trifop-methyl as surface sprays or incorporated treatments of tri-allate, trifluralin and chlorpropham. Standard, approved, herbicides behaved as expected on the other three legumes with only a few exceptions, notably simazine pre-emergence which damaged field bean. Acifluorfen showed good safety in peas, pre- but not post-emergence. Generally effects on nodulation corresponded to herbicide effects on other plant parts. The use of the herbicides for weed control in these crops is discussed.

INTRODUCTION

Fenugreek, Trigonella foenumgraecum, L. (Papillionaceae) is an annual legume grown as a minor crop in several Mediterranean countries, India, Burma, China and Russia. The seed has flavouring properties and is often used in curry powders. The endosperm of the seed contains diosgenin which is a valuable precursor in the steroid industry. Its use as a valuable protein source in animal feeds or as silage has been suggested and because of its nitrogen fixing capacity, it could be useful as a break crop. (Hardman, 1975). Some research is in progress with a view to cultivation of the crop in the UK. (Hardman, 1975). Recently the National Research Council of the USA National Academy of Sciences has been studying several leguminous species which they consider are underexploited, yet which could

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* Herbicide Group

have promise for economic development in the tropics. Fenugreek was one of 36 species out of the 400 considered, which had exceptional merit. If a crop is to become of any importance, consideration has to be given to herbicides which can be used safely to control weeds.

Very little information on weeds and weed control in fenugreek is available. Richardson and Parker (1978) found that it tolerated alloxydim-sodium and pyridate. Mohlgaard (pers.comm.) tested six herbicides in a small plot field test in 1977 and found that dimefuron and MCPB caused a little damage when applied early post-emergence, while a bentazon/MCPB mixture was well tolerated when applied at the 3-trifoliate leaf stage. Prometryne applied pre-emergence after drilling caused a little damage at the recommended rate, although there was recovery later. Trifluralin was not satisfactory. Unfortunately, the plots were hand weeded so that no information was obtained on weed control. More recently, in a field trial at Rothamsted Experimental Station, a terbutryne/terbuthylazine mixture ('Opogard'), approved for use in peas, was found to be lethal to fenugreek (Pattison, pers. comm.). Pot trials were established at WRO in 1978, in which 40 post-emergence and 45 pre-emergence herbicide treatments were tested. The more interesting herbicides were examined in a further post-emergence selectivity test. Several of the possible herbicides are used in other important legume crops (i.e. pea, dwarf and field bean) and these crops were included as reference species. Some new herbicides for which approval by the Ministry of Agriculture had not yet been granted were also included. In addition the effect of herbicides on the nodulation of all four of the legume crops, an aspect often neglected in herbicide work, was examined.

MATERIALS AND METHODS

Plant raising

Details of plant raising are given in Table 1. Seeds were sown in 9 cm diameter plastic pots containing sandy loam soil, from a field at Begbroke (Begbroke North) with an organic matter content of 4.2%, a clay content of 13%, silt 7%, sand 80% and pH of 7.2. Fritted trace elements (0.01 g/kg), magnesium sulphate, $MgSO_4 . 7H_2O$ (1.0 g/kg) and DDT insecticide (0.5 g/kg of a 5% dust) were incorporated into the soil. Base fertilizer was not included in the hope that this might facilitate nodulation of the roots.

Fenugreek seeds were sown onto a thin layer of a peat based inoculum of Rhizobium meliloti Dang. (Rothamsted Catalogue No. 2012) and then covered with a 0.5 cm layer of soil. Seeds of the other species were pre-treated with a fungicidal dressing ('captan' for pea, 'fernasan A' for dwarf and field bean). Plants were raised in the open in bird proof cages. In addition to normal rainfall, tap water was given when necessary. Spare inoculated plants were examined periodically and after successful nodulation, extra nutrient was given by irrigating twice during the course of the experiment at approximately 14 day intervals with 0.5% v/v 'Bio No. 7' (2/1/1 of N/P/K).

Herbicide treatment

a) Post-emergence (experiments 1 and 3)

A few days prior to spraying, plants were thinned to a constant number per pot. They were brought in from the open the evening before spraying to protect from rainfall. Treatment was carried out on 2/8/78 (experiment 1) and 2/11/78 (experiment 3) using a laboratory pot sprayer operating at a pressure of 207 kPa (30 lb/in^2) and delivering 345 l/ha through a spraying systems fan jet moving at constant speed 45 cm above the plants. After 24 hrs. they were given an overhead watering to wash any herbicide residues off the foliage. Pots were laid out in 3 randomized blocks in the open,but in experiment 3 they were kept in a cold frame to protect from early frosts.

b) Pre-emergence (experiment 2)

Pots for surface treatment and tins containing soil for the incorporated treatments were sprayed on 26 and 27/8/78 with the same laboratory pot sprayer. The soil surface was 30 cm below a 8002E Spraying Systems fan jet calibrated to deliver 394 l/ha. The tins were emptied immediately after spraying and the herbicides incorporated by passing the soil six times through a large polythene funnel before sowing. On completion of spraying,pots were laid out in 3 randomized blocks in the open, adjacent to the post-emergence treatments, and immediately given an overhead watering.

Herbicides were applied as the commercial formulation in distilled water. Doses are given in terms of active ingredient (i.e. kg/a.i./ha). Protection from heavy rainfall was provided by moveable polythene covered frames. During the course of experiments 1 and 2 the mean temperature was 15^{o}C (maximum 24^{o}C, minimum 6^{o}C) and mean relative humidity 40% (maximum 50%, minimum 15%). The mean temperature during experiment 3 was 10^{o}C (maximum 15^{o}C, minimum 2^{o}C) and the mean relative humidity 45% (maximum 50%, minimum 30%).

Assessment and processing of results

Symptoms of herbicidal effects were recorded after 24 hrs. and observations made periodically. Final assessments were made on the post-emergence treatments about three weeks after spraying and on the pre-emergence treatments, 5 to 6 weeks after spraying. Plants surviving treatment were counted and scored on the following scale:-

		As % of control
0 =	Completely dead.	0
1 =	Moribund, but not all tissue dead.	14
2 =	Alive, with some green tissue, but unlikely to make much further growth.	29
3 =	Very stunted, but apparently still making some growth.	43
4 =	Considerable inhibition of growth.	57
5 =	Readily distinguishable inhibition of growth.	71
6 =	Some detectable adverse effect as compared with control-colour difference, morphological abnormality, epinasty or very slight reduction in growth.	85
7 =	Indistinguishable from control.	100

These results were converted to percentages for presentation in the tables of results. Shoots were harvested to near ground level and fresh and dry weights recorded. Root systems were examined and scored for nodulation on the following simple scale:-

		As % of control
0 =	no nodules	0
1 =	Few, 'ineffective' nodules.	33
2 =	Moderate number of mainly effective nodules.	67
3 =	Many effective nodules	100

For the more interesting treatments dry weights of roots were taken. Results were subjected to analysis of variance.

Table 1 Plant raising data

Species	Variety	Growth Stages/Dates		
		at spraying		at assessment
		post em	post em	pre em
Fenugreek	Paul	expt 1 ½ trifoliate (2/8/78)	6 trifoliates (21/8/78)	-
		expt 2 - (26/27/8/78 pre em)	-	7 trifoliates (11/9/78)
		expt 3 4-4½ trifoliates (2/11/78)	7 trifoliates (20/11/78)	-
Dwarf Bean	The Prince	½ trifoliate (2/8/78)	2+ trifoliates (23/8/78)	2+ trifoliates (4/9/78)
Field Bean	Maris Bead	3 pairs of leaves (2/8/78)	7 pairs of leaves (22/8/78)	5½ pairs of leaves (31/8/78)
Pea	Dark Skinned Perfection	7 pairs of leaves (2/8/78)	10 pairs of leaves (22/8/78)	9 pairs of leaves (30/8/78)

RESULTS

These are presented in the appendix in Tables 3 to 11 together with a summary of tolerance for fenugreek in table 2 on page 12.

Post-emergence (experiments 1 and 3) (Tables 3 and 11)

(i) Fenugreek

Herbicides to which fenugreek shoots and roots showed complete tolerance at both doses tested were as follows:- MCPB, bentazon ± Actipron, bifenox, metamitron, bentazon + MCPB, diphenamid, chlorthal-dimethyl, propyzamide, barban and diclofop-methyl. Several herbicides caused no adverse effects on shoot systems but the root dry weights were reduced by the high dose i.e. benazolin, dimefuron and alloxydim-sodium. Methazole and nitrofen showed reductions of root dry weight at both doses but were relatively safe to the shoots. Of the urea herbicides, methabenzthiazuron, chlortoluron and

chloroxuron were safe at the low dose, while isoproturon affected only the roots. Metoxuron and linuron caused severe damage at both doses however. The majority of the triazine herbicides tested were too damaging, only aziprotryne, desmetryne and the cyanazine/MCPB mixture being satisfactory (at the lowest dose). Difenzoquat treated plants made a vigorous recovery from early symptoms, which were probably caused by the surfactant in the spray liquid. Trifop-methyl and lenacil were safe at the lowest dose but very damaging at the high dose. In all cases where shoots and roots showed adequate herbicide tolerance, nodulation was normal. However nodulation was often unaffected, even where shoots or roots were severely reduced, e.g. with ioxynil, oxadiazon and several of the ureas and triazines.

In experiment 3 (Table 11) the wettable powder formulation of bifenox was the only herbicide to which fenugreek showed complete tolerance. However the liquid formulation was very damaging, especially to the shoot system. Methazole and metamitron were relatively safe at low doses but high doses were damaging. Addition of Actipron to metamitron resulted in a loss of crop tolerance even at the low dose. Nodulation of roots was normal except with metamitron plus Actipron and liquid bifenox.

(ii) Pea (Table 5)

A high degree of tolerance was found with benazolin, alloxydim-sodium and bentazon + Actipron. The result with bentazon is surprising in that the high dose of the herbicide alone caused some depression of shoot weights but this was less when Actipron was added. The following treatments showed complete tolerance only at the lower dose: chloroxuron, cyanazine, cyanazine/MCPB and bentazon/MCPB; the higher dose of the latter mixture showed an effect only on dry shoot weight. Low doses of acifluorfen and terbutryne also showed an effect only on dry shoot weight whereas trifop-methyl was damaging at both doses. Root nodulation was not influenced by any of the treatments.

(iii) Dwarf bean (Table 7)

Bentazon $\overset{+}{-}$ Actipron and alloxydim-sodium were the only two herbicides to which dwarf bean showed tolerance at both doses tested. Acifluorfen and bentazon/MCPB were safe at the lower doses and at higher doses dry, but not fresh weights of shoots, were affected. Trifop-methyl at both doses caused scorch symptoms but plants made good recovery, such that shoot fresh weight was similar to untreated controls although dry weight was still less. All other treatments were very damaging. Effects on nodulation generally corresponded to those on shoot systems.

(iv) Field bean (Table 9)

Bentazon and trifop-methyl were the only herbicides which did not significantly reduce shoot weight at either of the doses tested, even though the latter herbicide caused some initial vigour depression which was still apparent at assessment. Addition of Actipron to bentazon led to some mild effects. Aziprotryne, alloxydim-sodium and bentazon/MCPB were safe, but only at lower doses, while all other treatments were damaging. Nodulation of roots was normal in those treatments which did not affect shoot systems.

Pre-emergence (experiment 2)

(i) Fenugreek (Table 4)

Herbicide tolerance at both doses was found with surface sprays of bentazon, nitrofen, methazole, methabenzthiazuron, chlortoluron, aziprotryne, chlorthal-dimethyl, propyzamide, carbetamide, perfluidone, butam, propachlor, alloxydim-sodium and trifop-methyl. Most of the incorporated treatments were safe namely - tri-allate, trifluralin, and chlorpropham while EPTC and dinitramine were slightly less so. Generally, nodulation of roots was satisfactory with all these herbicides with the exception of EPTC and the high dose of dinitramine where some adverse effects were observed. Several herbicides were safe only at the lowest dose, e.g. bifenox, isoproturon, chloroxuron, prometryne, lenacil, chloridazon, diphenamid and K 1441. Metamitron was also safe at the lowest dose and showed reductions at the highest dose on shoot and root dry weights and nodulation but not on shoot fresh weight. A high sensitivity was shown to several of the triazines (including terbuthylazine and terbutryne alone or in mixture) and other herbicides e.g. fluridone, which are used in some other legume crops.

(ii) Pea (Table 6)

In most instances the standard herbicides behaved as expected with a good margin of crop tolerance. However bentazon and trietazine/simazine caused some damage. Of the newer herbicides tested, acifluorfen, pendimethalin, metolachlor, alloxydim-sodium and trifop-methyl were safe. Older herbicides such as methabenzthiazuron, chloroxuron and surprisingly, methazole, were also satisfactory. Nodulation of roots was generally unaffected by those herbicides to which the shoot systems were tolerant.

(iii) Dwarf bean (Table 8)

Tolerance to the standard approved herbicides was generally satisfactory. Several of the new herbicides tested were safe namely - oxyfluorfen, pendimethalin, perfluidone, K 1441, butam, metolachlor, alloxydim-sodium and trifop-methyl. Although shoot fresh weight was unaffected by dimethachlor, dry weight was reduced by both doses, while root nodulation was reduced by more than 50%. Older herbicides such as bifenox, oxadiazon, methabenzthiazuron and chloroxuron showed good safety margins on the crop, although the latter herbicide reduced nodulation at the higher dose. While satisfactory nodulation generally corresponded to tolerance of the shoot systems, there were a number of exceptions. Oxyfluorfen, ethofumesate, perfluidone, K 1441, butam, alloxydim-sodium, trifop-methyl, tri-allate, trifluralin and chlorpropham as well as dimethachlor and chloroxuron, all caused some reduction.

(iv) Field Bean (Table 10)

Standard, approved herbicides showed an adequate safety margin with the exception of simazine, which was very damaging. However this result is perhaps not so surprising as depth protection, which is known to be so important for tolerance in the field, is less effective in pots. Of the newer herbicides, bifenox, perfluidone, alloxydim-sodium and trifop-methyl showed good safety. The older herbicides, methabenzthiazuron and chloroxuron were also well tolerated. Effects on root nodulation only appeared where shoot systems were damaged.

DISCUSSION

Fenugreek

About one third of the herbicides tested showed an adequate safety margin, while similar proportions were moderately tolerated or were not tolerated. Metamitron and methazole, although not tolerated as well by fenugreek as by the respective crops for which they are approved, namely sugar beet and onions, nevertheless would be expected to control selectively a broad-spectrum of weeds including grasses and broad-leaved species. For the control of dicotyledonous weeds MCPB, bentazone - Actipron, bentazone + MCPB, bifenox and benazolin could prove useful post-emergence. Grass weeds could be controlled selectively with post-emergence treatments of alloxydim-sodium, propyzamide, barban and diclofop-methyl. The two former herbicides have the distinct advantage of controlling a wider species range, including perennial as well as annual grasses, while the two latter would be more specific e.g. to wild oats. Diphenamid and chlorthal-dimethyl would also give some broad leaved weed control but this would be expected to be greater pre- than post-emergence. Herbicides which control grass weeds pre-emergence formed by far the largest group and of these alloxydim-sodium and trifop-methyl control the most species. However both are inactive on broad-leaved weeds and perform indifferently on Poa annua and, the inclusion of another herbicide to control these species may be necessary (Richardson and Parker, 1977 a and b, 1978 and 1979a). The residual life of alloxydim-sodium in the soil may also be too short for it to be an effective pre-emergence herbicide. Unfortunately, there is some doubt about the future development this herbicide and trifop-methyl. Although several other pre-emergence herbicides may not have the potential of the two previously mentioned on perennial grasses, others relatively effective on a fairly broad spectrum of annual grass and broad-leaved weeds are; chlorthal-dimethyl, methabenzthiazuron, chlortoluron, aziprotryne, perfluidone, butam and nitrofen, although some gaps in the weed spectra are apparent, e.g. the lack of control of Stellaria media by the latter herbicide. All of the incorporated herbicides tested were safe to fenugreek and may be expected to control most annual grasses and some broad-leaved weeds. As well as single herbicide treatments, consideration may have to be given to tank mixtures of one or more herbicides, or to sequences. The present work may form a basis for choosing herbicides for this purpose and in fact, some of the herbicides successful here are already available in proprietary mixtures, for example chlorthal-dimethyl + methazole ('Delozin S' approved for use in peas and transplanted brassicas); propachlor + chlorthal-dimethyl (brassicas and onions); propachlor + chlorpropham (in onions and leeks).

The margin of selectivity between the weeds and fenugreek may be extended by exploiting the nature of the crop canopy. Firstly, as the canopy is not very dense it should be possible to apply residual herbicides late in the development of the crop, which would reach the soil and maximise effectiveness provided the weed density is not too great. Similarly, foliage-acting herbicides would appear to have a much better chance of reaching the target weed species. Secondly, as nastic movement during the day changes the orientation of the leaf surfaces of the fenugreek it may be possible to considerably reduce the amount of spray intercepted by suitably matching the angle of spray application to the orientation of the leaf surfaces. In the present test the spray was directed vertically downwards. It may also be possible to increase the resistance of the fenugreek, to specific pre-emergence treatments by making use of 'depth protection' and sowing somewhat deeper.

With peas, most of the standard herbicides approved for use behaved as expected, although some damage was often seen at the high dose. Of the newer herbicides, acifluorfen, alloxydim-sodium and trifop-methyl showed most promise. Although peas were very sensitive post-emergence to acifluorfen they tolerated doses pre-emergence which will control a wide spectrum of annual broad-leaved weeds and possible even some perennials. The resistance of Stellaria media could be a serious limitation however and consideration will have to be given to mixture with other herbicides which will control this species and also grass weeds (Richardson and Parker, 1979 b). Alloxydim-sodium was safe to peas both pre- and post-emergence, at doses well above that needed to control most annual and perennial grass weeds, even when the latter are well established. [Nodulation of roots was generally normal, contrasting somewhat with previous experience (Richardson and Parker 1978, 1979 a, Greaves et al. 1978)]. Trifop-methyl, which can be expected to control the same weeds as alloxydim-sodium, was relatively safe pre- but not post-emergence, although much higher doses were used than is needed for weed control (Richardson and Parker, 1977 a and b,1978, 1979 a). Of the older herbicides tested, which are not approved in peas but which may be considered as components of mixtures, worth noting for possible pre-emergence use, are methazole, methabenzthiazuron, chloroxuron, prometryne, chlorthal-dimethyl and pendimethalin.

The tolerance of dwarf bean to standard, approved herbicides was generally good. The majority of pre-emergence herbicides were safe, and of the newer herbicides acifluorfen, alloxydim-sodium and trifop-methyl showed some tolerance but effects on nodulation were noted, particularly pre-emergence. A wide range of herbicides would appear to be available pre-emergence for consideration as components of mixtures. Some of these are already in use but methabenzthiazuron and chloroxuron require special mention because of their relative low cost and wide spectra of weed control which includes annual grasses and broad-leaved weeds.

Results with field bean corresponded to dwarf bean, in that resistance was generally greater to pre-emergence herbicides. Simazine, the standard, approved herbicide was damaging however, presumably because the herbicide reached the roots of the plant under the irrigation regime used in the experiment. Although none of the other herbicides may have quite the weed spectrum of simazine, methabenzthiazuron, chloroxuron and possibly the low dose of terbutryne/terbuthylazine should be mentioned as safer alternatives for pre-emergence weed control. Alloxydim-sodium and trifop-methyl showed some potential although an odd result was obtained with the latter at the low dose pre-emergence.

Effects on nodulation

The opportunity was taken to examine herbicide effects on nodulation of the four legumes, an aspect which is not always considered in herbicide tests. Problems of such experimentation have already been considered in other work (Greaves et al. 1978). Care has to be taken in interpreting the significance of this data however. Assessments were

made only on a subjective scoring scale and at a fairly early stage in the life of the plant. Generally nodule effects corresponded to effects on other plant parts, i.e. if the herbicide caused no visible damage, no adverse effects were seen on the nodules. Conversely where severe effects were seen on the plant, nodulation was also usually severely affected. This corresponds to the work of Peters and Ben Zbiba, 1979 with alfalfa and red clover. Narayana and Jain, 1978, found that post-emergence applications of alachlor to fenugreek reduced growth and nodule numbers and this effect increased with increasing concentration. Nitrofen on the other hand was stimulatory at high concentrations but neither of these two herbicide treatments affected the bacterial zone of the nodules. Fewer cases were seen in the present work of herbicides which were safe to shoots and other plant parts, but detrimental to the nodules. The only examples were EPTC pre-emergence on fenugreek and pre-emergence treatments of perfluidone, K 1441, butam and trifop-methyl on dwarf bean. Such effects were not found with post-emergence treatment of any of the species. A number of cases occurred where severe effects were seen on shoots but nodulation was unaffected. This was especially noticeable with post-emergence treatments to fenugreek and pea. In fact with the latter species nodulation was normal with all of the post-emergence treatments. The present report indicates the need for further work on effects of herbicides on nodulation as well as serving the primary purpose of pin-pointing herbicide treatments for fenugreek and other legume species.

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APPENDIX

Table 2. Herbicide tolerance table for fenugreek

1) Post-emergence

Tolerated	Moderately tolerated	Not tolerated
barban	alloxydim-sodium	acifluorfen
bentazon + actipron	aziprotryne	asulam
bentazon/MCPB	benazolin	atrazine
bifenox	chloroxuron	bromoxynil
chlorthal-dimethyl	chlortoluron	cyanazine
diclofop-methyl	cynazine/MCPB	ethofumesate
diphenamid	desmetryne	flamprop-methyl
MCPB	difenzoquat	ioxynil
metamitron	dimefuron	linuron
propyzamide	isoproturon	metoxuron
	lenacil	metribuzin
	methabenzthiazuron	oxadiazon
	methazole	phenmedipham
	nitrofen	terbutryne
	trifop-methyl	

2) Pre-emergence

alloxydim-sodium	bifenox	acifluorfen
aziprotryne	chloridazon	cyanazine
bentazon	chloroxuron	dimefuron
butam	dinitramine *	dimethachlor
carbetamide	diphenamid	ethofumesate
chlorpropham *	EPTC *	fluridone
chlorthal-dimethyl	isoproturon	linuron
chlortoluron	K 1441	metolachlor
methabenzthiazuron	lenacil	metribuzin
methazole	metamitron	oxadiazon
nitrofen	prometryne	oxyfluorfen
perfluidone		pendimethalin
propachlor		simazine
propyzamide		terbuthylazine
tri-allate *		terbutryne
trifluralin *		terbutryne/ terbuthylazine
trifop-methyl		trietazine/simazine

* incorporated

Table 3 Response of fenugreek (Trigonella foenumgraecum, L.) to post-emergence herbicides

(*** indicates values not significantly less than control)

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%	SHOOT DRY WT. mean	%	ROOT NODULATION	ROOT DRY WT. mean	%
CONTROL	-	100	8.96	100	1.23	100	100	0.61	100
Substituted ureas									
CHLOROXURON	4.0	90	7.42	83 ***	1.02	83 ***	100	0.46	75 ***
"	8.0	83	6.04	67	0.77	63	100	0.34	56
CHLORTOLURON	0.5	98	8.53	95 ***	1.19	97 ***	100	0.52	85 ***
"	1.0	83	6.91	77	0.94	76	100	0.32	52
DIMEFURON	0.75	95	7.98	89 ***	1.17	95 ***	100	0.69	113 ***
"	1.5	93	7.69	86 ***	0.98	80 ***	100	0.38	62
ISOPROTURON	0.375	95	7.14	80 ***	1.01	82 ***	100	0.37	61
"	0.75	93	6.80	76	0.91	74	100	0.38	62
LINURON	0.5	74	5.60	63	0.76	62	100	-	-
"	1.0	36	1.16	13	0.20	16	67	-	-
METHABENZTHIAZURON	0.75	86	7.77	87 ***	1.11	90 ***	100	0.48	79 ***
" "	1.5	76	5.92	66	0.87	71	100	0.38	62
METOXURON	1.0	76	5.38	60	0.68	55	90	-	-
"	2.0	48	2.57	29	0.33	27	77	-	-
Triazines and related compounds									
ATRAZINE	0.5	79	6.23	70	0.83	68	100	-	-
"	1.0	26	1.02	11	0.15	12	43	-	-

Table 3 continued

Triazines and related compounds										
AZIPROTRYNE	1.0	81	7.88	88	***	1.04	85 ***	100	0.32	52
"	2.0	83	6.23	70		0.79	64	100	0.29	48
CYANAZINE	1.0	86	6.10	68		0.91	74	100	-	-
"	2.0	43	2.12	24		0.39	32	57	-	-
CYANAZINE/MCPB	1.0	86	7.95	89	***	1.09	89 ***	100	0.47	77 ***
"	2.0	79	6.24	70		0.83	68	100	0.41	67
DESMETRYNE	0.2	83	7.35	82	***	1.05	85	100	-	-
"	0.4	71	5.44	61		0.76	62	100	-	-
METAMITRON	2.5	100	9.03	101	***	1.33	108 ***	100	0.69	113 ***
"	5.0	86	7.85	88	***	1.08	88 ***	100	0.64	105 ***
METRIBUZIN	0.2	45	2.28	26		0.39	32	90	-	-
"	0.4	10	0.09	1		0.02	2	0	-	-
TERBUTRYNE	0.5	79	6.55	73		0.90	73	100	-	-
"	1.0	31	1.70	19		0.26	21	43	-	-
"Wild oat" herbicides										
BARBAN	0.375	95	8.23	92	***	1.06	86 ***	100	0.48	79 ***
"	0.75	95	9.84	110	***	1.27	103 ***	100	0.53	87 ***
DICLOFOP-METHYL	1.0	100	9.74	109	***	1.40	114 ***	100	0.61	100 ***
" "	2.0	100	9.03	101	***	1.21	98 ***	100	0.76	125 ***
DIFENZOQUAT	1.0	86	9.08	101	***	1.21	98 ***	100	-	-
"	2.0	71	7.25	81	***	0.97	79 ***	100	-	-
FLAMPROP-METHYL	0.5	43	6.27	70		0.99	81 ***	90	-	-
" "	1.0	43	5.58	62		0.93	76	77	-	-

Table 3 cont'd

Other herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT mean	%	SHOOT DRY WT. mean	%	ROOT NODULATION	ROOT DRY WT. mean	%
ACIFLUORFEN	0.2	64	8.10	90 ***	1.12	91	100	-	-
"	0.4	48	4.80	54	0.74	60	100	-	-
ALLOXYDIM-SODIUM	3.0	98	7.71	86 ***	1.16	94 ***	100	0.47	77 ***
" "	6.0	100	7.63	85 ***	1.13	92 ***	100	0.41	67
ASULAM	2.0	40	2.89	32	0.54	44	77	-	-
(sodium salt)	4.0	29	1.39	16	0.37	30	43	-	-
BENAZOLIN	0.375	95	8.17	91 ***	1.10	89 ***	100	0.50	82 ***
(salt)	0.75	86	8.01	89 ***	1.08	88 ***	100	0.39	64
BENTAZON	1.0	95	8.63	96 ***	1.19	97 ***	100	0.49	80 ***
"	2.0	90	7.91	88 ***	1.11	90 ***	100	0.56	92 ***
" + ACTIPRON (5% v/v)	1.0	81	7.61	85 ***	1.02	83 ***	100	0.57	93 ***
" "	2.0	86	7.40	83 ***	0.99	81 ***	100	0.49	80 ***
BENTAZON/MCPB	1.5	100	7.89	88 ***	1.14	93 ***	100	0.57	93 ***
" "	3.0	90	8.16	91 ***	1.07	87 ***	100	0.45	74 ***
BIFENOX	0.5	90	9.26	103 ***	1.33	108 ***	100	0.45	74 ***
"	1.0	86	9.47	106 ***	1.30	106 ***	100	0.51	84 ***
BROMOXYNIL	0.375	52	2.74	31	0.39	32	100	-	-
(ester)	0.75	31	0.50	6	0.09	7	77	-	-
CHLORTHAL DIMETHYL	3.0	100	8.66	97 ***	1.23	100 ***	100	0.39	64
" "	6.0	100	8.89	99 ***	1.17	95 ***	100	0.46	75 ***
DIPHENAMID	3.0	100	9.14	102 ***	1.22	99 ***	100	0.65	107 ***
"	6.0	100	9.13	102 ***	1.27	103 ***	100	0.45	74 ***
ETHOFUMESATE	0.75	60	7.47	83 ***	0.83	68	100	-	-
"	1.5	50	4.71	53	0.57	46	90	-	-

Table 3 continued

IOXYNIL	0.375	67	3.91	44		0.59	48		100	-	-	
(octanoate ester)	0.75	45	1.71	19		0.27	22		100	-	-	
LENACIL	0.75	98	8.34	93	***	1.19	97	***	100	0.56	92	***
"	1.5	86	6.44	72		0.89	72		100	0.42	69	***
MCPB	1.5	95	9.00	101	***	1.23	100	***	100	0.60	98	***
(sodium salt)	3.0	76	7.17	80	***	1.01	82	***	100	0.51	84	***
METHAZOLE	0.375	90	7.83	87	***	1.16	94	***	100	0.38	62	
"	0.75	88	7.12	80	***	1.06	86	***	100	0.34	56	
NITROFEN	1.0	86	8.22	92	***	1.17	95	***	100	0.35	57	
"	2.0	74	7.26	81	***	1.01	82	***	100	0.29	48	
OXADIAZON	0.25	62	5.72	64		0.77	63		100	-	-	
"	0.5	48	3.58	40		0.47	38		100	-	-	
PHENMEDIPHAM	0.5	79	6.59	74		0.89	72		100	-	-	
"	1.0	52	3.24	36		0.42	34		90	-	-	
PROPYZAMIDE	1.0	100	9.98	111	***	1.35	110	***	100	0.46	75	***
"	2.0	100	10.82	121	***	1.47	120	***	100	0.72	118	***
TRIFOP-METHYL	3.0	100	9.30	104	***	1.30	106		100	0.42	69	***
" "	6.0	64	4.52	51		0.59	48		100	0.21	34	

S.E. ±	-	0.67	7.5	0.10	8.2	-	0.07	11.4	

Table 4 Response of fenugreek (Trigonella foenumgraecum, L.) to pre-emergence herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT mean	%	SHOOT DRY WT mean	%	ROOT NODULATION	ROOT DRY WT. mean	%
CONTROL	-	100	7.93	100	0.99	100	100	0.47	100
Substituted ureas									
CHLOROXURON	2.5	100	7.59	96 ***	0.93	94 ***	100	0.46	98 ***
"	5.0	81	5.05	64	0.61	62	100	0.30	64 ***
CHLORTOLURON	0.5	96	7.95	100 ***	1.02	103 ***	100	0.61	130 ***
"	1.0	96	6.42	81 ***	0.74	75 ***	100	0.32	68 ***
DIMEFURON	1.0	54	2.07	26	0.22	22	57	-	-
"	2.0	14	0.34	4	0.04	4	0	-	-
ISOPROTURON	0.5	100	7.37	93 ***	0.97	98 ***	100	-	-
"	1.0	29	0.97	12	0.11	11	23	-	-
K 1441	2.5	90	6.35	80 ***	0.82	83 ***	100	-	-
"	5.0	69	3.93	50	0.46	47	57	-	-
LINURON	0.5	83	5.69	72 ***	0.67	68	100	-	-
"	1.0	11	0.11	1	0.01	1	10	-	-
METHABENZTHIAZURON	1.0	100	8.60	108 ***	1.12	113 ***	100	0.53	113 ***
" "	2.0	90	5.97	75 ***	0.70	71 ***	100	0.32	68 ***
Triazines and related compounds									
AZIPROTRYNE	1.0	100	9.05	114 ***	1.14	115 ***	100	0.54	115 ***
"	2.0	-	5.90	74 ***	0.68	69 ***	-	0.39	84 ***

Table 4 continued

Triazines and related compounds										
CYANAZINE	1.0	69	3.47	44	0.40	40	90	-	-	
"	2.0	14	0.35	4	0.04	4	10	-	-	
METAMITRON	0.25	100	8.36	105 ***	1.06	107 ***	100	0.49	104 ***	
"	5.0	83	5.73	72 ***	0.66	67	100	0.27	57	
METRIBUZIN	0.2	19	0.88	11	0.11	11	23	-	-	
"	0.4	0	0	0	0	0	0	-	-	
PROMETRYNE	1.0	96	6.91	87 ***	0.85	86 ***	100	-	-	
"	2.0	64	3.03	38	0.36	36	77	-	-	
SIMAZINE	0.5	50	1.58	20	0.17	17	23	-	-	
"	1.0	0	0	0	0	0	0	-	-	
TERBUTHYLAZINE	1.0	0	0	0	0	0	0	-	-	
" "	2.0	0	0	0	0	0	0	-	-	
TERBUTRYNE	1.0	79	4.87	61	0.59	60	100	-	-	
"	2.0	46	1.14	14	0.13	13	33	-	-	
TERBUTRYNE/ TERBUTHYLAZINE	0.75	33	1.56	20	0.18	18	43	-	-	
" " "	1.5	0	0	0	0	0	0	-	-	
TRIETAZINE/ SIMAZINE	0.75	69	4.30	54	0.52	53	90	-	-	
" "	1.5	14	0.22	3	0.03	3	57	-	-	
Other herbicides										
ACIFLUORFEN	0.5	47	1.98	25	0.27	27	43	-	-	
"	1.0	40	2.30	29	0.29	29	33	-	-	
ALLOXYDIM-SODIUM	3.0	100	7.89	100 ***	1.01	102 ***	100	0.46	98 ***	
" "	6.0	96	7.01	88 ***	0.86	87 ***	100	0.49	104 ***	

Table 4 cont'd

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%	SHOOT DRY WT. mean	%	ROOT NODULATION	ROOT DRY WT. mean	%
BENTAZON	1.0	100	9.48	120 ***	1.21	122 ***	100	0.54	115 ***
"	2.0	90	7.29	92 ***	0.90	91 ***	100	0.42	89 ***
BIFENOX	1.5	81	6.84	86 ***	0.83	84 ***	100	-	-
"	3.0	64	3.65	46	0.43	43	67	-	-
BUTAM	2.0	100	7.50	95 ***	0.93	94 ***	100	0.47	100 ***
"	4.0	100	7.80	98 ***	1.00	101 ***	100	0.44	94 ***
CARBETAMIDE	1.0	100	7.85	99 ***	1.04	105 ***	100	0.50	106 ***
"	2.0	100	8.27	104 ***	1.01	102 ***	100	0.49	104 ***
CHLORIDAZON	2.0	100	6.71	85 ***	0.81	82 ***	77	-	-
"	4.0	61	2.66	34	0.27	27	43	-	-
CHLORTHAL-DIMETHYL	2.5	100	8.06	102 ***	1.06	107 ***	100	0.51	109 ***
" "	5.0	96	7.06	89 ***	0.89	90 ***	100	0.44	94 ***
DIMETHACHLOR	1.5	46	2.34	30	0.28	28	43	-	-
"	3.0	10	0.09	1	0.01	1	0	-	-
DIPHENAMID	2.5	100	7.59	96 ***	0.96	97 ***	100	0.46	98 ***
"	5.0	86	5.48	69	0.63	64	90	0.31	66 ***
ETHOFUMESATE	1.0	67	5.39	68	0.56	57	77	-	-
"	2.0	57	5.12	65	0.51	52	67	-	-
FLURIDONE	0.5	0	0	0	0	0	0	-	-
"	1.0	0	0	0	0	0	0	-	-
LENACIL	0.75	83	6.03	76 ***	0.75	76 ***	100	-	-
"	1.5	47	2.19	28	0.25	25	33	-	-
METHAZOLE	0.75	90	8.34	105 ***	1.06	107 ***	100	0.49	104 ***
"	1.5	100	8.80	111 ***	1.06	107 ***	100	0.52	111 ***
METOLACHLOR	1.5	71	6.07	77 ***	0.64	65	77	-	-
"	3.0	60	4.82	61	0.48	49	67	-	-

Table 4 continued

NITROFEN	1.5	96	8.59	108 ***	1.06	107 ***	100	0.51	109 ***
"	3.0	90	7.04	89 ***	0.84	85 ***	100	0.40	85 ***
OXADIAZON	0.75	69	3.95	50	0.46	47	67	-	-
"	1.5	61	2.41	30	0.28	28	43	-	-
OXYFLUORFEN	0.5	64	2.91	37	0.34	34	57	-	-
"	1.0	43	1.56	20	0.23	23	33	-	-
PENDIMETHALIN	2.0	53	5.10	64	0.61	62	100	-	-
"	4.0	29	1.56	20	0.28	28	23	-	-
PERFLUIDONE	2.5	90	7.32	92 ***	0.96	97 ***	100	0.45	96 ***
"	5.0	81	5.88	74 ***	0.80	81 ***	90	0.40	85 ***
PROPACHLOR	2.5	100	9.09	115 ***	1.11	112 ***	100	0.45	96 ***
"	5.0	86	7.24	91 ***	0.85	86 ***	100	0.45	96 ***
PROPYZAMIDE	1.0	100	8.74	110 ***	1.07	108 ***	100	0.52	111 ***
"	2.0	76	6.88	87 ***	0.78	79 ***	100	0.41	87 ***
TRIFOP-METHYL	3.0	100	8.33	105 ***	1.09	110 ***	100	0.43	92 ***
"	6.0	90	6.54	83 ***	0.87	88 ***	100	0.42	89 ***
	S.E. ±	-	0.85	10.8	0.11	11.2		0.06	13.5

Table 4 continued - Incorporated treatments

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%	SHOOT DRY WT. mean	%	ROOT NODULATION	ROOT DRY WT. mean	%
CONTROL	-	100	5.68	100	0.70	100	100	0.32	100
CHLORPROPHAM	1.5	90	4.93	87 ***	0.58	83 ***	100	0.25	78 ***
"	3.0	100	7.03	124 ***	0.83	119 ***	100	0.39	122 ***
DINITRAMINE	0.5	81	5.05	89 ***	0.62	89 ***	100	0.37	116 ***
"	1.0	74	3.33	59 ***	0.42	60 ***	77	0.31	97 ***
EPTC	2.0	89	4.94	87 ***	0.55	79 ***	90	0.25	78 ***
"	4.0	81	4.38	77 ***	0.50	71 ***	67	0.24	75 ***
TRI-ALLATE	1.0	100	6.39	113 ***	0.82	117 ***	100	0.34	106 ***
"	2.0	100	6.24	110 ***	0.74	106 ***	100	0.44	138 ***
TRIFLURALIN	0.5	90	5.29	93 ***	0.62	89 ***	100	0.32	100 ***
"	1.0	100	6.03	106 ***	0.73	104 ***	100	0.35	109 ***
	S.E. ±	-	1.03	18.2	0.13	18.7	-	0.06	18.9

Table 5 Response of peas to post-emergence herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%		SHOOT DRY WT. mean	%		ROOT NODULATION
CONTROL	-	100	14.28	100		1.92	100		100
MCPB	1.5	96	11.15	78	***	1.37	71		100
	3.0	71	9.63	67		1.23	64		100
BENTAZON	1.0	100	13.21	93	***	1.68	88	***	100
"	2.0	86	10.02	70		1.33	69		100
" + ACTIPRON	1.0	100	12.43	87	***	1.58	82	***	100
" + "	2.0	86	10.85	76	***	1.58	82	***	100
BENAZOLIN	0.375	89	11.45	80	***	1.51	79	***	100
	0.75	96	13.20	92	***	1.74	91	***	100
ACIFLUORFEN	0.2	83	10.94	77	***	1.38	72		100
	0.4	69	10.41	73		1.32	69		100
CHLOROXURON	4.0	96	13.03	91	***	1.66	87	***	100
	8.0	79	9.24	65		1.29	67		100
CYANAZINE	1.0	86	10.89	76	***	1.49	78	***	100
	2.0	64	7.91	55		1.12	58		100
AZIPROTRYNE	1.0	100	11.45	80	***	1.48	77		100
	2.0	90	10.37	73		1.37	71		100
TERBUTRYNE	0.5	90	10.95	77	***	1.46	76		100
	1.0	81	10.25	72		1.45	76		100
ALLOXYDIM-SODIUM	3.0	96	13.94	98	***	1.85	96	***	100
	6.0	90	11.16	78	***	1.56	81	***	100
TRIFOP-METHYL	3.0	76	8.34	58		1.21	63		100
	6.0	69	9.53	67		1.41	73		100
BENTAZON/MCPB	1.5	100	13.55	95	***	1.72	90	***	100
	3.0	83	10.80	76	***	1.46	76		100
CYANAZINE/MCPB	1.0	96	11.50	81	***	1.55	81	***	100
	2.0	83	9.70	68		1.27	66		100
	S.E. ±		1.30	9.1		0.16	8.4		

Table 6 Response of peas to pre-emergence herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%	SHOOT DRY WT. mean	%	ROOT NODULATION
CONTROL	-	100	16.82	100	1.91	100	100
BENTAZON	1.0	96	12.97	77	1.46	76 ***	100
	2.0	60	8.33	50	1.00	52	77
BIFENOX	1.5	81	10.69	64	1.24	65 ***	77
	3.0	74	8.86	53	1.01	53	90
OXADIAZON	0.75	57	5.42	32	0.60	31	67
	1.5	36	2.60	16	0.34	18	43
ACIFLUORFEN	0.5	96	14.50	86 ***	1.70	89 ***	100
	1.0	90	15.23	91 ***	1.71	90 ***	100
OXYFLUORFEN	0.5	76	10.07	60	1.15	60	90
	1.0	67	7.95	47	0.88	46	90
METHAZOLE	0.75	96	19.88	118 ***	2.29	120 ***	100
	1.5	90	17.53	104 ***	1.91	100 ***	100
ETHOFUMESATE	1.0	86	15.81	94 ***	1.61	84 ***	100
	2.0	57	7.47	44	0.79	41	67
METHABENZTHIAZURON	1.0	100	15.65	93 ***	1.75	92 ***	100
	2.0	93	16.21	96 ***	1.82	95 ***	100
DIMEFURON	1.0	81	10.73	64	1.12	59	90
	2.0	21	2.23	13	0.32	17	23
CHLOROXURON	2.5	90	17.20	102 ***	1.84	96 ***	100
	5.0	81	14.59	87 ***	1.61	84 ***	90
CYANAZINE	1.0	81	12.05	72	1.40	73 ***	90
	2.0	86	14.41	86 ***	1.67	87 ***	100
TERBUTRYNE	1.0	86	14.14	84 ***	1.64	86 ***	100
	2.0	81	12.41	74	1.41	74 ***	100
PROMETRYNE	1.0	90	17.56	104 ***	1.96	103 ***	100
	2.0	79	12.60	75	1.33	70 ***	100
TERBUTHYLAZINE	1.0	69	11.85	71	1.27	67 ***	77
	2.0	69	10.15	60	0.94	49	43

Table 6 continued

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean		SHOOT DRY WT. mean		ROOT NODULATION
METAMITRON	2.5	74	10.49	62	1.02	53	77
	5.0	54	6.79	40	0.61	32	57
CHLORTHAL-DIMETHYL	2.5	96	18.31	109 ***	2.03	106 ***	100
	5.0	90	16.15	96 ***	1.73	91 ***	100
PENDIMETHALIN	2.0	83	12.73	76	1.37	72 ***	90
	4.0	89	15.48	92 ***	1.78	93 ***	100
PERFLUIDONE	2.5	71	9.56	57	1.16	61	77
	5.0	76	12.12	72	1.56	82 ***	90
BUTAM	2.0	71	10.94	65	1.06	56	90
	4.0	46	3.28	20	0.28	15	43
FLURIDONE	0.5	60	9.34	56	0.94	49	90
	1.0	14	0.67	4	0.09	5	0
METOLACHLOR	1.5	67	10.48	62	1.12	59	67
	3.0	83	14.79	88 ***	1.75	92 ***	90
ALLOXYDIM-SODIUM	3.0	100	17.26	103 ***	1.80	94 ***	90
	6.0	100	17.14	102 ***	1.84	96 ***	100
TRIFOP-METHYL	3.0	89	13.53	80 ***	1.51	79 ***	100
	6.0	81	11.92	71	1.42	74 ***	77
TERBUTRYNE/ TERBUTHYLAZINE	0.75	90	15.49	92 ***	1.71	90 ***	90
" "	1.5	89	15.83	94 ***	1.80	94 ***	90
TRIETAZINE/SIMAZINE	0.75	74	13.04	78	1.40	73 ***	67
	1.5	76	10.05	60	1.12	59	67
	S.E. ±		0.77	4.6	0.25	13.2	
CONTROL *	-	100	12.59	100	1.45	100	100
TRIALLATE *	1.0	100	12.23	97 ***	1.40	97 ***	90
	2.0	100	15.08	120 ***	1.86	128 ***	100
CHLORPROPHAM *	1.5	100	13.91	111 ***	1.58	109 ***	100
	3.0	100	13.43	107 ***	1.61	111 ***	100
	S.E. ±		1.85	14.7	0.19	13.3	

* INCORPORATED TREATMENTS

Table 7 Response of dwarf bean to post-emergence herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%		SHOOT DRY WT. mean	%		ROOT NODULATION
CONTROL	-	100	13.83	100		2.51	100		97
BENTAZON	1.0	96	14.37	104	***	2.36	94	***	93
"	3.0	100	15.13	109	***	2.69	107	***	93
" + ACTIPRON	1.0	81	13.69	99	***	2.34	93	***	93
" + "	2.0	76	11.95	86	***	2.06	82	***	79
ACIFLUORFEN	0.2	74	12.66	92	***	2.09	83	***	104
	0.4	71	11.75	85	***	1.98	79		79
CHLOROXURON	4.0	47	4.70	34		0.87	35		10
	8.0	19	1.94	14		0.66	26		0
CYANAZINE	1.0	14	1.47	11		0.64	26		0
	2.0	14	1.67	12		0.70	28		10
AZIPROTRYNE	1.0	53	6.53	47		1.07	43		35
	2.0	17	1.85	13		0.66	26		0
TERBUTRYNE	0.5	21	3.18	23		0.83	33		0
	1.0	24	3.02	22		0.85	34		10
ALLOXYDIM-SODIUM	3.0	90	11.61	84	***	1.80	72		104
	6.0	83	12.99	94	***	2.12	85	***	79
TRIFOP-METHYL	3.0	74	11.22	81	***	1.77	71		79
	6.0	71	11.66	84	***	1.82	73		69
BENTAZON/MCPB	1.5	69	12.75	92	***	2.00	80	***	93
	3.0	67	12.32	89	***	1.89	75		104
CYANAZINE/MCPB	1.0	43	4.51	33		0.89	36		35
	2.0	24	3.84	28		0.95	38		24
	S.E. ±	-	0.99	7.2		0.18	7.1		-

Table 8 Response of dwarf bean to pre-emergence herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT mean	%		SHOOT DRY WT. mean	%		ROOT NODULATION
CONTROL	-	100	15.43	100		2.63	100		100
BENTAZON	1.0	96	17.64	114	***	3.02	115	***	100
	2.0	100	15.83	103	***	2.61	99	***	100
BIFENOX	1.5	90	14.39	93	***	2.37	90	***	100
	3.0	79	15.33	99	***	2.49	95	***	100
OXADIAZON	0.75	96	17.08	111	***	2.79	106	***	100
	1.5	100	14.28	93	***	2.21	84	***	100
ACIFLUORFEN	0.5	96	14.53	94	***	2.50	95	***	57
	1.0	67	9.93	64		1.41	54		10
OXYFLUORFEN	0.5	100	17.33	112	***	2.92	111	***	67
	1.0	93	18.14	118	***	3.08	117	***	77
ETHOFUMESATE	1.0	79	12.70	82	***	2.05	78	***	77
	2.0	81	16.82	109	***	2.77	105	***	90
METHABENZTHIAZURON	1.0	96	14.62	95	***	2.58	98	***	90
	2.0	86	17.39	113	***	2.20	84	***	90
CHLOROXURON	2.5	96	17.99	117	***	2.91	111	***	90
	5.0	86	17.13	111	***	2.67	102	***	67
METAMITRON	2.5	67	13.04	85	***	1.73	66		33
	5.0	4	0.45	3		0.16	6		0
DIPHENAMID	2.5	100	17.15	111	***	2.60	99	***	90
	5.0	81	13.18	85	***	1.95	74	***	100
PENDIMETHALIN	2.0	100	18.46	120	***	3.02	115	***	90
	4.0	86	15.22	99	***	2.61	99	***	90
PERFLUIDONE	2.5	96	16.80	109	***	2.98	113	***	77
	5.0	90	16.15	105	***	2.77	105	***	57
K 1441	2.5	100	13.63	88	***	2.31	88	***	100
	5.0	90	14.53	94	***	2.31	88	***	57
BUTAM	2.0	61	13.02	84	***	1.96	74	***	77
	4.0	64	13.45	87	***	2.00	76	***	57

Table 8 continued

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%		SHOOT DRY WT. mean	%		ROOT NODULATION
DIMETHACHLOR	1.5	67	13.74	89	***	1.80	68		43
	3.0	50	10.89	71	***	1.64	62		43
METOLACHLOR	1.5	100	18.56	120	***	3.18	121	***	100
	3.0	100	17.25	112	***	2.75	105	***	90
ALLOXYDIM-SODIUM	3.0	100	14.84	96	***	2.14	81	***	87
	6.0	90	14.86	96	***	2.37	90	***	77
TRIFOP-METHYL	3.0	100	14.80	96	***	2.50	95	***	67
	6.0	69	11.42	74		1.90	72	***	10
TERBUTRYNE/ TERBUTHYLAZINE	0.75	36	3.42	22		0.58	22		0
" "	1.5	19	2.08	14		0.53	20		0
	S.E. ±		1.81	11.7		0.29	10.9		
CONTROL *	1.0	100	16.09	100		2.67	100		100
TRIALLATE *	1.0	100	13.59	85	***	2.06	77	***	100
	2.0	93	14.18	88	***	2.07	78	***	67
TRIFLURALIN *	0.5	100	15.72	98	***	2.47	93	***	77
	1.0	100	15.41	96	***	2.58	97	***	77
CHLORPROPHAM *	1.5	100	14.53	90	***	2.23	84	***	90
	3.0	74	12.11	75	***	1.74	65		33
EPTC*	2.0	100	14.55	90	***	2.34	88	***	100
	4.0	100	15.56	97	***	2.51	94	***	90
	S.E. ±		1.37	8.5		0.24	9.1		

* INCORPORATED TREATMENTS

Table 9 Response of field bean to post-emergence herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%		SHOOT DRY WT. mean	%		ROOT NODULATION
CONTROL	-	100	14.99	100		1.60	100		100
BENTAZON	1.0	100	16.36	109	***	1.74	109	***	100
"	2.0	81	12.47	83	***	1.41	88	***	100
" + ACTIPRON	1.0	76	12.29	82	***	1.29	81	***	100
	2.0	76	11.50	77		1.24	78		100
ACIFLUORFEN	0.2	46	6.81	45		0.86	54		57
	0.4	39	4.18	28		0.65	41		43
CHLOROXURON	4.0	26	1.56	10		0.18	11		23
	8.0	10	0.48	3		0.07	4		10
CYANAZINE	1.0	10	0.55	4		0.05	3		10
	2.0	4	0.06	1		0.01	1		0
AZIPROTRYNE	1.0	100	14.29	95	***	1.43	89	***	100
	2.0	81	11.02	74		1.18	74		77
TERBUTRYNE	0.5	0	0	0		0	0		0
	1.0	0	0	0		0	0		0
ALLOXYDIM-SODIUM	3.0	67	12.88	86	***	1.34	84	***	100
	6.0	61	10.98	73		1.20	75		90
TRIFOP-METHYL	3.0	67	12.41	83	***	1.38	86	***	90
	6.0	67	12.21	81	***	1.34	84	***	100
BENTAZON/MCPB	1.5	96	14.35	96	***	1.47	92	***	100
	3.0	81	8.49	57		0.94	59		90
CYANAZINE/MCPB	1.0	0	0	0		0	0		0
	2.0	0	0	0		0	0		0
	S.E. ±		1.05	7.0		0.11	7.1		

Table 10 Response of field bean to pre-emergence herbicides

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%		SHOOT DRY WT. mean	%		ROOT NODULATION
CONTROL	-	100	25.22	100		2.30	100		100
BENTAZON	1.0	90	22.78	90	***	1.99	87	***	100
	2.0	86	19.64	78	***	1.91	83	***	100
BIFENOX	1.5	100	25.52	101	***	2.35	102	***	100
	3.0	100	19.84	79	***	1.84	80	***	100
ACIFLUORFEN	0.5	96	19.66	78	***	1.75	76	***	100
	1.0	74	17.58	70		1.54	67		67
OXYFLUORFEN	0.5	86	18.46	73		1.66	72		100
	1.0	74	15.13	60		1.32	57		100
METHABENZTHIAZURON	1.0	100	20.81	83	***	1.84	80	***	90
	2.0	100	28.17	112	***	2.42	105	***	100
CHLOROXURON	2.5	96	22.17	88	***	2.07	90	***	100
	5.0	96	23.60	94	***	2.10	91	***	90
SIMAZINE	0.5	74	19.63	78		1.54	67		90
	1.0	47	7.51	30		0.67	29		33
PENDIMETHALIN	2.0	96	25.15	100	***	2.37	103	***	100
	4.0	74	16.52	66		1.67	73		90
PERFLUIDONE	2.5	100	25.70	102	***	2.32	101	***	100
	5.0	86	23.13	92	***	2.04	89	***	100
ALLOXYDIM-SODIUM	3.0	100	26.82	106	***	2.30	100	***	100
	6.0	96	22.61	90	***	2.09	91	***	100
TRIFOP-METHYL	3.0	96	17.51	69		1.59	69		100
	6.0	100	24.84	99	***	2.26	98	***	100
TERBUTRYNE/ TERBUTHYLAZINE	0.75	100	23.40	93	***	1.95	85	***	100
" " "	1.5	76	12.42	49		1.01	44		90
	S.E. ±		2.21	8.8		0.20	8.8		

Table 10 continued

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%		SHOOT DRY WT. mean	%		ROOT NODULATION
CONTROL *	-	100	17.27	100		1.64	100		100
TRIALLATE *	1.0	100	21.35	124	***	2.03	124	***	100
	2.0	100	17.59	102	***	1.72	105	***	100
TRIFLURALIN *	0.5	100	18.26	106	***	1.74	106	***	100
	1.0	100	16.06	93	***	1.64	100	***	100
CHLORPROPHAM *	1.5	100	17.10	99	***	1.61	98	***	100
	3.0	86	13.09	76	***	1.21	74	***	100
	S.E. ±		1.94	11.3		0.17	10.3		

* INCORPORATED TREATMENTS

Table 11 Response of fenugreek to post-emergence herbicide treatments

	DOSE (kg ai/ha)	PLANT VIGOUR (as % of control)	SHOOT FRESH WT. mean	%	SHOOT DRY WT. mean	%	ROOT NODULATION	ROOT DRY WEIGHT mean	%
CONTROL	-	100	12.19	100	1.35	100	100	0.64	100
METHAZOLE	1.5	100	10.21	84 **	1.03	76 *	100	0.51	80 ***
"	3.0	79	8.54	70	0.86	64	100	0.40	63 **
METAMITRON	4.0	100	10.84	89 ***	1.16	86 ***	100	0.51	80 ***
"	8.0	93	8.86	73	0.92	68	100	0.45	70 *
" + ACTIPRON	4.0 + 5%	43	4.08	34	0.66	49	67	0.30	47
" + "	8.0 + 5%	41	4.09	34	0.74	55	60	0.36	56
BIFENOX W.P.	1.5	86	11.14	91 ***	1.23	91 ***	100	0.57	89 ***
" "	3.0	86	11.35	93 ***	1.26	93 ***	93	0.52	81 ***
" e.c.	1.5	43	5.76	47	0.88	65	83	0.51	80 ***
" "	3.0	37	5.01	41	0.89	66	83	0.41	64 *
	S.E. ±		0.60	5	0.07	5		0.05	9

*, **, *** refer to treatments not significantly less than control at P 0.01, 0.1 and 0.5 respectively.

ABBREVIATIONS

ångström	Å	freezing point	f.p.
Abstract	Abs.	from summary	F.s.
acid equivalent*	a.e.	gallon	gal
acre	ac	gallons per hour	gal/h
active ingredient*	a.i.	gallons per acre	gal/ac
approximately equal to*	≃	gas liquid chromatography	GLC
aqueous concentrate	a.c.	gramme	g
bibliography	bibl.	hectare	ha
boiling point	b.p.	hectokilogram	hkg
bushel	bu	high volume	HV
centigrade	C	horse power	hp
centimetre*	cm	hour	h
concentrated	concd	hundredweight*	cwt
concentration	concn	hydrogen ion concentration*	pH
concentration x time product	ct	inch	in.
concentration required to kill 50% test animals	LC50	infra red	i.r.
		kilogramme	kg
cubic centimetre*	cm^3	kilo ($x10^3$)	k
cubic foot*	ft^3	less than	<
cubic inch*	in^3	litre	l.
cubic metre*	m^3	low volume	LV
cubic yard*	yd^3	maximum	max.
cultivar(s)	cv.	median lethal dose	LD50
curie*	Ci	medium volume	MV
degree Celsius*	°C	melting point	m.p.
degree centigrade	°C	metre	m
degree Fahrenheit*	°F	micro ($x10^{-6}$)	μ
diameter	diam.	microgramme*	μg
diameter at breast height	d.b.h.	micromicro (pico: $x10^{-12}$)*	μμ
divided by*	÷ or /	micrometre (micron)*	μm (or μ)
dry matter	d.m.	micron (micrometre)*†	μm (or μ)
emulsifiable concentrate	e.c.	miles per hour*	mile/h
		milli ($x10^{-3}$)	m
equal to*	=	milliequivalent*	m.equiv.
fluid	fl.	milligramme	mg
foot	ft	millilitre	ml

† The name micrometre is preferred to micron and μm is preferred to μ.

millimetre*	mm
millimicro* (nano: $x10^{-9}$)	n or mμ
minimum	min.
minus	-
minute	min
molar concentration*	M (small cap)
molecule, molecular	mol.
more than	>
multiplied by*	x
normal concentration*	N (small cap)
not dated	n.d.
oil miscible concentrate	o.m.c. (tables only)
organic matter	o.m.
ounce	oz
ounces per gallon	oz/gal
page	p.
pages	pp.
parts per million	ppm
parts per million by volume	ppmv
parts per million by weight	ppmw
percent(age)	%
pico (micromicro: $x10^{-12}$)	p or μμ
pint	pint
pints per acre	pints/ac
plus or minus*	±
post-emergence	post-em
pound	lb
pound per acre*	lb/ac
pounds per minute	lb/min
pound per square inch*	lb/in^2
powder for dry application	p. (tables only)
power take off	p.t.o.
precipitate (noun)	ppt.
pre-emergence	pre-em.
quart	quart
relative humidity	r.h.
revolution per minute*	rev/min
second	s
soluble concentrate	s.c.
soluble powder	s.p.
solution	soln
species (singular)	sp.
species (plural)	spp.
specific gravity	sp. gr.
square foot*	ft^2
square inch	in^2
square metre*	m^2
square root of*	$\sqrt{}$
sub-species*	ssp.
summary	s.
temperature	temp.
ton	ton
tonne	t
ultra-low volume	ULV
ultra violet	u.v.
vapour density	v.d.
vapour pressure	v.p.
varietas	var.
volt	V
volume	vol.
volume per volume	v/v
water soluble powder	w.s.p. (tables only)
watt	W
weight	wt
weight per volume*	w/v
weight per weight*	w/w
wettable powder	w.p.
yard	yd
yards per minute	yd/min

* Those marked * should normally be used in the text as well as in tables etc.

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52. Antidotes for the protection of field bean (Vicia faba L.) from damage by EPTC and other herbicides. February 1979. A M Blair. Price - £1.35

53. Antidotes for the protection of wheat from damage by tri-allate. February 1979. A M Blair. Price - £2.00

54. The activity and pre-emergence selectivity of some recently developed herbicices: alachlor, metolachlor, dimethachlor, alloxydim-sodium and fluridone. April 1979. W G Richardson and C Parker. Price - £3.00

55. The activity and selectivity of the herbicides carbetamide, methazole, R 11913 and OCS 21693. May 1979. W G Richardson and C Parker. Price - £1.80

56. Growing weeds from seeds and other propagules for experimental purposes. July 1979. R H Webster. Price - £1.10

57. The activity and pre-emergence selectivity of some recently developed herbicides: R 40244, AC 206784, pendimethalin, butralin, acifluorfen and FMC 39821. December 1979. W G Richardson, T M West and C Parker - Price - £3.55

58. The tolerance of fenugreek (Trigonella foenumgraecum L.) to various herbicides. December 1979. W G Richardson. Price - £1.55