WEED RESEARCH ORGANIZATION

TECHNICAL REPORT No. 51

THE ACTIVITY AND SELECTIVITY OF THE HERBICIDES METHABENZTHIAZURON, METOXURON, CHLORTOLURON AND CYANAZINE

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September 1978

Price - £2.20

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ISBN 0 7084 0093 0
ISSN 0511-4136

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NOTE

RICHARDSON, W.G. and PARKER, C. (1978) The activity and selectivity of the herbicides methabenzthiazuron, metoxuron, chlortoluron and cyanazine. Technical Report Agricultural Research Council Weed Research Organization, 1978, (51), pp 40.

THE ACTIVITY AND SELECTIVITY OF THE HERBICIDES METHABENZTHIAZURON, METOXURON, CHLORTOLURON AND CYANAZINE

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SUMMARY

In a series of pot experiments in the glasshouse, four herbicides which inhibit photosynthesis were examined for pre- and/or post-emergence selectivities in 26 to 50 temperate and tropical crop and weed species. The route of action of these herbicides was examined in a separate test on six selected test species. In conjunction with the pre-emergence selectivity tests, persistence of the herbicides in the soil was examined.

All four herbicides tended to be more phytotoxic via the soil rather than as foliar sprays, although symptoms occurred with the latter, more so on broad-leaved than grass species.

With methabenzthiazuron better selective control occurred post- rather than pre-emergence, several annual weeds being susceptible to doses tolerated by such crops as pea, perennial ryegrass, onion and maize.

Similarly, metoxuron was more effective post-emergence, when several annual weeds, including <u>Galium aparine</u> were controlled at doses tolerated by carrot and certain cereals.

Chlortoluron was effective pre- and post-emergence and potentially selective in certain temperate and tropical cereals. An advantage of the pre-emergence application was the control of <u>Avena fatua</u> as well as several other grass and broad-leaved weeds.

Cyanazine, only tested for pre-emergence selectivities, controlled several annual broad-leaved and grass weeds at doses tolerated by maize, sorghum, cotton and large-seeded temperate and tropical leguminous crops.

Persistence in the soil was short for metoxuron and cyanazine but somewhat longer for chlortoluron and methabenzthiazuron.

INTRODUCTION

This report records the activity of chlortoluron and cyanazine, pre-emergence selectivities for these two herbicides and methabenzthiazuron and post-emergence selectivities for methabenzthiazuron, metoxuron and chlortoluron. For comparison, pre-emergence selectivities for metoxuron have been included from a previous report, as well as activity experiment data for this herbicide and methabenzthiazuron. These experiments were carried out between 1967 to 1970 but results were not published for various reasons. Although therefore of limited value for

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some purposes it was felt that the results could still prove useful, for example, for comparison of herbicides used in similar situations, for consideration as components of herbicide mixtures and also for possible uses against more recent weed problems, e.g. volunteer cereals and brassicas.

It should be emphasized that the work was carried out on only one crop variety or source of weed species, in one particular soil type without intraspecific competition and at one growth stage. Also, plant responses in pots, especially in the glasshouse, can be very different from those in the field.

METHODS AND MATERIALS

Activity experiments. These were carried out in the manner standardized by Richardson and Dean (1973a). Herbicides were applied to the standard six test species (i) as a foliar spray, avoiding contact with the soil, (ii) as a post-emergence soil drench, avoiding foliage, (iii) as a pre-emergence surface application and (iv) as a pre-planting spray with thorough incorporation. The four annual species were raised from seed and the two perennials grown from rhizome fragments. Species data and environmental conditions are summarised in Tables 1 and 2.

Table 1. Plant data for activity experiments

Species	Cultivar/ source	No. per pot at spraying		Depth of planting (cm)	Stage of growth of post-emergence treatments	Stage of growth at assessment (leaf numbers exclusive of cotyledons)	
		pre-	post-			pre-	post-
Dwarf bean (*Phaseolus vulgaris*)	The Prince	2-3	2-3	1.8	2 unifoliates	1½-2½ trifoliate leaves	1½ trifoliate leaves
Kale (*Brassica oleracea acephala*)	Marrow stem	8-10	5	0.6	1-2 leaves	3-4½ leaves	3½-4½ leaves
Polygonum amphibium	WRO Clone 1	6	2-5	1.2	2½-4½ leaves	7-8 leaves	5-8½ leaves
Perennial ryegrass (*Lolium perenne*)	S 23	10-15	8-10	0.6	2-2½ leaves	4-8 leaves, tillering	4½-9 leaves, tillering
Avena fatua	Boxworth 1967 Wytham 1961	8-10	4-6	1.2	2-3 leaves	5-9 leaves, tillering	4½-9 leaves, tillering
Agropyron repens	WRO Clone 31	6	4-5	1.2	1½-2½ leaves	4½-8 leaves, tillering	5-9 leaves, tillering

Selectivity experiments. These were of the standard form as reported previously by Richardson and Dean (1973a, 1973b). Soil and environmental conditions are summarised in Table 2 and plant data and stages of growth in Appendices I and II.

In the pre-emergence experiments, soil from a field at Begbroke was confined in tins and sprayed with the herbicides. The tins were emptied and the soil was thoroughly mixed to incorporate the herbicides. Individual species were sown in pots at measured depths. The pots were kept in the glasshouse and watered from overhead.

In the post-emergence experiment, plants were grown in soil from the field and treated at one stage of growth, following thinning to a constant number. Temperate species were raised throughout in the open on a paved area and tropical species in a glasshouse.

Radish (Raphanus raphanistrum) was included for ease of propagation and may be regarded as a crop or weed. To improve establishment, the following treatments were applied:-

Chenopodium album. Seeds soaked in 0.1M KNO_3 and kept in the light for three days before planting.

Cyperus esculentus. Tubers stored moist at 4°C for 5 weeks.

Polygonum aviculare. Seeds immersed in concentrated sulphuric acid for five minutes, washed in running water for one hour, dried and kept at 2°C for one week prior to sowing (post-emergence test only).

Herbicide treatment

Herbicides were applied by a laboratory sprayer embodying a Tee jet fan nozzle operating at a pressure of 2.11 bars (30 lb/in^2) moving at a constant speed 30 cm above the soil or plants. All doses are in terms of active ingredient (a.i.) unless otherwise specified.

Assessment and processing of results

In the selectivity experiments surviving plants were counted and their vigour was scored on a 0-7 scale as defined by Richardson and Dean (1973a) where 0 = dead and 7 = control. A computer was used to process the selectivity experiment data as before. For each herbicide a table of results is presented which includes a pair of figures; the first representing mean plant survival and the second, mean vigour score, both calculated as a percentage of untreated controls. Thus 100/100 = as control; 0/0 = complete kill. In the activity experiment a histogram is presented for each treatment, the upper row of x's representing mean plant survival and the lower, mean vigour score. Each x represents a 7% increment and a "+" indicates a value in excess of 100%. "R" indicates a result based on one replicate only and "M" represents a missing treatment. For methabenzthiazuron and metoxuron, the assessment was based on the vigour of surviving plants (not numbers).

Herbicide persistence in the soil

Soil treated with chlortoluron or cyanazine from pre-emergence experiment 3 was stored in glass jars at 23°C in the dark and sub-sampled at intervals. The soil moisture level fell from 14% at the start of the experiment to 8% after one year. Soil sprayed with methabenzthiazuron was kept in tins under temperate glasshouse conditions, moistened by normal overhead watering and sub-sampled for pot bioassays periodically after emptying the tins and thoroughly mixing the soil. Untreated soil was stored and sown in a similar manner in each type of experiment. Sensitive species were planted and assessments made at the 2-4 leaf stage (Richardson and Dean, 1973a).

Table 2. Soil and environmental conditions

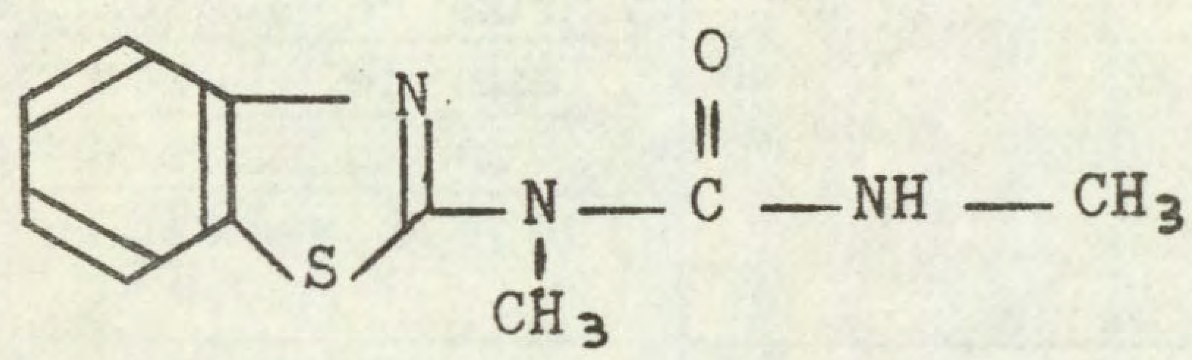
	Activity experiments			Selectivity experiments							
				pre-emergence						post emergence	
Experiment type and number	AE 1 Metoxuron Methabenz-thiazuron	AE 2 Chlortoluron	AE 3 Cyanazine	1 Metoxuron		2 Methabenz-thiazuron		3 Chlortoluron Cyanazine		Methabenz-thiazuron Metoxuron Chlortoluron	
Date of spraying	9.5.67	15.5.70	4.7.69	21.3.67		(25 (26.10.67		20.1.70		5.8.70	
Main assessment completed	25.5.67	15.6.70	1.8.69	28.4.67		8.12.67		10.3.70		21.8.70	
Soil moisture (%)	-	-	-	-		-		14.0		-	
Organic matter (%)	1.8	1.8	1.8	1.8		1.8		1.8		1.8	
Clay content (%)	19.2	13.0	13.0	14.0		19.2		13.0		13.0	
pH	7.0	7.3	7.3	6.8		7.0		7.3		7.3	
John Innes base fertiliser (g/kg)	4.0	4.0	4.0	4.0		4.0		1.5		1.0	
5% DDT dust (g/kg)	0.5	0.5	0.5	0.5		-		0.5		0.5	
Aldrin dust (g/kg)	-	-	-	-		3.0		-		-	
	Temperate	Temperate	Temperate	Temperate	Tropical	Temperate	Tropical	Temperate	Tropical	Temperate	Tropical
Temperature (°C)											
Mean	19	20	22	15	20	15	23	17	22	17	25
Maximum	29	32	35	22	26	20	25	25	26	23	28
Minimum	11	11	17	10	15	9	15	14	18	11	23
Relative humidity (%)											
Mean	60	60	55	60	55	65	55	60	55	75	80
Maximum	90	95	84	89	80	90	86	90	90	95	95
Minimum	30	34	30	28	30	42	38	40	40	40	55

METHABENZTHIAZURON

<u>Code number</u> Bayer 74283 <u>Trade name</u> Tribunil

<u>Chemical name</u> N-(benzothiazol-2-yl)-N, N'-dimethylurea

<u>Structure</u>



<u>Source</u> Bayer UK Ltd
Agrochemical Division
Eastern Way
Bury St Edmunds
Suffolk IP23 7AH

<u>Information available and suggested uses</u>

Approved for control of <u>Alopecurus myosuroides</u>, <u>Poa annua</u> and certain other annual weeds pre- or early post-emergence in winter cereals and perennial ryegrass seed crops; also <u>Poa</u> species and certain broad-leaved weeds in spring barley and winter rye.

<u>Formulation used</u> Wettable powder 70% w/w a.i.

<u>Spray volume</u> 347 l/ha (30.9 gal/ac) for activity and pre-emergence selectivity tests.
338 l/ha (30.1 gal/ac) for post-emergence selectivity test.

RESULTS

Full results are given on pages 9 - 11 and potential selectivities are summarised in the following tables.

Table 3. <u>Potential pre-emergence selectivities</u>

RATE (kg a.i./ha)	CROPS: vigour reduced by 15% or less	WEEDS: number or vigour reduced by 70% or more
3.36	None	None listed as no crops tolerant
1.12	wheat dwarf bean field bean pea maize groundnut	<u>Stellaria media</u>
0.37	None listed as no weeds controlled	None

Table 4. Potential post-emergence selectivities

RATE (kg a.i./ha)	CROPS: vigour reduced by 15% or less	WEEDS: number or vigour reduced by 70% or more
1.6	pea	Polygonum aviculare Galium aparine Agrostis stolonifera Eleusine indica Echinochloa crus-galli + species below
0.4	species above + perennial ryegrass onion maize	Poa annua Poa trivialis Sinapis arvensis Raphanus raphanistrum Tripleurospermum maritimum Senecio vulgaris Polygonum lapathifolium Rumex crispus Chenopodium album Stellaria media Spergula arvensis Portulaca oleracea + species below
0.1	species above + wheat barley oat field bean white clover kale cabbage carrot parsnip sorghum rice groundnut soyabean	Amaranthus retroflexus

Comments on results

Activity experiment (see page 9)

Although this herbicide was mainly soil acting, at least on the grasses, nevertheless considerable effects were found on broad-leaved species with the foliar sprays, the lowest dose of these being even more active than the soil drench on these species. Although some effects resulted on grass species from the foliar spray, the soil drenches were much more active. There was a tendency towards more effectiveness with the pre-emergence treatments than with the soil drenches, although these differences were not large except possibly with kale at the lowest dose. Generally, treatments incorporated into the soil resulted in slightly more activity than the surface pre-emergence treatments. This should be borne in mind when considering the results of the pre-emergence selectivity experiment, where the herbicide was fully incorporated.

Symptoms

These were typical of photosynthetic inhibition; the foliar spray causing scorch, especially on broad-leaved species, sometimes accompanied by chlorosis. The latter symptom was prominent with the soil drenches, in some instances being seen to spread out from the mid-rib and veins of the broad-leaved species, necrosis developing afterwards. Germination was unaffected by pre-emergence treatments, chlorosis developing after the plants reached the cotyledon and true leaf stages and again being followed by necrosis and die-back.

Soil persistence

Swede was used as the sensitive test species to monitor persistence. The dose of 1.12 kg/ha was detectable 38 weeks after spraying but not after 49 weeks. At this latter date, 3.36 kg/ha was still lethal to this species.

Selectivity among temperate species

Pre-emergence

Stellaria media was the only weed controlled at 1.12 kg/ha. The sensitivity of brassica crops (kale and swede) to this dose would suggest that cruciferous weeds will be controlled however. At the highest dose all weeds except *Agropyron repens* and *Galium aparine* were controlled, the latter showing considerable resistance.

All large-seeded legumes tolerated 1.12 kg/ha, field bean and pea being reduced in vigour by only 29% at 3.36 kg/ha. Wheat was the only cereal to withstand 1.12 kg/ha, although barley was only marginally reduced in vigour. Results with the cereals would suggest the possibility of controlling these, should they occur as volunteer weeds in field bean and pea.

Post-emergence

Eleven annual weeds were controlled at 0.4 kg/ha, these being mainly broad-leaved species but also the two *Poa* species. At the highest dose, *Polygonum aviculare*, *Galium aparine* and *Agrostis stolonifera* were also controlled. *Alopecurus myosuroides*, *Avena fatua*, *Chrysanthemum segetum* and *Agropyron repens* were not adequately controlled, although *Alopecurus* was affected at the highest dose (33% kill and 43% vigour reduction).

Pea was the most tolerant crop, withstanding the highest dose of 1.6 kg/ha. At 0.4 kg/ha, only perennial ryegrass and onion were tolerant. Cereals, however, were reduced in vigour by only 21% at this dose and recovery was such that two months after treatment shoot fresh weights of barley and wheat were 86% and 88% of control, respectively. Wheat appeared to be the most tolerant of the cereals suffering only a 29% vigour reduction at the highest dose. Results at the latter dose again suggest the possibility of at least a suppression of volunteer barley and oat in peas.

Although more of a soil than a foliar acting herbicide, much better weed control was obtained post-emergence rather than pre-emergence. The post-emergence control of Poa species in perennial ryegrass was confirmed. Unfortunately, these weeds were not included in the pre-emergence experiment. The marginal tolerance of the cereals is perhaps not so surprising as spring rather than winter varieties were used. However, good control of Poa species and certain annual broad-leaved weeds can be expected even in spring varieties of wheat and barley. The inadequate control of Alopecurus myosuroides was disappointing. However, some other work has shown that different soil properties such as the content of clay, organic matter and $CaCO_3$, as well as pH, can influence herbicidal activity (Laermann and Heitefuss, 1974). It may be of interest to point out that under very different soil and environmental conditions, even "Avena fatua" (since re-identified as A. ludoviciana) can be controlled in wheat (Gill and Brar, 1975) although there is neither recommendation nor any claims for such a use in temperate regions. The broad spectrum of weed control (annual broad-leaved and Poa species) lends support to the use of this herbicide as a component of a mixture, both pre- and post-emergence.

Selectivity among tropical species

Pre-emergence

Only one tropical annual weed species, Digitaria sanguinalis, was included and as this was not controlled at 1.12 kg/ha, the tolerance of maize and groundnut to this dose is of uncertain significance and no positive conclusions can be reached.

Post-emergence

Maize showed good tolerance of 0.4 kg/ha at which dose annual broad-leaved weed species were killed but annual grasses were not. Sorghum was almost as tolerant as maize but as annual grasses were not controlled at this dose, the usefulness of this result is dubious. Apparent selectivity against Amaranthus in soyabean at 0.1 kg/ha suggests that small doses of this compound would be worth testing against the more difficult broad-leaved weeds in soyabean.

Perennials, Cynodon and Cyperus were very little affected.

ACTIVITY EXPERIMENT

METHABENZTHIAZURON

		0.56 kg a.i./ha	1.68 kg a.i./ha	5.04 kg a.i./ha
DWARF BEAN	F	xxxxx	xxx	x
	S	xxxxxxxx	xxx	o
	P	xxxxxxxxx	x	o
	I	xxxxxx	o	o
KALE	F	xxx	o	o
	S	xxxxxx	o	o
	P	o	o	o
	I	o	o	o
<u>POLYGONUM AMPHIBIUM</u>	F	xxxxxxxx	xxxxxx	xxxx
	S	xxxxxxxxxxx	xxxxxx	xx
	P	xxxxxxxx	xxx	x
	I	xxxxxxxxxxx	x	x
PERENNIAL RYEGRASS	F	xxxxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxx
	S	xxxxxxxx	xxxxx	xx
	P	xxxxxxxx	xxxx	x
	I	xxxxxxxxxxx	xxx	o
<u>AVENA FATUA</u>	F	xxxxxxxxxxxxxx	xxxxxxxxxxxxx	xxxxxxxxx
	S	xxxxxxxxxxxx	x	x
	P	xxxxxxxxxxxxx	xxxxx	o
	I	xxxxxxxxxxxxx	o	o
<u>AGROPYRON REPENS</u>	F	xxxxxxxxxxxxx	xxxxxxxxxxxxx	xxxxxxxxxxxx
	S	xxxxxxxx	xxxxxx	xxx
	P	xxxxxxx	xxx	x
	I	xxxxxxx	xx	x

Key: F = post-emergence, foliar application
S = post-emergence, soil drench
P = pre-emergence, surface film
I = pre-planting, incorporated

(NB These histograms are for vigour only - no numbers available)

METHABENZTHIAZURON

SPECIES	No.	PRE-EMERGENCE 0.37	1.12	3.36	POST-EMERGENCE 0.1	0.4	1.6
		kg a. i./ha			kg a. i./ha		
WHEAT	(1)	105/100	112/86	112/21	100/93	100/79	100/71
BARLEY	(2)	122/86	122/71	122/29	100/86	100/79	88/50
OAT	(3)	106/86	88/64	97/29	100/100	100/79	100/64
PER RYGR	(4)	105/100	102/57	27/14	100/100	100/93	63/57
ONION	(8)	128/93	93/57	5/14	80/93	100/86	50/71
DWF BEAN	(9)	100/100	83/93	100/36	100/79	117/57	100/14
FLD BEAN	(10)	109/86	109/86	82/71	100/93	100/71	20/21
PEA	(11)	90/93	90/86	120/71	100/100	100/100	100/86
W CLOVER	(12)	78/86	5/7	0/0	100/86	69/43	0/0
KALE	(15)	90/93	16/21	0/0	100/100	100/43	0/0
CABBAGE	(16)	-	-	-	100/93	80/43	0/0
SWEDE	(17)	98/86	0/0	0/0	100/79	80/43	0/0
CARROT	(18)	90/93	83/64	0/0	100/93	92/57	8/14
PARSNIP	(19)	-	-	-	100/86	50/43	0/0
LETTUCE	(20)	-	-	-	0/0	0/0	0/0
SUG BEET	(21)	82/100	65/79	10/14	100/79	100/64	67/36
AVE FATU	(26)	-	-	-	100/71	88/86	88/71
ALO MYOS	(27)	110/86	86/36	5/7	100/93	100/79	67/57
POA ANN	(28)	-	-	-	100/93	57/29	0/0
POA TRIV	(29)	-	-	-	94/71	69/29	0/0
SIN ARV	(30)	-	-	-	100/71	83/21	33/7
RAPH RAP	(31)	-	-	-	100/71	90/29	0/0
CHRY SEG	(32)	-	-	-	M/86r	M/86r	M/43r
TRIP MAR	(33)	-	-	-	100/86	13/43	0/0
SEN VULG	(34)	-	-	-	100/79	0/0	0/0
POL LAPA	(35)	91/100	64/86	0/0	100/71	0/0	0/0
POL AVIC	(36)	-	-	-	100/79	100/64	0/0
RUM CRIS	(37)	-	-	-	100/57	0/0	0/0
GAL APAR	(38)	101/100	98/86	94/86	100/100	100/86	67/29
CHEN ALB	(39)	75/86	113/86	9/7	100/57	67/29	0/0
STEL MED	(40)	91/100	6/7	0/0	44/36	0/0	0/0

Key = No. of plants surviving/Vigour of survivors

Untreated = 100/100

METHABENZTHIAZURON

SPECIES	No.	PRE-EMERGENCE			POST-EMERGENCE		
		0.37	1.12	3.36	0.1	0.4	1.6
			kg a. i./ha			kg a. i./ha	
SPER ARV	(41)	-	-	-	50/36	0/0	0/0
AG REPEN	(47)	-/100	-/71	-/43	100/93	100/93	100/79
AG STOLO	(48)	-	-	-	100/93	100/79	63/29
MAIZE	(58)	88/86	100/86	88/64	100/100	100/100	100/71
SORGHUM	(59)	86/93	86/79	86/64	100/93	100/79	100/71
RICE	(60)	99/79	69/36	0/0	100/93	100/71	63/36
GRNDNUT	(64)	140/93	140/93	60/29	100/86	100/64	0/0
SOYABEAN	(65)	-	-	-	100/86	100/71	100/43
COTTON	(66)	109/93	82/79	27/21	100/71	100/29	25/14
JUTE	(67)	-	-	-	44/29	0/0	0/0
KENAF	(68)	-	-	-	100/36	13/7	0/0
TOBACCO	(69)	-	-	-	80/36	0/0	0/0
ELEU IND	(74)	-	-	-	100/93	100/57	6/14
ECH CRUS	(75)	-	-	-	100/100	100/71	0/0
ROT EXAL	(76)	-	-	-	100/100	100/100	100/93
DIG SANG	(77)	122/93	150/57	0/0	-	-	-
AMAR RET	(78)	-	-	-	0/0	0/0	0/0
PORT OLE	(79)	-	-	-	83/57	17/29	0/0
CYN DACT	(82)	-	-	-	-/86	-/86	-/64
CYP ROTU	(86)	-/100	-/86	-/93	100/100	100/100	100/100

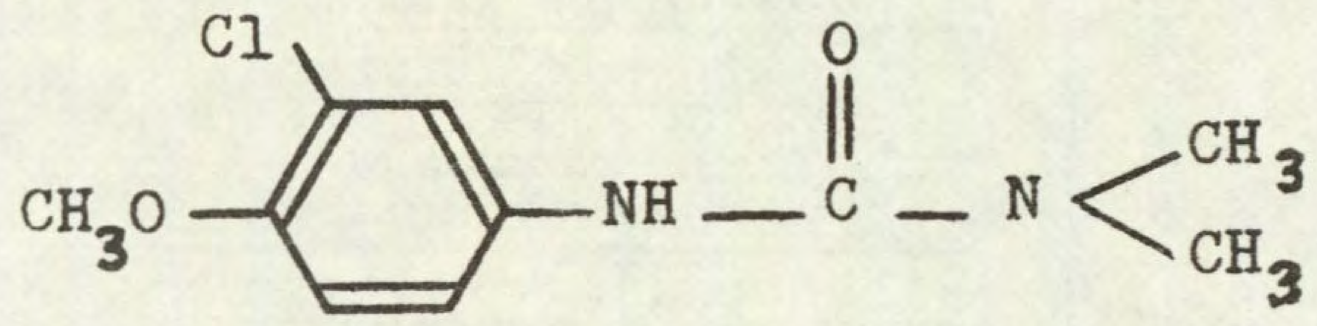
KEY = No. of plants surviving/Vigour of survivors
Untreated = 100/100

METOXURON

Code number HZ 6602 Trade name Dosanex

Chemical name N'-(3-chloro-4-methoxyphenyl)-N'N-dimethylurea

Structure



Source Sandoz Ltd
Station Road
King's Langley
Herts WD4 8LJ

Information available and suggested uses

Approved for control of Alopecurus myosuroides, Matricaria spp. (mayweeds) and some other annual grass and broad-leaved weeds post-emergence in carrot and certain varieties of winter barley and winter wheat. Also approved as a mixture with (i) simazine ('Fylene') post-emergence in certain varieties of winter barley and winter wheat, (ii) linuron for control of volunteer potatoes and large plants of Polygonum aviculare, Veronica spp. and Poa annua, post-emergence, in carrot.

Formulation used Wettable powder 80% w/w a.i.

Spray volume 347 l/ha (30.9 gal/ac) for activity and pre-emergence selectivity experiments.

338 l/ha (30.1 gal/ac) for post-emergence selectivity experiment.

RESULTS

Full results are given on pages 16-18 and potential selectivities are summarised in the following table.

Table 5. Potential pre-emergence selectivities

RATE (kg a.i./ha)	CROPS: vigour reduced by 15% or less	WEEDS: number or vigour reduced by 70% or more
5.04	None	None listed as no crops tolerant
1.68	rice	Senecio vulgaris Chenopodium album Stellaria media Agrostis stolonifera
0.56	None listed as no weeds controlled	None

Table 6. Potential post-emergence selectivities

RATE (kg a.i./ha)	CROPS: vigour reduced by 15% or less	WEEDS: number or vigour reduced by 70% or more
1.6	carrot	Avena fatua Alopecurus myosuroides Chrysanthemum segetum Agropyron repens Agrostis stolonifera Eleusine indica Echinochloa crus-galli Rottboellia exaltata Cynodon dactylon + species below
0.4	species above + wheat barley pea parsnip sorghum	Poa annua Poa trivialis Sinapis arvensis Raphanus raphanistrum Tripleurospermum maritimum Senecio vulgaris Polygonum lapathifolium Polygonum aviculare Rumex crispus Galium aparine Spergula arvensis + species below
0.1	species above + oat perennial ryegrass onion kale cabbage swede sugar beet maize rice groundnut	Chenopodium album Stellaria media Amaranthus retroflexus Portulaca oleracea

Comments on results

Activity experiment (see page 16)

Soil drench applications to plants had consistently greater effect than foliage sprays. The latter severely damaged kale and dwarf bean but grasses and Polygonum showed only mild effects. Pre-emergence surface treatments were generally comparable in effect to post-emergence soil drenches. Incorporated treatments were a little less active, particularly on Polygonum. This should be taken into account when considering the results of the pre-emergence selectivity experiment where the herbicide was incorporated into the soil.

Symptoms

Symptoms were similar to those brought about by other photosynthetic inhibiting herbicides. The foliar spray caused scorch, sometimes accompanied by yellowing and chlorosis, more notably on the broad-leaved species. With soil drenches and pre-emergence treatments a severe chlorosis developed which preceded necrosis and die-back. Germination was unaffected by the pre-emergence treatments.

Soil persistence

Turnip was used to monitor persistence. The dose of 0.56 kg/ha was undectable three weeks after spraying and the 1.68 kg/ha dose after 10 weeks. The highest dose of 5.04 kg/ha was causing only a 37% shoot fresh weight reduction after 10 weeks and was undectable at the later assay. Thus a relatively short period of persistence in the soil is indicated, agreeing with data supplied by the manufacturers (Sandoz Ltd, 1972).

Selectivity among temperate species

Pre-emergence

Weed control was generally poor, with only Agrostis stolonifera and three annual broad-leaved weeds susceptible at 1.68 kg/ha. All weeds except Galium aparine and Agropyron repens, were susceptible to 5.04 kg/ha. Results on brassica crops suggest cruciferous weeds will probably be controlled at 1.68 kg/ha or above.

None of the crops tolerated 1.68 kg/ha although barley and dwarf bean were only marginally reduced in vigour at this dose. Control of volunteer cereals would appear to be unattainable in any of the crops tested.

Post-emergence

Weed control was of a high order, the dose of 0.4 kg/ha controlling 13 annual species which included both Poa species, Galium aparine and Polygonum aviculare. At the highest dose, all other weeds were controlled including Avena fatua, Alopecurus myosuroides and Agropyron repens.

Carrot showed outstanding tolerance, being unaffected at 1.6 kg/ha. The cereals, wheat and barley tolerated 0.4 kg/ha as did parsnip and pea, the latter being only marginally reduced in vigour even at 1.6 kg/ha. Lettuce was highly sensitive. Control of volunteer oats as well as brassicas would appear to be a possibility in certain of the tolerant crops such as carrot and peas.

These tests confirm the use of metoxuron mainly as a post-emergence herbicide even though most of the herbicidal effect is via the soil. The sensitivity of Galium aparine gives it a clear advantage over many other herbicides. As with methabenzthiazuron the low relative tolerance of cereals (wheat and barley) was possibly because spring varieties were used in this test. The broad spectrum of activity would be a considerable advantage either as a single treatment or as the component of a mixture.

Selectivity among tropical species

Pre-emergence

Rice showed good tolerance of 1.68 kg/ha but the only annual weed, Digitaria, was not controlled, and there seems no reason to suppose this compound has any definite value in this crop.

Post-emergence

Small-seeded annual broad-leaved species proved very susceptible and these appear likely to be selectively controlled in the cereals at quite low doses. Sorghum tolerated a higher dose than rice or maize and the compound deserves further testing where there is any difficulty with the use of 2,4-D or atrazine.

/CTIVITY EXPERIMENT

METOXURON

		0.56 kg a.i./ha	1.68 kg a.i./ha	5.04 kg a.i./ha
	F	xxxxxxxx	xxxxxxxx	xxxxx
DWARF BEAN	S	xxxxxxxxxxx	xxx	o
	P	xxxxxxxxxxxxx	xxxxxxxxxxxx	o
	I	xxxxxxxxxxx	xxxxxxxxxxx	xx
	F	xxxxxxxx	xxxxxx	xx
KALE	S	x	x	o
	P	x	o	o
	I	xxxxxx	o	o
	F	xxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxx
POLYGONUM AMPHIBIUM	S	xxxxxxxxxxx	xxxxxx	x
	P	xxxxxxxxxxx	xxxxx	x
	I	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxx
	F	xxxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxx
PERENNIAL RYEGRASS	S	xxx	x	o
	P	xxxxx	o	o
	I	xxxxxxxxxxx	xxx	x
	F	xxxxxxxxxxxxxx	xxxxxxxxxxxxxx	xxxxxxxxxxxxx
AVENA FATUA	S	xxxxxxx	x	o
	P	xxxxxxxxx	xxx	o
	I	xxxxxxxxxxx	xxxx	o
	F	xxxxxxxxxxxxxx	xxxxxxxxxxxxx	xxxxxxxxx
AGROPYRON REPENS	S	xxxxxx	xxx	xx
	P	xxxxxxxxxxx	xxxx	x
	I	xxxxxxxxxxxx	xxxxxxxxx	xxxxxx

Key: F = post-emergence, foliar application
S = post-emergence, soil drench
P = pre-emergence, surface film
I = pre-planting, incorporated

(NB These histograms are for vigour only - no numbers available)

METOXURON

SPECIES	No.	PRE-EMERGENCE			POST-EMERGENCE		
		0.56	1.68	5.04	0.1	0.4	1.6
			kg a. i./ha			kg a. i./ha	
WHEAT	(1)	96/86	83/57	102/43	100/100	100/86	100/64
BARLEY	(2)	111/93	111/79	87/50	100/86	100/86	100/71
OAT	(3)	133/86	117/57	75/21	100/93	100/57	0/0
PER RYGR	(4)	102/79	76/43	9/29	100/93	88/36	0/0
CKFOOT	(5)	24/21	204/36	12/7	-	-	-
TIMTHY	(6)	46/64	7/7	7/7	-	-	-
ONION	(8)	108/79	74/50	10/7	90/86	70/64	20/14
DWF BEAN	(9)	100/93	100/79	83/43	100/64	100/36	100/21
FLD BEAN	(10)	109/79	82/64	55/43	100/79	100/71	0/0
PEA	(11)	133/93	133/71	133/57	100/100	100/100	100/79
W CLOVER	(12)	55/57	24/14	0/0	69/43	56/36	0/0
KALE	(15)	75/50	46/36	0/0	100/100	100/43	0/0
CABBAGE	(16)	-	-	-	100/100	100/36	0/0
SWEDE	(17)	91/57	21/14	0/0	100/86	90/29	0/0
CARROT	(18)	79/86	71/64	95/57	100/100	100/100	100/100
PARSNIP	(19)	-	-	-	100/100	100/86	83/71
LETTUCE	(20)	97/57	24/14	0/0	0/0	0/0	0/0
SUG BEET	(21)	97/86	3/7	0/0	100/86	100/71	33/29
AVE FATU	(26)	75/79	102/57	75/29	100/79	100/64	0/0
ALO MYOS	(27)	95/79	60/43	25/29	100/86	78/50	0/0
POA ANN	(28)	-	-	-	100/43	0/0	0/0
POA TRIV	(29)	-	-	-	94/43	25/7	0/0
SIN ARV	(30)	-	-	-	100/79	100/29	17/14
RAPH RAP	(31)	-	-	-	100/71	60/21	0/0
CHRY SEG	(32)	-	-	-	M/71r	M/57r	M/0r
TRIP MAR	(33)	-	-	-	81/57	0/0	0/0
SEN VULG	(34)	62/64	0/0	0/0	69/57	0/0	0/0
POL LAPA	(35)	97/79	81/71	0/0	100/57	6/7	0/0
POL AVIC	(36)	-	-	-	100/93	25/14	0/0
RUM CRIS	(37)	-	-	-	92/43	0/0	0/0
GLA APAR	(38)	103/86	67/64	83/50	100/50	17/14	0/0

KEY = No. of plants surviving/Vigour of survivors
Untreated = 100/100

METOXURON

SPECIES	No.	PRE-EMERGENCE			POST-EMERGENCE		
		0.56	1.68	5.04	0.1	0.4	1.6
		kg a.i./ha			kg a.i./ha		
CHEN ALB	(39)	69/64	0/0	0/0	92/29	0/0	0/0
STEL MED	(40)	37/43	8/14	0/0	6/14	0/0	0/0
SPER ARV	(41)	-	-	-	94/64	0/0	0/0
AG REPEN	(47)	-/100	-/71	-/57	100/86	100/71	100/29
AG STOLO	(48)	-/79	-/21	-/7	100/86	100/43	75/22
MAIZE	(58)	104/86	104/57	104/43	100/93	100/71	100/43
SORGHUM	(59)	-	-	-	100/100	100/86	80/43
RICE	(60)	85/93	111/86	65/57	100/93	100/43	0/0
GRNDNUT	(64)	-	-	-	100/86	100/71	75/21
SOYABEAN	(65)	-	-	-	100/57	100/43	25/7
COTTON	(66)	94/79	131/71	19/21	100/79	100/43	50/14
JUTE	(67)	-	-	-	0/0	0/0	0/0
KENAF	(68)	-	-	-	75/43	0/0	0/0
TOBACCO	(69)	-	-	-	10/36	0/0	0/0
ELEU IND	(74)	-	-	-	100/86	100/43	0/0
ECH CRUS	(75)	-	-	-	100/86	75/64	0/0
ROT EXAL	(76)	-	-	-	100/79	100/64	13/14
DIG SANG	(77)	102/71	78/64	4/29	-	-	-
AMAR RET	(78)	-	-	-	0/0	0/0	0/0
PORT OLE	(79)	-	-	-	0/0	0/0	0/0
CYN DACT	(82)	-	-	-	85/79	95/71	62/29
CYP ROTU	(86)	-/93	-/86	-/86	92/100	103/100	86/93

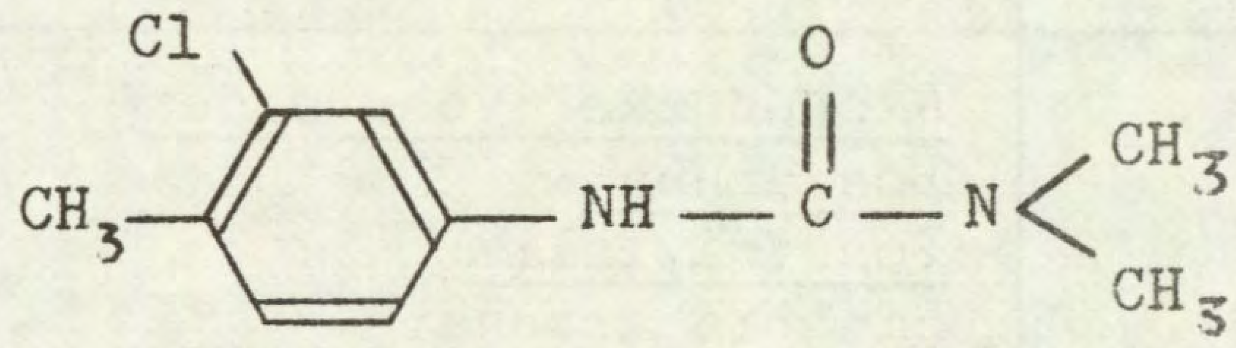
KEY = No. of plants surviving/Vigour of survivors
Untreated = 100/100

CHLORTOLURON

Code number C2242 Trade name Dicurane

Chemical name N'-(3-chloro-4-methylphenyl)-N,N-dimethylurea

Structure



Source Ciba-Geigy (UK) Ltd
Agrochemical Division
Whittlesford
Cambridge
CB2 4QT

Information available and suggested uses

Approved for control of Alopecurus myosuroides, some other grass and broad-leaved weeds when applied pre- or post-emergence in certain varieties of winter barley and winter wheat. Avena fatua is controlled pre-emergence.

Formulation used Wettable powder 80% w/w a.i.

Spray volume 338 l/ha (30.1 gal/ac)

RESULTS

Full results are given on pages 23-25 and potential selectivities are summarised in the following tables.

Table 7. Potential pre-emergence selectivities

RATE (kg a.i./ha)	CROPS: vigour reduced by 15% or less	WEEDS: number or vigour reduced by 70% or more
5.04	None	None listed as no crops tolerant
1.68	maize sorghum	Senecio vulgaris Tussilago farfara Echinochloa crus-galli + species below
0.56	species above + wheat sugar beet groundnut cotton	Avena fatua Alopecurus myosuroides Poa annua Polygonum lapathifolium Chenopodium album Stellaria media Agropyron repens Cirsium arvense Rumex acetosella Digitaria sanguinalis Eleusine indica

Table 8. Potential post-emergence selectivities

RATE (kg a.i./ha)	CROPS: vigour reduced by 15% or less	WEEDS: number or vigour reduced by 70% or more
1.6	None	None listed as no crops tolerant
0.4	wheat sorghum	Alopecurus myosuroides Poa annua Poa trivialis Sinapis arvensis Raphanus raphanistrum Chrysanthemum segetum Tripleurospermum maritimum Senecio vulgaris Polygonum lapathifolium Polygonum aviculare Rumex crispus Spergula arvensis Eleusine indica + species below
0.1	species above + barley perennial ryegrass onion* pea carrot radish maize groundnut soyabean	Chenopodium album Stellaria media Amaranthus retroflexus Portulaca oleracea

* but note some stand reduction

Comments on results

Activity experiment (see page 23)

Some contact effect was seen as a result of the foliar spray, more so on kale and dwarf bean than on the grasses and Polygonum amphibium. Most activity was found with the soil treatments however. Pre-emergence treatments were marginally more effective than post-emergence soil drenches. There was little difference in the level of effect between surface or incorporated pre-emergence treatments with regard to dwarf bean, Polygonum and Agropyron repens, but kale and the annual grasses (ryegrass and Avena fatua) were completely killed even at the lowest dose so that any differences between the two application methods could not be picked up.

Symptoms

As with the two previous herbicides, symptoms caused on susceptible species were typical of other herbicides which inhibit photosynthesis. Scorch resulted from foliar or post-emergence spraying. Chlorosis preceded necrosis and die-back in all of the soil treatments while germination was unaffected by pre-emergence treatments.

Soil persistence

Perennial ryegrass was used as the test species to monitor persistence. Under the conditions of the experiment a considerable period of persistence in the soil was indicated. Although the dose of 0.56 kg/ha eventually disappeared, it was still detected after 43 weeks, while 1.68 and 5.04 kg/ha were severely reducing or killing plants after 52 weeks. The drier soil conditions and absence of leaching probably account for this long persistence. It was found to be much less in later field persistence tests (Banting, Richardson and Holroyd, 1976).

Selectivity among temperate species

Pre-emergence

All of the grass weeds (Avena fatua, Alopecurus myosuroides, Poa annua and Agropyron repens) were controlled at the lowest dose of 0.56 kg/ha. The susceptibility of the perennials, Cirsium arvense, Rumex acetosella and Agropyron at this dose and Tussilago farfara at 1.68 kg/ha was interesting. Galium aparine was the only annual weed not controlled at 1.68 kg/ha, the highest dose being necessary for its control as well as for the other perennial, Allium vineale.

Wheat and sugar beet were the only crops to tolerate the lowest dose of 0.56 kg/ha. All other crops, except perhaps for barley, were very sensitive. Some possibility for the control of volunteer oats, brassicas and perennial ryegrass in wheat and sugar beet is indicated by these results.

Chlortoluron would seem to have a distinct advantage over the other herbicides used in this test, in its potential control of Avena fatua in wheat, as well as many other important weeds. The susceptibility of barley is not so surprising, as a spring variety was used in this test.

Post-emergence

All weeds except Avena, Galium and the perennial grasses (Agropyron and Agrostis) were controlled at 0.4 kg/ha. At 1.6 kg/ha Agrostis was eventually killed and only one plant of Agropyron survived treatment. The broad-leaved weed control spectrum was particularly impressive with all cruciferous weeds (Sinapis arvensis, R. raphanistrum), composite weeds (C. segetum, T. maritimum, S. vulgaris), caryophyllaceous weeds (Stellaria media and Spergula arvensis) and polygonaceous weeds (P. lapathifolium, P. aviculare, R. crispus) being susceptible, in addition to the annual grasses (Alopecurus and both Poa species).

Wheat was the only crop to tolerate 0.4 kg/ha, although barley and pea were only marginally reduced in vigour at this dose. The sensitivity of various crop species, e.g. perennial ryegrass and brassicas suggests the possibility of controlling these should they occur as volunteer weeds in wheat, pea and possibly barley. Control of volunteer oat may also be possible. The considerable difference in response between wild oat (A. fatua) and cultivated oat (A. sativa) is interesting and corresponds to the known wide differences in varietal susceptibility within wheat and barley cultivars. Had the more resistant winter varieties been used, a greater selectivity margin would have been evident.

Although the activity experiment showed that phytotoxicity occurred to a greater extent with the soil treatments, nevertheless it can be utilized pre- and post-emergence. Generally weed control and crop tolerance are similar, in species, type and degree, with only a few exceptions, the most notable of which is the susceptibility (and hence selective control in wheat) of Avena fatua, pre- but not post-emergence.

Selectivity among tropical species

Pre-emergence

The small seeded annual weeds in this test were well controlled by 1.68 kg/ha and maize and sorghum showed good tolerance. It is doubtful if this compound would have any advantage over atrazine in maize but it deserves testing in situations where atrazine is not sufficiently safe in sorghum.

Post-emergence

Small seeded broad-leaved species were highly susceptible, several being controlled at 0.1 kg/ha. At this level soyabean and groundnut were tolerant and there could be some use against difficult broad-leaved weeds in soyabean. Sorghum tolerated a higher dose of 0.4 kg/ha but selectivity against grass weeds appears somewhat less than in the pre-emergence test. Rottboellia and the perennials Cyperus and Cynodon were resistant to 0.4 kg/ha and only partially suppressed at 1.6 kg/ha.

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