SEQUENTIAL APPLICATIONS OF TRI-ALLATE AND METHABENZTHIAZURON FOR THE CONTROL OF WEEDS IN WINTER WHEAT AND WINTER BARLEY

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Summary The results of trials carried out during 1974 to 1977 to evaluate the pre-emergence and very early post-emergence sequential applications of tri-allate granular and methabenzthiazuron have demonstrated an improvement in the level of control of Alopecurus myosuroides over that of tri-allate alone. The trials also showed a similar but less pronounced increase in the level of control of Avena species. The use of methabenzthiazuron in the sequential treatment effectively demonstrated good control of a wide range of autumn and winter germinating broad-leaved weeds, generally obviating the use of a spring herbicide treatment. The sequential treatment proved very safe to winter wheat and winter barley and gave increases in yield and grain quality.

Résumé Les résultats d'essais effectués de 1974 à 1977 afin de connaître l'action en pré-levée et en post-levée hâtive d'applications séparées de tri-allate granulé et de méthabenzthiazuron ont démontré une augmentation du pourcentage de destruction d'Alopecurus myosuroides par rapport au tri-allate utilisé seul. Les essais ont également montré une augmentation similaire mais moins prononcée du taux de destruction d'Avena sp.

L'emploi du méthabenzthiazuron en traitement séparé a effectivement donné un bon contrôle d'une série importante de dicotylédones croissant en automne et en hiver, permettant ainsi d'éviter l'emploi d'un herbicide au printemps suivant. Le traitement séparé s'est avéré très sélectif pour le froment d'hiver et l'escourgeon et a augmenté le rendement et la qualité du grain.

INTRODUCTION

Where tri-allate (Avadex BW) in either liquid or granular formulation is applied according to label instructions good control of Avena spp. and Alopecurus myosuroides is normally obtained. When conditions are not ideal the control of A. myosuroides declines to an unacceptable level. Tri-allate in the granular form is often applied up to two weeks after cereal drilling when the seedbed has completely settled and when A. myosuroides is germinating. This can lead to poor control in commercial practice. The objective of the trials programme was to find a suitable additive for tri-allate granular which would improve the control of A. myosuroides and add a bonus of broad-leaved weed control.

In 1974 extensive greenhouse testing indicated that sequential application of tri-allate followed by a reduced rate of methabenzthiazuron resulted in excellent control of A. myosuroides, and a number of broad-leaved weeds whilst maintaining good control of Avena spp.

MATERIALS AND METHODS

Four series of trials were carried out in commercial crops of winter cereals. Monsanto Ltd., carried out three series (A. B & C) and Bayer UK Ltd., the remaining series (D).

Series (No. of trials)	Crop	Application Time	Application Crop stage	Replicates	Plot size (m^2)	Sprays Applicator	Volume (L/ha)	Pressure (Bars)	Granules Applicator
A. (1) (1)	W.W. W.W.	Aut.1974 Sp.1975	pre-em post-em	4	20	Oxford Precision (Knapsack)	450	1.4	Horstine Farmery (Knapsack)
B. (15)	W.W.	Aut.1975	pre-em	3	100	Evers & Wall (Land-Rover)	450	1.4	Horstine Farmery TMA2 airflow (Tractor)
C. (18)	W.W.	Aut.1976	pre-em(12) E.post-em(6)	4	20-40	Oxford Precision (Knapsack)	450	1.4	Fischer (Knapsack)
D. (12)	W.W.(9) W.B.(3)	Aut.1976	pre-em(11) E.post-em(1)	3	87	Bayer (Tractor)	280	2.5	Horstine Farmery TMA2 airflow (Tractor)

W.W. - Winter Wheat: W.B. - Winter Barley

In all the trials commercial formulations of tri-allate (10% granular) and methabenzthiazuron (70% wettable powder) were used. The competitive standards chlortoluron, isoproturon, difenzoquat and benzoylprop-ethyl, included in the trials, were the commercial formulations applied at recommended rates and timings.

A number of assessments were carried out in all the trials:-

a) Broad-leaved weeds: In series A, B and C trials, assessments were made in late March/April by counting the numbers of each species present in a 0.25 m^2 quadrat thrown six or ten times per plot depending on plot size. In series D trials counts were made in March of each species in a 0.1 m^2 quadrat thrown ten times per plot.

b) Alopecurus myosuroides: In all the trials counts were made in June of seed heads in 5 x 0.25 m^2 quadrats per plot.

c) Avena spp: In series A, B and C trials, assessments were made in late July/ early August by counting the number of panicles in 10 x 1 m^2 quadrats per plot. In series D trials panicle counts were made, during the same period, in 8 x 0.25 m^2 quadrats.

d) Crop phytotoxicity: These assessments were made at the same time as the broad-leaved weed assessments. In series A, B and C a 0-100 scale (100 = 100% kill of crop plants) was used. Whereas in series D the BBA 1-9 scale of plant tolerance was used, where 1 = no damage and all plants present; 9 = all plants destroyed with up to 100% plants missing.

e) Crop yields: In six of the series B trials, the farmer's combine harvester was used to cut out 60 m^2 from each treatment plot. In seven of the series C trials a Wintersteiger small-plot combine cut out 25 m^2 from each plot. In seven of the series D trials 53 m^2 was cut from each plot using a Claas small-plot combine. In all the trials grain yields were recorded in Kilogrammes and a sample of grain taken from each plot to determine percent moisture content; grain yields were then corrected to 86% dry matter. In five of the series D trials measurements were made of 1000 grain weight and hectolitre weight.

RESULTS

Broad-leaved weeds

In the series A trials the pre-emergence applications of tri-allate granular and methabenzthiazuron resulted in improved broad-leaved weed control over similar post-emergence applications (Table 1). In all 47 trials carried out during the period 1974 to 1977 tri-allate applied alone gave a very low level of b.l. weed control, whereas the sequential addition of methabenzthiazuron resulted in good control of a number of species (Tables 1, 2, 3). The sequential addition of methabenzthiazuron resulted in good control of *Aethusa cynapium*, *Aphanes arvensis*, *Myosotis arvensis*, *Papaver spp*, *Stellaria media*, *Tripleurospermum maritimum*, *Veronica agrestis*, *Veronica persica* and *Viola arvensis*. Of the remaining weeds *Fumaria officinalis* was only moderately controlled and *Galium aparine*, *Polygonum aviculare*, *Polygonum convolvulus*, *Sinapis arvensis* and *Veronica hederifolia* were poorly controlled. Chlortoluron was the most frequently used standard and gave good control of *A. cynapium*, *A. arvensis*, *M. arvensis*, *Papaver spp*, *S. media*, *T. maritimum*, *V. agrestis* and *Viola arvensis*, but poor control of *S. arvensis*, *V. hederifolia*, *V. persica* and *P. convolvulus* (Table 3).

Table 1

Mean % control of broad-leaved weeds, Alopecurus myosuroides and Avena spp and crop phytotoxicity in two trials in Winter Wheat 1974/5

Treatment	Rate (kg ai/ha)	Crop Stage	% control: Myosotis arvensis	Stellaria media	Veronica persica	Alopecurus myosuroides	Avena spp	Crop Phyto. %
Untreated control		-	0	0	0	0	0	0
Tri-allate	1.7	pre-em	-	-	75	67	-	0
Tri-allate	2.7	post-em	60	3	53	48	68	0
Methabenzthiazuron	1.5	pre-em	-	-	99	80	-	0
Methabenzthiazuron	1.5	post-em	99	62	99	39	50	0
Tri-allate + Methabenzthiazuron) Seq.	1.7 + 1.5	pre-em	-	99	90	80	90	0
Tri-allate + Methabenzthiazuron) Seq.	2.7 + 1.5	post-em	99	22	90	51	70	0

Alopecurus myosuroides

In the series A trials the pre-emergence applications of tri-allate and methabenzthiazuron resulted in improved blackgrass control when compared with similar post emergence applications (Table 1). In all the 47 trials carried out during the period 1974 to 1977 tri-allate applied alone gave only 67% control (Tables 1, 2 & 4). Increasing the rate of tri-allate from 1.7 to 2.25 kg.ai/ha. increased the level of control to 72% (Table 2). This slight increase in control was not repeated in the 1976/7 trials where a mean control of only 66% was recorded (Table 4). In all the trials the sequential addition of methabenzthiazuron to tri-allate resulted in an improved level of weed control (Tables 1, 2 & 4). In the 16 trials carried out pre crop and weed emergence (Series A and B) from 1974 to 1976 the level of control increased to 80% (Tables 1 & 2). In the 30 trials (Series C and D) the level of control increased to 87% (Table 4). The level of control from chlortoluron or isoproturon was always superior by approximately 10% to that of the sequential treatments of tri-allate and methabenzthiazuron (Table 2). Similarly in 1976/7 the highest levels of control were always achieved by chlortoluron or isoproturon in combination with post emergence applications of either benzoylprop-ethyl or difenzoquat (Table 4).

Table 2

Mean % control of broad-leaved weeds, Alopecurus myosuroides and Avena spp., crop phytotoxicity and yields in fifteen trials in Winter Wheat 1975/6

Treatment	Rate (kg ai/ha)	% control: Stellaria media	% control: Veronica persica	% control: Alopecurus myosuroides	% control: Avena spp	Crop Phyto. %	Crop Yield (t/ha)
(Number of trials)		2	2	13	11	15	6
Untreated controls		0 (40)	0 (2)	0 (44)	0 (61)	0	100 (2.6)
Tri-allate	1.7	2	10	67	79	3	159
Tri-allate	2.25	-	-	72	85	3	155
Tri-allate) +)Seq. Methabenzthiazuron)	1.7 + 1.5	75	87	77	87	3	145
Tri-allate) +)Seq. Methabenzthiazuron)	2.25 + 1.5	-	-	81	91	0	115*
Chlortoluron	3.6	98	0	90	54	0	152
Isoproturon	2.48	-	-	94	80	0	124*
Isoproturon	2.5	-	-	90	73	0	112*

Figures in parenthesis () mean numbers of b.l. weeds and A.myos/0.25 m^2; Avena spp/1 m^2; mean yields in t/ha.

* Crop yield data from one trial only.

Avena species

Pre-emergence application of tri-allate and methabenzthiazuron in the series A trials resulted in 90% wild oat control compared with 70% when similar treatments were applied post-emergence (Table 1). Increasing the rate of tri-allate from 1.7 to 2.25 kg.ai/ha. in the series B trials increased the level of control from 79% to 85% (Table 2). In the series C and D trials tri-allate at 2.25 kg.ai/ha. gave a mean of 80% control (Table 4). In all 45 trials carried out in the period 1975 to

Table 3

Mean % control of broad-leaved weeds in thirty trials in Winter cereals 1976/7 (Series C and D)

Treatment	Rate (kg ai/ha)	Aethusa cynapium	Aphanes arvensis	Fumaria officinalis	Galium aparine	Myosotis arvensis	Papaver spp	Polygonum aviculare	Polygonum convolvulus	Sinapis arvensis	Stellaria media	Tripleurospermum maritimum	Veronica agrestis	Veronica hederifolia	Veronica persica	Viola arvensis	Mean all Weeds
(Number of trials)		2	1	1	1	2	2	5	4	2	7	6	1	9	1	1	
Untreated controls		0 (61)	0 (18)	0 (128)	0 (10)	0 (110)	0 (77)	0 (40)	0 (35)	0 (16)	0 (43)	0 (58)	0 (50)	0 (18)	0 (29)	0 (13)	0 (47)
Tri-allate	2.25	60	-	60	-	-	18	13	27	0	-	6	-	23	-	-	26
Tri-allate	2.5	-	-	-	60	-	-	2	0	-	12	6	-	28	-	-	18
Tri-allate) +)Seq. Methabenzthiazuron)	2.25 + 1.5	84	99	69	13	85	92	37	22	46	82	94	99	48	99	99	71
Methabenzthiazuron) +)Seq. Benzoylprop-ethyl)	3.0 + 1.12	95	-	60	56	99	96	36	53	23	98	89	99	33	-	99	72
Chlortoluron	3.6	-	99	-	-	-	-	-	-	58	96	94	-	16	-	-	72
Chlortoluron) +)Seq. Difenzoquat)	3.6 + 0.99	-	-	-	-	-	87	-	-	-	95	-	-	5	22	-	52
Chlortoluron) +)Seq. Benzoylprop-ethyl)	3.6 + 1.12	99	-	-	-	94	-	-	61	-	70	98	94	26	-	92	79
Isoproturon) +)Seq. Benzoylprop-ethyl)	2.48 + 1.12	-	-	-	-	87	-	24	-	-	52	70	-	44	-	-	55

Figures in parenthesis () mean numbers per 0.25 m^2

Table 4

Mean % control of Alopecurus myosuroides and Avena spp; crop phytotoxicity and yields in thirty trials in winter cereals 1976/7

(Series C and D)

Treatment	Rate (kg ai/ha)	% control: Alopecurus myosuroides	% control: Avena spp	Crop phytotoxicity %	Crop phytotoxicity BBA Scale	Crop Yields (t/ha)	Grain Quality: 1000 grain weight (g)	Grain Quality: Hectolitre weight (kg)
(Number of trials)		22	23	15	12	14	5	5
Untreated controls		0 (154)	0 (42)	0	1	100 (4.45)	100 (45.6)	100 (74.5)
Tri-allate	2.25	66	80	2	-	118 ▲	-	-
Tri-allate	2.5	60	84	2	-	104	-	-
Tri-allate) +)Seq. Methabenzthiazuron)	2.25 + 1.5	87	90	2	1	119	104	101
Methabenzthiazuron) +)Seq. Benzoylprop-ethyl)	3.0 + 1.12	87	83	2	-	119	-	-
Chlortoluron	3.6	97	70	-	1	114	100	100
Chlortoluron) +)Seq. Difenzoquat)	3.6 + 0.99	90	99	-	1	119	104	101
Chlortoluron) +)Seq. Benzoylprop-ethyl)	3.6 + 1.12	97	99	4	1	120	-	-
Isoproturon) +)Seq. Benzoylprop-ethyl)	2.48 + 1.12	92	99	-	1	124	107	101

Figures in parenthesis () mean numbers of A.myos/0.25 m^2; Avena spp/1 m^2; mean yields in t/ha; mean grain wt in g., and mean hectolitre weights in kg.

▲ data from 2 trials treated post emergence crops and weeds

1977 the sequential addition of methabenzthiazuron to tri-allate resulted in improved wild oat control when compared to tri-allate applied on its own (Tables 2 & 4). Increasing the rate of tri-allate in the combination from 1.7 to 2.25 kg.ai/ha. resulted in the level of control increasing from 87% to 91% (Table 2). In the series C and D trials the level of control was increased to 90% (Table 4). In the series B trials chlortoluron and isoproturon applied on their own gave 54% and 73% control respectively (Table 2). In series C and D trials chlortoluron on its own gave 70% control (Table 4). When chlortoluron or isoproturon were combined with post-emergence sprays of either benzoylprop-ethyl or difenzoquat the control level increased to 99% (Table 4).

Crop Phytotoxicity

In the series B trials some crop phytotoxicity was observed at three sites, but only at a very low level, in the treatments involving tri-allate (Table 2). This same low level of phytotoxicity in the tri-allate treatments was also observed in two of the series C and D trials (Table 4).

Crop Yields

In the series B trials the results showed varying increases above those of the untreated controls as a result of the treatments (Table 2). The highest increases were from tri-allate, chlortoluron and the sequential application of tri-allate at 1.7 kg.ai/ha. and methabenzthiazuron. The yield increase from tri-allate at 2.25 kg.ai/ha. followed sequentially by methabenzthiazuron, and from isoproturon applied pre-emergence on its own, were less marked but this data was available from only one site.

In the series C and D trials yield data from fourteen sites showed that all treatments had resulted in yield increases of approximately twenty per cent above those of the untreated controls (Table 4). Differences between treatments were slight. The highest increase was from the isoproturon treatment followed by the post-emergence spray of benzoylprop-ethyl. The lowest increases were recorded at two sites where tri-allate at 2.5 kg.ai/ha. was applied post-emergence of both crop and weeds. At five sites in the series D trials where measurements of grain quality were made, the 1000 grain weights and hectolitre weights showed increases from all treatments with the exception of chlortoluron which was only equal to that of the untreated control.

DISCUSSION

After successful trials in the 1969/70 winter cereal crop (Evans 1970) tri-allate granules were introduced commercially into the U.K. in 1970. In trials detailing further field experience with tri-allate granules for the control of *Avena* species (Hodkinson 1972 A) and *Alopecurus myosuroides* (Hodkinson 1972 B), it was emphasised that immediate post drilling pre-emergence applications gave the highest levels of control. It was also pointed out that if warm dry weather conditions followed application then weed control, especially that of *A. myosuroides*, could be variable. These important parameters are further emphasised by the present series of forty seven field trials involving tri-allate granules in winter cereals covering a three year period. The trials highlighted the poor level of control of *A. myosuroides* from tri-allate when compared with earlier results.

For many seasons farmers in the U.K. have experienced difficulty in controlling weeds in winter cereals due to two important factors - the succession of mild, wet Autumn/Winters and a changing broad-leaved weed spectrum. Methabenzthiazuron was first introduced into the U.K. in Autumn 1968 for the control of *A. myosuroides* in winter wheat at 3.0 kg.ai/ha. (Bagnall & Jung 1968). It was later recommended in Autumn 1973 at 1.5 kg.ai/ha for the control of *Poa annua*, *Poa trivialis* and a wide range of annual broad-leaved weeds in cereals (Clark, et al. 1974).

Three years of trials in winter cereals comparing the sequential treatment of tri-allate granular and methabenzthiazuron have demonstrated good control of a wide range of Autumn and Winter germinating weeds. The level of control was such that there was no need for a further Spring application of a broad-leaved herbicide, this being a common course of action where only tri-allate is used.

Another important feature to emerge from the trials with the sequential addition of methabenzthiazuron was the consistent improvement in the level of control of A. myosuroides over that of tri-allate alone. Both chemicals have individual activity against this weed with tri-allate at 2.25 kg.ai/ha being more active than methabenzthiazuron at 1.5 kg.ai/ha. However the trials have shown that when the chemicals were sequentially applied there was an increase in activity leading to improved weed control, often approaching that of chlortoluron and isoproturon. The trials also demonstrated a similr but less pronounced increase in the level of control of Avena species from the sequential addition of methabenzthiazuron to tri-allate.

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THE FLEXIBILITY IN USE OF AN HYDROXYBENZONITRILE:MECOPROP ESTERS MIXTURE FOR BROAD-LEAVED WEED CONTROL IN CEREALS

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Summary A mixture based on the esters of ioxynil, bromoxynil and mecoprop was examined for broad-leaved weed control in cereals, including those undersown to grasses, and also in direct sown forage grasses.

When applied in the spring to autumn and spring sown wheat, oats, barley and rye at growth stages from Zdc 12 to Zdc 30-31, this mixture was tolerated at rates of up to double that required for efficient herbicidal action. When applied in the autumn/mid winter period to autumn sown wheat and barley, at growth stages from Zdc 12 onwards, the maximum herbicidal rate, followed in the spring by an application of double this amount, was also tolerated by the crop. All the important annual broad-leaved weeds of U.K. cereals were controlled with the exception of *Viola arvensis*, *Spergula arvensis* and large overwintered plants of *Galeopsis* spp. Application rate (1.05 to 1.84 kg a.i./ha) and optimum timing may be decided wholly on weed development once the cereal has 2 leaves. Undersown and direct sown grasses appear to be as tolerant as cereals.

Resumé Un melange d'ioxynil, de bromoxynil et de mecoprop (MCPP) sous forme d'esters a été mis au point pour lutter contre les dicotylédones, adventices dans les céréales, y compris les céréales suivies de graminées en culture dérobée et les graminées fourrageres installées de semis direct.

Appliqué au printemps sur céréales de printemps et d'automne - blé orge, avoine, seigle - du stade Zdc 12 au stade Zdc 30-31, ce mélange n'a montré aucune phytotoxicité à des doses doubles de celles suffisant à une bonne activité herbicide. Une application en automne jusqu'au milieu de l'hiver de la dose maximum d'emploi, suivie au printemps de l'application de double de cette dose, sur du blé et de l'orge d'automne, a partir du stade Zdc 12, a également été parfaitement supportée par le culture. Toutes les dicotylédones annuelles importantes rencontrées sur céréales en Grande-Bretagne ont été détruites, à l'exception de *Viola arvensis*, *Spergula arvensis*, et des grandes orties royales (*Galeopsis* spp) qui ont passè l'hiver. Les doses d'emploi (1.05 à 1.84 kg m.a./ha) et les epoques de traitment peuvent ainsi être determinees uniquement au vu du développement des adventices, dès que la céréale a atteint le stade 2 feuilles. Les graminées de semis direct, ou semées en culture dérobée se montrent aussi résistantes que les céréales.

INTRODUCTION

The herbicidal activity of hydroxybenzolitrile ester mixtures has been reported (Wilson et al, 1968) and it has been shown that these mixtures as esters are markedly more active than as salts (Folland et al, 1966). Moreover, the negligible phytotoxicity, in cereals of the hydroxybenzonitriles resulted in safety of use over a wide range of cereal growth stages (Tottman, 1977).

The mecoprop/bromoxynil/ioxynil ester mixture described in this paper was designed to make the maximum use of this quality of extreme safety to the crop at rates necessary for efficient weed control. The objective was to develop a herbicide that would effectively control overwintered and spring germinated broad-leaved weeds in the spring, in all autumn and spring cereal varieties, and in direct sown and undersown grasses.

In addition, the herbicide should be capable of effective use in autumn or spring sown cereals at any crop stage from two leaves onwards with the object of early removal of weed competition, the advantage of which has been reported (Wilson et al 1978).

METHODS & MATERIALS

Compounds used

Ioxynil + bromoxynil (both as octanoate and heptanoate esters) + mecoprop (iso-octyl ester) as emulsifiable concentrate - containing 52.5% total a.i.

Site details

(a) Small plot replicated - 3-4 replicates, sprayed with Ongar small plot motorised (wheeled) sideboom precision sprayer. 200-250 l/ha. Plots 2.5-3.0m x 10-20m.

(b) User trials - up to 3 replicates, sprayed with farm machinery. Plots 1 ha. Volume rates 200-275 l/ha.

Assessments

(a) Weed control - 3 x 0.5m^2 quadrats per small plot - up to 20 per user trial plot.

(b) Crop tolerance - plots scored (EWRC system) by minimum 3 assessors. Ears examined for distortion and crop height measured in 3 x 0.5m^2 quadrats per plot. Yields taken from replicated trials by means of adapted Claas "Colombus" combine and expressed at a calculated 85% dry matter.

RESULTS

TABLE 1 - SPRING APPLICATIONS. CONTROL OF THE MAJOR WINTER AND SPRING CEREAL WEEDS.

Mean % control of individual weed species over 4 years.
Number of occurrences thus - (2). Small plot replicated and farmer user trials.

Species	Hydroxybenzonitrile:mecoprop esters total kg a.i./ha 1.05	1.31	1.84	Maximum growth stage at spraying
Aphanes arvensis	95(1)	98(3)	92(5)	8 cms
Atriplex patula	-	100(3)	100(3)	8 lvs
Capsella b.pastoris	95(3)	85(1)	94(3)	10 "
Chenopodium spp.	95(3)	99(13)	98(4)	6 "
Chrysanthemum segetum	-	71(4)	77(4)	10 "
Fumaria officinalis	92(3)	100(1)	95(1)	(FL)
Galeopsis spp.	91(2)	90(5)	93(2)	8 lvs
Galium aparine	85(1)	86(4)	92(4)	16 cms
Lamium purpurem	68(2)	96(3)	95(1)	7 lvs
Mayweeds	95(10)	97(10)	-	6 "
Mayweeds*	-	96(11)	95(24)	16 "
Myosotis arvensis	95(1)	97(3)	100(1)	8 "
Papaver rhoeas	99(1)	97(10)	96(7)	12 "
Polygonum aviculare	94(9)	95(12)	-	7 "
" aviculare	-	80(7)	91(12)	12 "
" spp.	93(9)	98(25)	98(5)	6 "
Raphanus raphanistrum	-	100(1)	100(1)	7 lvs
Sinapis arvensis	97(3)	98(1)	98(1)	7 "
Stellaria media	90(14)	92(14)	-	16 cms (FL)
" media*	-	90(8)	93(23)	22 cms FL
Spergula arvensis	-	71(2)	80(2)	8 cms
Veronica spp.	95(5)	88(2)	-	14 cms
" spp.*	-	84(6)	90(18)	26 cms FL
Viola arvensis	61(4)	50(4)	57(4)	8 lvs
Weed beet	-	97(1)	-	4 "

* Includes overwintered plants. FL = flowering. (FL) = point of flowering.

TABLE 2 - SPRING APPLICATIONS. GRAIN YIELDS

Yield expressed as % of unsprayed control yield

Cereal type and variety		Crop growth stage at spraying Zdc scale	Hydroxybenzonitrile:mecoprop esters total kg a.i./ha 1.31	1.84	2.63	3.67	Unsprayed control yield t/ha	
1. W.wheat	Cappelle	15-16, 22-26	155 ab	140 b	-	-	2.54 c	*
2. "	J.Cambier	"	108 de	122 a	-	-	4.24 f	*
3. "	Flinor	13-15, 23	-	112	-	109	5.12	N.S.D.
4. "	M.Huntsman	13-15, 23-24	-	116	-	99	5.46	"
5. W.Barley	Senta	15-16, 22-26	115	117	-	-	3.98	"
6. "	M.Otter	14-15	-	105	-	117	4.05	"
7. S.Wheat	Sappo	14-15, 23-24	119	-	129	-	2.52	"
8. S.Barley	Aramir	13-14, 23-24	115	-	120	-	3.89	"

* Duncans Multiple Range test.

TABLE 3 - AUTUMN/WINTER APPLICATIONS. CONTROL OF MAJOR WINTER GERMINATING WEEDS

Mean % control of individual weed species. Number of occurrences thus - (2)

Weed species	Hydroxybenzonitrile:mecoprop esters total kg a.i./ha 1.31	1.84	Growth stage at spraying
Aphanes arvensis	96 (2)	97 (2)	Cot - 3 lvs
Galium aparine	100 (2)	100 (2)	Cot - 10 cms
Mayweeds	98 (3)	99 (4)	Cot - 6 lvs
Myosotis arvensis	86 (1)	87 (1)	2-3 lvs
Papaver rhoeas	99 (1)	100 (2)	4-8 lvs
Stellaria media	96 (12)	98 (11)	1 - 15 cms
" "	-	50 (1)	15 cms
Veronica spp	99 (6)	99 (6)	Cot - 4 lvs
Viola arvensis	41 (5)	55 (6)	Cot - 3 lvs

TABLE 4 - AUTUMN/WINTER APPLICATIONS.

Hydroxybenzonitrile:mecoprop ester mixture. Tolerance of winter cereal varieties.

Maximum EWRC crop score recorded following November application of 3.68 kg a.i./ha	Cereal type and variety and growth stage at spraying: Winter wheats Zdc 12-13, 20		Winter barleys Zdc 12-13, 20
3.0	Armada	Copain	Gerbel
	Atou	Flinor	M.Trojan
	Bouquet	Velmy	
2.5	Fleurus	M.Nimrod	Mirra
	Hobbit	M.Ranger	Katy
	Hustler	Mardler	M.Otter
	Kador	Sentry	
	Kinsman	Sportsman	
	M.Freeman	Waggoner	
	M.Huntsman	Wizard	
2.0 or <2.0	Aquila	M.Fundin	Astrix
	Bounty	M.Templar	Athens
	Brigand	M.Widgeon	Hoppel
	Champlein	Mega	Igri
	Flanders	Score	Malta
	Iona		Sonja

March repeat application of 3.68 kg a.i./ha	Zdc 15-17 23-25	Zdc 15-17,23-25
3.0	-	Katy
<2.0	All varieties	All other varieties

DISCUSSION

The hydroxybenzonitrile:mecoprop ester mixture has now had one year's commercial use for spring control of over-wintered or spring germinated weeds in United Kingdom cereals at dose rates of from 1.05 to 1.85 kg total a.i./ha. Table 1 summarises the hitherto unpublished spring weed control information and shows the range of weed species controlled, omitting less common species. A total of 42 weed species are very susceptible including the increasingly important volunteer field beans, beet and oilseed rape. Chrysanthemum segetum and Spergula arvensis are only moderately susceptible and Viola spp are resistant. Galeopsis spp as indicated in Table 1 are normally well controlled but these may occasionally overwinter as very strong plants and then MCPA should be used. The mixture was well tolerated by a wide range of cereal cultivars at twice the maximum weed control dose, at growth stages from Zdc 12 to Zdc 31, and interim 1978 results show applications to be safe up to Zdc 32. The safety of single and double weed control dose rates used in spring is demonstrated by the grain yield data in Table 2.

The applications of the hydroxybenzonitrile:mecoprop mixture in the 1977/78 autumn to mid winter gave control of the major weeds generally equal or superior to that achieved by spring application (Tables 1 & 3). Control of Galium aparine, mayweeds and the important overwintered Veronica hederifolia and V.persica was excellent. Control of Stellaria media was also generally excellent excepting for the strong large plants on one "thin" crop site (50% control only). However, Myosotis arvensis was only moderately controlled even at the higher dose rate, and the resistance of Viola spp was confirmed.

Other species which germinated in the autumn/winter showed similar susceptibility to that achieved by spring application (Table 1). Cerastium holostoides, Fumaria officinalis, Lamium purpureum, Lapsana communis, Polygonum aviculare and Sinapis arvensis were very susceptible. Lamium aplexicaule however, which can be of local importance, was only moderately controlled at the higher weed control dose rate. Spring germinating weeds, notably Polygonums and mayweeds, were in most cases effectively smothered by the developing crops. It was necessary to respray in spring with a low dose at three of the thirteen trials where a second germination of chickweed occurred.

The tolerance of cereals to this mixture is illustrated by the application of 3.68 kg total a.i./ha to a wide range of wheat and barley cultivars at 2-3 leaf stage in mid November in a light frost followed by a spring repeat of the same dose i.e. two applications of twice the maximum weed control rate (Table 4). At double rates no wheat or barley variety gave a mean EWRC crop score in excess of the commercially acceptable, 3.0 whilst at weed control rates, scores were lower with the exception of the wheat Bouquet and barley Katy which scored 3.0.

The exceptional safety of the hydroxybenzonitrile:mecoprop mixture on cereals at efficient herbicidal rates allows commensurate flexibility in its use. Doses may be selected according to weed growth stages, irrespective of either autumn or spring sowing, and hence irrespective of crop development between two leaves and jointing. The time of spraying in autumn sown wheat or barley may be from autumn onwards once weeds are germinated. Yield benefits from the autumn control of broad-leaved weeds in cereals with isoproturon, chlortoluron and similar materials have been reported (Wilson et al 1978). These materials, used primarily in the autumn and winter for grass weed control, give a bonus of control of certain broad-leaved species. However, where grass weeds are not important, the hydroxybenzonitrile:mecoprop mixture is more suitable, controlling a wider range of broad leaved species at a lower price. As well as any yield benefit accruing, the transfer of the spray operation from the busy spring to the autumn or winter will generally provide a useful operating advantage.

Current work shows the hydroxybenzonitrile:mecoprop mixture at 3.68 kg a.i./ha to be extremely safe in a wide range of diploid and tetraploid Italian ryegrasses, perennial ryegrasses and Westerwolds ryegrasses sprayed from the 2-3 leaf stage up to well tillered when either direct sown, or undersown in barley. A range of other grass species has shown similar tolerance.

The data obtained to date shows weed control in the direct or undersown grasses to be comparable with that in cereals (Table 1).

This development of the use in forage grasses is continuing and will add to the flexibility of the mixture in mixed cereal/short term ley farming.

Acknowledgment

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LEAF SHEATH LENGTH AS A GUIDE TO APICAL DEVELOPMENT AND SPRAY TIMING IN WINTER WHEAT

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Summary Measurements and dissections of plants of 8 winter wheat varieties collected by ADAS officers from 8 trials in England and Wales confirmed the close relationship between leaf sheath length and apical development, suggested by an earlier study at the Weed Research Organization (Tottman, 1977 a). The early stages of ear development could be predicted from the length of the longest leaf sheath, measured from ground level to the base of the last unfolded leaf blade.

Taking into account the variation of growth stage recorded in a farm crop and the results of MCPA treatments at different times, a practical guide to correct herbicide timing was established. Spraying the phenoxyacid herbicides when at least 19 of a random sample of 20 plants have main shoot leaf sheaths in excess of 5 cm is unlikely to cause ear deformity. To avoid risks of poorly-filled grain from late applications of herbicides, particularly those containing dicamba or 2,3,6-TBA, spraying should be completed before the leaf sheaths reach 10 cm.

INTRODUCTION

The recommendations for the use of most broad-leaved weedkillers in winter wheat stipulate their application between the fully-tillered and jointing stages (Fryer & Makepeace, 1972). Outside these limits they can damage the crop. For example, spraying 2,4-D or MCPA too early deforms the ears (Andersen & Hermansen, 1950) and dicamba or 2,3,6-TBA applied too late prevent grain swelling (Friesen et al, 1964). Accurate identification of the earliest stage at which spraying can safely begin will leave more time to take account of weed growth and adverse weather conditions before incurring the risks of late spraying. The 'fully-tillered' stage cannot be defined precisely and an objective criterion, easily judged in the field, is needed to determine correct spray timing.

Ear deformities, caused by early spraying, are the result of interference from the herbicide in the cell divisions and differentiation of the spikelets in the young ear (Myers, 1953). The stages of development of the young ears at the shoot apices are therefore regarded as critical to the safe timing of herbicide treatments. They can be exposed and classified only after micro-dissection in the laboratory. Our object, therefore, has been to seek external characters of the winter wheat plant that reflect the stages of apical development.

Several years study at the Weed Research Organization showed that the length of the longest leaf sheath was closely correlated with the stage of apical development for a wide range of varieties in three seasons (Tottman, 1977). This paper reports an extension of that study to samples of winter wheat plants of different varieties collected by ADAS officers at widely separated trial sites in England and Wales. It also describes a herbicide timing experiment in a farm crop of winter wheat with measurements of the plant to plant variation in growth stage.

METHOD AND MATERIALS

ADAS variety trials

ADAS officers were asked to sample 8 varieties from ADAS/NIAB winter wheat variety trials at 3 growth stages. The varieties selected were Armada, Atou, Freeman, Gamin, Hobbit, Huntsman, Kinsman and Sportsman and the aim was to sample them when the longest leaf sheaths were approximately 3, 5 and 7 cm long. Samples were collected from sites in Wiltshire, Avon, South Glamorgan, Warwickshire, Cambridge, North Humberside and Durham. All the trials were drilled between 13 October and 19 November 1976 at seed rates of 150-190 kg/ha into clay, silty or sandy loam soils. They received normal autumn fertilizer treatments and were top dressed in the spring with nitrogen at rates between 75 and 106 kg/ha. The samples, each of about 20 randomly dug plants were stored in deep freezes for later measurement and dissection. More than three sets of samples were taken at some sites to span the required growth stages in all varieties. Three were taken in the Cambridge area at the required growth stages but from different trials.

Fig. 1. A winter wheat plant illustrating the measurement of leaf sheath length

The longest leaf sheaths on the main shoots of 10 plants in each sample were measured from ground level to the base of the uppermost unfolded leaf (Fig. 1) and their main shoot apices exposed by dissection under a binocular microscope. The apices were classified by the latest type of primordia to appear on the most advanced spikelets, numbered as follows (Tottman, 1976):-

i - vegetative, foliar primordia

ii - elongation of apical meristem

iii - double ridges

iv - spikelet primordia

v - glume primordia

vi - lemma primordia

vii - floral primordia

viii - anthers and carpels

<u>Herbicide timing experiment</u>

A farm crop of Atou winter wheat at Begbroke Hill was sampled 5 times between 15 April and 10 May 1977 (Table 1) and plots were sprayed with MCPA (K salt) at 2.52 kg a.i./ha on each occasion. The treatments were replicated 6 times. The growth stages of 10 plants from each plot were recorded. Leaves and tillers were counted, leaf sheaths and true stem lengths measured and the shoot apices dissected out and classified. The herbicide was applied to plots of one square metre with a sprayer designed at WRO (Blair <u>et al</u>, 1974) using 2 x 8002 Spraying Systems tee-jets with an output of 221 l/ha at 2.1 bars. At harvest, ears were cut from 30 cm x 3 rows in each plot. Their number and the proportions of ears bearing opposite or supernumerary spikelets were recorded.

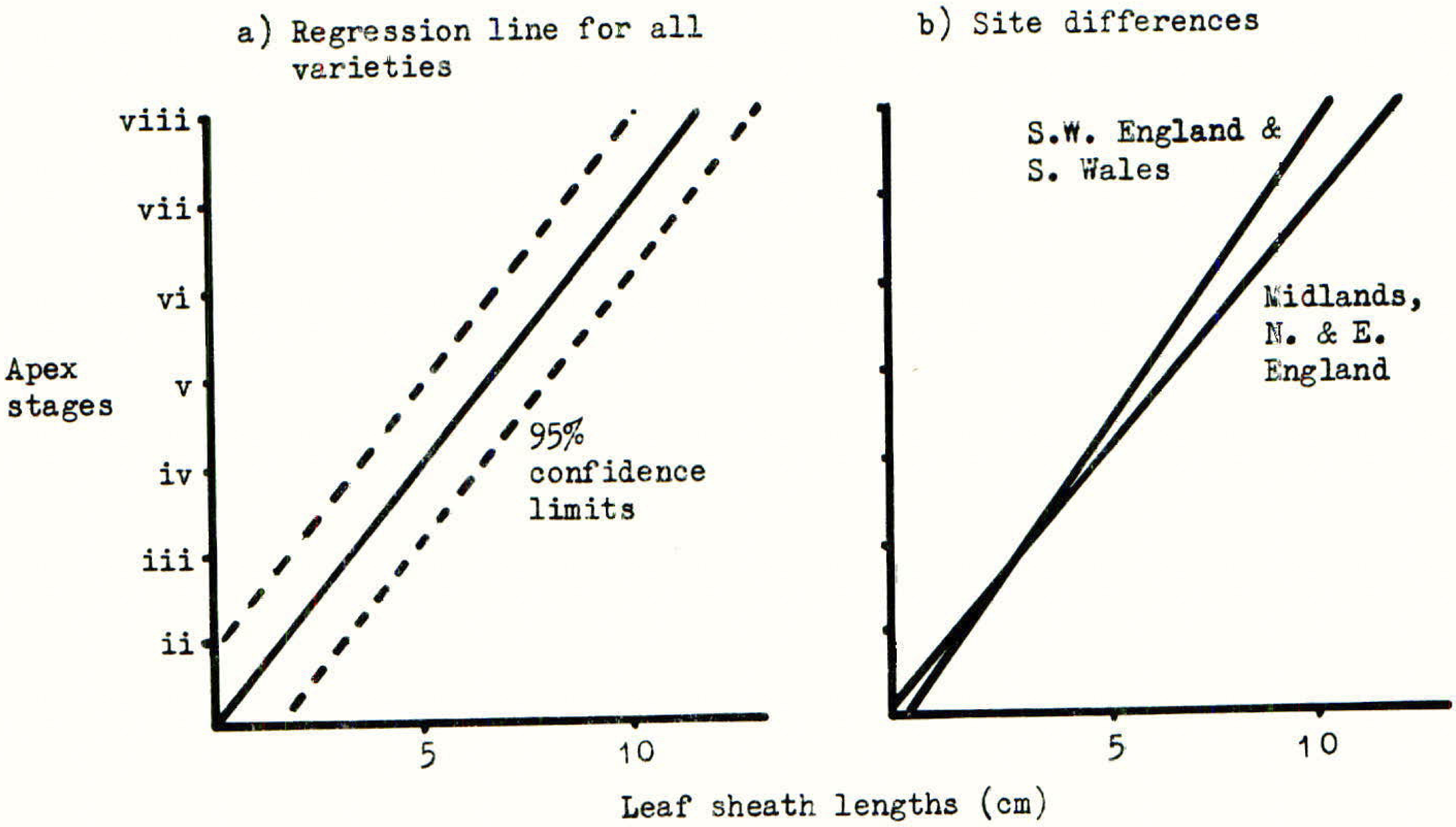
RESULTS

<u>ADAS variety trials</u>

An analysis of the mean values of the 10 plant samples for all varieties at all sites, a total of 182 observations, showed a very high correlation between leaf sheath length and the stages of apical development (correlation coefficient = 0.96). The fitted regression line with 95% confidence limits is drawn in Fig. 2a. The correlations for individual varieties were also high, with all coefficients better than 0.90 and no significant difference between the slopes of their regression lines.

When the leaf sheath length averaged 5 cm spikelet primordia had appeared on most apices (stage iv), with double ridge (iii) and glume initial stages (v) at the extremes of the 95% confidence limits. When the sheath length reached 10 cm most apices bore floral primordia (vii).

Fig. 2. The relationship between leaf sheath length and apical development in the main shoots of winter wheat plants, ADAS variety trials 1977



The slopes of regression lines drawn for different sites differed at the 5% probability level (Fig. 2b). This did not, however, seriously affect the correlation between leaf sheath length and apical development while the sheaths were about 5 cm. Separation of the regression lines only became obvious at sheath lengths exceeding 8 cm. At these later stages the apical development of plants growing in the south west tended to be further advanced in relation to their leaf sheath lengths than that of plants growing in the Midlands, north and east of the country.

Herbicide timing experiment

An analysis of the 180 plants sampled on 24, 28 April and 4 May from the crop of Atou winter wheat at Begbroke Hill again showed a high correlation between leaf sheath length and the degree of apical development (coefficient 0.89), with a 5 cm sheath length corresponding to the appearance of spikelet primorida.

The relatively high standard errors associated with the mean sheath lengths and apical development stages presented in Table 1 show a considerable variation among the plants in a crop at any one time. When the leaf sheath length was 5 cm nearly a third of the plants had sheaths less than 4 or more than 6 cm. At the same time, most apices were showing spikelet primordia (iv) but 25% already had glume initials and 7% were still at the double ridge stage.

Table 1

The growth stages of Atou winter wheat plants on 5 dates and the ear deformities caused by the application of MCPA at 2.5 kg a.i./ha on those dates

	Main shoot						1st tiller		Ears with opposite spikelets		Ears with extra spikelets	
Date	Leaf No.	Tiller No.	Leaf sheath length	SE	Apical stage	SE	Leaf sheath length	Apical stage	%	$\sqrt{x} + 1$	%	$\sqrt{x} + 1$
15/4	5.2	2.0	2.3		2.9		1.7	2.1	14.1	4.6	0.9	1.7
24/4	5.6	2.1	3.4	± 0.94	3.3	± 0.48	2.6	2.7	3.9	2.9	6.5	3.2
28/4	6.1	2.3	5.1	± 1.12	4.2	± 0.54	3.4	3.2	3.0	2.5	10.3	4.0
4/5	6.8	2.5	7.9	± 1.03	6.0	± 0.86	5.8	4.3	0	1.0	1.6	1.8
10/5	6.6	2.2	10.5		7.9		7.5	5.9	0	1.0	1.7	2.1
							unsprayed control		0	1.0	0.3	1.2
							SE treatment means			± 0.46		± 0.34

Throughout the sampling period the sheath lengths and apex stages of the tillers lagged behind the main shoots. On 28 April, when the main shoot leaf sheaths were 5 cm long, those of the first tillers were about 1.5 cm shorter and most of their apices were at the double ridge stage (iii). Second tillers were even less advanced but these survived to produce fertile ears on only about 10% of plants.

Spraying MCPA on the first three dates deformed some of the ears (Table 1). Only the first spray application caused many opposite spikelets but the third, on 28 April, when the leaf sheaths averaged 5 cm, resulted in most extra spikelets. Six days later, when the mean leaf sheath length had extended to 8 cm, MCPA produced extra spikelets on only a very few ears and otherwise had no obvious effect on the crop.

DISCUSSION

The results presented in this paper support the tentative conclusions drawn from an earlier study of winter wheat development at the Weed Research Organization (Tottman, 1977). The close relationship between leaf sheath length and the stage of apical development applied to all the varieties tested. Although there were small differences between sites they did not affect the prediction of the double ridge and spikelet initiation stages from the length of the leaf sheaths.

If herbicide tolerance is determined by the stage of apical development, leaf sheath length should provide a reasonably accurate guide to spray timing. Despite some controversy over the precise apical stages sensitive to MCPA and 2,4-D (Andersen and Hermansen, 1950; Myers, 1953), there is general agreement that ear deformities are unlikely in plants sprayed when the shoot apices have progressed beyond the double ridge stage. There remains, however, some doubt about the degree to which herbicide tolerance is influenced by plant size and root development (Voevodin et al, 1975) and patterns of translocation (Petersen, 1958; Olunuga et al, 1977). Here again, leaf sheath length might offer a practical guide to such developmental changes in the plant.

Coupling the results of the herbicide experiment with those obtained in the earlier study (Tottman, 1977 a) suggests some practical advice on spray timing. Winter wheat may be sprayed, without risk of ear deformity, once 19 or more of a random sample of 20 plants have main shoot leaf sheaths in excess of 5 cm. A larger sample would be desirable, particularly in an uneven crop. This growth stage is described as 'pseudostem erect' (stage 30) by Zadoks et al (1974) in their decimal code.

Spraying broad-leaved weedkillers, particularly those containing dicamba or 2,3,6-TBA, when the crop is jointing can severely reduce cereal yields (Tottman, 1977 b). It seems likely that the herbicide interferes with the supply of assimilates to the developing grain. Growth stage is one of several factors determining the risk of damage and only broad guidelines can be offered on spray timing. Although our previous study showed a close correlation between a leaf sheath length of 10 cm and the detection of the first node (Tottman, 1977 a), the sheaths were 12 cm or more before the obvious appearance of joints in the Begbroke Hill crops. However, evidence of faster apical development at such leaf sheath lengths in crops in the south west suggests the safest interpretation of the jointing stage would still be a sheath length of 10 cm.

The best time to spray winter wheat plants with the conventional broadleaved weedkillers is when their main shoot leaf sheaths exceed 5 cm but before they reach 10 cm.

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THE TOLERANCE OF YOUNG STRAWBERRY CROPS TO A TRIETAZINE/SIMAZINE MIXTURE

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Summary A trietazine/simazine mixture (a ratio of 7:1) was applied at 1.37 and 2.74 kg/ha total a.i. to newly-planted or young strawberries in spring or autumn over a 3 year period. Effects were compared with those from lenacil (2 kg/ha), a safe treatment, and with simazine (1-2 kg/ha) which is normally damaging.

On four out of eight dates there was no damage from any treatment. On four occasions, when wet conditions followed spraying, simazine caused marked crop damage. On these treatment dates the lower rate of trietazine/simazine caused moderate leaf injury (chlorosis and necrosis) but only small reductions in subsequent growth and yield. Spraying 9 month old crops in April/early May led to a 20% yield reduction.

The results indicate that trietazine/simazine at 1.37 kg/ha is intermediate in toxicity to young strawberries between lenacil and simazine at normal rates of use. The results from these and other recent trials in the British Isles suggest it cannot be recommended on newly-planted crops but should be safe on young crops in situations where simazine is recommended.

INTRODUCTION

A trietazine/simazine mixture has been in use for annual weed control in strawberries in the British Isles for the past 4 years. It has advantages over other residual herbicides recommended for strawberries in that it has greater activity in dry soil conditions, controls some weeds at the early post-emergence (cotyledon) stage and controls certain weeds resistant to lenacil (Ellis, 1973). It is also cheaper than other post-planting herbicide treatments. Commercial development trials suggested the herbicide would be too damaging to use on crops less than a year old (Ellis, 1973) although there were reports of successful use by growers in young crops.

To obtain further information on the tolerance of young crops a series of experiments, co-ordinated by the ARC Fruit Weed Control Group, was carried out at a number of centres in the British Isles. In the experiments at WRO from 1974 to 1978 a standard and double dose of trietazine/simazine was applied on eight dates in spring or autumn to crops ranging in age from newly-planted to 10 months from planting. Lenacil, at the rate recommended for use in strawberries (MAFF, 1978) was used for comparison.

METHOD AND MATERIALS

Six experiments were carried out at Begbroke Hill on a sandy loam soil with 2-3% organic matter content and pH 6-7. Planting and treatment dates are given in Table 1.

Table 1

Herbicide application dates, plant age at treatment and rainfall amounts following treatment in six experiments with trietazine/simazine on young strawberries

Experiment number	1	2A	2B	3	4A	4B	5	6
Crop age at treatment	5 months	9 months	10 months	3 weeks	2 days	6 months	2 weeks	2 weeks
Date of treatment	16/9/74	15/4/75	8/5/75	11/4/75	17/10/75	1/4/76	1/4/76	15/4/77
Rainfall, weeks after treatment								
Average (mm/week)								
0-1 weeks	15	19	8	27	2	1	1	9
1-3 "	18	2	12	2	3	3	3	19
3-6 "	16	12	3	11	9	2	2	5
6-12 "	15	4	8	2	6	7	7	14
Total (mm)								
0-6 weeks	100	59	41	66	36	14	14	63
6-12 "	88	22	48	12	37	41	41	84

The cultivar Cambridge Favourite was used for Experiments 1-4 and cv. Gorella for the remainder. In Experiments 1-4 runners were planted at a spacing of 25 x 25 cm spacing in 1 m^2 plots to give nine plants per plot with 1 m wide discard between plots. In Experiments 5 and 6, runners were planted 0.25 m apart along rows which were 1.5 m apart. The single row plots were 2 m long with 0.5 m discard between adjacent plots along rows but no discard plots between rows. All experiments were laid out as randomised blocks with four replicates but with either two or three lenacil treatments per replicate. The recommended trietazine/simazine dose for the soil type plus a double dose were applied at each date in comparison with the standard lenacil treatment. In most experiments a single rate of simazine was also applied as a 'damaging' standard to indicate if the weather conditions in the treatment period were conducive to damage from soil-acting herbicides. The following herbicide formulations were used:- trietazine/simazine 50% w.p., containing 43.75% trietazine + 6.25% simazine (a ratio of 7:1); lenacil 80% w.p.; simazine 50% w.p. Herbicides were applied using an Oxford Precision Sprayer and a volume rate of 400 l/ha. On the metre square plots the sprayer was used in conjunction with a screened spraying frame (Blair et al., 1975).

Plots not receiving experimental treatments for 6-10 months after planting were sprayed with lenacil (2 kg/ha) post-planting. In Experiment 6 all plots received the recommended simazine treatment (1.5 kg/ha) in September. Any weeds developing on the plots were removed at the small seedling stage by shallow hand-hoeing. In Experiments 1, 3 and 4 stolons and runners were removed from the plots as they developed and numbers and weights recorded. In Experiment 2 runners were allowed to root in the metre square plots but those extending beyond were removed and recorded. In Experiments 5 and 6 runners were allowed to root in the plots to form matted rows.

Crop vigour was assessed visually at intervals after treatment using a 0-9 scoring scale (0 = plant dead, 3 = very stunted, still growing, 5 = 50% growth reduction, 7 = readily distinguishable growth reduction, 9 = plant normal). Growth was assessed in winter by recording numbers of crowns/plot (Experiments 2-4) or numbers of rooted runners/plot (Experiments 5 and 6). Fruit yield was recorded in most of the experiments, usually by a single harvest of all ripe and unripe fruit when most of the fruit was ripe. With spring planted crops (Experiments 3, 5 and 6) flower trusses were removed and no crop taken in the first year. In 1978 (Experiment 6) successive picks were made over a 3 week period.

RESULTS

Application to newly-planted crops

The results of both trietazine/simazine and simazine applications to newly-planted crops varied according to weather conditions. Trietazine/simazine at 1.37 kg/ha applied to newly-planted strawberries in April 1975 (Experiment 3) caused chlorosis and necrosis of plants after treatment, but there was no long-term adverse effect on growth in 1975 or fruit yield in 1976 (Table 2). The double rate of trietazine/simazine caused greater leaf injury and some growth and yield reduction. Simazine at 1.5 kg/ha caused severe leaf damage and death of plants. Rain fell very soon after the application of the herbicides in this experiment (Table 1). Lenacil also caused leaf chlorosis and necrosis but the crop appeared to recover rapidly from this check. There was no observable damage from lenacil in any of the other experiments.

Trietazine/simazine applied at 1.37 kg/ha to newly-planted strawberries in autumn 1975 (Experiment 4) caused severe leaf injury after treatment resulting in less vigorous plants in spring 1976 (Table 3). Fruit yield and subsequent growth were reduced though not significantly. The double rate of trietazine/simazine and simazine at 1.0 kg/ha were very damaging. Rainfall amounts were small after this treatment (Table 1).

Applications of both rates of trietazine/simazine and of simazine (1.5 kg/ha) in spring 1976 (Experiment 5) had no effect on growth of the plants (Table 4), whereas the same treatments applied in spring 1977 caused damage. Although there was obvious leaf damage with trietazine/simazine in 1977 there were no significant reductions in runner growth in that year nor in fruit yield the following year. Many plants were killed by the 1977 simazine treatment. There was little rain in the 6 weeks following treatment in 1976 but appreciable rain in 1977 (Table 1).

Application to 5-10 month-old crops

No leaf damage was observed from applications of lenacil to these crops. The two rates of trietazine/simazine applied in September 1974 to 5-month-old strawberries (Experiment 1) caused temporary leaf chlorosis in October but had no adverse effect on fruit yield the following summer (Table 5). There was a lot of rain in the 12 weeks following treatment (Table 1). Trietazine/simazine applied to July-planted strawberries in the following April or early May 1975 (Experiment 2) caused some leaf chlorosis after spraying and a 20% reduction in fruit yield compared with lenacil (Table 6). Simazine at 1.5 kg/ha reduced yield at the first treatment date but not the second. Subsequent growth was not affected by the trietazine/simazine treatments. Average amounts of rain fell in the 6 week period after treatment. When applied to 6 month-old crops in spring 1976 (Experiment 4) both rates of trietazine/simazine and of simazine had no effect on crop growth or fruit yield compared with lenacil (Table 3). Conditions were very dry after treatment (Table 1).

Table 2

The effect of trietazine + simazine applied to newly-planted strawberries in spring (Expt 3)

Herbicide	Dose (kg total a.i./ha)	Vigour score (0-9) 21/5/75	Vigour score (0-9) 22/7/75	Runner wt (kg/m^2) autumn 75	No. living plants/m^2 16/12/75	Crowns/m^2 16/12/75	Total fruit yield (t/ha) July 76
Lenacil	2.0	7.6	7.4	1.22	8.1	30	23.9
Trietazine + simazine	1.37	7.0	6.8	1.29	8.0	27	25.5
	2.74	5.8	5.1	0.81	7.0	23	18.9
Simazine	1.5	2.5***	1.1***	0.26***	1.8***	5***	4.8***
	4.5	1.2***	0.2***	0.03***	0.3***	1***	0.7***

Table 3

The effect of trietazine + simazine applied to autumn-planted strawberries at two dates (Expt 4)

Herbicide	Dose (kg total a.i./ha)	Application date	Vigour score (0-9) 10/5/76	Vigour score (0-9) 21/6/76	Fruit yield (t/ha) 21/6/76	Plants/m^2 16/11/76	Crowns/m^2 16/11/76	Runner wt (g/m^2)
Lenacil	2.0	17/10/75 + 1/4/76	8.0	8.1	2.59	8.9	25.5	488
Trietazine + simazine	1.37	17/10/75	5.0***	5.0***	1.75	8.0	19.3	389
	2.74	"	2.0***	2.0***	0.31***	3.3**	14.5**	112***
Simazine	1.0	"	1.5***	1.3***	0.1***	2.3***	5.8***	92***
	2.0	"	0.5***	0.3***	0 ***	0.3***	0.8***	4***
Trietazine + simazine	1.37	1/4/76	7.5	8.3	2.66	9.0	26.3	496
	2.74	"	6.8**	7.3	2.47	8.8	26.5	439
Simazine	1.0	"	8.0	8.3	2.86	9.0	23.8	515
	2.0	"	8.0	8.0	2.63	8.8	24.5	413

*, **, *** indicates values significantly different from the lenacil treatment at 5, 1 and 0.1% respectively.
Statistical analysis carried out on transformed data

Table 4

The effect of trietazine + simazine applied to newly-planted runners in spring (Expts 5, 6)

Herbicide	Dose (kg total a.i./ha)	1976 (Expt 5) Vigour score (0-9) 11/5/76	1976 (Expt 5) Vigour score (0-9) 4/6/76	1976 (Expt 5) Rooted runners (No/plot) 3/3/77	1977 (Expt 6) Vigour score (0-9) 20/5/77	1977 (Expt 6) Vigour score (0-9) 15/8/77	1977 (Expt 6) Rooted runner count (No/plot) 29/3/78	1977 (Expt 6) Fruit yield (t/ha) July 78
Trietazine	1.37	7.0	8.0	95	6.3	8.5	56	32.2
+ simazine	2.74	7.0	7.3	101	4.8	6.3	51	29.4
Simazine	1.5	7.5	7.5	98	3.5	3.3	18	12.9
Lenacil	2.0	7.6	8.8	95	8.3	8.6	56	33.5
SE ±		0.29	0.29	5.8	0.31	0.44	4.6	2.22
LSD 5%		NS	0.7	NS	0.76	1.08	12	5.5
1%		NS	1.0	NS	1.02	1.45	15	7.3
0.1%		NS	1.3	NS	1.34	1.90	20	9.6

Table 5

The effect of trietazine/simazine applied to young strawberries in autumn (Expt 1)

Herbicide	Dose (kg total a.i./ha)	Vigour score (0-9) 9/10/74	Fruit yield (t/ha) July 75
Trietazine	1.37	7.2	19.9
+ simazine	2.74	7.2	21.9
Lenacil	1.5	8.5	22.3
SE ±		0.25	1.54

Table 6

The effect of trietazine/simazine applied to young strawberries in spring (Expt 2)

Herbicide	Dose (kg total a.i./ha)	Application date	Vigour score (0-9) 30/5/75	Fruit yield (t/ha)	Runner wt (kg/plot)	Crowns/m^2 9/12/75
Lenacil	2.0	15/4/75	9.0	14.8	1.90	65
Trietazine	1.37	"	9.0	11.9	2.13	60
+ simazine	2.74	"	7.8	11.9	2.03	66
Simazine	1.5	"	8.0	11.8	1.84	56
	4.5	"	6.0	7.2	1.51	57
Trietazine	1.37	8/5/75	7.8	11.2	1.85	60
+ simazine	2.74	"	6.8	11.6	2.24	62
Simazine	1.5	"	8.3	14.5	2.04	60
	4.5	"	7.0	11.2	1.54	60
SE ±			0.20	0.92	0.219	3.4
LSD 5%			0.4	2.0	NS	NS
1%			0.6	2.7	NS	NS
0.1%			0.8	3.5	NS	NS

DISCUSSION

Results from these experiments indicate that damage to young plants from the standard rate of trietazine/simazine (1.37 kg/ha) occurred when wet conditions followed spraying in spring. On newly-planted crops this damage appeared severe (chlorosis and leaf necrosis) but few plants were killed and subsequent growth was almost as good as with the lenacil standard (Tables 3, 4). The double rates caused severe leaf damage although crops grown as matted rows largely recovered from this. On all occasions when the standard rate of trietazine/simazine was damaging, simazine at the 1-2 kg/ha rate was much more damaging suggesting that the trietazine/simazine mixture is intermediate in causing phytotoxicity between simazine and relatively safe herbicides such as lenacil. Yield reductions from trietazine/simazine were also found after applications to 9-month-old plants in spring (Table 6) indicating possible dangers from use in spring on larger plants. There appeared to be a difference in response to autumn treatments according to plant age, a newly planted crop being damaged even where conditions were relatively dry following treatment (Table 3) whereas a 6 month old crop was undamaged when there was a lot of rain after treatment (Table 5).

Results from other trials in the British Isles show a similar pattern of variation from experiment to experiment. Ellis (1973) reported a number of cases of damage to young crops in S.E. England. No damage was found in N. Ireland from spring applications to autumn-planted crops in 1975 - 1977 (Loughgall, 1978). In S.W. England spring applications to newly-planted crops in 1976 and 1977 were safe (Parfitt and Stott, 1978). Damage was reported from S.E. Ireland where applications were made in February/March to young strawberries; conditions were wet following herbicide applications (Rath and O'Callaghan, 1976). In Yorkshire spring-planted runners on a sandy loam soil were undamaged by trietazine/simazine applied immediately post-planting but severe leaf chlorosis was caused by treatments 2 and 4 weeks after planting; subsequent growth was unaffected (Delaney, 1978).
In experiments in 1976, 1977 in E. Scotland spring applications of 1.7 kg/ha trietazine/simazine to newly-planted runners caused slight injury after spraying but did not affect subsequent growth; higher rates were more damaging. Simazine at 1.1 kg/ha caused little injury in these trials (Lawson and Wiseman, 1978).

With the evidence available it is clear that trietazine/simazine could not be generally recommended for use on newly-planted strawberries in the British Isles, even though it would often be safe particularly on heavier soils. It would appear however that it could be safely used in the British Isles.on crops less than one year old in situations where simazine is recommended. These would include treatments from July onwards on autumn-planted crops and treatments in autumn on spring-planted crops (MAFF, 1978). It is likely that post-planting use on plants with roots previously dipped in activated charcoal would also be safe.

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RESPONSE OF SPRING PLANTED STRAWBERRIES TO RATES AND TIME OF APPLICATION OF TRIETAZINE/SIMAZINE

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Summary:-In 1976 and 1977 experiments were done at Long Ashton Research Station (LARS) to assess the value of a 7:1 trietazine/simazine mixture on a clay loam soil as an alternative to lenacil and simazine for the control of annual weeds in spring-planted strawberries.

Simazine damage to the plants in both years indicated that environmental conditions had been damp enough to activate these residual herbicides. Trietazine/simazine at 1.86 kg/ha a.i. post planting gave more initial damage than lenacil (2 kg/ha a.i.) but very much better weed control, particularly by autumn, at a third of the cost. In 1977 the number of runners and crowns (which determine potential crop weights) were significantly better than in lenacil treatments.

Weed control with trietazine/simazine applied post planting and at a half rate post planting and a few weeks later was almost as good as that of simazine, but delayed applications (to catch late developing weeds) gave progressively less weed control.

Résumé En 1976 et 1977 on a fait des expériences à Long Ashton Research Station pour évaluer les effets d'un mélange à 7:1 de triètazine/simazine sur un sol argile-limoneux comme alternative au lénacil ou à la simazine pour la luttre contre les mauvaises herbes annuelles chez les fraisiers plantés au printemps.

Les dégâts aux plantes provoqués par la simazine en les deux années ont montré que les conditions du milieu avaient été assez humides pour activer ces désherbants residuels. Triétazine/simazine à 1.86 kg/ha après la plantation a provoqué plus de dégâts au dèbut que lénacil (2 kg/ha), mais a donné des résultats beaucoup meilleurs dans la luttre contre les mauvaises herbes, particulièrement vers l'automne, avec un tiers des frais. En 1977 les nombres de stolons et de couronnes (qui fixent les poids potentiels des rendements) étaient significativement meilleurs que dans les traitements à lénacil.

La suppression des mauvaises herbes avec triétazine/simazine, appliqué après la plantation, à demi-taux après la plantation, et plusieurs semaines plus tard a été presque aussi bonne que celle réalisée avec la simazine, mais des applications retardées (pour atteindre les mauvaises herbes de développement tardif) ont donné des résultats de plus mauvais.

INTRODUCTION

Young spring planted strawberries are very susceptible to competition from annual weeds (Lawson and Wiseman 1976). Unfortunately current commercial weed control programmes based mainly on lenacil and simazine are often inadequate. Lenacil is expensive and though it rarely damages strawberries, weed control can be poor, particularly if a dry period follows application. The cheaper material simazine gives a good control of weeds but usually causes unacceptable damage to newly planted strawberries. Hence there is a continuing need for the evaluation of herbicides for newly planted strawberries (Clay, 'et al.' 1974a; Clay, 'et al.' 1974b; Rath and O'Callaghan 1976).

A trietazine/simazine mixture which promised to have advantages of some post emergence activity, a broader weed control spectrum than lenacil, and less dependance on soil moisture for activity than lenacil and simazine, was reported safe in established strawberries (Ellis 1973). Since its toxicity is intermediate between lenacil and simazine (Clay, 1978), its tolerance by young strawberries was uncertain. It was necessary to establish the effect of the treatment on the growth and yield of strawberries up to one year old, on a range of soil types and climatic areas. Hence the experiments here reported were part of a joint programme of evaluation by the ARC Fruit Weed Control Group.

The experiments compare the effects on weeds and strawberries of a trietazine/simazine mixture applied at various combinations of rates and post planting times with lenacil as one standard and simazine (at a normally damaging rate) as another. The simazine standard was included to indicate whether the conditions of the experiment had been too dry to draw any conclusions on the safety of the experimental treatments. Because of the possibility of anomalous effects resulting from the exceedingly dry conditions in 1976 the experiment was repeated in 1977 in the same form, though on a different site.

METHOD AND MATERIALS

The experiments were carried out at LARS on clay loam soils belonging to the Worcester shallow phase soil type (Cope 1970) which have an organic matter content (as determined by loss-on-ignition) of 4%.

The plots were treated with paraquat, rotavated before planting, and any residual weeds removed by hand before the first herbicide sprays were applied. The plots were planted on March 31st 1976 and April 15th 1977 with cold stored runners of cv. Cambridge Favourite at 1 m x 0.5 m; the area was divided into 28 sub-plots, each containing 24 plants in 4 rows of 6 plants, separated and bounded by guard rows.

The design of the experiment was an Incomplete Latin Square, allowing variability between Blocks and Rows to be taken out. Seven treatments, in four randomised replicate blocks were compared, consisting of:-

1. Trietazine/simazine at 1.86 kg/ha a.i. post planting
2. Trietazine/simazine at 0.93 kg/ha a.i. post planting and again after 4 weeks
3. Trietazine/simazine at 1.86 kg/ha a.i. 2 weeks post planting
4. Trietazine/simazine at 1.86 kg/ha a.i. 4 weeks post planting
5. and 6. Lenacil at 2.0 kg/ha a.i. (commercial rate) as a standard, post planting
7. Simazine at 1.5 kg/ha a.i. (a normally damaging rate) as control, post planting.

Trietazine/simazine was formulated as a 62% wettable powder containing 54.25% trietazine/7.75% simazine; lenacil as an 80% w.p. and simazine as a 50% w.p. The first treatments were applied on 8 April 1976 and 22 April 1977. Sprays were applied with a knapsack sprayer at 1,000 litres/hectare and a pressure of 1.2 kg/cm^2.

Records were taken of:-

1. Number of weed seedlings present in May on each 0.1 m^2 quadrat, thrown at random 10 times in each plot (11.5.1976, 26.5.1977)
2. Number of plants showing chlorosis or scorch in May (13.5.1976, 25.5.1977)
3. Number and type of weeds, and percentage weed cover in 7 randomly thrown 0.1 m^2 quadrats per plot in June (11.6.1976, 23.6.1977)
4. Fruit weight and number, (two harvests in June 1976, and three in July 1977)
5. Tolerance of strawberry plants to herbicides scored in July on a linear 0-9 scale where 0 = plant dead, 5 = 50% growth reduction, 9 = the best plants in the lenacil standard treatment (15.7.1976, 21.7.1977)
6. Number of crowns and runners per plant in October (11-22.10.1976, 17-28.10.1977).

The data for percentage weedcover and chlorosis were transformed for statistical analysis. The standard errors of differences between two means (SED) are given in the Tables and also an indication of the significance of the more important comparisons, where * denotes a difference between two means significant at the 5% level and ** at the 1% level.

RESULTS

In both years the weather in March was wet prior to planting. Following herbicide applications in 1976 only 20 mm of rain had fallen by 11 May and a further 34 mm by 11 June when records of weed suppression were taken. In 1977, though April and May were also relatively dry, 87 mm of rain fell between 22 April and 26 May and a further 107 mm between 26 May and 23 June.

Table 1

Rainfall mm (± deviation from the 40 year average)

1976	March	April	May	June	July	August
	70	17	42	25	24	30
	+10	-40	-22	-29	-59	-57
1977	76	45	50	109	11	130
	+16	-13	-14	+54	-72	+43

1. Effect on weeds

The mean number of weed seedlings per 0.1 m^2 quadrat, six weeks (1976) and five weeks (1977) after first herbicide applications (Table 2), showed that in both years initial weed control was best with simazine (7). Trietazine/simazine (1) was almost as good, and significantly better than lenacil (5,6). Other trietazine/simazine treatments varied from almost as good as treatment 1 to worse than lenacil.

Estimates of percentage weed cover of the plots were made on 11 June 1976 and 23 June 1977 (Table 2). The different numbers of weed seedlings recorded in May (Table 2) grew to produce large differences in percentage weed cover, ranging from 4.9% to 25.5% in 1976 and 1.6% to 34.4% in 1977.

Table 2

Effect of herbicides on weeds

Treatment No.	Mean No. of Weed seedlings per 0.1 m^2		Proportion weed cover			
	May 1976	May 1977	June 1976		June 1977	
			%		%	
1	10.2	1.0	11.7	(20.0)	2.0	(8.1)
2	12.4	1.1	13.4	(21.5)	2.5	(9.0)
3	14.2	1.1	25.5	(30.4)	5.8	(14.0)
4	19.5	4.6†	17.2	(24.5)	30.1	(33.3)
5	14.6	2.2	21.6	(27.8)	33.8	(35.5)
6	20.1	2.3	23.4	(28.9)	34.4	(35.9)
7	6.7	0.8	4.9	(12.8)	1.6	(7.2)
S.E.D.	3.25	0.51		(3.76)		(3.06)
	4,6>**1,7	5,6>* 1,7	3,5,6>**7		4,5,6>**1,2,3,7	

Figures in ( ) are for angular transformations.
† This very high value was due to the germination of weeds before this treatment was applied. Hence it was omitted from the statistical analysis.

In 1976 the predominant weed on trietazine/simazine and simazine treatments was Chenopodium album. Spergula arvensis and Polygonum spp. were frequent, other annuals and perennials occasional. The same weeds were present on lenacil treatments, but Spergula arvensis dominated Chenopodium album. In 1977, Veronica spp. predominated in all treatments; Gallium aparine was also frequent in lenacil treatments.

In both years, simazine gave significantly the best weed control with trietazine/simazine (1) the next best and lenacil the worst. Although inactivation of herbicides by the dry spring in 1976 produced much higher seedling numbers than in 1977, due to the continuing dry weather the subsequent growth of weeds was much poorer, and individual plants were smaller

2. Effect on Plants

Approximately one week after the final herbicide application (treatment nos. 2 and 4), counts were made of the number of plants per plot showing leaf chlorosis or scorch (Table 3). Damage was greatest on plants sprayed with simazine and least on those sprayed with lenacil. Trietazine/simazine sprayed plants fell roughly between these two, except for treatment 4, probably because insufficient time i.e. only a week, had elapsed between spraying and damage assessment. Trietazine/simazine and simazine produced a well-defined, moderately intense chlorosis of the leaf margins, whereas lenacil treated plants showed a more diffuse, interveinal chlorosis. Damage was confined to leaves exposed to sprays and subsequent leaves developed normally.

Approximately three weeks after the date of the first harvest, the plants were assessed for vigour (Table 3). In both years the standard for comparison was taken as the "best" (largest and most luxuriant) of the plants on the lenacil sprayed plots (treatment nos. 5 and 6). Since all plants (including lenacil sprayed) were generally poorer in 1976 than in 1977, the scores are not directly comparable. In both years, vigour was least on simazine sprayed plots. Vigour on trietazine/simazine sprayed plots appeared progressively less with later sprayings. Lenacil treatments were significantly the most vigorous in 1977, but not in 1976 when some of the trietazine/simazine treatments returned higher scores.

In 1976 simazine killed very significantly more plants than any other treatment but in 1977 the results, though similar were not so pronounced.

Table 3

Effect of herbicides on strawberries

Treatment No.	Proportion of plants showing chlorosis %				Vigour score (0-9)		Dead plants /plot	
	May 1976		May 1977		July 1976	July 1977	July 1976	July 1977
1	38.8	(38.5)	53.1	(46.8)	6.1	5.7	1.3	3.3
2	31.2	(34.0)	41.7	(40.2)	5.4	5.2	2.0	0.8
3	34.1	(35.7)	47.9	(43.8)	4.8	4.9	1.3	3.0
4	8.2	(16.6)	9.4	(17.9)	4.4	4.6	2.5	1.8
5	5.4	(13.4)	5.6	(13.7)	4.7	6.5	1.0	1.5
6	5.0	(12.9)	6.1	(14.3)	5.0	6.6	1.8	1.0
7	72.5	(58.4)	81.7	(64.7)	3.1	4.2	8.5	4.5
S.E.D.		(4.75)		(6.10)	0.73	0.26	0.09	0.79
	1976 and 1977 7>**1,2,3>**4,5,6				1,2,3,5,6 >*7	5,6>**1,2,3 1,2,3>**7	all <***7	7>** 5,6

Figures in ( ) are for angular transformations.

Table 4

Crop Yield. Number (10^3) and Weight (tonnes) of fruit per hectare

Treatment No.	1976 No.	1976 Wt.	1977 No.		1977 Wt.	
1	48	0.23	121	(1.95)	0.49	(2.57)
2	43	0.19	72	(1.73)	0.30	(2.35)
3	67	0.33	91	(1.84)	0.37	(2.45)
4	48	0.22	130	(1.99)	0.62	(2.67)
5	53	0.24	164	(2.09)	0.78	(2.77)
6	62	0.28	172	(2.11)	0.79	(2.78)
7	25	0.12	58	(1.64)	0.19	(2.15)
S.E.D.	11.9	0.064		(0.037)		(0.041)
	3,6>*7	3,6>*7	5,6>**1,3,4>**7		5,6>**1,3,4>**7	

Figures in ( ) are for $\log_{10}$ (No./plot) and $\log_{10}$ (g/plot) transformations used for the analysis of 1977 data.

3. Effect on Crop Yield

Late spring-planted runners do not produce a commercial yield in their first year; the weight and number of berries was therefore low. In both years, the weight and number of berries from simazine sprayed plots was significantly less than from any other treatment (Table 4). In 1976 there was no significant difference in yield between trietazine/simazine and lenacil sprayed plots, but in 1977, yield was significantly greater from lenacil than from trietazine/simazine.

4. Effect on Potential Yield

Potential yield in the year following planting is a function, in part, of the number of crowns and runners produced from the parent plants, and these were counted on all plants during October following planting. In 1976 there was no significant difference in the number of runners produced, (either per plot or per live plant), between any of the herbicide treatments. In 1977, the number of runners per plot and per live plant was greatest on trietazine/simazine (1) and least on simazine, treated plots (Table 5).

The mean number of crowns per live plant in 1976 was significantly less on plots sprayed with simazine than on any others, but in 1977 the results, though similar were not so marked. In 1977 significantly more crowns survived in trietazine/simazine (1) than in any other treatment (Table 5).

Table 5

Effect of herbicides on potential strawberry yield

Treatment No.	October 1976 No. crowns per live plant	October 1976 No. runners per live plant	October 1977 No. crowns per live plant	October 1977 No. runners per live plant
1	1.43	3.1	1.76	5.6
2	1.40	2.9	1.29	4.8
3	1.53	1.8	1.34	3.6
4	1.48	2.1	1.26	3.7
5	1.35	2.6	1.27	3.5
6	1.50	2.4	1.44	3.9
7	0.90	2.7	1.10	3.3
S.E.D.	0.146	0.68	0.098	0.71
	all>**7	ns	1>**2,3,4,5,5,7	1>*3,4,5,6,7

DISCUSSION

Simazine at 1.5 kg/ha a.i. was included as a standard treatment to indicate the response of these individual herbicides to soil and climate. The presence of severe crop damage (more chlorosis, less vigour, more dead plants and fewer crown and runners) on simazine plots indicated that soil and climate conditions had been favourable to the activation of residual herbicides and set a standard of crop damage against which other treatments could be compared. The choice of potential herbicides lies between lenacil and the four trietazine/simazine treatments.

Lenacil was the least damaging to strawberries, but also the least effective weed killer, allowing such a build up of weeds in late summer that weed control in subsequent crops would be difficult. Similar results have been obtained previously at Long Ashton Research Station (Parker and Stott, 1970).

Trietazine/simazine treatments caused less overall damage than simazine but generally more initial damage than lenacil; they gave much better weed control than lenacil. Treatments 3 and 4, were applied two and four weeks after planting respectively in an attempt to control late developing weeds. However, weed control was worse than with applications made immediately post planting, possibly because by the time these treatments were applied, weed seedlings were too large to be controlled by contact action, and the soil was then too dry to initiate residual activity against germinating seeds. Unlike Rath and O'Callaghan (1976) who reported good activity against weed seedlings in dry conditions in Ireland, our results suggest that these treatments could have failed because in both years their application coincided with a dry period (Table 1).

Trietazine/simazine applied immediately post planting (1) or at half rate post planting and again four weeks later (2) were more effective than full rate treatments 3 and 4 delayed for 2 and 4 weeks after planting respectively. Splitting the dose of herbicide viz. Treatment 2 vs. Treatment 1, gave no advantage in weed control or crop damage to cv. Cambridge Favourite. However, split doses might be advantageous on lighter soils, or with cultivars that are particularly susceptible to residual herbicides like Senga Gigana (Clay 1976).

Trietazine/simazine applied immediately post planting (1) was the best treatment. It was not much more damaging than lenacil and weed control was almost as good as simazine, and much better than lenacil, particularly from July onwards. Competition between weeds and strawberries was reduced giving more crowns and runners and consequently greater potential second-year yield.

The activity of trietazine/simazine, as with most residual herbicides is affected by environmental conditions (Clay 1978). We found that in the dry year of 1976 both weed control and crop damage were less than in 1977. Between spraying and the assessment of weeds in May only 20 mm of rain fell compared with 87 mm in 1977. The residual activity of all herbicides was reduced and weed seedlings were 10 times as numerous in 1976; had the season not continued abnormally dry (Table 1) these would have developed and in the lenacil treatments in particular, would have needed to be controlled with phenmedipham.

In Ireland Rath and O'Callaghan (1976) obtained variable results with trietazine/simazine and in Scotland Lawson and Wiseman (1978) concluded that damage to young spring planted strawberries is unacceptable. When compared with our results these differences illustrate the value of trials under different soil and climatic conditions. Under Long Ashton Research Station conditions, trietazine/simazine at 1.86 kg/ha a.i. applied immediately post planting appears a possible alternative to lenacil for weed control in spring planted strawberries; the disadvantage of greater initial plant damage is outweighed by the advantages of better weed contrcl, an increased second year crop potential and a price advantage of 3:1 compared with lenacil only and 6:1 should lenacil have to be followed with phenmedipham.

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