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THE COMPATIBILITY OF HYDROXYBENZONITRILE (HBN) BASED HERBICIDES WITH OTHER CEREAL SPRAYS

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Summary In order to save time, cost, and machinery damage to crop, tank-mixes are increasingly being used by farmers. It is therefore necessary to ascertain that the individual components of such mixtures retain their individual activity levels (hereafter termed "biological compatibility").

During 1978 HBN/mecoprop esters and isoproturon/HBN salts were tested in two-component tank mixes with major wild oat, foliar-fungicide and growth regulator formulations.

All mixtures tested were chemically and physically compatible, i.e. miscible and sprayable.

Of the 14 HBN/mecoprop tank mixes 10 proved biologically compatible, and of the 9 HBN/isoproturon tank mixes 7 proved biologically compatible. The difficulties encountered during this work indicated the complexity of obtaining tank-mix data and emphasized the need for this problem to be solved by the industry as a whole, rather than by isolated trials by individuals.

Résumé Pour gagner du temps, économiser de l'argent et réduire les dégâts produits par les machines sur les cultures, les fermiers utilisent de plus en plus les mélanges extemporanés. Il est donc nécessaire de savoir si les constituants individuels de tels mélanges conservent leur propre efficacité (ci-apres appellée "compatibilité biologique").

Pendent l'année 1978 les esters HBN/mécoprop et les sels isoproturon/HBN étaient évalués dans les mélanges extemporanés à deux constituants avec des formulations herbicides pour la destruction des folles-avoines, fongicides pour les traitements des feuilles, et des régulateurs de croissance.

Tous les mélanges évalués étaient compatibles chimiquement et physiquememt, c'est a dire miscibles et pulvérisables.

Parmi les 14 mélanges extemporanés HBN/mécoprop, 10 se sont montrés compatible biologiquement et parmi les 9 mélanges HBN/isoproturon, 7 se sont montrés compatibles biologiquement. Les difficultés rencontrées au cours de cette expérimentation ont montré la complexité à trouver les renseignements sur ces mélanges et ont souligné le besoin de résoudre ce probleme par l'industrie dans son ensemble plutôt que par des essais isolés réalisés individuellement par des firmes.

INTRODUCTION

The economic advantages of tank-mixes are considerable (Long 1976). Since the early days of crop spraying, farmers have tank-mixed pesticides and growth regulators. This practice has increased to the extent that many farmers apply tank-mixes of chemicals at most spray applications.

In 1975, a B.C.P.C. working party recommended: "That there is no case for holding a symposium on the broad subject of compatibility of pesticides etc. (As per Terms of Reference), due to lack of quantitative data".

This paper outlines an attempt to gain such data with a short list of spray materials in two-component mixes only.

The term "chemically and physically compatible" denotes that there is no physical or chemical interaction between tank-mixture components for up to 12 hours post-mixing. "Biological compatibility" here denotes that the individual components of the tank-mix retain their respective weed control, etc., activities whilst retaining normal crop tolerance.

METHOD AND MATERIALS

Methods

The results were obtained from field trial plots as follows:-

Avena spp and chlormequat data from triplicated small plots ($30m^2$).
Foliar-fungicide data from unreplicated plots ($560m^2$).
Varietal tolerance data from unreplicated plots of 2.5m x 63m (winter cereals) and 2.5m x 47m (spring cereals).

Replicated and varietal tolerance trials were sprayed using an Ongar-motorized single-wheel precision sprayer at a volume rate of 263 litres/ha.

Foliar-fungicide trials were applied using a tractor-sprayer at a volume rate of 239 litres/ha.

Tank mixes were applied at the following timings:-

Avena spp at 2 to 3 leaves	:	Barban
Avena spp at 5 to 6 leaves	:	Other wild oat herbicides
Wheat tillering	:	Chlormequat and fungicides
Barley tillering	:	Fungicides

Materials

	% a.i.		% a.i.
Ioxynil, bromoxynil & mecoprop*	52.5	Flamprop-methyl	15.0
Ioxynil, bromoxynil & isoproturon**	42.0	Chlormequat	46.0
Barban	12.5	Thiophanate-methyl***	50.0
Barban	23.5	Benomyl	50.0
Benzoylprop-ethyl	25.0	Carbendazim	50.0
Diclofop-methyl	36.0	Ethirimol	28.0
Difenzoquat	63.0	Triadimefon	25.0
L-Flamfenprop-isopropyl	20.0	Tridemorph	75.0

* formulated as M&B 'Brittox' ** formulated as M&B 'Twin-Tak'
***formulated as a flowable suspension concentrate

Sites were assessed for crop safety using the E.W.R.C. crop safety score at intervals of 7, 14, 28 and 42 days post-spraying. Weeds were counted in 3 x $0.5m^2$ quadrats, recording weed number and height, when the wild oats were in head. Trials will be taken to yield.

RESULTS

Table 1

Winter wheat: % control of *Avena* spp - compared with the wild oat herbicide alone (= 100%)

Tank-mix constituents	Dose (kg a.i./ha)	% Control of bulk
HBN/Mecoprop + Barban*	1.84 + 0.31	69
HBN/Mecoprop + Benzoylprop-ethyl	1.84 + 0.90	84
HBN/Mecoprop + Diclofop-methyl	1.84 + 1.08	99
HBN/Mecoprop + Flamprop-methyl	1.84 + 0.52	67
HBN/Mecoprop + Difenzoquat	1.84 + 1.00	99
HBN/Isoproturon + Barban	1.89 + 0.31	106
HBN/Isoproturon + Benzoylprop-ethyl	1.89 + 0.90	101
HBN/Isoproturon + Diclofop-methyl	1.89 + 1.08	101
HBN/Isoproturon + Flamprop-methyl	1.89 + 0.52	86
HBN/Isoproturon + Difenzoquat	1.89 + 1.00	100
HBN/Isoproturon	1.89 + 0	63***

All the above mixtures were chemically and physically compatible.

Table 2

Spring Barley: % control of *Avena* spp compared with the wild oat herbicide alone (= 100%)

Tank-Mix constituents	Dose (kg a.i./ha)	% Control of bulk
HBN/Mecoprop + Barban **	1.31 + 0.35	110
HBN/Mecoprop + Diclofop-methyl	1.31 + 1.08	85
HBN/Mecoprop + l-flamfenprop-isopropyl	1.31 + 0.60	99
HBN/Mecoprop + Difenzoquat	1.31 + 1.00	101
HBN/Isoproturon + Barban	1.68 + 0.35	112
HBN/Isoproturon + Diclofop-methyl	1.68 + 1.08	99
HBN/Isoproturon + l-flamfenprop-isopropyl	1.68 + 0.60	93
HBN/Isoproturon + Difenzoquat	1.68 + 1.00	100
HBN/Isoproturon	1.68 + 0	77***

All the above mixtures were chemically and physically compatible.

Wild oat populations ranged from 23/m^2 to 129/m^2

* 12.5% a.i. formulation
** 23.5% a.i. formulation
*** Control of bulk weeds compared to unsprayed control.

Table 3

Winter Wheat: Mean % control of broad-leaved weed species*

Tank-mix constituents	Dose (kg a.i./ha)	% Control of bulk
HBN/Mecoprop	1.84 + 0	100
HBN/Mecoprop + Barban**	1.84 + 0.31	102
HBN/Mecoprop + Benzoylprop-ethyl	1.84 + 0.90	106
HBN/Mecoprop + Diclofop-methyl	1.84 + 1.08	101
HBN/Mecoprop + Difenzoquat	1.84 + 1.00	103
HBN/Mecoprop + Flamprop-methyl	1.84 + 0.52	106
HBN/Isoproturon	1.89 + 0	100
HBN/Isoproturon + Barban	1.89 + 0.31	105
HBN/Isoproturon + Benzoylprop-ethyl	1.89 + 0.90	102
HBN/Isoproturon + Diclofop-methyl	1.89 + 1.08	82
HBN/Isoproturon + Difenzoquat	1.89 + 1.00	64
HBN/Isoproturon + Flamprop-methyl	1.89 + 0.52	103

All the above mixtures were chemically and physically compatible.

* HBN-based herbicide as standard control (i.e. = 100%)
** 12.5% in formulation

The main weeds present were: mayweeds, Stellaria media, Polygonum convolvulus, Polygonum aviculare, Papaver rhoeas.

Table 4

Spring Barley: Mean % control of broad-leaved weed species*

Tank-mix constituents	Dose (kg a.i./ha)	% Control of bulk
HBN/Mecoprop	1.31 + 0	100
HBN/Mecoprop + Barban**	1.31 + 0.35	93
HBN/Mecoprop + Diclofop-methyl	1.31 + 1.08	96
HBN/Mecoprop + Difenzoquat	1.31 + 1.00	93
HBN/Mecoprop + l-flamfenprop-isopropyl	1.31 + 0.60	92
HBN/Isoproturon	1.68 + 0	100
HBN/Isoproturon + Barban	1.68 + 0.35	102
HBN/Isoproturon + Diclofop-methyl	1.68 + 1.08	90
HBN/Isoproturon + Difenzoquat	1.68 + 1.00	85
HBN/Isoproturon + l-flamfenprop-isopropyl	1.68 + 0.60	103

All the above mixtures were chemically and physically compatible.

* HBN-based herbicide as standard control (i.e. = 100%)
** 23.5 % a.i. formulation

The main weeds present were mayweeds, Aethusa cynapium, Polygonum aviculare, Polygonum convolvulus, Stellaria media, Veronica spp.

Table 5

Tank mixes tested in varietal tolerance trials

Tank-mix constituents	Dose Rate (kg a.i./ha) Winter Cereals	Spring Cereals
HBN/Mecoprop + Barban	1.84 + 0.31*	1.31 + 0.35**
HBN/Mecoprop + Benzoylprop-ethyl	1.84 + 0.90	1.31 + 0.90
HBN/Mecoprop + Diclofop-methyl	1.84 + 1.08	1.31 + 1.08
HBN/Mecoprop + Difenzoquat	1.84 + 1.00	1.31 + 1.00
HBN/Mecoprop + Flamprop-methyl	1.84 + 0.52	1.31 + 0.52
HBN/Mecoprop + l-flamfenprop-isopropyl	1.84 + 0.60	1.31 + 0.60
HBN/Isoproturon + Barban	1.89 + 0.31*	1.68 + 0.35**
HBN/Isoproturon + Benzoylprop-ethyl	1.89 + 0.90	1.68 + 0.90
HBN/Isoproturon + Diclofop-methyl	1.89 + 1.08	1.68 + 1.08
HBN/Isoproturon + Difenzoquat	1.89 + 1.00	1.68 + 1.00
HBN/Isoproturon + Flamprop-methyl	1.89 + 0.52	1.68 + 0.52
HBN/Isoproturon + l-flamfenprop-isopropyl	1.89 + 0.60	1.68 + 0.60

* 12.5% a.i. formulation
** 23.5% a.i. formulation

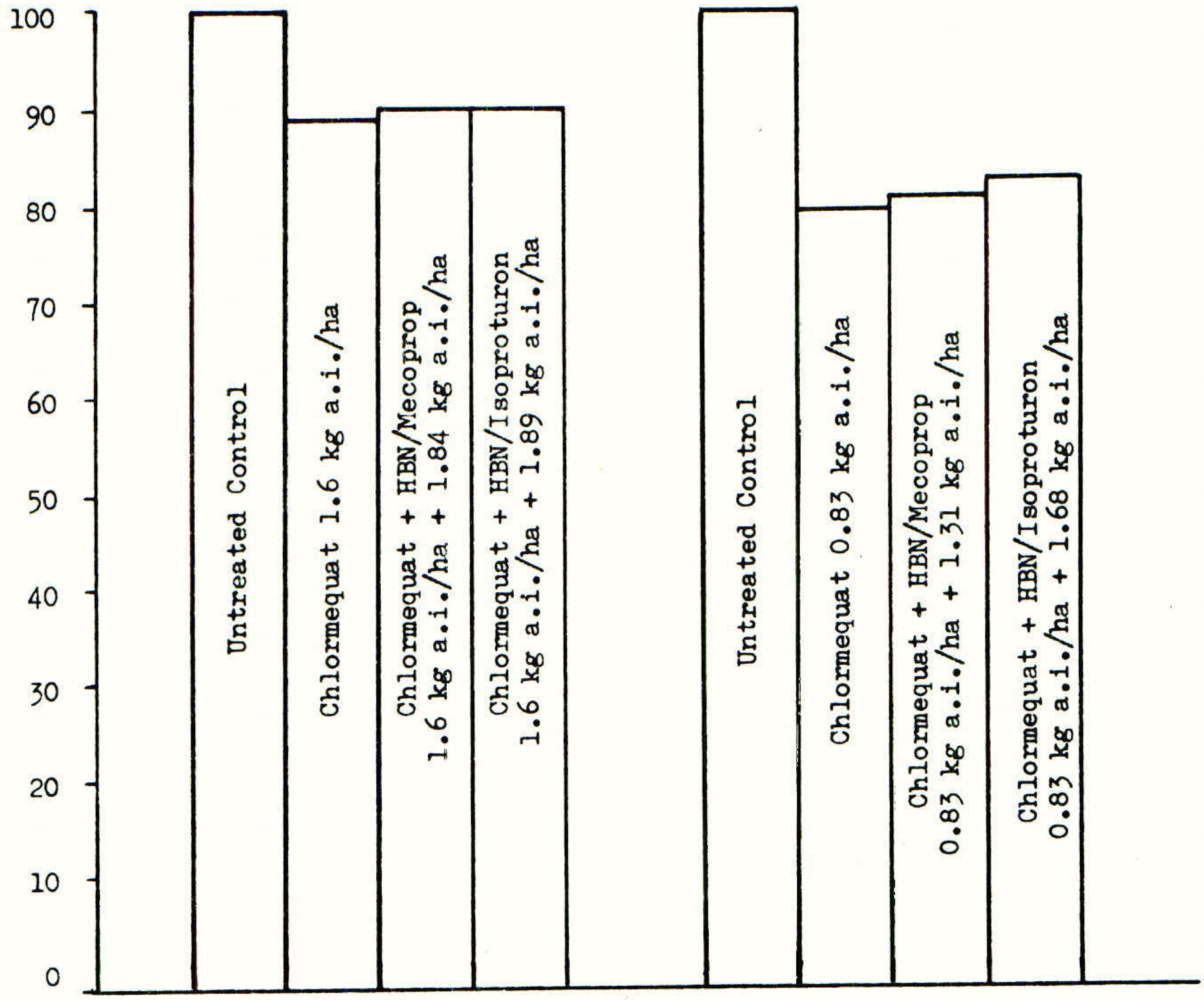
The wild oat herbicides listed above were also applied individually to the spring and winter cereal varieties. All tank-mixes were chemically and physically compatible.

Table 6

Cereal varieties tested in tolerance trials

Wheat			Barley		
Winter		Spring	Winter	Spring	
Armada	M. Hobbit	M. Dove	Athene	Aramir	M. Mink
Atou	M. Huntsman	Sappo	Astrix	Ark Royal	Mazurka
Bouquet	Kador	Sicco	Hoppel	Athos	Midas
Champlein	Kinsman		Igri	Geordie	Porthos
Flanders	Mega		M. Otter	Golden Promise	Sundance
Flinor	M. Nimrod		Sonja	Hassan	Wing
M. Freeman	M. Ranger		M. Trojan	Lofa Abed	
M. Fundin	M. Widgeon				

Figure 1



% Mean height of chlormequat-treated winter and spring wheat varieties compared with untreated control (= 100%) (Varieties as in table 6)

Chlormequat was chemically and physically compatible with both HBN-based herbicides.

Table 7

Winter Wheat (Var. Atou): Mean % Weed Control - fungicide tank mixes*

Tank-mix Constituents	Dose (kg a.i./ha)	% Control of Bulk
HBN/Mecoprop	1.84 + 0	100
HBN/Mecoprop + Benomyl	1.84 + 0.25	99
HBN/Mecoprop + Carbendazim	1.84 + 0.25	97
HBN/Mecoprop + Triadimefon	1.84 + 0.125	99
HBN/Mecorpop + Tridemorph	1.84 + 0.525	101
HBN/Mecoprop + Thiophanate-methyl	1.84 + 0.70	99
HBN/Isoproturon	1.89 + 0	100
HBN/Isoproturon + Thiophanate-methyl	1.89 + 0.70	101

* HBN-based herbicide as standard control (i.e. = 100%)

All mixtures were chemically and physically compatible.

Table 8

Spring Barley (Var. Mazurka): Mean % Weed Control - fungicide tank-mixes*

Tank-mix Constituents	Dose (kg a.i./ha)	% Control of Bulk
HBN/Mecoprop	1.84 + 0	100
HBN/Mecoprop + Benomyl	1.84 + 0.25	96
HBN/Mecoprop + Carbendazim	1.84 + 0.25	94
HBN/Mecoprop + Ethirimol	1.84 + 0.35	102
HBN/Mecoprop + Triadimefon	1.84 + 0.125	95
HBN/Mecoprop + Tridemorph	1.84 + 0.525	96
HBN/Mecoprop + Thiophanate-methyl	1.84 + 0.70	92
HBN/Isoproturon	1.89 + 0	100
HBN/Isoproturon + Thiophanate-methyl	1.89 + 0.70	105

* HBN-based herbicide as standard control (i.e. = 100%)

All mixtures were chemically and physically compatible.

DISCUSSION

Without exception, tank-mixtures under evaluation (tables 5, 7 & 8) were well tolerated by all winter and spring cereal varieties treated.

Avena spp and broad leaf weed control were normal with HBN/Mecoprop in mixture with difenzoquat and diclofop-methyl in winter wheat (tables 1 & 3) and with difenzoquat, barban and -flamfenprop-isopropyl in spring barley (tables 2 &4).

Loss of *Avena* spp control was observed when HBN/mecoprop was mixed with benzoylprop-ethyl,L-flamprop-methyl and barban in winter wheat and with diclofop-methyl in spring barley (tables 1 & 2). Further work is anticipated with the above mixtures.

Avena spp and broad leaf weed control were normal with HBN/isoproturon in mixture with barban and diclofop-methyl in spring barley (tables 2 & 4).

Broad-leaf weed control, in both winter and spring cereals, was reduced when difenzoquat was mixed with HBN/isoproturon (tables 3 &4).

Loss of *Avena* spp control occurred with HBN/isoproturon plus flamprop-methyl in winter wheat and L-flamfenprop-isopropyl in spring barley (tables 1 &2).

HBN/isoproturon alone gave limited control of *Avena* spp.

All winter and spring wheat varieties in the varietal tolerance trial (table 6) exhibited the straw shortening effect of chlormequat when it was applied in mixture with either of the HBN-based formulations.

Crop tolerance and weed control were excellent with both HBN-based formulations when in mixture with any of the foliar fungicides under test, despite using the maximum recommended dose rate for both constituents of each tank-mix (tables 7 & 8).

The level of activity of the fungicides could not be reliably ascertained since, apart from a low level of mildew infection in the winter wheat trial, no major cereal diseases developed in either crop.

The above results emphasize the problems that arise when attempting to obtain quantitative data on the biological compatibility of tank-mixed chemicals.

The problem of giving such data on the vast number of permutations of chemicals, spray-timings, crops and varieties will only be resolved by the combined efforts of all members of the B.C.P.C. involved in crop-spraying, rather than the unavoidably limited data that can be obtained by individual members working alone.

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References

LONG, P. (1976) Proceedings 1976 British Crop Protection Conference, 1035-1038.

Recommendations of working party on compatibility, (1976) Proceedings 1976 British Crop Protection Conference, 1039 (unpublished report of April 1975).

(1977) Cereal Seed Sales by U.K. Agricultural Merchants, A.S.I. Oct. 7th 1977 Vol. 7 No. 40.

CONTROL OF VOLUNTEER CEREALS, GRASS AND BROADLEAF WEEDS IN WINTER OILSEED RAPE WITH A TANK-MIX OF TRIFLURALIN AND TCA

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Summary There has recently been an increase in the acreage of winter oilseed rape that is conventionally drilled into a seedbed. Consequently, there is now a need to control volunteer cereal, grass and broadleaf weeds during the establishment of the crop. This paper reports the results of trials carried out in the United Kingdom and France in 1977 where a tank-mix combination of trifluralin and TCA was tested against these requirements. The results show that trifluralin or TCA alone was inadequate in some areas of weed control but the tank-mix met the high standard of weed control required, with complete safety to the crop.

INTRODUCTION

Although much of the winter oilseed rape acreage in the United Kingdom is direct-drilled a rapidly increasing proportion is being sown into conventionally prepared seedbeds. Crops grown using these techniques benefit from uniform seed covering and establish quickly in a well structured aerated soil. In addition such crops are less prone to water-logging and to attack from slugs. However, under dry conditions, some soil moisture may be lost during the processes of seed-bed preparation.

Oilseed rape has the capacity to smother weeds once it is well established. However, some weeds that germinate early with the crop can be very competitive in terms of nutrients, space and moisture.

Stellaria media, Veronica spp., volunteer cereals, Avena spp. and other annual grasses, which reduce the value of the crop as a disease break, are proving to be major weeds and their early control is essential. The commonly used post-emergence treatments do not give a weed free environment during crop establishment.

Trifluralin, incorporated into the soil before sowing has already proved to be successful in giving this early weed control. Its long term residual activity has resulted in increased yields, and easier combining. S. media, Chenopodium album, Polygonum aviculare and Polygonum persicaria are well controlled and there is also some control of volunteer cereals Alopecurus myosuroides and any Avena spp. germinating in the treated zone. The use of TCA, applied prior to sowing and incorporated into the soil, is becoming increasingly popular as an effective means of controlling graminaceous weeds, especially volunteer cereals, Avena spp. and annual grasses.

This paper reports on trials from the United Kingdom and France where tank-mixes of trifluralin and TCA were found to give extremely effective and safe weed control in conventionally sown winter oil seed rape.

METHOD AND MATERIALS

During September, 1977, trials were laid down at three locations in the United Kingdom, in Hampshire (Trial site A) and Northamptonshire (Trial sites B and C). These trials were of replicated block design using the following dose rates:

Trifluralin	0.96 kg ai/ha	48% EC	(TREFLAN®)
TCA	10.0 kg ai/ha	90% Prill	(Hoechst Nata®)

The treatments were sprayed with an Azo-propane unit and using equipment recommended for the incorporation of trifluralin. The trifluralin was added first to the spray tank and followed by the TCA, previously dissolved in a small quantity of water. All treatments were applied at a volume of 300 litre/ha.

The trial results from France reported in this paper were laid down in the Autumn of 1977 at seven locations, each with various soil types, supporting different weed floras. The treatments were applied at a volume of 300-500 l/ha.

The dose rates were higher than those used in the United Kingdom:

Trifluralin	1.2 kg ai/ha	48% EC	(TREFLAN®)
TCA	13.5 kg ai/ha	90% Prill	(Hoechst Nata®)

The trials were again of randomised block design with alternate control plots. The applications were made with Azo-propane knapsack units and incorporated within an hour of spraying, again using equipment recommended for the incorporation of trifluralin.

RESULTS AND DISCUSSION

The results from the locations in the United Kingdom are given in Tables 1-3. Assessments were made of the area covered by each weed using the assessment scale devised by Barratt-Horsfall (1945). The data was then analysed; the efficacy data is expressed as % weed control and selectivity to the crop is rated on a linear scale where 0 represents total crop failure and 10 the condition of plants in the control plots.

Table 1 shows the excellent crop safety of trifluralin and TCA to the oilseed rape crop. There was no significant depression in emergence and crop vigour remained unimpaired throughout the winter months - only at the Hampshire site was there some depression at 3 months but this disappeared in subsequent months.

TABLE 1

The Selectivity of Trifluralin and TCA to Winter Oilseed Rape with Respect to Crop Emergence and Crop Vigour

Trial Site Treatment	Crop Emergence	Crop Vigour Assessment Date (months post-drilling) abc 1	bc 2	a 3	a 4	b 5	b 6	ac 7
Trifluralin 0.96 kg ai/ha	101.7	9.9	9.8	9.8	10.0	9.7	9.7	10.2
TCA 10.0 kg ai/ha	100.5	9.6	9.8	8.6	9.2	10.0	10.0	10.1
Trifluralin + TCA 0.96 + 10.0 kg ai/ha	95.0	9.2	9.8	8.6	9.4	9.6	10.0	10.1
Untreated controls	100.0	10.0	10.0	10.0	10.0	10.0	10.0	10.

The herbicidal efficacy of the mixture of trifluralin and TCA against volunteer cereals and annual grass weeds is illustrated in Table 2. Trifluralin alone showed insufficient commercial control of volunteer cereals and the data shows that this control was considerably improved by the addition of TCA. The data is not adequate to determine synergism. In addition, the data suggest that although TCA has early activity against grass weeds, it is the trifluralin that maintains the control into the following Spring.

TABLE 2

The Efficacy of Trifluralin and TCA against Volunteer Cereals and Annual Grass Weeds Expressed as % Control

	Assessment Date (months post-drilling)							
	Volunteer Cereals					Annual Grass Weeds		
Trial Site	ac	abc	ac	c	a	b	b	c
Treatment	1	2	3	5	7	2	6	7
Trifluralin 0.96 kg ai/ha	15.9	41.1	59.7	16.6	15.9	65.9	95.7	50.0
TCA 10.0 kg ai/ha	50.0	69.2	81.1	83.3	69.0	79.5	87.3	0.0
Trifluralin + TCA 0.96 + 10.0 kg ai/ha	82.3	68.0	94.0	30.0	74.7	93.1	89.4	70.2
Untreated Control (% cover of weeds)	0.0 (22.3)	0.0 (39.1)	0.0 (55.4)	0.0 (1.76)	0.0 (5.11)	0.0 (4.3)	0.0 (2.79)	0.0 (18.75)

A similar effect is illustrated in Table 3. These data show that TCA, unlike trifluralin possesses only limited activity against broadleaved weeds, especially in the first few months when control is important. The mixture of the two generally out-performed the single treatments. This was particularly true where the weed infestation was heavy (sites a and c). Where the level of infestation was low (site b) the results are more variable.

TABLE 3

The Efficacy of Trifluralin and TCA against Broadleaved Weeds Expressed as % Control

	Assessment Date (months post-drilling)									
	Total broadleaved weeds					Stellaria media				
Trial Site	b	a	c	b	ac	b	a	c	b	a
Treatment	2	4	5	6	7	2	4	5	6	7
Trifluralin 0.96 kg ai/ha	62.8	88.3	83.7	56.2	70.4	80.0	40.5	82.5	100.0	94.9
TCA 10.0 kg ai/ha	70.2	87.2	8.2	56.2	41.2	39.0	76.2	8.2	53.2	85.8
Trifluralin + TCA 0.96+10.0 kg ai/ha	62.8	93.1	87.5	62.4	79.9	80.0	68.7	85.1	60.0	92.1
Untreated Control (% cover of weeds)	0.0 (3.9)	0.0 (48.6)	0.0 (37.5)	0.0 (4.7)	0.0 (54.3)	0.0 (1.45)	0.0 (3.94)	0.0 (18.8)	0.0 (0.9)	0.0 (18.7)

The results of the French trials are summarised in Table 4. Again the excellent selectivity is confirmed at even higher dose rates. The control of blackgrass and volunteer cereals was considerably better with the combination than trifluralin alone. The broadleaved weed control data confirm the pattern shown in the United Kingdom trials and results from one location suggest that the control of

TABLE 4

A Summary of the Selectivity and Efficacy shown by Trifluralin and TCA in Winter Oilseed Rape in France - 1977

Treatment	Selectivity		Efficacy against Broadleaved weeds (Crop at 4-5 leaf stage)				Efficacy against Grassweeds (Crop at 4-5 leaf stage)		
	No. of plants at 3 leaf stage	Plant Density 4-5 leaf stage	Matricaria spp.	Galium aparine	Stellaria media	Anthemis arvensis	Alopecurus myosuroides	Volunteer Barley	Annual Grasses
Trifluralin 1.2 kg ai/ha	102.8	96.2	52.0	81.0	60.0	67.0	77.5	62.0	93.0
Trifluralin + TCA 1.2 + 13.5 kg ai/ha	106.0	96.0	70.5	93.0	81.0	67.0	91.5	92.0	97.0
Control (No. of plants/m^2)	100.0 (82.2)	100.0	0.0 (115.0)	0.0 (6.0)	0.0 (24.0)	0.0 (14.0)	0.0 (900-300)	0.0 (9.5)	0.0 (700.0)
No. of Trials	3	5	1	1	2	2	3	2	3

trifluralin-resistant weeds may well be improved by the addition of TCA. The improved herbicidal efficacy of the mixture has also been seen in Germany (Koch, W. and Kemmer, A. 1977). In a series of 10 trials good control of volunteer cereals, S. media, Lamium spp., Galium aparine, A. myosuroides, Viola arvensis and other broadleaved weeds was seen with the mixture. A high level of crop safety was also observed. The mean yield increase in these trials over control plots was 6%. The reference treatments of propyzamide and carbetamide + dimefuron gave yield responses of +5.7% and +2.2% respectively.

CONCLUSIONS

The results presented in this paper indicate that the soil-incorporated combined treatment of trifluralin and TCA has direct benefits to the farmer who wants reliable and complete control of volunteer cereals, grass and broadleaf weeds throughout the growing period of winter oilseed rape. The data show that the activity of these two soil-incorporated herbicides, when used alone, is commercially unacceptable with respect to broadleaf weeds (TCA) and volunteer cereals (trifluralin). When used together as a tank-mix the weed control is complementary and provides the farmer with broad spectrum weed control throughout the season, especially during crop establishment.

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References

1. Koch, W. and Kemmer, A., 1977, 69-82. Berichte aus dem Fachgebeit Herbologie der Universität Hohenheim, Stuttgart, Heft 13.

2. Barratt, R.W. and Horsfall, J.G. (1945). An improved grading system for measuring plant disease, Abstr. Phytopath., 35, 655.

NOTES

WEED CONTROL IN SWEDES - THREE YEARS' WORK IN WALES WITH STRAIGHT CHEMICALS AND MIXTURES OF CHEMICALS

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Summary Treatments, consisting of straight chemicals and mixtures of chemicals were compared at six centres over three years.

Trifluralin proved superior to all other straight herbicides in the study but its effects were enhanced when used in association with napropamide in particular and also with propachlor.

Straight butam and propachlor plus chlorthal-dimethyl treatments, applied in the 1978 experiments only, appeared highly promising.

INTRODUCTION

The adoption of the stale seed bed technique for weed control became established some twenty-five years ago in association with precision seeding (Prytherch and Toulson, 1960) and the practice still continues in some situations. The problem inherent in the technique, however, is getting weeds to braird so that they may be killed off in good time for drilling the crop. It means that land needs to be prepared early in an attempt to obtain a flush of weed growth for the ensuing necessary operations. In damp season it is found that the system can work well but during a dry spring there are great difficulties.

Whilst a post-emergence spraying technique may be regarded as the most desirable method for weed control in swedes, there have been dramatic developments in recent times in the application of soil incorporated herbicides. The current investigation reported in this paper reviews three years' work in Wales where straight herbicides have been evaluated alongside treatments consisting of a mixture of two chemicals or of two chemicals not applied simultaneously. (For convenience in this report the term mixture is used where a treatment consists of two herbicides.)

Site details for the project over the three years are included.

METHODS AND MATERIALS

Details of the experimental treatments common to the three years' work are given in Table 2. The records for 1978 are incomplete in that treatment yields (tonnes/ha) will not become available until the end of the year.

Table 1

Site details

	1976		1977		1978	
Centre	1	2	1	2	1	2
Location	Talgarth Powys	Tywyn Gwynedd	Talgarth Powys	Dyserth Clwyd	Merthyr Cynog Powys	Llangerny Clwyd
Soil type	Very fine sandy loam	Silty clay loam	Very fine sandy loam	Silty loam	Fine sandy loam	Silty loam
Altitude (m)	310	15	200	107	366	160
Rainfall (cm)	114	132	100	90	150	120
Variety	Broadland	Doon major	Marian	Ruta otofte	Marian	Ruta otofte
Drilled	22 May	15 June	25 May	23 June	18 May	12 June
Harvested	13 December	17 December	10 November	15 December	Not yet harvested	

Table 2

Experimental Treatments

Treatment	Timing	Herbicide	%	Form	Dose/ha kg a.i.
A (1)	a	dinitramine	25	e.c.	0.38
B (2)	a	trifluralin	48	e.c.	1.12
D (4)	a	trifluralin plus	12	e.c.)	0.84)
		napropamide	+12	s.c.)	+0.84)
E (5)	d	propyzamide	50	w.p.	0.85
F (6)		untreated			
H (8)	a	trifluralin	48	e.c.	0.84
		followed by			
	b	propachlor (Ramrod)	65	w.p.	3.25
(9)*	a	trifluralin	48	e.c.	0.84
		followed by			
	b	nitrofen	25	e.c.	1.22
(10)*	c	nitrofen plus	25	e.c.	1.22
		alloxydim-sodium	75	s.p.	+0.94
L (11)	b	carbetamide plus	70	w.p.	1.60
		dimefuron	50	w.p.	+0.40
(12)*	b	propachlor plus	65	w.p.	3.90
		chlorthal-dimethyl	75	w.p.	+4.55
(14)*	a	butam	72	e.c.	4.32

Timings: a - pre-sowing treatments
b - pre-emergence, soon after drilling
c - post crop emergence, weeds up to 2 true leaves
d - post-emergence, crop at least two leaves, weeds as small as possible

Application: Treatments applied in 200 litre/ha water at 2.0 bar.

* 1978 only

RESULTS

(a) 1976. The season was particularly dry, crop growth was affected and plant population tended to be lower on all herbicide treatments. The effects on plant population and root yields are given and show no treatment to behave significantly different in comparison with untreated.

The main weed was *Sinapis arvensis* which was not controlled by any treatment. Others recorded were *Poa* spp. *Achillea millefolium*, *Fumaria officinalis*, *Euphorbia helioscopia*, *Chenopodium album* and *Lamium purpureum* and on these the use of trifluralin plus napropamide and trifluralin plus propachlor gave generally effective control. These treatments were clearly better than others.

Table 3

Plant population ('000/ha), number of weeds/m^2 and root yield (tonnes/ha)

Treatment	Centre (1) Plant Population '000/ha	Centre (1) Root Yield Dry Matter t/ha	Centre (2) Plant Population '000/ha	Centre (2) Number of weeds/m^2	Centre (2) Root Yield Dry Matter t/ha
A (1)	58.6	4.15	76.9	10.5	2.56
B (2)	73.5	4.29	77.7	6.7	2.58
D (4)	60.5	4.47	65.5	6.8	2.39
E (5)	-	-	78.9	11.6	2.26
F (6)	65.3	4.16	83.7	12.7	2.40
H (8)	58.6	4.43	77.7	7.4	2.80
L (11)	-	-	75.5	13.0	2.48
Sig. Difs	9.89	1.03	20.7		0.51
c/v %	9.1	13.5	12.9		9.7

(b) 1977

Table 4

Plant population ('000/ha), number of weeds/m^2 and root yield (tonnes/ha)

Treatment	Centre (1) Plant population '000/ha	Centre (1) Number of weeds/m^2	Centre (1) Root Yield Dry Matter t/ha	Centre (2) Plant population '000/ha	Centre (2) Number of weeds/m^2	Centre (2) Root Yield Dry Matter t/ha
A (1)	105.4	101	6.59	55.7	71	6.40
B (2)	110.4	87	6.80	56.1	48	6.63
D (4)	108.6	15	9.00	58.4	29	6.79
E (5)	97.5	124	4.38	61.6	87	6.37
F (6)	105.1	95	4.93	62.1	141	6.58
H (8)	99.7	78	8.22	56.6	23	6.65
L (11)	91.9	28	7.48	58.0	37	5.94
L.S.D.	18.1		3.47	9.2		0.68
c/v%	9.9		28.8	9.3		6.1

The main weeds were S. arvensis, Anthemis arvensis, Polygonum persicaria, C. album, Poa spp. F. officinalis, Polygonum aviculare, Stellaria media and Ranunculus spp.

The general observations made during the season were:

(1) Mixtures as represented by D, H & L gave better control of weeds than straight herbicides at both centres.

(2) Trifluralin/napropamide gave good control of A. arvensis, C. album and P. persicaria and was superior to all other treatments. This was followed by mixtures trifluralin/propachlor and carbetamide/dimefuron for C. album and P. persicaria.

(3) Trifluralin/napropamide and carbetamide/dimefuron gave very good control of Poa spp. but were no better than trifluralin alone.

(4) There were no treatment significant differences in plant population at either centre.

(5) Two mixtures viz trifluralin/napropamide and trifluralin/propachlor gave significantly higher dry matter yield of root at Centre 1.

(c) 1978 The incidence of *S. media* was extremely high at both centres, probably accounting for about 80% of the weed cover in the untreated plots. Control of this weed is well reflected in the mean % cover of weed and vigour of weed growth in assessments carried out at the end of July as shown in Table 5.

The % ground cover of weed together with vigour of weed growth per treatment at end of July were:

Table 5

% weed cover and vigour of weed growth

Treatment	Centre 1		Centre 2		Mean % cover
	% weed cover	Vigour of weed growth 0-9 scale (9 = max)	% weed cover	Vigour of weed growth 0-9 scale	
A (1)	18	1.0	34	6.0	26
B (2)	12	1.0	28	6.3	20
D (4)	3	0.5	11	6.3	7
E (5)	45	5.0	62	7.3	54
F (6)	90	9.0	91	8.7	90
H (8)	28	0.5	9	5.7	19
L (11)	56	6.0	8	4.7	32

The other main weeds were as follows: Centre 1; *Ranunculus* spp., *Spergula arvensis*, *P. persicaria* and *Rumex* spp., Centre 2; *Poa* spp. *Ranunculus* spp., *Rumex* spp., *Urtica urens*, *Capsella bursa-pastoris* and *C. album*.

Control of these weeds by individual treatments was similar to that of *S. media* and is reflected in the total numbers of broad-leaved weeds per treatment as given in Table 6.

Table 6

Plant population ('000/ha) and number of weeds/m^2

Treatment	Centre 1		Centre 2	
	Plant population '000/ha	Number of weeds/m^2	Plant population '000/ha	Number of weeds/m^2
A (1)	89.5	20.8	75.0	4.8
B (2)	71.5	8.6	81.5	2.4
D (4)	109.2	11.5	90.0	3.5
E (5)	102.7	9.2	85.0	5.5
F (6)	74.3	32.6	78.0	9.5
H (8)	116.8	14.6	76.5	5.5
L (11)	96.1	23.2	83.0	3.5

A particularly important feature was the depressing effect of certain chemicals on weed growth in general. In this connection dinitramine and trifluralin played a major function and the depression of weed vigour enhanced by the addition of napropamide and propachlor respectively to trifluralin (treatments D and H).

Other observations recorded in the 1978 trials deserve noting:

(a) propyzamide appeared inadequate for C. album control and was generally disappointing.

(b) propachlor gave poor control of C. album and S. media.

(c) dinitramine, although giving good general weed control, was inferior to trifluralin for the control of C. album and C. bursa-pastoris.

(d) butam proved highly promising, giving very satisfactory weed control without any apparent depression of crop growth. Moist conditions after application were favourable for good effects.

(e) the addition of napropamide and propachlor to trifluralin improved the spectrum of weed control in each case but the addition of napropamide was more effective.

(f) propachlor plus chlorthal-dimethyl showed promise for the control of many weeds with the notable exception of C. bursa-pastoris.

(g) a common feature in treatments where nitrofen had been used in conjunction with other chemicals viz trifluralin, alloxydim-sodium and propachlor, was a reduction of crop vigour in each case.

DISCUSSION

The trials reported have shown the superiority of trifluralin/napropamide and trifluralin/propachlor over trifluralin itself. The other mixture tested over the three years viz carbetamide/dimefuron has shown promise and treatments butam and propachlor plus chlorthal-dimethyl tested in 1978 only, are worthy of further study.

The plant population figures at each centre over the three years, whilst showing variability, do not indicate correlation with yield. This is in line with High Mowthorpe work which showed that there was no loss in yield with a fall from 86 000 to 35 000 plants/ha.

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References

PRYTHERCH, E.I. and TOULSON, C.A.(1960) Application of herbicides in conjunction with precision drilling in kale, turnips and swedes. Proceedings 5th British Weed Control Conference, 1, 133-140

UK HIGH MOWTHORPE EXPERIMENTAL HUSBANDRY FARM (1962) Saving labour with swedes. Report High Mowthorpe Experimental Husbandry Farm

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WEED CONTROL BY HIGH VOLTAGE ELECTRIC SHOCKS

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Summary Weed control by electricity involves passing an electric current through plants by means of an electrode contacting the upper plant and another placed in the soil. The passage of the current causes damage to the cell structure so that the plants lose turgor and subsequently wither and die. The required time of application depends upon the level of the electrical power used; a plant can have a mild shock and be left to die over several days, or a very large shock sufficient to destroy it in a few seconds. Treatments can range from 50 volts (1mA) for newly emergent seedlings to 10,000 volts or more and several amperes for well established weeds.

After a short review, some experiments are described which illustrate the behaviour of the current in plants and results are presented of variations of treatment times required for various values of voltage for three different weed species.

Résumé Le contrôle électrique des mauvaises herbes s'effectue grâce à un courant électrique qui passe entre une première électrode en contact avec le haut de la plante et une deuxième électrode souterraine. Le passage du courant endommage la structure des cellules, de sorte que les plantes perdent leur vigueur et puis se fanent et meurent. Le temps d'application requis varie en fonction de la puissance électrique utilisée; on peut faire subir à une plante un choc relativement faible qui la tue au bout de quelques jours, ou un choc tres fort qui la détruit en quelques secondes. Les applications peuvent varier entre 50 volts (1mA) pour des semis naissants et 10,000 volts voire plus et plusieurs ampères pour les mauvaises herbes déjà établies.

Après une brève revue des développements anterieurs, on décrit des expériences qui montrent le comportement du courant dans les plantes, et l'on presente les résultats des variations de temps d'application requis pour des tensions différentes dans le cas de trois espèces de mauvaises herbes.

INTRODUCTION

The idea of electrical weed control is not new, since a U.S. Patent was granted in 1895 for a steam driven electric shock weed killer! (Scheible 1895). A few other related machines have been produced in the intervening years (Baker 1949, Burt 1928) and the latest company to produce a range of equipment is the Lasco Corporation of the United States. Russian researchers have favoured using very high voltage (up to 50kV) corona discharge shocks. A very high electric field is produced which breaks down the air and a spark jumps from electrode to the plant.

In laboratory tests, Slesarev et al (1972a, 1972b) treated several weed species with 30-50kV pulses of 10^{-6}s duration and death occurred after 4-6 days. Damage was found to have occurred to the plant cells, and an increase in either or both of voltage and pulse length accelerated the process. In field tests, White Mary plants were treated with 25kV shocks (10^{-6}s) and transpiration, photosynthesis and respiration had all ceased after three days. Necrosis of root tissue of field thistle (Circium arvense) was observed 23cm below ground level after a 25kV pulse.

Svitalka (1976) suggested that damage was done by the spark channel elevated high temperature shock wave during the discharge, in contrast to Bayev and Savchuk (1974) who claimed the destruction of cell tissue was caused by high density currents flowing in the plant, and not by the actual spark itself.

The Russian approach is different from the U.S. and European systems which favour lower voltages (i.e. 10kV) and direct contact between the live electrode and the plant. The equipment requirements for the "contact" systems are simpler, consisting of a generator, transformer and electrodes as opposed to the complex apparatus used to produce high voltage d.c. sparks lasting fractions of a second (Bayev and Savchuk 1976).

Some experiments have been made on the passage of low density currents through plants. Cholodny and Sankewitsch (1937) found that the growth of oats (Avena sativa) was enhanced when d.c. currents of 10^{-7} to 10^{-6} were passed from the base to the apex and growth was reduced when the current direction was reversed. Black et al (1971) increased the linear growth of tomato plants 5-30% and increased the concentrations of potassium, calcium and phosphorous by 15%, 15% and 14% respectively as well as the amounts of total nitrogen. Plants were made negative with respect to the ground but if they were made positive, damage occurred to the tissue surrounding the electrode, and current flow was interrupted.

Dixon and Bennet Clark (1927) passed impulses of 50Hz a.c. current through leaves of ivy (Hedera helix) to cause a lowering of the leaf resistance. Small stimuli resulted in temporary changes, but large ones i.e. 120V for 0.1s caused permanent damage. Variations in behaviour to electricity were noted for temperature and seasonal variations. The Lasco Corporation of America (Howe 1977) have produced a wide range of post-emergent weed control apparatus with power capabilities of 15 to 200kW. Successful results are claimed on broad leafed weeds, grasses, shrubs and small trees (Bramblett 1977). Weeds averaging 2½m high of density 10,000 to 30,000 stems per acre were treated with an electrode 3m wide and 1.3m above ground level at speeds of 2-4kmh^{-1} ($\simeq$ 2-3 acres h^{-1}). It was claimed that over 95% of the weeds over 1.3m were dead after 3 days (Dykes 1977). In addition it has been reported that high weeds were cleared from around sycamore seedlings, with little damage to the latter.

Machines using electricity have been patented for desiccating the tops of root crops (30-45kW per metre of treatment width) and pruning blueberries (6-9kW per metre width) (U.S. Patent Nos. 3935670; 3919806; 4007794) and a variety of weed clearance applications from amongst crops, and also railways and roadside verges.

Most of the recent literature available has been in the form of advertising produced by the commercial concern itself, and so investigations are being made into the claims to see if they are justified, and also to find new uses for the method if viable. This paper presents some of the laboratory work completed at Sheffield, and illustrates some of the effects of electric currents in plants, and gives measurements of the power levels required for control of three different weed species.

METHOD AND MATERIALS

The first experiments to be reported were on potted pea plants between 35cm to 45cm high (grown in the greenhouses of the University's Botanical Experimental Gardens). The current was applied via a stainless steel electrode wire, (20×10^{-3} inches diameter) through the stem of the plant 25cm above soil level; and the return electrode was a brass rod 10mm in diameter pushed into the soil. Direct current from a stabilised supply was used and the uppermost electrode was made negative. A positive electrode in this position is unsuitable because charring occurs around the wire, and the electrical contact is impaired. A negative polarity, however, results in a frothing around the electrode, which does not impede the current. (This response is similar to observations made by Black et al (1971)).

The voltage applied between the electrodes was initially zero and then raised to 5 volts. After this, increments of 5 volts were made every two minutes until 60μA was flowing, and then the periodic change was increased to 50 volts.

Other pea plants had initial currents in the order of 100μA established, and the voltage increments were 50 or 100 volts. These were not periodic but were executed when the current appeared to settle down after its change. Towards the end of each experiment it was no longer necessary to increase the voltage in order to increase the current, as this happened naturally. The rise in current became self sustaining, until it had risen to such an extent, that the plant burnt and split into two sections, and the current path was broken.

Peas, radish and wheat plants 8 weeks old, were used to investigate the relationship between the applied voltage and the time necessary for the destruction of the plant. These species were used as they were readily available, and uniform growth could be expected.

A strip of silver foil was wrapped around the top of the plant, gathering in all the foliage, and the second electrode was a brass rod pressed into the soil. The currents flowing and applied voltages were monitored on a chart recorder, and were now alternating rather than direct, since other laboratory experiments had shown the two forms of electricity to have an equivalent effect. Alternating voltages of 750V to 2,000V were applied and the current in each case was allowed to build up and flow until the plant burnt in two. The time this took was obtained from the chart recorder traces, as well as values of the maximum current that passed. Between six and ten plants of each species were used for each voltage chosen.

Similar experiments were performed on three weed species - Chrysanthemum segetum, Arvenis sinapsis and sugar beet bolters. The alternating voltages used were altered for the different species as the plants have different size and therefore different electric resistance. Sinapsis arvensis was sorted into two types - large and small. The former were examples 1m or more in height with a main stem diameter of 5 to 10mm, whilst the latter were single stemmed; 0.2 to 0.6m high with a stem diameter between 2 and 5mm.

RESULTS

The results of the first experiment are shown in Figure 1 with the ordinate plotted on a logarithmic scale, and the abcissa on a linear one. Curve (a), shows that currents of 100μA or less can be supported by the plant tissue, since all the values are constant with time. Above 100μA, then tissue breakdown occurs, and the currents begin to rise during each constant voltage period. Curves (b) and (c) also demonstrate this and show how the current values remain steady at first (trace b actually begins to fall) and then as the voltages are increased above the stability threshold the currents begin to rise. Above 6mA for trace (c) and 30mA for trace (b) the current increases become self sustaining, and no longer need further voltage increases. Maximum current values of 28mA and 46mA (curves (c) and (b) respectively) are reached before the plants burn in two and become open circuit - hence the rapid fall in current values at the end of each trace. If the currents were stopped at values of 10mA to 20mA that is before the plant is burnt, then loss of turgor is observed and the extent of the loss, depends upon the strength of the current. With peas 25cm to 45cm high, current values of 20mA are sufficient to cause very rubbery stems, which have to be supported, else they collapse completely. Experience has shown that drying of the stem and subsequent plant death occurs in a few days.

Radish is plotted twice in Figure 2, on the same time scale as wheat and peas for direct comparison, and then with a x10 time scale for a full trace. The relationship between the applied a.c. voltage and the treatment time is not linear in any case, and low voltages require very long times in contact with the electrodes. Radish, for example, needs to be shocked for 406s with 750V a.c. whilst 1500V a.c. requires only 10s to obtain the same effect. This is a forty fold decrease in time for a doubling of voltage.

The same trends can be observed in Table 1 which shows the results of the weed experiments. The higher the voltage applied then the quicker the action. The currents measured and shown in Table 1 are much higher than those attained in Figure 1, the highest being 1.34A passing through a sugar beet bolter at 5,000V. The current value for Chrysanthemum segetum at 5,000 volts is smaller than at 2,500 and 1,000V. This is probably due to the plants that were shocked at the higher voltage being slightly smaller than the others, but this is unusual, since the current nearly always rises with applied voltage, as shown for sugar beet bolters and Sinapsis arvensis. Table 1 also shows the differences between large and small plants of the same age and species of Sinapsis arvensis. The smaller plants burning faster than the larger, especially so at low voltages, where the small plants are lost 9 times as fast as the large, (2000V a.c.) as opposed to only 3 times as fast at 4000V a.c.

Volts	Chrysanthemum segetum		Sugar Beet (bolters)		Sinapsis arvensis (large)		Sinapsis arvensis (small)	
	time (s)	I_{max} (Arms)	time (s)	I_{max} (Arms)	time (s)	I_{max} (Arms)	time (s)	I_{max} (Arms)
1000			33.7	0.11				
2000	37.2	0.88			147.8	0.29	16.2	0.20
2500			32.2	0.4				
3000	8.5	0.81			52	0.71	8.9	0.27
4000					13.2	1.34	4.8	0.87
5000	6.9	0.66	8.5	0.67				

Table 1.

The variation in treatment times and maximum current values (I_{max}) for control of three types of weeds.

DISCUSSION

In order to destroy plants electric currents must be used which are above a threshold value and which cause structural damage and loss of turgor. In the case of peas 35cm to 45cm high, this means values of 15mA to 20mA (corresponding to voltages of 200-300 volts). Provided loss of turgor occurs, the damage is permanent and the plant does not recover. If currents are allowed to reach higher values, then plants can physically burn in two.

Experiments with six different species of crops and weeds show that the shocking time is not directly proportional to the applied voltage and in the case of 8 week old peas, reducing the a.c. voltage from 2000 to 1500 to 1000 to 750 means shocking times of 7.6, 10, 22.8 and 33.9s respectively are required. The older a plant is, then the more power it will need to control it and plants of the same age but different physical size will also require different treatments; the largest plants requiring the biggest powers. Preliminary field experience show that plants growing in situ require more power than their greenhouse bred contemporaries, perhaps two or three times as much, but not the ten-fold increase reported by Chandler (1977).

In practice, as Table 1 indicates, the treatment and electrical requirements will depend upon circumstances and will have to be adjusted by the operator. A field of sugar beet infested with bolters would need 6kV-10kV and 2 or 3A, but clearing a field of weeds such as Chrysanthemum segetum would best be done with 3kV-5kV and a 10A to to 20A supply.

Electrical weed control is not offered as a panacea for all weed control problems, and it must be treated with respect because of the possible dangers to operators.

It is especially applicable in situations where selective chemical control is difficult i.e. sugar beet bolters. Any weeds which are higher than the crops can be treated, as well as the removal of weeds between crop rows and clearing fields completely. It is possible to combine electrical weed control (with the applicator at the front of a tractor) with other jobs where the apparatus is at the back of or towed behind the tractor i.e. above and between crop weeds can be treated, and perhaps crop thinning as well, with fertiliser or insectisides being applied from behind the machine.

Laboratory and field work show it to be an effective, quick acting, pollution free, and a useful addition to existing weed management practices.

References

BAKER, G.M. (1949) Electrical weed killer, U.S. Patent No. 2,484,443, filed May 7 1945, granted Oct. 11 1949.

BAYEV, V.I., SAVCHUK, V.N. (1974) The effective factors of electric spark discharge in treatment of plants, Electrochemistry in Industrial Processing and Biology, 1, 73-75.

BAYEV, V.I., SAVCHUK, V.N. (1976) Breakdown voltages of plate electrodes for spark treatments of plants, Electrochemistry in Industrial Processing and Biology, 1, 69-73.

BLACK, J.D.,FORSYTH, F.R., FENSOM, D.S., ROSS, R.B. (1971) Electrical stimulation and its effects on growth and ion accumulation in tomato plants, Canadian Journal of Botany, 49, (3), 1809-1815.

BRAMBLETT, J. (1977) New device Zaps weeds, Progressive Farmer, April issue, 70.

BURT, W.E. (1928) Weed destroyer, U.S. Patent No. 1,661,030, filed June 28 1926, granted Feb. 28.

CHOLODYNY, N.G., SANKEWITSCH, E.Ch. (1937) Influence of weak electric currents upon the growth of coleoptiles,Plant Physiology, 12, 243-251.

DIXON, BENNETT CLARK, H.H. (1927) Responses of plant tissues to electric currents, Notes from the Botanical School of Trinity College, Dublin, 4, (4), 33-54.

DYKES, W.G. (1977) E.D.S. - for control of broad leaf weeds in sycamore trees, Available from the President, Lasco Corporation. P.O. Box 187, Vicksburg, Ms 39180, U.S.A.

HOWE, D. (1977) Zap! Another way to control weeds, Nebraska Farmer, June 18, Reprint available from the President, Lasco Corporation, P.O. Box 187, Vicksburg, Ms 39180, U.S.A.

LASCO CORPORATION, P.O. Box 187, Vicksburg, Ms 39180, U.S.A.

SCHEIBLE, A. (1895) Apparatus for exterminating vegetation, U.S. Patent No. 546,682, filed Jan. 22 1895, granted Sept. 24 1895.

SLESAREV, V., CUBANOVA, N.Yu., NECHAEV, B.V. (1972a) The destruction of weeds by electric current, Mechanisation and Electrification of Socialist Agriculture (translation), 12, 45-46.

SLESAREV, V., CUBANOVA, N.Yu., NECHAEV, B.V. (1972b) The use of electric spark discharges in agriculture, Zemledelie (translation), 9, 56-57.

SVITALKA, P.I. (1976) The effective factors of spark discharge and their role in damaging vegetable tissues, Electrochemistry in Industrial Processing and Biology, 2, 65-68.

U.S. Patent Nos: 3,935,670 (Feb. 3 1976, Pluenneke et al); 3,919,806 (Nov. 18 1975, Pluenneke et al); 4,007,794 (Feb. 15 1977, Pluenneke et al).

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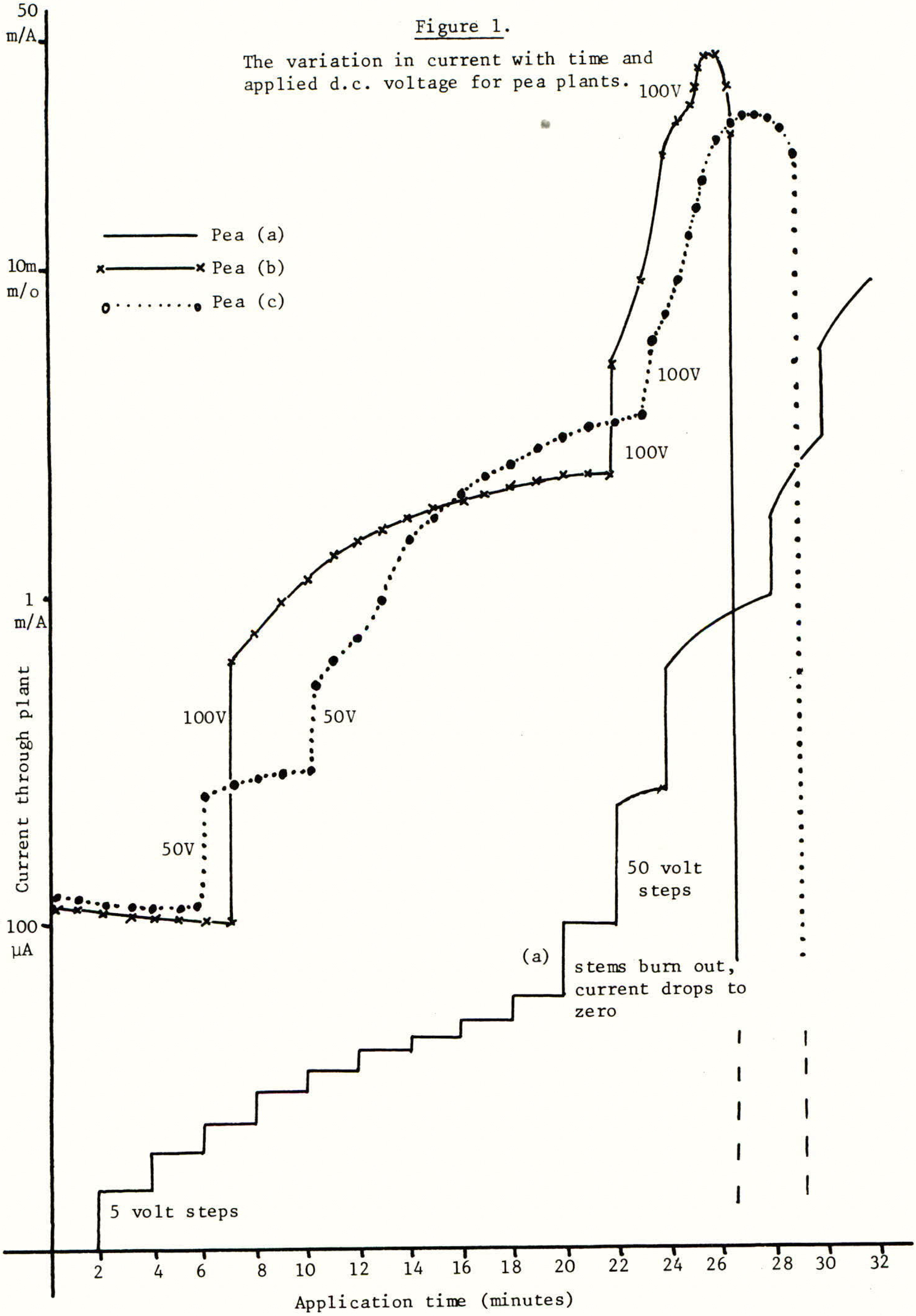

Figure 1.
The variation in current with time and applied d.c. voltage for pea plants.
50 m/A
10m. m/o
1 m/A
100 µA
Current through plant
Pea (a)
Pea (b)
Pea (c)
100V
100V
100V
100V
50V
50V
50 volt steps
(a)
stems burn out, current drops to zero
5 volt steps
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Application time (minutes)

Figure 2.

The variation in treatment time required for varying applied a.c. (50Hz) voltages for three plant species.