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ETHEPHON, A GROWTH REGULATOR FOR WINTER BARLEY

EVALUATION OF EFFICACY AND PRESENT STATUS IN THE UNITED KINGDOM

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Summary A collaborative development programme over 3 years with more than 40 small plot trials showed that ethephon applied to winter barley at 480 g ai/ha between Zadocks growth stages 37-49 reduced plant height by an average of 15% and gave very satisfactory control of lodging. Ethephon was safe to the crop and gave small increases in crop yield, even in the absence of lodging and a mean increase in yield of 9% in lodged crops. Other benefits resulting from the use of ethephon are also discussed.

INTRODUCTION

The recent large increase in the use of minimum cultivation and direct drilling practices has allowed a dramatic increase in the area of winter cereals sown. High potential yields are possible with the use of appropriate levels of nitrogen fertilizer but may not be realised if lodging of the crop results in grain losses and harvesting difficulties. The growth regulator chlormequat is widely used commercially in winter wheat to reduce lodging by shortening and strengthening the straw but no similar chemical has been available for winter barley.

The use of the growth regulator ethephon to successfully shorten the straw of spring barley has been reported previously (Murray & Dixon 1970) but the selection of an inappropriate timing of the application at growth stages 21-31 gave rise to unacceptable reductions in the number of mature tillers and in grain size thus reducing yield. Further research on winter barley indicated that later applications of ethephon between growth stages 37-49 would reduce the length of the straw without damaging the yield components.

This paper describes the results of many replicated field trials forming the joint 3 year development programme between the 3 companies for the use of ethephon as an anti-lodging agent in winter barley.

METHOD AND MATERIALS

The use of ethephon was investigated in more than 40 small plot field trials on good commercial crops of a range of currently recommended winter barley varieties over 3 years (1978-80). Ethephon was applied using conventional commercial small plot sprayers at rates of 360-960 g ai/h in a volume of 200-220 l/ha and at crop growth stages between the flag leaf becoming visible and the awns becoming visible

(Zadocks 37-49). In all trials the treatments were fully randomised and replicated a minimum of 3 times.

At least 20 tillers per plot were randomly selected just prior to harvest and assessments were then made on each tiller of the height of the crop measured to the base of the ear, ear length and the number of grains per ear.

Lodging at harvest was assessed by estimating the angle of lodging on a 0-5 scale and the proportion of each plot affected within each of these categories, thus allowing a lodging index to be calculated (Caldicott and Nuttall 1979).

Trials were harvested for yield using standard commercial plot combines and yields were corrected to 15% moisture. Ear loss prior to harvest was assessed using random quadrats to count the number of ears left in the stubble after combining.

RESULTS

The results of individual trials are not considered in detail because of the many trials carried out, but mean figures have been calculated from the results of the three co-operators which, in view of the wide range of trial sites in time, space and conditions, can be regarded as reflecting an accurate record of the effects of ethephon under UK conditions.

Table 1

Height of crop treated with ethephon as a percentage of that on untreated control

Year	rate of ethephon g ai/ha			
	360	480	600	960
1978	86.9	82.0	80.2	-
1979	89.5	88.4	87.8	84.5
1980	87.9	84.8	-	77.8
Mean	88.1	85.1	84.0	81.2
Number of trials on which mean is based	31	42	15	14

Table 1 shows that ethephon reduced plant height by between 10% and 22% compared to control with the reduction being influenced by dose since increasing rates of ethephon gave progressively shorter plants. Although the overall response varied between years, the dose response was consistent within any one year.

Table 2

Effect of ethephon on lodging index in the trials where lodging occurred

Year	Number of trials		rate of ethephon g ai/ha		
		Control	360	480	960
1979	6	28.5	7.5	3.3	1.0
1980	8	52.3	18.0	12.0	12.6
Mean		40.4	12.8	7.7	6.8

Table 2 shows that in 1979, which was a year with only slight lodging as shown by the control lodging index of 28.5, then the use of ethephon almost completely eliminated lodging.

In 1980, when lodging was more prevalent and heavier (control lodging index 52.3), ethephon was able to greatly reduce the extent and degree of lodging. In both years, there was a dose response since increasing the rate of ethephon reduced the incidence of lodging.

Table 3

Effect of ethephon on crop yield as a percentage of control in lodged crops

Year	Number of trials	rate of ethephon g ai/ha		
		360	480	960
1979	8	112.1	109.9	109.2
1980	12	107.7	107.3	105.1
Mean		109.9	108.6	107.2

No lodging occurred at any of the trial sites in 1978. In 1979, on those trials where there was lodging, the use of ethephon resulted in increases of yield between 9% and 12% compared to control (Table 3). In 1980, with more severe lodging, the use of ethephon gave increases in yield of between 5% and 7%. Different rates of ethephon did not greatly or consistently affect the increase in yield in either 1979 or 1980.

In addition to lodging, it was noted that ethephon largely prevented the occurrence of brackling, the bending and breaking of the stem about half way up its length which may result in ears hanging down below cutterbar height. Counts of the number of ears present in the stubble after combining confirmed that fewer ears had been lost.

Table 4 shows that 480 g ai/ha of ethephon reduced ear length and also slightly reduced the number of grains per ear and 1000 grain weight. 960 g ai/ha of ethephon did not greatly increase any of these effects. However, the harvested yield of barley treated with ethephon tended to be greater than control even in the absence of lodging and particularly at the 480 g ai/ha rate.

Table 5 provides confirmation that, at a given rate, ethephon produces very consistent effects on several crop characteristics when applied between the recommended growth stages of 37-49.

Table 4

Effect on ethephon on ear length, number of grains per ear and yield in the absence of lodging as a percentage of the untreated control

Year	Ear length			Grains per ear			1000 grain weight			Yield in absence of lodging		
	No. of trials	rate of ethephon 480	960	No. of trials	rate of ethephon 480	960	No. of trials	rate of ethephon 480	960	No. of trials	rate of ethephon 480	960
1979	3	92.4	88.6	6	97.4	93.8	3	93.6	94.9	5	104.2	102.8
1980	4	95.5	93.3	10	98.6	93.5	2	99.5	99.7	4	102.2	96.3
Mean		94.0	91.0		98.0	93.7		96.6	97.3		103.2	99.6

Table 5

Effect of timing of ethephon application on lodging, yield and yield components

	No. of trials	Zadocks Growth Stage 37 Rate of ethephon g ai/ha 360	480	960	Zadocks Growth Stage 41 Rate of ethephon g ai/ha 360	480	960	Zadocks Growth Stage 49 Rate of ethephon g ai/ha 360	480	960
Crop height as percentage of control	7	87.9	85.3	78.2	86.5	83.0	77.5	86.2	83.3	78.0
Lodging index	4	22.5	13.5	6.5	17.0	8.5	4.0	18.5	15.5	6.0
Grains per ear as percentage of control	8	97.3	96.3	90.9	97.5	96.8	93.7	99.4	98.5	96.9
1000 grain weight as percentage of control	2	98.2	100.2	98.6	98.6	98.8	98.5	98.3	99.4	99.0
Yield in absence of lodging percentage of control	3	100.3	101.8	92.6	103.6	100.1	96.0	103.8	102.3	100.4
Yield in lodged crops as percentage of control	4	111.1	108.7	106.9	105.9	106.8	105.1	109.7	109.9	106.7

Table 6

Effect of ethephon and increasing nitrogen fertilizer on lodging and yield (mean of 2 trials)

	Lodging (% of plot > 60° from vertical) no ethephon	Lodging (% of plot > 60° from vertical) 480g ai/ha ethephon	Yield (% of normal N) no ethephon	Yield (% of equivalent N treatment without ethephon) 480g ai/ha ethephon
Normal N	50.5	0.56	100	110.7
N + 25%	79.9	0.1	94.8	125.3
N + 50%	89.1	1.0	94.9	114.7

In trials where the growers normal nitrogen top dressing was increased by 25% and 50%, ethephon allowed the higher rates of nitrogen to be used without the risk of increased lodging (Table 6). Additional nitrogen fertilizer without ethephon treatment resulted in severe lodging and consequently the yield was reduced. Lodging was prevented by ethephon at both the elevated levels of fertilizer and substantial yield increases were recorded.

DISCUSSION

This series of trials has demonstrated that ethephon at 480 g ai/ha is an excellent growth regulator for winter barley, being able to consistently reduce the height of the crop by about 15% (Tables 1 and 5), which could be correlated with an absence or greatly reduced incidence of lodging (Tables 2, 5 and 6).

Ethephon may safely be applied between Zadocks growth stages 37-49 (Table 5) thus providing a period of 10-14 days in which to carry out the spraying operation at a time of year that fits in conveniently with the farming programme and when spraying conditions may be expected to be good. The late timing of the application is also beneficial as it allows the lodging potential of the crop to be assessed before the decision is taken whether to use ethephon or not.

Ethephon is safe to the crop, even at double rate, shortening those parts of the plant which are still elongating at the time of application, i.e. the last one or two internodes and the ear. Slight reductions may occur in some of the components of yield such as number of grains per ear and 1000 gain weight but this is not reflected in the harvested yield which has been at least equivalent to that from the untreated crop even in the absence of lodging. It is believed that a reduction in the losses of ears due to 'brackling' and/or an increase in the number of fertile tillers may account for this apparent discrepancy and these factors are still being investigated. Increased secondary tillering has been noted occasionally, usually when crops have been under stress, but this does not normally pose a serious problem.

In those trials where lodging has been a factor, yield increases have always been recorded after the application of ethephon with a mean increase of 9% in yield (Table 3) on good commercial crops, averaging about 6 tonnes/ha on untreated areas. The use of ethephon allows the use of optimum rates of nitrogen fertilizer without the problem of lodging so that the full yield potential of modern varieties may be exploited.

However, it should be noted that other benefits such as easier and quicker harvesting of a more upright and drier crop and less damage from birds may be equally important factors in favour of the use of ethephon (Sterry & Szoke 1980).

As a result of this collaborative development programme, ethephon, is available commercially in the UK as a growth regulator in winter barley.

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NOTES

CONTROL OF LODGING IN BARLEY

USING A MIXTURE OF MEPIQUAT-CHLORIDE AND ETHEPHON

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Summary Results are presented from replicated small plot trials carried out by BASF in the United Kingdom from 1977 to 1980 using BAS 09800W . A range of application rates were evaluated on winter and spring barley at different crop growth stages and a rate/timing response is exhibited in terms of crop height reduction and lodging control.

The need for adequate disease control for optimum results is demonstrated, and the interaction between BAS 09800W and nitrogen fertiliser is investigated by applying various nitrogen fertiliser rates extra to the farm application, with and without BAS 09800W. The resulting nitrogen response curves show the benefits in terms of lodging control and yield response from an application of this growth regulator. BAS 09800W reduces lodging in barley which is induced by the use of optimum nitrogen fertilisation to achieve maximum yields.

Résumé On présente les résultats d'épreuves répétées en petits lots effectuées par le BASF au Royaume Uni de 1977 à 1980, employant le BAS 09800W On a évalué une rangée de doses d'application en orges d'hiver et escourgeons, à des stades variés de développment, et l'on montre la réponse dose/période sur le plan de raccourcissment de pailles et de contrôle de la verse.

On démontre la necessité du contrôle efficace des maladies pour les résultats optimum, et l'on examine l'interaction entre BAS 09800W et l'engrais azoté par l'application à doses variées d'engrais azoté outre et pardessus l'application de ferme, avec et sans le BAS 09800W. Les courbes de réponse qui en résultent montrent les avantages en ce qui concerne l'amélioration du contrôle de la verse, et du rendement, suivant l'application de ce regulateur de croissance. Le BAS 09800W prévient la verse dans les cultures d'orges que favorise l'emploi de la fumure optimum avec l'azote pour achever les rendements maximum.

INTRODUCTION

In recent years the trend in the United Kingdom has been for the area of winter barley, currently estimated as 740,000 hectares, to increase. The involvement of winter barley in a suitable rotation with oilseed rape and winter wheat has often necessitated it being grown in very fertile conditions. Growers have been reluctant to increase levels of nitrogen fertiliser appreciably since in over-fertile conditions the barley crop tends to lodge. Even in view of the recent changes in ADAS recommendations, many barley crops receive nitrogen levels substantially below the optimum for maximum yields because of the awareness of the risk of lodging.

Lodging causes severe yield losses and the growth stage at which it occurs is particularly imporant, as demonstrated by work at the Plant Breeding Institute (Stanca, A.M. et al, 1979). In this work a yield reduction of approximately 40% was apparent if permanent lodging occurred at anthesis. Temporary lodging at this growth stage reduced yield by approximately 25%. Lodging 20 days after anthesis had a lesser effect, approximately 24% if permanent, and approximately 10% if temporary. These results have been confirmed at the BASF research station in Germany. Hence a growth regulator was required to improve the lodging resistance of the barley crop, particularly at anthesis and the early stages of grain filling.

METHOD AND MATERIALS

All the BASF field trials are of randomised block design with four blocks. The individual plot size was $50m^2$, and they were sprayed with a Van der Weij knapsack sprayer, using cone nozzles at 40 cms spacing. The sprayer operated at 2.5 bars, giving 250 l/ha water volume. Lodging was assessed on a 0-10 scale (Table 1).

Table 1

Lodging assessment, 0-10 scale

Lodging Score	Angle of uniform crop from vertical (degrees)	If lodging is not uniform, % of plot severely lodged
0	0	0
2	20	20
4	40	40
6	60	60
8	80	80
9	90	90
10 (irreversible)	90	100

Crop height was measured at 25 points within the plot from ground level to the tip of the awns.

Plots were harvested with a Claas Compact 25 combine harvester modified with weighing apparatus and each plot yield was corrected to 85% dry matter.

BAS 09800W is an aqueous solution of 305 g/l mepiquat chloride and 155 g/l ethephon, (Terpal).

Two commercially available products were used for comparison in BASF trials. Chlormequat chloride was applied as 3.5 l/ha Barleyquat. Ethephon was applied as 1.0 l/ha Cerone. Both products were applied as recommended.

RESULTS AND DISCUSSION

Development with BAS 09800W began in the United Kingdom in 1977 with two trials on spring barley (Table 2).

Table 2

Mean results from 2 trials on spring barley (cvs. Abacus, Mazurka) in 1977.

Treatment *	Crop Height (cms)	Lodging Score	Yield (dt/ha)
Untreated	114	2.5	57.9
BAS 09800W 2.0 l/ha	93.0	0	59.9
2.5 l/ha	92.7	0	59.5
3.0 l/ha	83.7	0	58.5
Additional nitrogen 55 kg/ha	115	2.5	60.4
Additional nitrogen 55 kg/ha + BAS 09800W 2.5 l/ha	91.3	0.5	61.0

* BAS 09800W and the additional nitrogen were applied at GS 32-37.

BAS 09800W gave good crop height reductions and a rate response was evident. It also gave excellent control of lodging and yield responses were better at the lower rates. Additional nitrogen did not increase lodging, but did increase yield which was enhanced by BAS 09800W.

From 1978, development of BAS 09800W was centred on the winter crop, since the acreage grown was expanding rapidly, and this crop received higher nitrogen fertilisation, leading to increased lodging. Lodging control in this crop, if grown with optimum fertilisation, would be an important factor in its success (Table 3).

Table 3

Results in 1978 from 2 trials with severe lodging (cvs. Maris Otter, Igri) compared to a mean of 3 trials with little or no lodging (cvs. Sonja, Malta, Maris Otter).

Treatment	Mean Crop Height* (cms)	Maris Otter Lodging Score	Maris Otter Yield (dt/ha)	Igri Lodging Score	Igri Yield (dt/ha)	Mean Yield** (dt/ha)
Untreated	121.4	9	51.9	6	59.8	60.1
BAS 09800W 2.0 l/ha	116.0	8	55.6	5	64.3	62.1
2.5 l/ha	113.6	7	57.6	4	63.5	60.6
3.0 l/ha	115.1	7	55.2	4	67.8	62.6
Additional nitrogen 25 kg/ha	122.5	9	51.6	6	49.0	63.2
Additional nitrogen 25 kg/ha + BAS 09800W 2.5 l/ha	114.6	7	51.2	5	56.4	65.7
	LSD ($p < 0.01$)		1.4		1.2	1.7

* Mean crop height of Maris Otter and Igri.

** Mean of 3 trials with little or no lodging.

BAS 09800W and the additional nitrogen were applied at GS 32-37.

Table 4

Results from 5 trials on winter barley in 1979 comparing applications of BAS 09800W at GS 30-31 with a standard commercial product.

Treatment *	Crop Height (cms)	Lodging Score	Yield (dt/ha)
Untreated	120.7	2.8	73.5
BAS 09800W 2.5 l/ha	113.5	1.4	74.0
3.0 l/ha	111.9	1.4	76.8
Chlormequat chloride	118.2	2.4	73.9
	LSD ($p < 0.01$)		0.4

* All treatments applied at GS 30-31.

Varieties were Igri, Maris Otter, Sonja (2), Athene.

Table 5

Results from 5 trials on winter barley in 1979 with applications of BAS 09800W at GS 39-45.

Treatment	Crop Height (cms)	Lodging Score	Yield (dt/ha)
Untreated	120.7	2.4	70.0
BAS 09800W 1.0 l/ha	113.3	0.6	74.3
1.5 l/ha	111.0	0.6	75.1
2.0 l/ha	109.3	0.6	76.4
5.0 l/ha	104.8	0.2	74.5
	LSD ($p < 0.05$)		1.3

Varieties were Igri, Maris Otter, Sonja (2), Athene.

At the optimum application time of GS 32-37 BAS 09800W gave better crop height reduction than chlormequat chloride applied at GS 30-31 (Table 6). The control of lodging with chlormequat chloride applied at this early growth stage was inferior, and this was reflected in correspondingly lower yield.

Ethephon gave good crop height reduction by shortening the higher internodes and gave complete lodging control. This was not reflected in the highest yield.

No visible crop damage or discolouration with BAS 09800W has been reported in trials from 1977 to 1980. At 2.5 l/ha at GS 32-37 no reduction in grains per ear has been noted.

Malting quality is an important factor for a proportion of the winter barley acreage, particularly since results so far indicate that the crop should be adequately fertilised. BAS 09800W has given no reduction in the germination capacity of malting grain, and no effect on grain nitrogen levels. Similarly, on crops grown for seed, BAS 09800W has no effect on germination capacity in the laboratory or in the field.

The use of a full fungicide programme is an important factor in the correct use of BAS 09800W (Table 7).

Table 6

Results from 5 trials on winter barley in 1979 with applications of BAS 09800W at GS 32-37, compared with two standard commercial products.

Treatment	Growth Stage of Application	Crop Height (cms)	Lodging Score	Yield (dt/ha)
Untreated	-	120.7	2.8	73.5
BAS 09800W 2.0 l/ha	32-37	110.2	0.6	75.0
2.5 l/ha	32-37	109.7	0.4	74.7
3.0 l/ha	32-37	108.5	0.2	75.3
Chlormequat chloride	30-31	118.3	2.4	73.9
Ethephon	39-45	105.1	0	74.6
		LSD ($p < 0.01$)		0.9

Varieties were Igri, Maris Otter, Sonja (2), Athene.

Table 7

Interaction of fungicide programme and BAS 09800W on 6 trials on winter barley.

Treatment	Lodging Score	Yield (dt/ha)
Untreated	1.5	53.0
BAS 09800W, 2.5 l/ha at GS 32-37	1.2	53.9
Fungicide programme*	1.0	59.0
BAS 09800W, 2.5 l/ha at GS 32-37 plus fungicide programme	0.8	64.1 (expected yield by additive effect = 60.0 dt/ha)
	LSD ($p < 0.01$)	1.2

* Cosmic (4 kg/ha) applied at GS 30-31, and again at ear emergence.

A full fungicide programme gave a good yield response on its own, mainly by good disease control, but also by giving a healthy plant which resisted lodging. The fungicide programme plus BAS 09800W gave more than an additive yield response. Thus, to fully realise the benefits of BAS 09800W, the crop should receive a full crop protection programme.

The relationship between lodging and yield with higher nitrogen levels than were commonly being used, required further study. In 1978-1980 trials were designed which allowed the production of nitrogen response curves with and without BAS 09800W (Fig. 2).

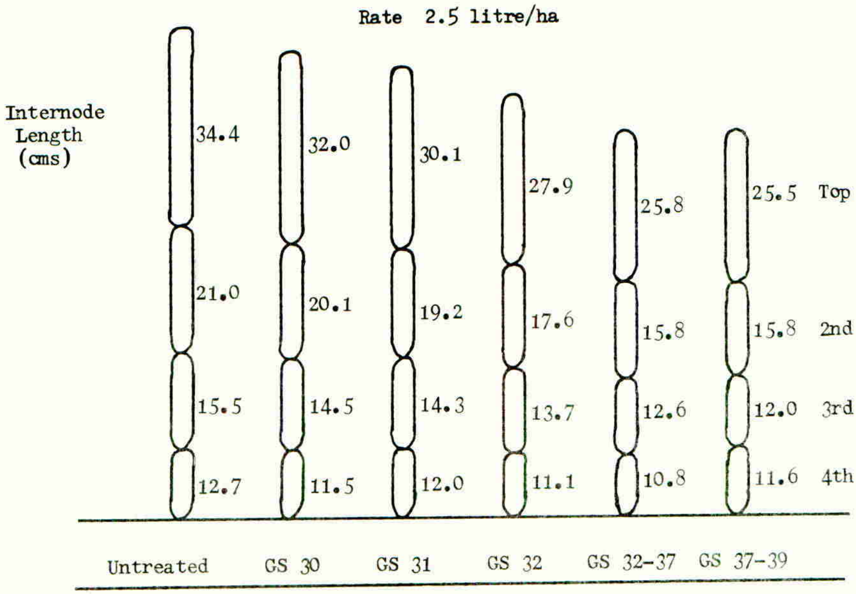
Without BAS 09800W lodging increased rapidly with increasing nitrogen. An application of BAS 09800W reduced lodging by approximately 65% at all additional nitrogen rates. This lodging control was reflected in yield. Without BAS 09800W, increasing nitrogen gave an increase in yield up to an optimum, after which the rapidly increasing lodging brought about by excessive nitrogen gave a decrease in yield.

In both severely lodged trials there was no yield benefit from additional nitrogen since at both sites the optimum nitrogen level for maximum yield was exceeded. At the 3 sites with very little lodging, additional nitrogen gave a good response. BAS 09800W gave variable results on its own, but a good response when applied with additional nitrogen.

The effect of BAS 09800W on internode length has been studied at different growth stages (Fig. 1).

Figure 1

The effect of application timing on internode length, 1978



Early applications gave temporary crop height reductions and the effect on the top internodes was minimal, leading to the possibility of brackling. Later applications shortened the higher internodes, but left the bottom of the plant susceptible to lodging.

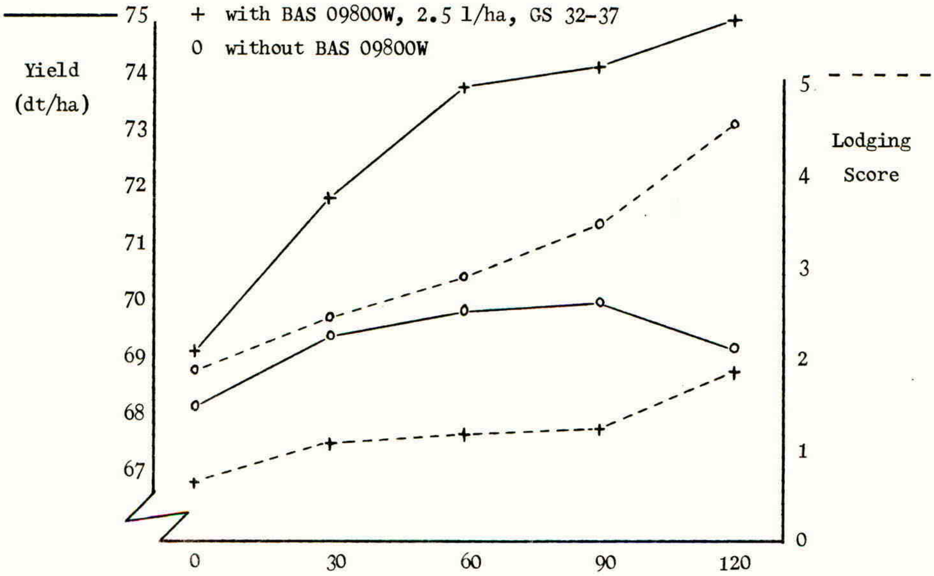
Hence it seemed that an application at GS 32-37 would be the optimum time of application to give greatest shortening of the lower three internodes. This gives the plant greatest resistance to the most frequently found lodging forces at the critical time of early grain filling, whilst allowing the crop to lean, especially near to harvest.

Applications at GS 30-31 were again studied in 1979, this time at the higher rates, to try to achieve shortening of the middle internodes. BAS 09800W compared favourably to chlormequat chloride, showing benefits in crop height reduction, lodging control and yield response, particularly at the higher rate (Table 4).

At a later timing good reductions in crop height occurred, due to the shortening of the higher internodes (Table 5). Lodging control was similar at all rates, although an increasing yield trend was noted.

Figure 2

Mean lodging and yield results from 5 trials in 1980 showing interaction of nitrogen and BAS 09800W.



Rate of nitrogen (kg/ha) applied extra to the farm application

Analysis of variance significant at $p < 0.05$. MSE of treatment means $\pm$ 0.73.

An application of BAS 09800W initially gave a yield response which increased dramatically with increasing additional nitrogen. This was because BAS 09800W was controlling lodging at the high nitrogen rates and allowing the nitrogen to be efficiently utilised. The sites for these trials were chosen because of their high fertility and high yield potential. The nitrogen fertiliser gives the potential for high yields, and BAS 09800W protects this potential by controlling the induced lodging.

Although the lodging scores presented in these results were recorded shortly before harvest, attention should be drawn to the fact that it is often the delay in the onset of early lodging that gives a yield response. It has already been stressed that BAS 09800W was designed to reduce lodging at this time, and not necessarily at harvest.

CONCLUSIONS

BAS 09800W should be used on intensively grown barley crops of high potential yield. Crops should be free from any stress, and should receive a full crop protection programme. The crop should be adequately fertilised to give maximum yield and an application of BAS 09800W will then protect this yield by controlling the induced lodging.

Work is continuing on the extensive range of spring barley varieties, and it is very likely that BAS 09800W will increase yields of this crop substantially if the grower will accept a higher level of input than at present. Results of using BAS 09800W on spring barley will be presented at another conference (Simpson, K., BASF, personal communication).

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BTS 44 584 - ITS YIELD-ENHANCING POTENTIAL IN SOYBEANS

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Summary BTS 44 584 is a new ternary sulphonium carbamate plant growth regulator which has shown yield enhancement potential on a number of crop species, particularly soybeans. 1978 and 1979 field trials in the United States have examined the effect of applying BTS 44 584 at a range of rates to a number of indeterminate and determinate soybean varieties at different developmental stages. At low rates of application (0.1-0.5 kg/ha) maximum yield response has occurred with treatments made during early reproductive stages of growth and there is a suggestion that increased yields may be achieved by reducing the abortion of pods. When BTS 44 548 is applied at rates above 0.5 kg/ha the growth of soybeans is retarded, thereby showing potential in preventing lodging in narrow row or solid seeded soybeans. Various effects on plant physiological processes have been shown by BTS 44 584 at different application rates and these would be expected to contribute to yield enhancement.

Resume Le BTS 44 584 est un nouveau carbamate sulphone ternaire. C'est un regulateur de croissance que peut ameliorer le rendement de nombreuses cultures, en particulier le soja. En 1979 et 1979, les essais de plein champ aux Etats-Unis ont permis d'etudier l'effet induit par l'application de BTS 44 584 a differentes doses sur un grand nombre de varietes de soja et a des stades phenologiques divers. On observe qu'aux faibles doses (0.5-1 kg/ha) le rendement maximum s'obtient avec des applications faites aux stades precoces de la reproduction. Il se pourrait que les augmentations de rendements puissent provenir de la diminution des avortements de gousses. Quand le BTS 44 584 s'applique a des doses superieures a 0.5 kg/ha, le croissance du soja est retardee. Ceci contribue a prevenir une verse possible sur des semis denses ou tres denses on a observe que le BTS 44 584 induit des effets varies sur la physiologie de la plante, aux differentes doses utilisees. On pense que ces effets contribuent a augmenter les rendements.

INTRODUCTION

The plant growth regulatory properties of BTS 44 584 were recently described (Garrod et al, 1979). The growth retardant properties on soybean, French bean, field bean, cotton, sunflower and chrysanthemum were reported and preliminary data on yield increase in soybean were presented. Further trials are in progress in the United States of America to examine the latter effect in more detail giving consideration to possible interactions between varieties and geographical location and to rates and timing of application. The results of these yield trials with BTS 44 584 will be presented and discussed in relation to the known growth regulatory effects of the compound.

METHOD AND MATERIALS

The varieties of soybean chosen for study were generally those most widely grown on a commercial basis in the geographical areas where the trials were laid down. Both determinate and indeterminate varieties were treated at a number of vegetative and reproductive growth stages according to the scheme devised by Fehr and Caviness (1977).

BTS 44 584, S-2,5-dimethyl-4-pentamethylenecarbomoyloxyphenyl-SS-dimethylsulphonium p-toluenesulphonate, formulated as a 90% water soluble powder was applied in all experiments as an aqueous foliar spray with a spray volume of between 200 and 300 litres per hectare.

Plot size and row spacing varied between trials but in general, sizes were approximately 10 m long by 4 rows wide, with a row width of 75-100 cm. Narrow rows were also employed in a few trials with widths of down to 18 cm. There were usually 4-6 replicate plots per treatment.

In some experiments supplementary irrigation was applied to the trial plots and where this occurred it is recorded on tables of results.

Harvesting for yield measurements was carried out by hand from the 2 inner rows of each plot but, in some instances it was only possible to harvest by machine. In some experiments supplementary assessments of plant height and pod number were made.

RESULTS

It is convenient to consider the results in two categories; those obtained with determinate soybeans and those with indeterminate soybeans. In broad terms determinate varieties are grown in the Southern States of the U.S.A. (Arkansas, Texas, Mississippi) and indeterminate varieties in the mid-West States including Illinois, Iowa, Missouri and Indiana although some varieties can be grown in both geographical areas.

Determinate soybeans

Three trials were undertaken on determinate varieties in Arkansas, Texas and Missouri with the varieties Davis, Bragg and Forrest.

In Arkansas, results showed a trend towards yield increase with Davis and Forrest varieties only when treatments were applied during reproductive stages of growth with significant increases achieved on Davis treated at R1 (Table 1). The optimum rate of application was 0.28 kg/ha but trends towards an increase were also observed with 0.14 and 0.56 kg/ha.

Table 1

Effect of BTS 44 584 on the yield of Davis and Forrest soybeans (Stutte - University of Arkansas)

Growth stage and rate of application (kg/ha)		Yield (kg/ha) Davis	Forrest
Control		2647	2493
V6	0.14	2530	2182
	0.28	2643	2698
	0.56	2523	2459
R1-R2	0.14	2789	2409
	0.28	2999*	2643
	0.56	2735	2093
R3-R4	0.14	2704	2525
	0.28	2851	2357
	0.56	2777	2329
LSD P = 0.05		248	329

The variety Bragg responded to treatments of BTS 44 584 applied at reproductive phases but no vegetative applications were made in these trials. Significant yield increases were achieved with rates of application between 0.14 and 0.56 kg/ha (Table 2) and in this case the optimum application was a sequential treatment at R1 and R3 although a single application of 0.56 kg/ha at R3 alone resulted in a significant yield increase.

A small reduction in plant height was recorded with the highest rate of application at growth stage R1 (Table 2).

Table 2

Effect of BTS 44 584 on yield and height

Bragg soybeans (Eastin - Texas A & M University)

Growth stage and rate of application (kg/ha)		Yield kg/ha	Plant height cm
Control		2240	65
R1	0.14	2554	64
	0.28	2286	59
	0.56	2480	54*
R3	0.14	2262	62
	0.28	2464	64
	0.56	2729*	60
R1 + R3	0.14	2591*	61
	0.28	2338	60
	0.56	2639*	62
LSD P = 0.05		327	9

Forrest soybeans treated during reproductive phases in Missouri showed a trend towards yield increases but a significant effect was only recorded with the 0.25 kg/ha rate applied at R2. Pod counts made from samples taken at harvest indicated an increase in this parameter in plants treated at R2 (Table 3) and significant lodging occurred in plants treated with a rate of 0.50 kg/ha which could have masked any increases in physiological yield.

Table 3

Effect of BTS 44 584 on yield and pod number of Forrest soybeans (Stewart Agric. Res. Inc. - Missouri)

Growth stage and rate of application (kg/ha)		Yield kg/ha	Pod number 45 cm of row
Control		2236.5	403
R2	0.125	2167.2	576*
	0.25	2696.4*	513*
	0.50	2242.8	547*
R4	0.125	2406.6	398
	0.25	2469.6	478*
	0.50	2324.7	372
LSD P = 0.05		425.88	48.9

Indeterminate Varieties

The majority of trials on indeterminate soybean varieties were carried out in Illinois and Iowa. In Iowa applications were made to the varieties Wayne, Corsoy and Harcor during reproductive stages only at rates between 0.25 and 1.0 kg/ha. Significant yield increases were recorded with the variety Wayne at 0.5 and 1.0 kg/ha at R1 and with two applications of 0.25 kg/ha and 0.5 kg/ha at growth stage R1 and R1 + 1 week (Table 4). Similar results were not recorded for the two other varieties. Significant reductions in plant height were recorded for all cultivars with applications made at growth stages R1 and R2 (Table 4).

A trial in Western Illinois with the variety Williams investigated the possible interaction between BTS 44 584 and row spacing. At rates between 0.1 and 1.0 kg/ha trends towards yield increases were observed with applications at both vegetative and reproductive stages in 18 cm rows but in 90 cm rows effects were reduced, and absent following application at later stages of reproductive growth (Table 5). The increases were non-significant at the 5% level due to high variability within samples.

Table 4

Effect of BTS 44 584 on yield and height of Wayne and Harcor soybeans (Anderson - University of Iowa)

Growth stage and rate of application (kg/ha)		Yield (kg/ha) Wayne	Yield (kg/ha) Harcor	Plant height (cm) Wayne	Plant height (cm) Harcor
Control		2721.6	3118.5	109.9	93.9
R1	0.25	2916.9	3093.3	82.0*	73.7*
	0.50	3345.3*	3017.7	85.6*	71.6*
	1.0	3546.9*	3288.6	76.9*	60.5*
	0.25 + 0.25	3616.2*	3301.2	71.9*	64.0*
	0.5 + 0.5	3439.8*	3383.1	67.1*	62.2*
Control		2998.8	3332.7	118.6	100.3
R3	0.25	3118.5	3490.2	96.5	83.3*
	0.50	3049.2	3458.7	88.7*	76.9*
	1.0	3042.9	3263.4	84.6*	73.7*
	0.25 + 0.25	3294.9*	3458.7	84.3*	77.5*
	0.5 + 0.5	3087.0	3238.2	80.5*	74.9*
LSD P = 0.05		327.6	352.8	8.9	7.1

Table 5

Effect of BTS 44 584 on yield of Williams soybeans (Gardner - University of Western Illinois)

Growth stage and application rate (kg/ha)		Yield kg/ha 18 cm rows	Yield kg/ha 90 cm rows
V4	0	2746.8	2576.7
	0.1	2683.8	2702.7
	0.5	2860.2	2740.5
	1.0	3231.9	2293.2
R2	0	2242.8	2431.8
	0.1	2916.9	2620.8
	0.5	2557.8	2601.9
	1.0	2973.6	2053.8
R4	0	2614.5	2551.5
	0.5	2765.7	2406.6
	1.0	2677.5	2362.5

DISCUSSION

It is clear from the results presented that BTS 44 584 will increase seed yield of a number of different varieties of soybean when applied at rates between 0.1 and 1.0 kg/ha. Certain varieties have, however, been shown to be relatively non-responsive to treatment under the conditions employed in these experiments.

Both indeterminate and determinate varieties respond to BTS 44 584 and the greatest effects occurred when applications were made during reproductive phases of growth from first flower through to mid-pod fill. Trials on the varieties Bragg and Wayne also suggest that more than one application may be necessary to maximise yield responses. In determinate varieties stem elongation has been largely completed by the time reproductive growth commences such that no marked effect on elongation rate would be expected by treatment at this stage and this was largely borne out by the data recorded. In indeterminate varieties significant stem elongation takes place after flower initiation and the growth retardant properties of BTS 44 584 were clearly demonstrated on the varieties Wayne and Harcor.

If a common mechanism of action of BTS 44 584 is operating in both determinate and indeterminate soybeans to cause yield enhancement then growth retardation cannot be responsible although with indeterminate varieties such a response could contribute towards an increase in seed yield. A growth retardant may act by causing a redistribution of photosynthetic assimilates from vegetative to reproductive growth, by rendering the plant more resistant to lodging or by confering water stress avoidance characteristics (Orchard and Lovett, 1976; Hewitt et al, 1980).

Yield enhancement with BTS 44 584 has been recorded with no obvious morphological effect on the plants. Work currently in progress suggests that treated plants have an increased net photosynthetic rate. The reasons for this are not clear and further experimental work is required to study the mechanism of action of BTS 44 584 on soybean yield.

That growth retardation is not alone responsible for stimulating yield in indeterminate beans is supported by the findings that low rates of application (0.1 to 0.25 kg/ha) increase yield without affecting elongation growth.

BTS 44 584 was more active on Williams soybeans grown in narrow 18 cm rows than in conventional 90 cm row spacings. This interaction is not easily explained but at high rates of application (1.0 kg/ha) it seems possible that a reduction in plant stature may have resulted in less competition between individual plants in narrow row spacing allowing a greater yield to be produced.

The majority of results show that the optimum rate of application for BTS 44 584 to induce increases in yield lies between 0.1 and 0.5 kg/ha although increases have been recorded at rates of 1 kg/ha. Further trial work is in progress and planned to further investigate the yield enhancing properties of this new plant growth regulator in an attempt to define those conditions and varieties of soybean in which the greatest and most reliable response might be obtained.

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NOTES

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DAMINOZIDE AS AN AID TO SEED POTATO PRODUCTION

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Summary Daminozide applied at the correct stage of tuber development can greatly enhance seed production in many of the main crop cultivars grown in the United Kingdom, without affecting total yield and with no phyto--toxicity or deformed tubers. The progeny from the treated crops grown-on the following year showed no adverse effects. Timeliness of application to the foliage of the plant appears to be the most essential factor for maximum yield response.

INTRODUCTION

Work on the beneficial aspects of the growth regulant daminozide has been widely reported in the literature. A number of reports have dealt with the influence of daminozide on aspects of potato physiology, including tuber initiation, number and growth rate. Dyson and Humphries (1966) confirmed that daminozide accelerated tuber initiation on the cultivar Majestic, while Purohit (1971) found daminozide to have increased tuber numbers per plant and also the growth rate of tubers when the growth regulator was applied two weeks after tuber initiation. On the other hand Bodleander and Algra (1966) and Dyson and Humphries (1967) showed independently that daminozide -treated potato plants had increased tuber weight but less aerial growth. Laycock and Tyson (1968) reported varietal response to daminozide but found the variety Arran Pilot to have shown no beneficial effects to timeliness of application. In contrast to the reports of other workers, Harper (1967) warned of residue carry-over effects on the progeny of treated plants; Laycock and Tyson (1970) could not confirm this but instead suggested that daminozide may be a means of enhancing seed on the evidence of its performance on the cultivar King Edward. This work, together with those of McIntosh (1975) on the control of common scab and Smith and Baker (1970) who demonstrated that daminozide-treated plants were less attractive to aphids, led to an examination of the wider beneficial aspects of daminozide for seed potato production in the United Kingdom.

Work started in 1977 with the purpose of fulfilling the following objectives: (a) to discover the most economical dose rate, and whether this rate of daminozide would have any adverse effects on treated and subsequent crops, (b) to find the cultivars responsive to daminozide treatments and the stage of plant development most favourable for application in order to maximise seed yield, and (c) to determine the mode of action of daminozide on the tuber. The result of a residue-check experiment on six cultivars, together with a comparison of two application dates of the growth regulant on Pentland Crown and Desiree and also another experiment on Maris Piper are described.

METHOD AND MATERIALS

Daminozide (85% a,i, soluble powder) was used as the product throughout the work. The doses used for the residue-check experiments, initially on farm crops were 0, 1.0, and 2.0 kg product per hectare respectively on each of the six cultivars as described in Tables 1, 2 and 3. The seeds (progeny) from the 1978 treated crops were kept in a commercial seed store until the spring of 1979 when they were screened for diseases and selected for evenness of size, and planted by hand in a farm seed crop at Wooden Estate, Roxburghshire. Apart from hand planting, all other husbandry and cultural practices were carried out as for a farm crop. The experiment was done on a randomised block design with three replicates. 30 tubers from each cultivar and treatment dose were planted per plot. Each plot contained one row by 10m length. No further daminozide was applied to this experiment in 1979. Assessments were made on the sprouts or stems of each tuber in the experiment after they emerged above soil level and careful observations were made routinely twice each week to check for any unusual growth. Finally, at harvest the entire experiment was hand lifted and graded for size, counted and weighed. Seed size was taken on a 32 - 60mm riddle/mesh, while those tubers above 60mm size were graded for ware and those below 32mm were discarded.

The next experiment on the comparison of two spray dates on two cultivars were done on two separate farms in the Border areas. Pentland Crown was treated at Mid - -Softlaw and Desiree at Leitholm. Maris Piper, in another experiment, was sprayed at Kaimes East Mains on a single treatment date.

There were three randomised blocks in the farm seed crop. The first spray date was 2.7.79 when the tubers were at the initiation and 'hook' stage, and the second was 20.7.79 when the tubers were at the marble stage of swelling. Daminozide was used at rates of 0.5, 1.0 and 2.0 kg/ha in a volume of 280 l/ha and sprayed on to the foliage of the plant with a precision small plot sprayer. The spray pressure was kept constant at 2-bars by pressurised butane gas cylinder. The spray nozzles were of the cone type and set 25cm apart on a 2m boom. Each plot consisted of three rows, 10m lo g. At harvest, the centre row only was lifted by hand, and the tubers graded as in the procedure outlined above. The experiment was conducted in exactly the same way for Maris Piper, except that spraying was done on 12. 7.79 when the tubers were at the small marble stage of development.

RESULTS

The results of the residue - check experiment are given in Tables 1, 2 and 3. Table 1 shows no adverse effects on stem counts per plant above soil level while Tables 2 and 3 show no reduction in seed and total yields, or deformed tubers.

Table 4 illustrates the differences between two application dates where the early spray treatment was superior to the later one on the cultivar Pentland Crown. Both seed numbers and seed weight were better in the first spray date when the application was done at the tuber-initiating -to-hook stage of development.

Table 5 shows a complete contrast in the behaviour of Desiree to that of Pentland Crown. The second spray application surpassed the first treatment in both seed numbers and seed weight. This demonstrates the responsiveness of Desiree to daminozide when the tubers are at the marble stage of swelling.

Table 6 demonstrates a negative response to the growth regulant which is typical of a group of seedy varieties which behaved in this manner.

Table 1

Residue check: Progeny of 1978 Treated Crops Grown 1979

Mean +Sprout Counts/Tuber in Field (+stem)

Dose kg/ha	Maris Peer	Crofts	Desiree	Estima	Record	Pentland Crown
0	5.800	6.607	4.644	4.633	3.700	4.944
1.0	5.644	6.122	4.856	5.433	4.678	5.867
2.0	5.633	6.611	6.200**	5.056	4.544*	6.233*

P= 0.01** P= 0.05* SED = 0.433 (for same cultivar)

Table 2

Residue check: Progeny of 1978 Treated Crops Grown 1979

Mean Seed Weight (t/ha)

Dose kg/ha	Maris Peer	Crofts	Desiree	Estima	Record	Pentland Crown
0	32.93	26.68	23.05	26.17	25.54	19.85
1.0	30.72	26.85	23.45	30.38	25.60	22.68
2.0	33.73	25.39	30.77*	28.56	32.41*	19.86
LSD at P= 0.05*	4.53	6.42	4.62	6.51	2.93	9.96

Table 3

Residue check: Progeny of 1978 Treatment Grown 1979

Means of Total Yield (t/ha)

Dose kg/ha	Maris Peer	Crofts	Desiree	Estima	Record	Pentland Crown
0	36.48	45.90	38.95	39.89	34.49	49.36
1.0	36.75	39.25	35.32	38.25	33.62	47.10
2.0	36.77	38.22	38.33	35.10	38.53	45.90
LSD at P= 0.05	5.88	17.29	11.42	6.71	7.84	9.94

Table 4

Comparison of two spray application dates on Pentland Crown

Date 1 spray: 2.7.79
Date 2 spray: 20.7.79

Dose kg/ha	Nos. of Seeds/plot		Wt. of Seed/plot (kg)		Total Yield (t/ha)	
	Date 1	Date 2	Date 1	Date 2	Date 1	Date 2
0.5	104.7**	67.0	9.73**	6.27	59.5*	45.8
1.0	95.3**	82.0	9.27**	8.13	58.2*	51.1
2.0	116.0**	95.0	10.87**	9.27	65.7*	58.1
SED	1.23		0.14		1.5	

P= 0.05* P= 0.01** (SED for comparison between treatment dates)

Table 5

Comparison of two spray application dates on Desiree

Date 1 spray 2.7.79
Date 2 spray 20.7.79

Dose kg/ha	Nos. of Seeds/plot		Wt. of Seed (kg/plot)		Total Yield-kg/plot	
	Date 1	Date 2	Date 1	Date 2	Date 1	Date 2
0.5	149.5	157.0	15.7	15.9	25.3	24.0
1.0	149.5	182.0*	14.0	17.6*	22.7	26.3
2.0	144.5	190.0*	13.4	18.3*	24.9	24.8
LSD at P=0.05*	9.67		2.01		N.S.	

Table 6

Comparison of Dose Rates on Maris Piper

Dose kg/ha		Nos. of seed/plot	Weight of seed (t/ha)	Total Yield (t/ha)
0		275.0	37.7	44.20
0.5		295.0	37.0	42.80
1.0		268.0	37.8	43.95
2.0		260.0	36.1	44.46
P = 0.05	SED	26.83	2.45	3.14

DISCUSSION

The residue carry-over experiment was done to allay doubts regarding the use of daminozide for seed production in potatoes, especially in view of the adverse effects reported by Harper (1967) and McIntosh (1975), who made mention of slight tuber deformity on pot treated plants. None of the cultivars in the experiment demonstrated any adverse symptoms or effects; in fact, the progeny of Desiree, Record and Pentland Crown showed benefit from the higher dose by producing more stem numbers than the untreated, and this was further demonstrated by higher seed yields on the cultivars Desiree and Record. It may very well be that the very high dose used by earlier workers could be a factor influencing the observations made by them. Indeed, Laycock and Tyson (1970) could not confirm phytotoxicity in their trials, and instead recorded benefits favouring the use of daminozide, in particular for seed production.

The comparative dates 1 and 2 experiments demonstrate a marked contrast in response to daminozide treatment between cultivars, which is in agreement with the findings of Laycock and Tyson (1968). Whereas, Pentland Crown was influenced by the early treatment date, Desiree on the other hand responded to the later application, with both cultivars producing seed yields and tuber numbers significantly better at the 5% level over the other treatment dates. Other cultivars which on observat-ion were typical of Pentland Crown in that they responded to the earlier treatment were: Pentland Hawk, Pentland Dell, Pentland Squire and King Edward. Further work is in progress to substantiate these preliminary observations. Laycock (1971) reported that King Edward was more responsive to daminozide when it was applied at haulm height of 15 - 25cm than at a later time. During these series of experi-ments however, it was not possible to tie-in foliage growth with tuber size accurately. This was because in 1978 the wet early spring encouraged lush foliage growth, whereas, in 1979 the dry spring caused stunted growth. The most useful guide was to dig up a plant and examine the tubers for size.

The implications of the experiments point to two principal factors which may influence the potato plant to be responsive to daminozide; these are: (1) timeliness of application to catch the tubers at the most sensitive stage of development, and (2) the inherent pattern of tuber formation around the plant. There appeared to be two distinct patterns of tuber formation. In the one instance the tubers grow away from the vicinity of the plant, while in the other the tubers form a 'nest' at the base of the plant. In the former type the cultivars are responsive to the growth regulant, while in the latter case they are not.

The main crop varieties mentioned above are those which grow away from the plant on long tuber-bearing stolons, thus producing larger tubers free of competition for space, water and nutrients; and as a consequence produce a higher ware to seed ratio in normal circumstances.

The other type are those which produce tubers in a cluster or 'nest' at the base of the plant and in this case they do not readily respond to daminozide simply because the tubers compete for space and nutrients in the soil; these are generally known to the grower as seedy varieties and include Maris Piper as shown in Table 6. There was no response to daminozide as judged by tuber numbers and tuber weight.

There was slight shortening of the foliage on the cultivars Desiree and Pentland Crown a week after the application of daminozide, but only at the 2kg/ha dose, and this was found to be advantageous to an observant grower who could walk through the crop during roguing without much difficulty. Shorter foliage had no effect on yield.

Contrary to the opinions of other workers, it would appear that the mode of action of daminozide on potatoes is to restrict the growth of the first formed tubers by allowing the free passage of food to the smaller ones, with the resultant production of a larger quantity of even sized tubers.

Finally, daminozide, as judged by the results of these series of experiments, appears to have a useful role in enhancing seed production, in particular where the multiplication of high quality seed is necessary. Holmes and Lang (1978) suggested that, to increase seed yield, the planting rate should be increased while at the same time reducing sett size. Daminozide could play a useful role in supplementing these cultural practices.

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GRASS GROWTH CONTROL IN APPLE ORCHARDS WITH MEFLUIDIDE

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Summary Grass sward growth suppression was studied in two experiments (one in a dessert apple orchard with a *Poa pratensis* plus *Festuca rubra* sward and one in a cider apple orchard with a predominantly *Agrostis* species sward) comparing several rates of mefluidide with a standard maleic hydrazide treatment with (experiment 1) or without (experiment 2) the addition of 2,4-D, and with an untreated sward.

The combined results suggest that two applications of mefluidide (May and July) at the two higher application rates of 0.75 and 1.0 Kg a.i./ha will inhibit growth of these grass species until apple harvesting in October/November.

Résumé La suppression de la croissance d'un gazon a été étudiée au moyen de deux essais (l'un dans un verger de pommes à couteau couvert de *Poa pratensis* plus *Festuca rubra* et l'autre dans un verger de pommes à cidre avec une prédominance d'*Agrostis* spp.) en comparant plusieur niveaux de méfluidide avec un traitement normal à l'hydrazide maléique, avec (essai 1) ou sans (essai 2) l'addition de 2,4-D, et aussi avec un gazon non-traité.

Les résultats combinés suggèrent que deux applications de méfluidide (en mai et en juillet) aux deux taux d'application plus élevés de 0,75 et 1,0 kg m.a./ha inhibiteront la croissance de ces graminées jusqu'à la récolte des pommes en octobre/novembre.

INTRODUCTION

Most commercial apple orchards have a bare weed-free tree row and a grassed alley which requires regular and expensive mowing throughout the growing season. A reduction in the labour and maintenance costs by the use of plant growth inhibitors would be of economic value (Stott, 1972).

In cider orchards the grass sward beneath the trees is important for mechanical harvesting and for keeping the fruit clean. Maintaining a low sward after July when the branches are weighed down with fruit is often not practicable and the use of a chemical inhibitor to control grass growth until the end of October would be of great value to cider apple growers. Plant growth inhibitors have been used to reduce the growth of grasses in amenity areas but in practice have not met with complete success (Elkins, 1974 and Elkins and Suttner, 1974). More recently, mefluidide has shown promise as a growth inhibitor of grasses (Bocion et al 1975 and Watschke, 1978). In the following experiments mefluidide was tested as a grass retardant and compared with maleic hydrazide + 2,4-D and maleic hydrazide alone, and untreated grass in the alleyways of a dessert and of a commercial cider orchard.

METHOD AND MATERIALS

Experiment 1 Dessert apple orchard

The orchard was planted at Long Ashton in 1969 at 4 x 2.75 m and consisted of alternate trees of Cox's Orange Pippin and Golden Delicious on MM 106 rootstock (Stott, 1976). The trees were grown in a herbicide strip with a grassed alleyway. The grass sward was sown in 1970 with a 50/50 mixture of *Poa pratensis* L.(meadow-grass), and *Festuca rubra* L., (red fescue). For the experiment the grassed alleyways were divided into randomised plots measuring 8 x 2 m and sprayed with the following treatments:

1) Mefluidide at 0.5 kg a.i./ha.

2) Mefluidide at 1.0 kg a.i./ha.

3) Maleic hydrazide (MH) with 2,4-D at 3.7 plus 3.7 kg a.i./ha.

4) Unsprayed controls.

The materials used were Embark containing 240 g/l of the amine salt solution of Mefluidide, and BBH 43 containing 360 g/l of the amine salts of maleic hydrazide and of 2,4-D.

The chemicals were applied on 31 May, 1979 using the Oxford Precision Sprayer. A repeat application was made to one half of each plot on 2 July, 1979. Each treatment was replicated four times.

Experiment 2. Cider apple orchard

The experimental site at Kingsbury Episcopy, Somerset consisted of 4 year old cider trees of several cultivars on MM 106 planted at 3.7 x 5.5 m. The trees were grown in a herbicide strip with a grassed alleyway. The "tumbledown" sward concsisted mainly of *Agrostis* spp. The grassed alleyways were divided into plots measuring 4 x 3 m for each treatment listed in Table 3. Mefluidide was applied as Embark and maleic hydrazide as Regulox 36, containing 240 g/l of the amino salt.

Treatments 1 - 10 were applied on 5 May, 1980 using the Oxford Precision Sprayer. Treatments 5, 6, 7, 8 and 10 were repeated on 22 July, 1980. Each treatment was replicated four times, once in each of four random blocks.

In both trials the grass was mowed 3 days before spraying; thereafter each treatment was mowed when it reached 10 - 15 cm high. The number of cuts and weight of grass clippings, both fresh and dry weight was recorded.

RESULTS

Table 1 shows that whilst the standard MH + 2,4-D treatment reduced both fresh and dry weight grass sward production compared with the unsprayed treatment (a statistically significant reduction), both the mefluidide treatments gave a further greater reduction than either the M.H.+ 2,4-D or unsprayed treatments. Furthermore the number of cuts needed to control the grass cover was reduced with the mefluidide treatments. A single application of mefluidide at 1.0 kg a.i./ha reduced grass dry weight by 48% compared with the unsprayed controls and 34% compared with the M.H.+ 2,4-D treated plots.

Table 1

The effect of growth retardants applied in May on grass growth

Treatment	Rate a.i. (kg/ha)	No. cuts/ season	Total fresh wt g/m^2	Total dry wt g/m^2
Mefluidide (Embark)	0.5	3	531	147
	1.0	3	500	139
M.H.+ 2,4-D (BBH 43)	3.7+3.7	5	753	209
Unsprayed (control)	-	6	963	267
	-	-	-	S.E.D. 21

Repeat spraying of mefluidide in late July reduced the number of subsequent cuts and the dry weight of grass clippings compared with M.H.+ 2,4-D treated and unsprayed plots (Table 2). The double application of mefluidide saved either three mowings (M.H.+ 2,4-D treatment) or four mowings (no spray applied) over the full crop season.

Table 2

The effect of re-application of growth retardants in late July on subsequent grass growth

Treatment	Rate a.i. (kg/ha)	No. cuts late July - November	Total fresh wt g/m^2	Total dry wt g/m^2
Mefluidide (Embark)	0.5	1	100	28
	1.0	1	88	24
M.H.+ 2,4-D	3.7+3.7	2	259	72
Unsprayed (control)	-	2	494	137
	-	-	-	S.E.D. 10

The data in table 2 contains any residual effect of the first treatment applications.

Experiment 2

Table 3 shows that all treatments reduced the number of mowings and the fresh and dry weight of grass. A single application of mefluidide at 1.0 kg a.i./ha (treatment 4) gave a 60% reduction in dry grass weight compared with the unsprayed sward and 48% compared with the single M.H. application (treatment 9). A single application of mefluidide at rates above 0.5 kg a.i./ha were significantly more effective than a single maleic hydrazide application.

Table 3

The effect of application of growth retardants on cider orchard grass growth

	Treatment	Rate kg a.i./ha	No. applications	Month cut June	July	August	Total fresh wt (g) /m^2	Total dry wt (g) /m^2
1	Mefluidide	0.25	1		+	+	685	190
2	Mefluidide	0.5	1		+	+	520	144
3	Mefluidide	0.75	1		+	+	498	138
4	Mefluidide	1.0	1		+	+	361	100
5	Mefluidide	0.25	2		+	+	425	118
6	Mefluidide	0.5	2		+		143	40
7	Mefluidide	0.75	2		+		99	28
8	Mefluidide	1.0	2		+		79	22
9	Maleic hydrazide (Regulox)	6.0	1		+	+	697	194
10	Maleic hydrazide	6.0	2		+		245	68
11	Unsprayed (control)	-	-	+	+	+	901	250
		-	-				-	S.E.D. 19

The unsprayed plots and those where mefluidide was reapplied at 0.25 kg a.i./ha on 22 July 1980 were cut once between mid-July and mid-September, but all other rates of reapplied chemicals inhibited grass growth and the plots have not needed cutting.

DISCUSSION

In a dessert apple orchard (experiment 1) where the grass cover was a 50/50 mixture of Poa pratensis and Festuca rubra the rate of application of mefluidide had little effect on grass growth inhibition. Overall, the effect of a single treatment application was to reduce the dry matter production by 22 per cent (M.H. + 2,4-D treatment) and 46 per cent (mean of two mefluidide rates - 0.5 and 1.0 Kg a.i./ha) compared with the untreated sward (table 1). Following the second treatment applications in late July, sward dry matter production was reduced by 47 and 81 per cent respectively in the latter part of the season. The comparable number of sward cuts over the full season were 5 and 3 compared with 6 for the untreated sward; chemical reapplication of mefluidide (both rates) gave an additional saving of 1 further cut compared with either the M.H. + 2,4-D or untreated swards. Spraying with mefluidide gave a dense, compact, acceptable sward, but repeated applications of M.H. + 2,4-D discoloured some grasses and killed others producing bare patches which allowed the ingress of undesirable broad leaved weeds and coarser grasses.

In experiment 2 where Agrostis species predominate single applications of mefluidide at four rates (0.25, 0.5, 0.75 and 1.0 Kg a.i./ha) reduced sward dry matter production by 24, 42 and 60 per cent respectively compared with the untreated sward; comparable figures for two applications of mefluidide at these rates were 53, 84, 89 and 91 per cent. In comparison with mefluidide a single and double application of a standard maleic hydrazide treatment reduced sward dry matter production by 22 and 83 per cent. Furthermore, all single application treatments reduced the number of cuts by one and all double applications, except mefluidide at the lowest rate of application reduced the number of cuts by two (table 3). In practice a grower who mows the grass sward until July could at this time suppress the grass growth until November by single application of mefluidide at 0.75 Kg a.i./ha.

The combined results suggest that a repeated application of mefluidide at rates in excess of 0.5 Kg a.i./ha may prove of particular value in cider orchards where, by maintaining a low sward until the end of the harvest period, the ground collection of healthy, unsoiled fruit will be made easier.

It would seem possible on the basis of the slender evidence concerning the grass species in this paper, that effective use of mefluidide to suppress sward growth may be species dependent.

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ETHEPHON AS A PLANT GROWTH REGULATOR ON WINTER BARLEY:

RESULTS AND PRESENT STATUS IN EUROPE

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Summary Detailed trials over the past 4 years in Belgium, France, West Germany, Netherlands and United Kingdom have proved ethephon to be a safe and efficient product for use on winter barley, to reduce lodging. Commercial results from sales in France for 3 seasons, the United Kingdom for 2 seasons and the other countries for 1 season have agreed substantially with experimental trial results.

Résumé Des essais détaillés durant les 4 dernières années en Belgique, France, Allemagne, aux Pays-Bas et au Royaume-Uni ont prouvé que l'éthephon est un produit sûr et efficace pour diminuer la verse des escourgeons et orges d'hiver. Les résultats dans les conditions de la pratique en France (3 saisons), au Royaume-Uni (2 saisons) et dans d'autres pays (1 saison) ont confirmé les résultats des essais expérimentaux.

INTRODUCTION

Barley is a very important crop in Western Europe (Table 1):

Table 1

Cereals area - West Europe (1976)

	West Europe	EEC-9
	%	%
Rye	3	4
Maize / Rice	12	10
Oats	10	10
Wheat	38	42
Barley	37(14,644,600 ha)	34(8,799,200 ha)
Total area	39,580,000 ha	25,880,000 ha

In the last 10 - 15 years or so, there has been a dramatic increase in the area sown to winter barley, and this trend is expected to continue (Table 2).

Table 2

Winter barley area (1000 ha) - EEC-9

Country	1965	1976	1980	1985 (predicted)
Belgium	28	103	170	180
Denmark	-	-	50	100
France	317	870	1370	1550
W. Germany	270	795	1210	1400
Italy	100	200	330	360
Netherlands	25	9	12	15
UK & Ireland	200	450	730	850
Totals	930	2427	3872	4455

All aspects of growing winter barley have been the subject of much husbandry, plant breeding, etc., research in many West European countries in recent years. A few years ago nitrogen fertilizer used at 60 - 80 kg/ha was fairly standard, but now 100 - 150 kg/ha is rather common, with over 200 kg/ha being used in some areas, to maximize yields. These high levels of nitrogenous fertilizer applications, together with new cultivars, disease control, and husbandry techniques have raised maximum yield potentials from around 4 - 5 tons/ha up to 6 - 8 tons/ha and more. These increased inputs and yields have been associated with an increase in lodging, even under fairly moderate climatic conditions. With high fertility and inclement weather, lodging can be a major problem.

Early lodging occurring from around ear emergence until end of flowering (Zadoks' 59 - 70) can have a severe effect on yield. Lodging at any time, early and late, is undesirable for several reasons:

1. Loss of yield as combine harvester is unable to pick up all the crop and ears are lost when hanging below cutter bar. Threshing and cleaning is less efficient.

2. Harvesting is quicker in a standing crop. Lodging reduces harvester speed, especially when weeds have grown through the lodged crop.

3. A lodged crop dries out more slowly in the morning and after rain.

4. Grain quality can be lower - more mouldiness and sprouting, especially important during period of bad weather.

5. Higher grain moisture increases drying costs.

6. Grain maturity and size is uneven, with more secondary tillers.

7. Harvester cutter bar must be set lower, to pick up crop, with more chance of mechanical damage.

8. Increased loss from birds - pigeons and rooks.

Ethephon released for field testing in 1966, was observed to inhibit the height and apical dominance of some plant families, including grasses, and was, therefore evaluated on cereals during the 1967 - 1970 period. It was compared to chlormequat on wheat at the end of tillering to early shooting growth stages, and gave good height inhibition and prevention of lodging. The rate required was in the order of 1.0 - 2.0 kg a.i./ha, which was uneconomic at that time. On spring barley these rates proved somewhat phytotoxic, giving some grain sterility.

Subsequently, with the increasing interest in winter barley and indications that ethephon was more active when applied at later stages of growth, trials were re-commenced in 1977.

METHOD

The trials subsequently referred to have been made in Belgium, France, West Germany, Netherlands and the United Kingdom by associated companies and independent research workers in 1977, 1978 and 1979. Plot size was 25 or 50 m^2 with 4, or more normally, 6 randomized replications. Application was by gas-operated knapsack sprayers and harvesting was by means of mechanical combine harvesters.

RESULTS

Lodging and yield

The reduction in lodging as a function of rate and time of application of ethephon is shown in Table 3:

Table 3

Ethephon - Influence of rate and growth stage at application on the % lodging of winter barley

Growth stage		ethephon kg a.i./ha					
Zadoks'	Feekes Large	0	0.24	0.36	0.48	0.60	0.96
30 - 58	5 - 10.5	58(111)	34(10)	26(27)	26(125)	16(36)	5(10)
30 - 37	5 - 8	-	56(3)	43(3)	36(31)	35(2)	-
37 - 45	8 - 10	-	-	26(10)	27(57)	18(21)	5(3)
45 - 58	10 - 10.5	-	28(7)	21(14)	19(37)	13(13)	4(7)

( ) = number of treatments recorded.

Data in Table 3 are derived from 60 trials on 20 different cultivars. It can be seen that there is little difference in lodging prevention between 0.36 and 0.48, 0.6 kg/ha being marginally better. The stage of application is obviously of more importance, treatments before G.S. Zadoks' 37 being markedly inferior to later treatments.

Table 4

Ethephon - Influence of rate and growth stage at application on the % yield of winter barley

Growth stage Zadoks'	Feekes Large	ethephon kg a.i./ha 0.36	0.48	0.60	0.96
30 - 58	5 - 10.5	105 (47)	106 (213)	106 (53)	103 (31)
30 - 37	5 - 8	101 (3)	104 (62)	108 (4)	99 (2)
37 - 45	8 - 10	108 (20)	108 (83)	108 (29)	103 (11)
45 - 58	10 - 10.5	104 (24)	106 (68)	104 (20)	102 (18)

( ) = number of treatments recorded.

The data in Table 4 are derived from 117 trials on 26 cultivars.

There are no obvious influences on yields from the rates of ethephon used, but there is a slight indication that yield increases are less with the earlier treatments (before G.S. Zadoks' 30 - 37, F.L. 5 - 8).

Intensity of Lodging

During 1978 and 1979, heavy lodging conditions ranging from 25 - 100 % of area lodged, occurred in 27 trials on 12 cultivars and average yields were:

Table 5

Ethephon 0.48 kg a.i./ha - Influence on lodging and yield under heavy lodging conditions

Growth stage	Lodging % Control	Ethephon	Yield %
Zadoks' 32 - 50 F.L. 7 - 10.1	67	23	108

34 trials on 11 cultivars where lodging was light, 0 - 24 %, gave the following average yields:

Table 6

Ethephon 0.48 kg a.i./ha - Influence on lodging and yield under light lodging conditions

Growth stage	Lodging % Control	Ethephon	Yield %
Zadoks' 37 - 55 F.L. 8 - 10.3	2	0	104

Grain size and weight

From treatments of 0.48 kg a.i./ha ethephon, applied from growth stages Zadoks' 31 - 55, F.L. 6 - 10.3, the 1000 grain weight averaged 101 % from 55 treatment samples and grain size, measured either greater than 2.5 or 2.8 mm, averaged 104 % from 27 treatment samples, compared to untreated control samples.

Nitrogen fertilizer status

Conventional nitrogen fertilizer rate recommendations have been established to maximize yields without encouraging lodging. By using ethephon to reduce lodging, the rate of nitrogen may be increased as shown by results from 6 trials, France 1979:

Table 7

Influence of ethephon 0.48 kg a.i./ha on yield with increased nitrogen fertilizer

Nitrogen rate	Normal *		Normal * + 25 %	
	Yield %	Lodging %	Yield %	Lodging %
With ethephon	108	0	113	6
Without ethephon	100	12	105	36

* Normal = 80 - 100 kg/ha

DISCUSSION

Tables 3 and 4 show 0.36 - 0.60 kg a.i./ha ethephon reduces the incidence of lodging in winter barley most effectively when applied after the appearance of the last leaf (G.S. Zadoks' 37) with a positive influence on yields. Treatment before this stage is less effective, or requires a higher dose of ethephon.

Under conditions of heavy lodging, the influence on yield is very positive, as shown in Table 5, and it is gratifying to note that even where lodging does not occur to any great degree, yield is not reduced, as shown in Table 6. In many instances, significant yield increases of up to 4 - 8 % have been noted in the absence of lodging. Why this happens is not yet clear but further work is continuing on factors that may be of importance, such as number of fertile tillers or loss of grain and ears before harvest.

Reduction in height appears to be an important factor in the reduction of lodging. Other trial results, not included here, show that ethephon reduces the length of internodes that are elongating at the time of application. The ultimate and penultimate internodes are, therefore, affected most with application made after G.S. 37.

After G.S. 37 the optimum stage of application has varied from trial to trial. In some cases reduction of lodging has been best at G.S. 37 - 39, in other cases G.S. 39 - 45 and in other G.S. 45 - 50. Although the reasons for this variation are very difficult to measure, we can be fairly certain that the crop growth activity at the time of treatment is of prime importance. The greatest growth regulating activity occurs when the crop is actively growing under optimum moisture and temperature conditions.

Grain weight and size have not been influenced adversely but, of course, ear length has been reduced. This is to be expected, as the ear, as well as the final internodes, are elongating at the time of ethephon application.

The present status in Europe for the use of ethephon to reduce the lodging of winter barley is:

Belgium	- approved for 1980 - 1 year's commercial sales
France	- temporary approval since 1978 - 3 years' commercial sales
West Germany	- approved for 1980 - 1 year's commercial sales
Netherlands	- approved for 1980 - 1 year's commercial sales
U.K.	- cleared under P.S.P.S. - 2 years' commercial sales.

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THE USE OF PLANT GROWTH REGULATORS IN THE MANAGEMENT OF ORCHARD SWARDS: SOME PRELIMINARY RESULTS WITH MEFLUIDIDE

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Summary The effect of mefluidide on the water use, mineral uptake and growth of *Phleum nodosum* and the growth of *Lolium perenne* has been investigated. The chemical had a small effect on the water use of both cut and uncut swards and increased the concentrations of N,P and K. There were substantial effects upon growth and flowering. Results suggest that it may be possible to replace the mowing of orchard swards with chemical treatments.

INTRODUCTION

In most of Europe's orchards, trees are grown in herbicide strips with grassed alleys (inter-row areas). Although an increasing number of orchards are grown under overall herbicide management (Atkinson and White, 1977) the use of grass in orchards seems likely to remain a common practice. Grassing-down was introduced in the 1940's to improve fruit quality (Rogers *et al*., 1948), to provide a better surface for machinery movement than that produced by cultivation; important during wet picking periods and for winter sprays, and to improve soil conditions (Furneaux, 1950). Grass competes with the fruit trees for water and mineral nutrients (Atkinson and White, 1976; Atkinson and Petts, 1978). This competition can be reduced by mowing (Atkinson and Petts, 1978) but to control a sward's vigour it may have to be mown at weekly intervals for at least part of the year. In commercial practice orchards seem to be mown 10-15 times per year; some orchards may need 20 cuts. With increasing petroleum and farm labour costs grass cutting is becoming increasingly expensive and difficult. The proximity of the crop to the ground surface may prevent mowing for part of the year particularly in high-density orchards. In addition the need to mow grass may compete for time with other farm operations such as summer pruning, fruit thinning, etc. There would be obvious advantages if mowing could be replaced by a single or a small number of chemical applications. If, in addition, a chemical treatment reduced water or nutrient uptake below that of a mown sward, this would be an added benefit. Preliminary results with the growth retardant 7-methylindole (Atkinson and Petts, 1978) suggested that this is possible. This paper gives preliminary results with the plant growth regulator mefluidide; N [2,4-dimethyl-5-[[(trifluoromethyl)sulphonyl] amino] phenyl] acetamide (Embark).

METHOD AND MATERIALS

Experiment 1 Plots of S50 Timothy (*Phleum nodosum*), 1.5 x 1.5 m, were sown in spring 1977 and either treated with mefluidide at 0.55 kg a.i./ha in late April or early May of 1978, 1979 and 1980 or left untreated. Half the plots were mown, approximately 20 times per year, and half uncut except once per year in early spring. All treatments were replicated six times.

The soil moisture content at 250, 500 and 750 mm depth was measured in all plots with a neutron moisture meter (Atkinson and Petts, 1978). Mineral nutrient content was assessed on a sample of mature but not senescent tillers collected in mid-August.

The percentage of the ground surface covered by grass was assessed in May 1980 with 50 points quadrat samples on all plots. The weight of vegetation was assessed in November 1979 by harvesting grass from an area 0.25 m^2. Samples were taken only from uncut plots. A similar procedure was used to record the weight of flowering heads in July 1980.

Experiment 2 Whole tree rows, 55 m long, with an inter-row sward sown in 1966 and dominated by perennial rye grass (*Lolium perenne*) were either, 1) sprayed with mefluidide in early May 1980 at 0.55 kg a.i./ha, 2) sprayed on this date and again in mid-July 1980, 3) sprayed with a maleic hydrazide (5.6 kg/ha)/2,4-D mixture (Retard) in early May 1980, 4) left unsprayed and uncut. All treatments were unreplicated.

Five 0.25 m^2 samples of grass were harvested in late July 1980, dryed and weighed.

RESULTS

Effects on growth

Mefluidide had a small effect on the percentage of the soil surface covered with grass in both cut and uncut plots, reduced the weight of grass present on the uncut plots and the weight of seed heads (Table 1) in Experiment 1. In Experiment 2 the weight of grass was again reduced but to a smaller extent. The mefluidide treatments had a similar effect to maleic hydrazide on the perennial rye grass (Table 2).

Table 1

The effect of mefluidide on ground cover, weight of vegetation and weight of seed heads of *Phleum nodosum*

Treatment: Chemical	Treatment: Cuttings	% of ground grass covered	Weight of grass (g(DW)/m2)	Weight of seed heads (g/m2)
Mefluidide	cut	79	-	-
	uncut	82	329	11.3
Unsprayed	cut	73	-	-
Control	uncut	74	594	24.5
Standard Error		4	80	5.6

Differences between mefluidide and control significant at P = 0.01 or greater.

Table 2

The effect of mefluidide and maleic hydrazide on the weight of *Lolium perenne*

Treatment		Weight of grass (g(DW)/m^2)
Mefluidide	May	285
Mefluidide	May + July	227
Maleic hydrazide		238
Unsprayed control		405

Effect on water use

In 1978 water use was relatively similar in both cut and uncut grass plots. Mefluidide appeared to reduce the water use of both cut and uncut plots slightly but more on uncut plots (Table 3). In all treatments water depletion decreased with depth. The effects of the treatments were generally greatest at 500 mm. The small difference between cut and uncut plots suggests that 1978 was an abnormal season. Atkinson and Petts (1978) showed large differences between cut and uncut grass plots in their water use.

Table 3

The effect of mefluidide on the soil moisture deficit (mm) under *Phleum nodosum* on two dates in 1978

Treatment		Date: 17th July			15 September		
		Depth (mm)					
Chemical	Cutting	250	500	750	250	500	750
Mefluidide	cut	23	8	4	24	11	7
	uncut	21	6	3	24	9	6
Control	cut	27	9	2	27	13	6
	uncut	27	12	4	25	16	9

Effect on nutrient concentrations

The effect of mefluidide on nutrient concentrations was generally smaller than that of cutting (Table 4) in the control treatment. Mefluidide seemed to increase N,P,K, particularly in the uncut treatment.

Table 4

The effect of mefluidide on nutrient concentrations, N,P,K % DW, Mn ppm DW; in Phleum nodosum in 1978

Treatment		Nutrient			
Chemical	Cutting	N	P	K	Mn
Mefluidide	cut	2.6	0.40	2.6	97
	uncut	2.7	0.40	2.6	106
Control	cut	2.4	0.40	2.5	133
	uncut	2.0	0.33	2.2	100
Standard Error		0.4	0.04	0.2	27

DISCUSSION

The main adverse effect of grass on apple trees seems to result from competition for water (Atkinson and White, 1976; Atkinson and Petts, 1978). A reduction in the water use of an orchard sward must involve a reduction in either sward ground cover, grass root density or a restriction of roots to a limited soil horizon or some other physiological effect, e.g. a direct effect on stomata. Mefluidide did not reduce ground cover but the pattern of water use suggested small effects on root density and distribution. The effect was greatest on the uncut sward, particularly on water use at depth. The effects were smaller than those found by Atkinson and Petts (1978) as a result of maleic hydrazide + PP 757 treatments. Part of this difference might have been due to the reduced water demand in 1978 compared to 1976.

Both mefluidide treatments increased the concentrations of N,P and K. This is similar to the effect of maleic hydrazide + PP 757 which Atkinson and Petts (1978) found to increase the concentrations of N,P,K,Ca,Mg and Mn. Despite the relatively small effects of mefluidide on water use and nutrition it substantially reduced growth and the production of seed heads, which tend to make the sward appear taller.

Results suggest that by using a chemical like mefluidide it should be possible to control the growth of an orchard sward. With the cost of mowing an orchard now at approximately £1.50-£2.50 per ha per occasion and 10-15 mowings needed per year, i.e. a total cost of £15-37/ha, chemical control may well be economic as well as reducing competition for labour at peak times.

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NOTES

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THE INFLUENCE OF DISUGRAN* ON THE YIELD AND QUALITY OF SUGARBEETS**

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Summary Disugran was applied as a foliar spray at 0.25-1.00 l/ha (a.i.) at different dates before sugarbeet harvest. Data were collected on the number of leaves per plant, yield of beet roots and tops, percentages of sucrose, phosphorus, calcium, crude protein and amount of gross energy of roots. The results showed an increase in sugar yield when the chemical was applied at 0.75 l/ha 8 weeks before beet harvest. This was manifested by an apparent reduction in the number of leaves per plant. No detectable effect was observed on the other components studied.

Resumé La betterave sucrière, à plusieures reprises avant so récolte, a été soumise à des applications foliaires de disugran à doses variant de 0.25 à 1.00 l/ha (i.a.). Des données ont été rassemblés sure le nombre de feuilles par plante, les rendements des racines et du feuillage, les pourcentages de sucrose, de phosphore, de calcium, de proteines brutes, et la quantité d'énérgie brute des racines.
Les résultats montrèrent une augmentation dans le rendement du sucre, lorsque le traitement était appliqué à la dose de 0.75 l/ha, huit semaines avant la récolte de la betterave sucrière. Cette augmentation a été manifesté par une réduction apparante du nombre des feuilles par plante. Les autres données n'ont montré aucun autre effét discernable des traitements.

INTRODUCTION

About half of the world production of sugar is extracted from sugarbeet (Campbell, 1976). In addition, by-products from beets such as tops, pulp and molasses are used as livestock feed. In the past few years, remarkable increases have been made in the yield of roots and sugar content of beets. This increase has been associated with the introduction of improved varieties, better cultural practices and proper use of pesticides.

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* Methyl, 3,6-dichloro-2-methexybenzoate.

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Considerable interest has developed in the use of growth regulators in sugarbeet production. These chemicals are known to evoke morphological changes, alter metabolic pathways and affect crop yield and quality. However, few reports have elaborated on the use of growth regulators in beets which have improved the root yield, sugar content and other quality characteristics of the crop.

Previous work has demonstrated that gibberellins (Nelson and Wood, 1958; Peterson, 1958; Pocock, 1975; Poostchi and Schmehl, 1971; Stout, 1959), benzyladenine and indole acetic acid (Wu et al., 1970), kinetin and abscisic acid (Palmer, 1966), maleic hydrazide (Shreiber and Ferguson, 1966; Thomson, 1970; Wort and Singh, 1970), pyrocatechol (Helper, 1973), pyrocatechin and hydroquinone (Khlemskii et al., 1977) have shown various effects on the root yield and sucrose content of sugarbeets. Saghir et al. (1971) used ethephon as a foliar spray on beets and food no detectable effect on the yield, amount of gross energy, percent sucrose, crude protein, calcium or phosphorus of the roots; Whereas Khun et al. (1977) reported that ethephon increased the root weight, and decreased the sugar content and leaf weight of beets.

The work reported on the growth regulator disugran is very limited. Furness (1970) reported that foliar application of disugran increased the sucrose recoverable from beets during factory extraction and purification processes. Sullivan (1977) showed that this compound applied on the folliage of sugarbeets, was ineffective. Similar work on sugarcane conducted by Nickell (1977) demonstrated that disugran gave inconsistent results. The aim of this investigation was to determine the influence of disugran on the root yield and quality components of sugarbeets, using different rates of the chemical sprayed at various dates of application.

METHOD AND MATERIALS

The experiments were conducted at the Agricultural Research and Education Center (A.R.E.C.) of the American University of Beirut during 1975, 1978 and 1979. The climate of the AREC is hot and dry in summer, and cold in winter. The soil is clayey with a cation exchange capacity of 38.7 m.e./100 g of soil, an organic matter content of 2.2%, and a pH of 7.8.

The experimental area was fertilized with 100 kg N and 150 kg P_2O_5/ha before sowing, followed by shallow disking. Furthermore, 100 kg/ha N were applied twice as side dressing 2½ and 4½ months after sowing, respectively. Seeds of the variety "Polybeta" were planted in 1975, and "KWS sacchapoly" in 1978 and 1979 at the rate of 38 kg/ha. Thinning of beets, to a stand of 20 cm between plants, was done 7 weeks after sowing. Sprinkler irrigation was employed for the first 13 weeks after sowing, and was followed with furrow irrigation for the remainder of the growing season. The plots were irrigated once per week according to their water requirements, and were sprayed with the necessary pesticides when needed during the growing season.

The experiments were arranged in a split-plot design with 4 replications. The main plots represented the rates of disugran used, and the sub-plots constituted the dates of the chemical applied. Each treatment contained 4 rows, each was 4 m long and 50 cm apart. In 1975, disugran was applied at 0.25, 0.50 and 1.0 l/ha (a.i.) as a foliar spray on sugarbeets 3, 5, and 7 weeks prior to crop harvest. In 1978, the chemical was sprayed at 0.25, 0.50, 0.75 and 1.0 l/ha (a.i.) on the beet foliage 2, 4, and 8 weeks before harvest; whereas in 1979 the rates used were 0.50, 0.75, and 1.0 l/ha (a.i.) sprayed 4, 8, and 12 weeks prior to harvest. One of the main plots in each replication was sprayed with water as control.

The data collected in 1975 included the number of leaves per plant, yield of beet roots and tops, and sucrose percentage of roots. In addition to these components, data collected in 1978 and 1979 included also the percentages of phosphorus, calcium, crude protein and amount of gross energy of beet roots.

The two middle rows, trimmed to 3 m in the center, were used for all determinations. Beets were lifted, topped, cleaned and weighed separately as roots and foliage tops. For counting the number of leaves and determining quality characteristics 5 representative beets were used. About 200 gms were oven-dried at 70°C for 48 hours, ground and stored at 4°C for the analyses of phosphorus, calcium, crude protein, and the amount of gross energy.

Sucrose was determined according to the standard method described by De Whalley (ICUMSA, 1964). Phosphorus was analyzed, colorimetrically by the ammonium vanado-molybdate method (Jackson, 1958), and calcium was determined by atomic absorption spectrophotometry (Isaac and Kerber, 1971). For crude protein, the nitrogen content of the dried material was determined by the conventional Kjeldhal method (A.O.A.C., 1970), and the percentage of crude protein was calculated by multiplying % N by the factor 6.25. Gross energy was determined by standard procedures using the ballistic bomb calorimeter (A.O.A.C., 1970). Analysis of variance was made according to the procedure described by Snedecor (1976) using the Duncan's multiple range test.

RESULTS

1975

Data on the effects of 3 different rates of disugran applied 3, 5 and 7 weeks before harvest on the number of leaves per plant, yield of roots and tops and sucrose percentage are compiled in Tables 1 and 2. The results indicate that disugran application reduced significantly the number of leaves per plant when sprayed 3 and 5 weeks prior to best harvest. Similar results were obtained for the yield of tops. In the case of yield of roots, a significant increase was observed when disugran was applied at 0.5 and 1.0 l/ha (a.i.) 3 and 5 weeks prior to beet harvest, and at 1.0 l/ha 7 weeks before harvest.

The growth regulator gave a significant increase in sucrose percentage when sprayed at 0.5 and 1.0 l/ha (a.i.) at all dates of application. When disugran was applied 7 weeks before harvest, a significant increase in % sucrose was noted even at 0.25 l/ha. When the beets were analyzed at weekly intervals from the time of chemical application until harvest, the increase in % sucrose became evident approximately 3 weeks after application, with no adverse effect on yield of beet roots.

1978

Data on the effect of disugran on the mean number of leaves per plant, yield of tops and roots and quality componenets of beets are summarized in Table 3. With the exception of the gross sugar yield, the results show that none of the rates of disugran used at the various dates of application caused any significant effect on the mean values of the characteristics studied. The application of the chemical 8 weeks before beet harvest, gave a significant increase in the gross yield of sugar as compared to the other two dates, namely 4 and 2 weeks prior to harvesting. This increase was apparent particularly at the rate of 0.75 l/ha (a.i.) when interactions between dates and rates of application were evaluated (unpublished data).

1979

The results on the effect of disugran on the characteristics studied in 1979 are compiled in Table 4. It was found that beets treated with disugran at 0.75 l/ha (a.i.) increased significantly the sucrose percentage in the roots. This treatment caused also an apparent reduction in the number of leaves per plant. Interaction values between rates and dates of application of disugran indicated that maximum levels of sucrose were detected when the chemical was applied at 0.75 l/ha 4 weeks prior to beet harvest, or at 0.50 l/ha 8 weeks before harvesting (unpublished data). However, the total sugar yield remained unaffected. Other quality components studied were not affected by the growth regulator.

DISCUSSION

The differences observed in data collected during the three years period were mainly due to the different varieties used, as well as the different environmental and growing conditions which prevailed. However, the lower values recorded in 1979 versus 1978, when the same beet variety was used, may be due to moisture stress resulting from the shortage of irrigation water during July, 1979.

The highest sugar yield recorded as a result of disugran application at 0.75 l/ha (a.i.) occurred when the chemical was applied 8 weeks before harvest. This increase was mainly due to an increase in the root yield, and to some extent in the sucrose percentage of the roots. The higher sucrose levels observed were manifested by an apparent reduction in the number of leaves per plant. This reduction in beet foliage may have created a poor physiological sink at the top of the plant, and allowed the root to accelerate its sucrose loading mechanism and maintain its sucrose at a high level in the case of the treated beets.

On the basis of these studies, it may be concluded that disugran is a promising growth regulator for the increase of sucrose percentage in beets. However, more work should be done to investigate the influence of different agricultural inputs on root yield, and to study their interaction with disugran for increasing the gross sugar yield of beets.

Table 1

Effect of disugran on number of leaves per plant and yield of beet tops in 1975*

Rates (1/ha,a.i.)	No. of leaves/plant			Yield of tops (t/ha)		
	7	5	3	7	5	3
	Weeks before harvest					
0.25	24.2c	26.7c	27.7c	21.8b	22.4b	23.9b
0.50	24.7c	21.7d	27.0c	25.3ab	16.2c	24.0b
1.00	26.2c	23.2d	20.5d	19.3c	22.1b	23.9b
Control	30.5bc	35.0a	33.0ab	21.6b	29.2a	29.6a

Table 2

Effect of disugran on yield and sucrose percentage of beet roots in 1975*

Rates (1/ha,a.i.)	Root yield (t/ha)			% Sucrose		
	7	5	3	7	5	3
	Weeks before harvest					
0.25	100.5bc	94.2c-e	90.3de	16.6a	16.0bc	16.1bc
0.50	87.3e	107.5a	107.5a	17.0a	16.8a	16.8a
1.00	109.4a	100.6bc	97.4bc	17.0a	16.5a	16.6a
Control	89.3dc	84.1e	92.5de	15.7c	16.3b	15.2c

* Means within columns followed by similar letters are not significantly different at P = 0.05 according to Duncan's multiple range test.

Table 3

Effect of disugran on the mean number of leaves/plant, yield of tops and roots and quality components of beets in 1978*

Rates (1/ha a.i.)	No. of leaves/ plant	Tops/ plant (g)	Roots (t/ha)	Sucrose (%)	Total sugar (t/ha)	Protein (%)	Ca (%)	P (%)	Gross energy (C)
0.25	41.6a	212.0a	90.4a	16.4a	14.7a	5.0a	0.22a	0.09a	4.10a
0.50	40.8a	196.9a	87.9a	16.9a	14.9a	4.4a	0.21a	0.09a	4.11a
0.75	39.7a	230.7a	90.3a	17.0a	15.4a	4.7a	0.23a	0.08a	4.09a
1.00	38.4a	206.9a	84.2a	16.8a	14.1a	4.6a	0.20a	0.07a	4.10a
Control	41.5a	195.2a	87.4a	16.6a	14.6a	5.0a	0.23a	0.08a	4.09a

Table 4

Effect of disugran on the mean number of leaves/plant, yield of tops and roots and quality components of beets in 1979*

Rates (1/ha, a.i.)	No. of leaves/ plant	Tops/ plant (g)	Roots (t/ha)	Sucrose (%)	Total sugar (t/ha)	Protein (%)	Ca (%)	P (%)	Gross energy (C)
0.50	37.6ab	182.1a	74.1a	17.3a-d	12.8a	3.3a	0.14a	0.05a	4.19a
0.75	35.9b	173.1a	68.9a	17.5a	12.0a	3.4a	0.14a	0.05a	4.23a
1.00	36.6ab	175.2a	73.2a	16.6e	12.1a	3.6a	0.14a	0.04a	4.21a
Control	38.2ab	167.2a	70.1a	16.8b-e	11.8a	3.2a	0.14a	0.05a	4.26a

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* Means within columns followed by similar letters are not significantly different at P = 0.05 according to Duncan's multiple range test.

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A SURVEY OF AQUATIC WEED GROWTH AND CONTROL IN THE CANALS AND RIVER NAVIGATIONS OF THE BRITISH WATERWAYS BOARD

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Summary Stretches of the British Waterways Board canal and river navigation system considered by B.W.B. staff, and by angling societies, to suffer heavy aquatic weed growth during 1976 were located by questionnaire surveys. Some 500 km (less than one-fifth of the system) suffered heavy weed growth. This comprised 7.4% of the total length of Commercial Waterways, 10.7% of Cruising Waterways and 34.2% of Remainder Waterways. The latter had the least maintenance and boat traffic of the three categories of waterway. Submerged macrophytes and filamentous algae were the main problem weeds. Mechanical control was used more than herbicides. Dalapon, diquat and cyanatryn were together used in 1976 to treat only 2.6% of the heavily weeded length. Data for the period 1975-79 show that 1976 was a fairly typical year in its low herbicide usage.

Sommaire Par l'utilisation de questionnaires quelques parties du system de canaux et de rivières navigable de British Waterways Board furent isolés. Le personnel de B.W.B. et les sociétés de pêche considèraient ces endroits furent sujet aux grandes infestations de mauvaises herbes aquatiques pendent 1976. Quelques 500 km (moins de 20% du system) souffrent d'une grande infestation. Cela consistèrent 7.4% du distance total des Commercial Waterways, 10.7% des Cruising Waterways, et 34.2% des Remainder Waterways, qui exhibitaient le minimum d'entretien et de passage de bateaux des trois catégories. Les macrophytes submergés et les algues filamenteuses furent les principales mauvaises herbes. La controle méchanique fut utilisée largement, au lieu d'herbicides. En 1976, dalapon, diquat et cyanatryn furent utilises pour la traitment de seulement 2.6% de la partie bien infesté. Une examination de l'information pour la periode 1975-79 indique que l'année 1976 fût in-peu-près typique en respect de l'utilisation d'herbicide.

INTRODUCTION

In recent years increasing attention has been paid to the problem of aquatic weed growth and its control. In Britain, Robson (1967, 1975) surveyed the usage of different control methods, and Newbold (1975) estimated that the cost of control was £8.6 m in 1972. No detailed survey of aquatic weed growth in British waters has however been published, and studies on canals are especially sparse, despite their long history of weed problems (e.g. Walker, 1912; Lindsay, 1968). This paper reports a study of the extent, nature and control of weed problems in the British canal system.

Of a total of some 2900 km of canal, 2558 km are under the control of the British Waterways Board (B.W.B.), together with 548 km of river navigation (Department of the

Environment, 1975). The total surface area of freshwater of the Board's system exceeds 3000 ha. Most of the system was constructed during the 18th and 19th centuries for freight transport. Today it is classified into Commercial, Cruising and Remainder Waterways. Commercial Waterways which are mainly river navigations and ship canals, are wider and deeper than other canal classes, and carry a relatively heavy traffic of high-tonnage commercial craft. Cruising and Remainder Waterways are canals of smaller cross-section. Cruising Waterways are used almost entirely by pleasure craft which have individually low tonnage (British Waterways Board, 1975; Hyde, 1977), but are numerous and frequently provide intense seasonal traffic movement. Remainder Waterways receive the minimum maintenance needed for public health, amenity and engineering safety, and may be unnavigable or little used by boats. An increasing length of Remainder Waterway has however been, or is being, restored to navigation with financial assistance from other bodies. Parts of the canal system also have land drainage, water conveyance and supply, angling, nature conservation and general amenity functions.

The term 'aquatic weed growth' is used here to mean growths sufficient to impair canal function. Although small growths of aquatic plants are important for fisheries, conservation and amenity, large growths may obstruct navigation and water flow, and reduce angling success.

METHOD

Early in 1977 a questionnaire survey form was sent to the 49 Sections of B.W.B. responsible for maintenance of individual canals within the system. Details were requested of the location and length of canal stretches considered by Section personnel to have suffered nuisance from aquatic weed growth during 1976, of the type of weed causing problems, and of any control measures in use in each stretch in 1976. A parallel questionnaire was sent to secretaries of 173 angling societies listed in British Waterways Board (1977) as holding fishing agreements on B.W.B. canals, asking for details of aquatic weed growth status ('none', 'light' or 'heavy' growth) of each of the stretches fished by the society in that year.

RESULTS

A 100% return of survey forms was achieved in the internal B.W.B. survey. Replies from angling societies totalled 51, a return rate of 29.5%. Collated results of the two surveys are given in Table 1. Lengths designated by angling societies as suffering heavy weed growth mainly coincided with those so-designated by B.W.B. Only 38.7 km were considered heavily weeded by the anglers but not by B.W.B.

Table 2 summarises the length of each class of waterway suffering weed problems in 1976. Table 3 shows the relative importance of different groups of aquatic weed in causing problems. The usage of different weed control measures is given in Table 4. and B.W.B. records of herbicide applications during the period 1975-79 are shown in Figure 1.

DISCUSSION

User-definitions of 'nuisance' weed growth are subjective and may vary between different groups of waterway users (Westlake, 1968; Robson, 1976). In the surveys reported here, however, there was close agreement between the B.W.B. and angling society designations of canal stretches as heavily weeded. Over 75% of the total length considered to be heavily weeded by the anglers coincided at least in part with lengths similarly designated by B.W.B. Section staff.

Table 1

Results of surveys of aquatic weed growth and control in waterways of the British Waterways Board during 1976

Waterway	Length (km)	Length with heavy weed growth (km)	Weed groups causing problems	Weed control measures '76
1. Commercial				
Aire & Calder Navigation	85.5	0	none	none
Calder & Hebble Navigation*	15.0	0	none	none
Caledonian	96.5	0	none	none
Crinan	14.5	0	none	none
Gloucester & Sharpness*	27.0	0	none	none
R.Lee Navigation	49.5	1.2	FA	none
R. Severn Navigation	69.0	0	none	none
Sheffield & S. Yorks Navigation	71.5	(16.5	E	none
(incl. New Junction) *		(20.8	U	none
Trent Navigation *	88.0	0	none	none
Weaver Navigation *	32.0	2.0	FF	none
2. Cruising				
Ashby	34.0	3.6	S/FA	none
Birmingham*	37.0	0.7	E	H1
Birmingham & Fazeley	34.0	4.8	U	none
Calder & Hebble Navigation*	20.0	3.2	U	none
Chesterfield*	41.0	3.7	S/FA	none
Coventry	61.0	0	none	none
Erewash*	1.5	1.5	E/FF/S/FA	none
Fossdyke	18.0	0	none	none
Grand Union Main Line (incl. Aylesbury		(1.0	S	none
Arm, Hertford Union, Paddington Arm,	269.0	(13.6	U	none
Regents)*		(4.8	U	M3
Leicester Section*	65.5	1.3	S/FA	D1
Market Harborough Arm	9.0	9.0	U	none
Northampton Arm	8.0	7.2	U	M3
Huddersfield Broad	6.0	1.9	U	M4
Kennet & Avon*	39.5	9.4	S	M3
Lancaster*	68.5	0	none	none
Leeds & Liverpool Main Line*	192.0	(40.0	S/FA	M4
		(10.0	E/FA	M4
		(0.5	S	M4
		(0.7	FR	M4
		(22.2	U	none
Rufford Branch	11.5	11.5	S/FA	M4
Leigh Branch	11.5	3.0	S/FA	M4
Macclesfield	44.0	0	none	none
Oxford N*	38.5	0	none	none
Oxford S	80.5	0	none	none
Peak Forest*	10.5	1.3	E	none
Ripon*	2.0	1.7	U	H2
Shropshire Union*	199.0	(4.0	U	none
		(0.6	FA	M3
Soar Navigation	41.5	2.0	FR	none
Staffordshire & Worcestershire*	75.5	2.9	FA	none
R. Stort Navigation	22.0	(3.0	FR/S	M2/M3
		(0.3	S/FA	M2/M3
Stourbridge*	8.5	5.0	E	none
Stratford	20.0	0	none	none
Trent Navigation*	21.5	0	none	none
Trent & Mersey Main Line	148.5	12.0	FF	none
R. Ure Navigation	13.0	0	none	none

continued

Table 1 cont.

Waterway	Length (km)	Length with heavy weed growth(km)	Weed groups causing problems	Weed control measures '76
Witham Navigation	53.0	0	none	none
Worcester & Birmingham	48.0	0	none	none
3 Remainder				
Ashton	13.0	2.9	U	H2
		0.5	U	M3
		0.9	U	none
Birmingham *	123.0	3.5	E	none
		3.0	FF	none
		0.1	E	H1
		3.0	U	none
Bridgewater & Taunton	23.0	4.7	FA	M1/M2
		11.5	S/FA	none
Calder & Hebble Navigation*	1.5	0	none	none
Caldon (incl. Leek Br.)	33.0	1.2	E	M1/M2
Chesterfield*	25.0	25.0	S/FA	none
Cromford	4.5	4.5	E	M1/D1
Erewash*	17.0	17.0	E/FF/S/FA	none
Forth & Clyde	58.0	5.1	E	none
		1.0	E/FF/S	none
Gloucester & Sharpness*	0.5	0	none	none
Grand Union Main Line * (inc.Leicester Section*, Paddington Arm*, Regents*, Wendover Arm*)	18.0	1.7	U	none
Slough Arm	8.0	6.4	U	none
Grantham	52.5	11.3	E/FF	none
		11.2	E	D1
		4.0	E	none
Huddersfield Narrow	27.0	7.1	E/U	none
Kennet & Avon*	99.5	41.4	U	none
		1.4	S/FA	H3
		1.9	E	M3
		4.3	E/FR	M3
		1.0	S	M3
Lancaster *	14.0	5.6	U	none
Leeds & Liverpool*	16.5	16.5	S/FA	M4
Manchester, Bolton & Bury	14.0	8.8	FF/S	none
Monkland	5.0	2.2	E/FF	none
Monmouth & Brecon	56.0	19.2	U	M2/M3
Nottingham	8.0	0	none	none
Oxford N*	7.0	0	none	none
Peak Forest*	14.0	10.4	E	none
Pocklington	15.0	8.2	FF	none
		1.0	E/FR	none
		2.1	S/FA	none
Ripon*	1.5	1.5	U	none
Sheffield & S. Yorkshire Navigation *	6.5	-	U	none
Shropshire Union *	67.0	3.5	U	none
		1.6	U	M1
		7.3	U	M3
St Helens	23.5	0	none	none
Staffordshire & Worcestershire*	2.5	0	none	none
Stourbridge*	3.5	0	none	none
Swansea	6.0	6.0	S	M1/H2

continued

Table 1 continued

Waterways	Length (KM)	Length with heavy weed growth(km)	Weed groups causing problems	Weed control measures '76
Union	48.5	(1.2	FF/S	M3
		(1.7	FR/S	M3
Weaver Navigation*	1.0	0	none	none

Key: Weed control: M1 = manual cutting; M2 = manual raking; M3 = mechanical cutting: M4 = mechanical weed removal; D1 = dredging; H1 = dalapon; H2 = diquat; H3 = cyanatryn. Weed group; E = emergent; FR = floating-leaved rooted; FF = free-floating; S = submerged; FA = filamentous algae; U = unspecified; * part only, other lengths being classified under other categories of waterway.

Table 2

Total lengths of different categories of British Waterways Board waterways suffering aquatic weed problems in 1976.

Category	Total length (km)	Length with weed problem (km)	Length with weed problem as % total length of (i) all canals (ii) each canal class (i) (%)	(ii) (%)
All waterways	3106.5	505.7	16.3	-
Commercial	548.5	40.4	1.3	7.4
Cruising	1743.0	186.4	6.0	10.7
Remainder	815.0	278.9	9.0	34.2

Table 3

Total lengths of British Waterways Board waterways suffering aquatic weed problems caused by different aquatic weed groups in 1976.

Weed group	Length with weed problem (km)	Length with weed problem as % total length with weed problem* (%)
Emergent	120.7	23.9
Floating-leaved rooted	12.7	2.5
Free-floating	68.2	13.5
Submerged	172.0	34.0
Filamentous algae	157.8	31.2
Unspecified	202.3	40.0

* Total exceeds 100% since more than one weed group caused problems in some canal stretches.

Table 4

Total lengths of British Waterways Board waterways suffering aquatic weed problems and treated with different aquatic weed control measures in 1976.

Weed control measure		Length treated (km)	Length treated as % total length with weed problem* (%)
Manual cutting	M1	18.0	3.6
Manual raking	M2	28.4	5.6
Mechanical cutting	M3	62.4	12.3
Mechanical removal	M4	84.1	16.6
Herbicide: Dalapon	H1	0.8	0.2
Diquat	H2	10.6	2.1
Cyanatryn	H3	1.4	0.3
Dredging **	D1	17.0	3.4
Untreated		321.9	63.6

* Total exceeds 100% since some canal stretches were treated with more than one weed control measure; ** dredging used primarily for weed control.

Results indicated that during 1976 somewhat less than one-fifth of the total length of B.W.B. waterways suffered aquatic weed problems. Most of this was on Remainder Waterways. Cruising Waterways suffered less from weed problems, and Commercial Waterways least. These results are in broad correlation with the intensity of boat traffic and maintenance of the three classes of waterway, and support the suggestion of Haslam (1978) that dense aquatic vegetation in canals is largely confined to disused or little-used stretches.

The division of aquatic plants into weed groups used here follows that of Robson (1976) except that we divide floating-leaved plants into species rooted in the mud (e.g. lilies), and free-floating forms such as duckweeds. Analysis of the data into the different weed groups causing problems indicated that submerged plants and filamentous algae were the principal causes of nuisance. Emergent species and free-floating plants caused problems in a lesser length of canal, whilst floating-leaved rooted species were rarely implicated. More than one group of plants was involved in lengths totalling 190.0 km (37.5% of total heavily-weeded length).

Aquatic herbicides were used on only 2.6% of the total heavily-weeded length, and almost half of the treated length was on one canal (Swansea Canal). From Figure 1 it appears that 1976 was a fairly typical year for herbicide usage, although dichlobenil was not used then in contrast to 1975 and 1977, and cyanatryn trials were conducted in place of the experimental terbutryne trials carried out in other years. Dalapon usage was variable, but applications in 1976 were neither exceptionally high nor low.

There was a high degree of reliance on manual and mechanical weed control measures. Almost 40% of the total length of heavily-weeded canal underwent at least one physical weed clearance operation during 1976. In Northern England 'Waterwitch' weed-clearance boats were extensively used to uproot and remove weed, whilst in Scotland and the South reciprocating-cutter boats were used. Dredging was little-used solely for weed control in canals, unlike in drainage channels where mechanical excavators are routinely used for weed removal (George, 1976; Wade, 1978).

Over 60% of the total length of heavily-weeded canal was untreated by any control measure in 1976. Of this, approximately 60% was on Remainder Waterways, further reflecting the lower maintenance standard of this class of canal.

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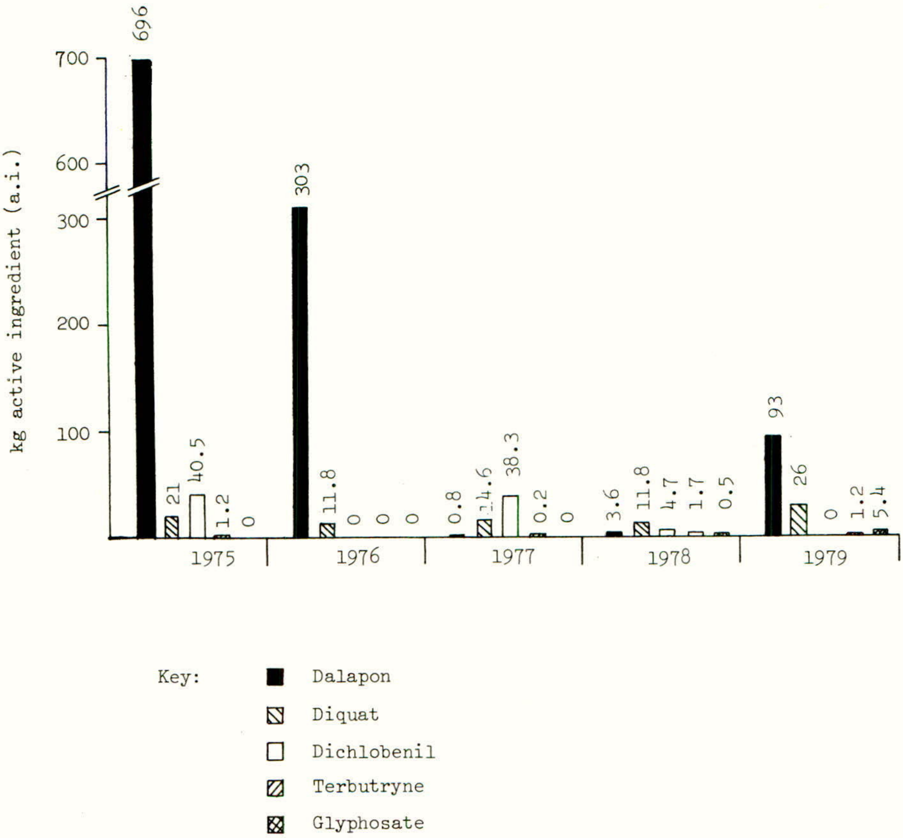
Fig. 1. Total quantities (as active ingredient) of aquatic herbicides applied to the waterways of the British Waterways Board, 1975-79.



Note: In addition 1 kg a.i. Cyanatryn was used in 1976 and 11.5 kg a.i. 2,4-D in 1979.

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ENDOTHAL-POTASSIUM AND ENVIRONMENT

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Summary - The biological activity of endothal-potassium in controlling aquatic weeds is well known as result of 30 years of field testing and commercial use. This paper covers the results of toxicity, persistence, and metabolism studies performed during 20 years, and concludes that the use of endothal-potassium as an aquatic herbicide does not represent any adverse or harmful effect to humans, animals, fish, wildlife, or the environment.

Résumé - L'activité biologique de l'endothal-potassium dans le contrôle des mauvaises herbes aquatiques est bien connue comme résultat de trente ans de'épreuves aux champs et d'usage commercial. Ce document couvre les résultate des études de toxicité, de persistence, et de metabolisme effectuées pendant vingt ans, et conclut que l'usage de l'endothal-potassium comme herbicide aquatique ne représente anucun effet adverse ou malfaisant aux humains, animaux, poissons, à la nature sauvage, ou à l'environment.

INTRODUCTION

Activity of endothal on aquatic weeds and algae was first suggested in 1951 (Tischler, 1951). Since then it has been extensively tested under a variety of conditions in ponds, lakes, and canals, primarily in the U.S.A. As a result of approximately 100 field trials it is established that endothal can be effectively and economically used either in the form of various inorganic salts to control certain vascular aquatic plants or in the form of dimethylalkylamine to control algae in addition to vascular weeds.

This presentation will address only the most widely used formulation, i.e., endothal-potassium. It has been registered in the U.S.A. since 1960 to control species from genera _Potamogeton_, _Sparganium_, _Ceratophyllum_, _Myriophyllum_, _Najas_, _Zannichellia_, _Heteranthera_, and _Hydrilla_.

Paper will not deal with the biological activity of endothal-potassium since it is already well known and recognized. It will instead summarize the most significant information generated during the last 20 years pertaining to its hazard (or safety) to humans, animals, fish, and wildlife, as well as its persistence and impact on the environment in general. The majority of data contained herewith is relatively new and should be considered important to people having direct or indirect interest in endothal.

USE PATTERNS

In order to compare concentrations and rates used in toxicological and other studies, it should be mentioned that for effective control of a majority of aquatic weeds, concentrations are 0.5 to 2.5 ppm acid equivalent, depending on the susceptibility of plant species and whether large or marginal areas are treated. Actually, significantly lower rates (and, accordingly, more economical ones) are being used practically by modified applications such as: (1) bottom application with weighted trailing hoses, (2) in invert emulsion carriers, (3) with polycarboxylate polymer carriers, (4) in mixture with copper compounds, (5) as pelletized formulations.

Less amount of product can be effectively used by employing these methods since placement is on the bottom where weeds are and/or carriers "plate" the active ingredient on target weeds.

RESULTS

Toxicology - Mammalian Species

Table 1 summarizes results of various studies performed with endothal-potassium (Pennwalt). Endothal technical is not marketed, but is included for comparison with the formulated product. The acute toxicity of endothal is relatively high, but this is not due to its toxic nature but rather due to its corrosive properties. Endothal given orally in concentrated form damages the lining of the gastrointestinal tract allowing greater chemical penetration. Endothal is not absorbed into the body. Effects on the skin are also proportional to the degree of desquamation and necrosis. As an analogy, concentrated acetic acid is very corrosive and yet in diluted form is used daily in vinegar as food. Of course, endothal is not a food.

A number of chronic studies show that endothal does not cause any adverse effect when fed to animals over a long period of time at relatively high concentrations. When comparing maximum use rate of 2.5 ppm for control of aquatic weeds (which drop sharply within a day or two) applied only once or twice yearly with those levels used in long-term toxicity studies, a great safety factor is evident. Accordingly, endothal, when used in accordance with label recommendations, does not represent any hazard to humans or domestic animals.

Table 1

Mammalian Toxicity

Acute	Oral	Dermal
	LD_{50} mg/kg	
Endothal Technical	51	< 200
Endothal-Potassium	125-280	> 200-10,000

Chronic and Others	No Harmful Effect
2 Year Dog - Toxicity	100, 300, 800 ppm
2 Year Mice - Carcinogenicity	300, 600, 1,200 ppm
2 Year Rats - Toxicity	100-2,500 ppm
7 Week Rats - Carcinogenicity	100 mg/wk in water
2 Year Rats - Carcinogenicity	600, 1,200, 2,400 ppm
Teratology	0.01, 0.15, 2.0 mg/kg
3 Generation Reproduction - Rats	100, 300 ppm
Mutagenicity - Rat Dominant Lethal Assay	150, 300, 600 ppm
- Rat Bone Marrow Cytogenetic	150, 300, 600 ppm
- Salmonella/Microsomal Assay	0.15-5 ug/ml
- Mam. Cell Point Mutation with Activation	0.01-1 ug/ml
- Mam. Cell Point Mutation without Activation	1-10 ug/ml