AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE

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CONTRACT REPORT
C880239
PROJECT FV/4a ALLIUM WHITE
ROT CONTROL: SOIL STERILIZATION

AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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Date 24/4/92 ....

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SUMMARY

The effects of the soil sterilants dazomet (Basamid) and metham sodium and the sclerotial stimulant diallyl disulphide (DADS) and combined treatments of both were evaluated for the control of white rot and yield at five sites. However, the effect of treatments on disease could only be evaluated at three sites where moderate to high disease occurred. Basamid and metham sodium gave significant disease control overall, although, inexplicably, no significant increases in marketable yields were detected following metham sodium treatments. In no trial did the sterilants give complete control of white rot. The effect of DADS on disease control was disappointing with the highest rate treatment giving 50% control. The disease scores following combined treatments of sterilants and DADS were similar to those of the sterilant alone with no significant advantages resulting from the dual treatment. Artificially buried sclerotia of the onion white rot pathogen were used to evaluate the various treatments. However, this technique proved not to be valuable in this trial series as the viability of the sclerotia was inexplicably affected in the untreated plots and overall valid comparisons could not be made. The overall effect of treatments on marketable yields was variable with significant yield increases following Basamid treatments. However, no significant marketable yield increases were recorded following spring-applied metham sodium or low rate DADS treatments.

To conclude, the use of sterilants dazomet or metham sodium alone cannot be relied upon to give complete control of white rot in the field. DADS gave insufficient control in these trials and there was no advantage from applying this treatment with the sterilants.

INTRODUCTION

Onion white rot disease caused by the fungus *Sclerotium cepivorum* remains a major disease affecting members of the genus *Allium* ie garlic, onions, shallots, leeks and chives. It is of increasing importance in all the main areas where these crops are grown. The areas and values of the main *Allium* crops in the UK in 1986/89 are given below.

Areas and values of Allium crops in the UK 1986/89

Year	1985/86		1989/90	
	ha	£m	ha	£m
Salad onions	1831	19.4	2209	20.6
Dry bulb onions	8364	22.6	7766	27.7
Leeks	2557	19.5	2812	22.1

Salad onions are mainly grown in the 'Midlands' (Worcestershire, Hereford and Warwickshire) and in Kent with smaller areas in Lincolnshire, Essex and Herts and the Thames Valley.

Leek growing is fairly well distributed throughout the Eastern and South-Eastern Counties, the Midlands and Lancashire.

Spring sown dry bulb onions are mainly grown in East Anglia and Lincolnshire with some in Kent.

Autumn sown dry bulb onions are grown in similar areas to the spring sown crop but with more grown in Lincolnshire. White rot has not been as much of a problem in this crop as in the spring sown one.

The majority of UK bulb onion crops are direct-drilled and in these crops fungicide treatments have been of limited value. More recently triadimenol and tebuconazole applied as foliar sprays prior to irrigation have given good disease control in trials in Southern Germany. However, these were experimental treatments and, should they be approved, would be dependant on irrigation (20mm immediately after fungicidal treatment). They are likely to have limited usage in the UK. A high degree of control was obtained in Kirton trials on module-raised bulb onions with pre-planting drenches of myclozolin and procymidone. However, these two fungicides are not registered for use in the UK and therefore, at present, there is no effective fungicidal control of white rot in bulb onions.

The white rot pathogen can survive in the soil for many years. Work at Hull University suggests that sclerotia can survive for at least 18 years and probably longer. Sclerotia will remain dormant in the soil until an *Allium* crop is grown. Treatment with partial soil sterilants based on products generating methyl isothiocyanate (eg metham sodium or dazomet) to kill the sclerotia in the soil has given variable results.

The onion white rot fungus is unusual in that the sclerotia of *Sclerotium cepivorum* only germinate in the presence of *Allium* host plants. The roots of plants exude compounds which are metabolised by the soil microflora to produce a mixture of thiols and sulphides which stimulate the sclerotia to germinate. Sclerotia germinate only once and in the absence of an onion crop they die. If an onion crop is present the sclerotia germinate, infect the roots and the base of the bulb and more sclerotia are ultimately produced. Synthetic stimulants offer control opportunities if applied in the absence of *Allium* hosts. Substantial reductions in the numbers of sclerotia and disease incidence have been recorded with the use of artificial onion oil in Australia and Canada. The major constituents of artificial onion oil have been tested and diallyl disulphide (DADS) has proved to be the most active. In 1986 at Moulton, Lincs, onion oil soil-injected at 500 l/ha gave some reduction in the numbers of viable artificially buried sclerotia and 36% disease control but did not significantly increase yield. At Kirton in 1987/88 high volumes of DADS gave a high degree of control (71-92%) in the two years of cropping of module-raised spring bulb onions following treatment of 0.05% in 6.25-25l/m^2.

The aim of this investigation was to evaluate the effect of soil sterilants dazomet (as Basamid) and metham sodium, and the sclerotial stimulant DADS and combination treatments of the sterilants and DADS applied in the autumn and in the spring on peat and silt soils, on white rot disease and yield .

MATERIALS AND METHODS

Sites

All the trials were located on sites in parts of fields where a severe attack of white rot had been noted in the past.

The trials were sited at:-

Mr R Wray
Northorpe Farm
Northorpe
Donington, Lincs

Kirton Experimental Horticulture Station
Kirton
Boston
Lincs PE20 1EJ

Arthur Rickwood Experimental Husbandry Farm
Mepal
Ely
Cambs CB6 2BA

Mr I Anthony
Augers Farm
Methwold Fen
Feltwell
Norfolk

Design

The experiment was arranged as randomised blocks, with 10 treatments in each of four replicate blocks. Each plot measured 4m by 1.83m in a treated area of 6-10m x 2-3m with four rows of module-raised plants of cv Hyton or Caribo. At Methwold three double rows of pickling onions cv Plastro were drilled in a 1.52m wide bed. The plots were separated from each other by 2m wide unplanted guard beds on each side and a 2m wide unplanted strip at each end.

Husbandry

All subsequent husbandry was according to local practice. The trials were sown or planted in March/April and harvested in August/September.

Treatments

The treatments were applied in the spring at Northorpe, on 13 May 1987, Kirton EHS (1) on 8 May 1987 (mineral soils) and Methwold Fen, (organic peat) on 29 March 1989, and in the autumn at Kirton EHS (2) on 7/8 November 1988 and Arthur Rickwood EHF (organic peat) on 27 October 1988. The treatments were identical in all trials and consisted of dazomet as Basamid (BASF) at 380 and 570kg product/ha, metham sodium at 600 and 1200l product/ha, DADS (Phillips Petroleum and Oxford Organic Chemicals) at 50l/ha and 200l/ha, Basamid at 380kg product/ha plus DADS at 50l/ha, metham sodium at 600l product/ha plus DADS at 50l/ha and metham sodium at 1200l product/ha plus DADS at 200l/ha. The metham sodium and the DADS treatments were applied by a Rumpstadt Combijet soil injector. Dazomet was applied using a MJF Basamid Incorporator at Northorpe and Kirton EHS and by hand at Arthur Rickwood EHF and Methwold. At sites where treatments were made by hand, plots were rotavated after application. In order to prevent contamination by DADS in other treatments, the DADS treatments were the last to be applied. All plots, including the untreated, were covered with 125g polythene which was left on for approximately 6 months at each site.

Assessments

Sclerotia of *Sclerotium cepivorum* were supplied by Professor John Coley-Smith of Hull University and were buried in the trial plots. Twenty-five sclerotia mixed with sand and placed in a nylon bag were inserted into a Netlon string. Two bags on each string were spaced out so that they could be buried at 7.5 and 20 cm at all sites except for Northorpe where three bags were buried at 2.5, 10 and 20 cm. Two strings were buried at the two ends of each plot immediately after treatment and were removed approximately 6 months later. Those from Northorpe and Kirton EHS were returned to Professor Coley-Smith for assessment; those from the Arthur Rickwood and Methwold Fen were assessed at Kirton. Field assessments were made of weed cover, disease incidence and marketable and unmarketable yields. Weed cover was recorded as % area covered by the various weeds per plot. Disease incidence in the trials except for Methwold Fen was recorded as % modules affected with white rot (recorded area based on 50 modules). At Methwold Fen the length (m) of each row of plants affected with white rot was measured and expressed as a percentage out of 12 m (there were 3 rows of plants each 4 m in length). In addition at Methwold mean plant number/plot (based on 3 x 1 m in lengths/plot) and crop vigour based on health and size of plants were assessed.

Statistical analyses

All data were subjected to analysis of variance; standard errors are quoted. Figures with the same letter following in the same column do not differ significantly from each other ($P<0.05$). Duncan's Multiple Range Test.

RESULTS

The results of weed assessments done at four sites are given in the following tables:-

Table 1 Effect of treatment on weed cover Northorpe and Kirton EHS (1)

Treatment	Mean % Weed cover Northorpe (1.9.87)	Kirton EHS (1) (9.9.87)
1. Untreated	96.75c	30.0b
2. Basamid 380kg/ha	7.75a	3.50a
3. Basamid 570kg/ha	3.75a	1.0a
4. Metham sodium 600l/ha	57.50b	10.75a
5. Metham sodium 1200l/ha	14.50a	1.50a
6. DADS 50l/ha	99.0c	68.75c
7. DADS 200l/ha	99.0c	22.50b
8. Basamid 380kg/ha + DADS 50l/ha	6.25a	1.25a
9. Metham sodium 600l/ha + DADS 50l/ha	48.75b	2.75a
10. Metham sodium 1200l/ha + DADS 200l/ha	11.25a	1.0a
SED 5%	12.55	6.83
CV%	39.95	67.58

Northorpe

The main weeds were fat hen, knotweed and redshank and to a lesser extent red dead nettle, speedwell and meadow grass. Nearly 100% weed cover was recorded in the untreated plots. As to be expected DADS gave no significant control but all the sterilant treatments gave a high degree of control. Plots treated with the lower rate of metham sodium had significantly higher weed cover than ones treated with the other sterilants.

Kirton EHS (1)

The main weeds were knotgrass, redshank, shepherds purse and meadow grass with mayweed, chickweed and nettle present to a lesser extent. Approximately a third of the area of the untreated plots was covered with weeds. All the treatments gave significant control apart from DADS which had significantly more weeds in the lower rate treated plots and similar weed cover to the untreated plots in the higher rate DADS ones.

Table 2 Effect of treatments on weed cover - Arthur Rickwood and Kirton EHS (2)

Treatment	Mean % Weed Cover Arthur Rickwood (6.4.89)	Kirton EHS (2) (12.4.89)
1. Untreated	92.5e	79.3d
2. Basamid 380kg/ha	1.1a	0.5a
3. Basamid 570kg/ha	0.6a	0.8a
4. Metham sodium 600l/ha	25.0bc	47.5c
5. Metham sodium 1200l/ha	17.3ab	6.3ab
6. DADS 50l/ha	61.3d	38.8c
7. DADS 200l/ha	43.8cd	42.5c
8. Basamid 380kg and DADS 50l/ha	0.9a	0.3a
9. Metham sodium 600l/ha + DADS 50l/ha	10.5ab	9.3ab
10. Metham sodium 1200l/ha + DADS 200l/ha	11.3ab	14.5b
SED 5%	9.71	8.81
CV%	52.04	52.00

Arthur Rickwood EHF

The main weeds were annual meadow grass and chickweed. To a lesser extent bindweed, mayweed, sowthistle, groundsel, field speedwell, poppy, redshank, knotgrass, cleavers and volunteer potatoes were recorded. Significant weed control was achieved by all treatments. A high degree of control was achieved by the Basamid treatments but these did not differ significantly from the higher rate of metham sodium on its own or both rates of metham sodium plus DADS.

Kirton EHS (2)

The main weeds were chickweed, mayweed and poppy. To a lesser extent speedwell, knotgrass, groundsel, shepherds purse, annual meadow grass, sowthistle, dandelion, nettle, fumitory and volunteer lilies were present. All the chemical treatments gave control but treatments which included Basamid gave a very high degree of control.

The effect of treatments on artificially buried sclerotia are given in the following tables:

Table 3 Effect of treatments on artificially buried sclerotia at 2 depths at Methwold Fen and Arthur Rickwood

Treatment	Methwold Fen 7.5cm %	Methwold Fen 7.5cm Trans***	Methwold Fen 20cm %	Methwold Fen 20cm Trans	Arthur Rickwood 7.5cm % *	Arthur Rickwood 7.5cm Trans	Arthur Rickwood 20cm % **	Arthur Rickwood 20cm Trans
1. Untreated	0.0	0.0	11.0	10.4	23.0	25.8	48.0	43.8
2. Basamid 380kg/ha	0.0	0.0	0.0	0.0	1.0	2.9	4.0	5.9
3. Basamid 570kg/ha	11.0	10.4	5.0	8.8	6.0	9.5	6.9	9.3
4. Metham sodium 600l/ha	9.0	12.1	14.0	12.1	10.7	11.5	2.8	5.9
5. Metham sodium 1200l/ha	10.0	12.1	18.0	18.4	4.2	3.4	0.7	0.7
6. DADS 50l/ha	2.0	4.1	0.0	0.0	1.3	0.8	1.2	0.8
7. DADS 200l/ha	8.0	8.6	0.0	0.0	3.3	2.6	4.7	4.1
8. Basamid 380kg/ha + DADS 50l/ha	14.0	15.1	17.0	20.1	0.0	0.0	5.0	6.6
9. Metham sodium 600l/ha + DADS 50l/ha	0.0	0.0	11.0	10.4	4.2	3.4	0.7	0.7
10. Metham sodium 1200l/ha + DADS 200l/ha	0.0	0.0	3.0	5.1	2.2	7.4	0.7	3.5
SED (5%)		9.7		10.4		7.25		7.7
CV%		220.0		172.0		174.2		138.0

* 8 missing values
** 10 missing values
***Data angular transformed

At Methwold Fen no significant differences in the numbers of viable sclerotia were found between treatments. No viable sclerotia were detected in the untreated plots at the 7.5 cm depth and 11% at the lower depth.

At the Arthur Rickwood site, approximately a quarter and a half the number of viable sclerotia were recovered from the upper and lower depths in the untreated plots respectively. Significant reduction of sclerotia at both depths was achieved by all treatments apart from the metham sodium treatment at the lower rate on sclerotia at the 7.5 cm depth.

Table 4 Effects of treatments on artificially buried sclerotia - results at 3 depths Northorpe

Treatment	Northorpe 2.5cm %	Trans*	10cm %	Trans	20cm %	Trans
1. Untreated	49.5	43.7	59.5	51.6	62.5	52.3
2. Basamid 380kg/ha	0.0	0.0	0.0	0.0	7.5	10.0
3. Basamid 570kg/ha	0.0	0.0	0.0	0.0	0.0	0.0
4. Metham sodium 600l/ha	0.0	0.0	0.0	0.0	0.0	0.0
5. Metham sodium 1200l/ha	0.0	0.0	0.0	0.0	0.0	0.0
6. DADS 50l/ha	54.5	47.6	87.0	69.5	76.0	61.8
7. DADS 200l/ha	61.0	53.2	77.0	63.7	74.0	60.9
8. Basamid 380kg/ha + DADS 50l/ha	0.0	0	0.0	0.0	0.5	2.0
9. Metham sodium 600 l/ha + DADS 50l/ha	0.0	0	0.5	2.0	0	0.0
10. Metham sodium 1200l/ha + DADS 200l/ha	0.0	0	0.0	0.0	0	0.0
SED (5%)		7.26		5.5		5.62
CV%		70.0		41.6		42.5

*Data angular transformed

At Northorpe sclerotia were buried at three depths. Approximately half the number of sclerotia remained viable in the untreated plots. A complete or nearly complete kill of sclerotia was achieved with all treatments which contained sterilants. Results from the DADS alone treatments were disappointing with no significant reduction in the numbers of viable sclerotia recovered indeed significantly more were recovered from the 10cm depth.

Table 5 Results of treatments on artificially buried sclerotia at 2 depths Kirton EHS (1) and Kirton EHS (2)

Treatment	Kirton EHS (1)				Kirton EHS (2)			
	7.5cm		20cm		7.5cm		20cm	
	%	Trans*	%	Trans	%	Trans	%	Trans
1. Untreated	0.0	0.0	0.0	0.0	52.3	45.8	79.9	63.0
2. Basamid 380kg/ha	0.0	0.0	8.0	8.6	57.0	49.7	57.0	48.9
3. Basamid 570kg/ha	2.0	4.1	0.0	0.0	8.0	11.8	2.0	4.1
4. Metham sodium 600l/ha	0.0	0.0	0.0	0.0	16.0	18.5	27.0	29.4
5. Metham sodium 1200l/ha	0.0	0.0	3.0	5.1	30.0	32.2	14.0	18.7
6. DADS 50l/ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7. DADS 200l/ha	7.0	7.3	0.0	0.0	0.0	0.0	3.0	5.1
8. Basamid 380kg/ha + DADS 50l/ha	0.0	0.0	0.0	0.0	23.0	24.5	1.0	2.9
9. Metham sodium 600l/ha + DADS 50l/ha	4.0	5.9	1.0	2.9	5.0	8.8	8.3	10.0
10. Metham sodium 1200l/ha + DADS 200l/ha	0.0	0.0	0.0	0.0	16.2	19.5	3.0	6.0
SED (5%)		4.47		4.67		10.5		8.9
CV%		364.5		339.5		70.2		66.6

*Data angular transformed

At the Kirton EHS (1) no significant differences in the numbers of viable sclerotia were found between treatments. No viable sclerotia were detected in the untreated plots at either depth.

At the Kirton EHS (2) approximately 50% and 80% viable sclerotia were recorded in the untreated plots. Significant 'kill' of sclerotia was recorded at both depths following treatments of Basamid high rate on its own, the two rates of DADS on its own and the combined treatments of metham sodium and DADS. No viable sclerotia were detected in plots treated with DADS at 50l/ha.

The results of disease assessments and yields are given in the following tables. In addition plant number and vigour assessments were made at Methwold Fen.

Table 6 Effect of treatments on white rot Kirton EHS (1) spring 1987 applied treatments overwintered bulb onion crop, summer 1988 harvest

Disease

Treatment	% Modules affected with white rot 13/6	27/7
1. Untreated	0.0	23.0
2. Basamid 380kg/ha	0.5	19.0
3. Basamid 570kg/ha	0.0	12.5
4. Metham sodium 600l/ha	1.5	11.5
5. Metham sodium 1200l/ha	0.0	6.5
6. DADS 50l/ha	2.0	16.5
7. DADS 200l/ha	0.0	7.0
8. Basamid 380kg/ha + DADS 50l/ha	1.0	15.5
9. Metham sodium 600l/ha + DADS 50l/ha	0.0	20.0
10. Metham sodium 1200l/ha + DADS 200l/ha	0.0	14.5
SED (5%)	1.03	8.47
CV%	316.0	86.0

In this overwintered crop, there was no significant disease control following any of the chemical treatments.

Table 7 Effect of treatments on yield Kirton EHS (1) spring 1987 applied treatments overwintered bulb onion crop, summer 1988 harvest

Treatment	Yield (t/ha) Total	Marketable	Unmarketable
1. Untreated	6.90a	6.00a	0.90ab
2. Basamid 380kg/ha	17.18c	15.13cd	2.05bc
3. Basamid 570kg/ha	18.53c	17.17d	1.35abc
4. Metham sodium 600l/ha	12.65b	11.55bc	1.10abc
5. Metham sodium 1200l/ha	18.17c	16.38d	1.79abc
6. DADS 50l/ha	6.48a	5.67a	0.81a
7. DADS 200l/ha	9.13a	8.42ab	0.71a
8. Basamid 380kg/ha + DADS 50l/ha	16.67c	14.55cd	2.12c
9. Metham sodium 600l/ha + DADS 50l/ha	13.23b	11.50bc	1.73bc
10. Metham sodium 1200l/ha + DADS 200l/ha	15.74bc	13.62cd	2.12c
SED (5%)	1.54	1.76	0.52
CV%	17.0	22.0	53.0

Significant increases in total and marketable yields were recorded following all treatments which included Basamid or metham sodium. DADS had no significant effect on yields.

Table 8 Effect of treatments on white rot Kirton EHS (1) spring 1987 applied treatments spring bulb onion crop summer 1988 harvest - year 1

Treatment	% Modules affected with white rot 13/6	28/6	12/7	02/8	05/9
1. Untreated	0.5	14.0	24.5	41.3c	48.5c
2. Basamid 380kg/ha	0.5	5.5	9.0	12.0ab	21.0ab
3. Basamid 570kg/ha	0.0	3.5	4.5	5.5a	12.5a
4. Metham sodium 600l/ha	1.0	4.5	7.0	10.5ab	25.5abc
5. Metham sodium 1200l/ha	0.0	0.0	3.0	6.0ab	12.5a
6. DADS 50l/ha	1.0	8.0	17.5	24.0abc	33.5abc
7. DADS 200l/ha	0.0	4.0	10.5	24.5abc	36.5abc
8. Basamid 380kg/ha + DADS 50l/ha	1.0	2.5	3.5	6.5ab	18.0ab
9. Metham sodium 600l/ha + DADS 50l/ha	0.0	1.5	4.0	7.5ab	27.5abc
10. Metham sodium 1200l/ha + DADS 200l/ha	0.0	0.0	1.5	3.0a	10.5a
SED (5%)	0.68	4.49	8.14	11.62	11.45
CV%	289.0	123.0	109.0	96.0	59.0

No significant disease control was recorded in June and July. However, in September significant disease control was recorded in plots with treatments which included Basamid and metham sodium at the higher rate. There was no control from the DADS alone treatments or from the low rate metham sodium treatment either on its own or combined with DADS.

Table 9 Effects of treatments on yield Kirton EHS (1) spring 1987 applied treatments spring bulb onion crop summer 1988 harvest

Treatment	Yield (t/ha) Total	Marketable	Unmarkable
1. Untreated	10.23a	8.90a	1.33
2. Basamid 380kg/ha	16.95bcd	14.92bcde	2.03
3. Basamid 570kg/ha	20.3d	17.92e	2.38
4. Metham sodium 600l/ha	14.60abc	11.90abcd	2.70
5. Metham sodium 1200l/ha	17.23cd	15.25cde	1.98
6. DADS 50l/ha	12.42ab	10.42a	2.00
7. DADS 200l/ha	13.48abc	11.23abc	2.25
8. Basamid 380kg/ha + DADS 50l/ha	17.63cd	15.55de	1.98
9. Metham sodium 600l/ha + DADS 50l/ha	15.58bc	12.90abcd	2.68
10. Metham sodium 1200l/ha + DADS 200l/ha	17.38cd	15.27cde	2.10
SED (5%)	2.01	1.83	0.71
CV%	19.0	20.0	48.0

Significant total and marketable yield increases were recorded in plots which had been treated with the two rates of Basamid on its own and in combination with DADS, and from the higher rate of metham sodium on its own and in combination with DADS. Although there was a significant total yield increase in plots treated with the lower rate metham sodium and lower rate DADS (treatment 9) it did not differ significantly from the metham sodium lower rate treatment on its own (treatment 4).

Table 10 Effect of treatments on white rot Kirton EHS (1) spring 1987 applied treatments spring bulb onion crop summer 1989 harvest - year 2

Treatment	Modules affected with white rot									
	13/6		27/6		13/7		4/8		21/8	
	%	Trans*	%	Trans	%	Trans	%	Trans	%	Trans
1. Untreated	7.5	13.5ab	15.8	20.3ab	22.5	27.3ab	24.7	28.6b	26.7	30.3c
2. Basamid 380kg/ha	2.4	6.0a	4.3	8.4a	6.3	12.3ab	6.7	12.7ab	7.2	13.0ab
3. Basamid 570kg/ha	6.9	7.9ab	8.3	8.8a	8.8	10.8a	8.8	10.8a	9.3	11.1a
4. Metham sodium 600l/ha	10.4	15.0ab	14.8	18.2ab	19.3	21.7ab	19.3	21.7ab	21.3	23.4abc
5. Metham sodium 1200l/ha	5.5	7.0a	9.0	11.0ab	11.0	14.5ab	11.5	15.3ab	13.6	17.4abc
6. DADS 50l/ha	18.9	18.9b	28.6	24.6b	34.2	27.9b	34.2	27.9b	34.7	28.2bc
7. DADS 200l/ha	10.5	13.6ab	12.0	14.7ab	16.0	17.2ab	17.5	18.1ab	17.5	18.1abc
8. Basamid 380kg/ha + DADS 50l/ha	4.5	8.3ab	8.4	14.0ab	10.9	16.0ab	11.9	16.8ab	14.3	18.7abc
9. Metham sodium 600l/ha + DADS 50 l/ha	8.7	12.3ab	11.5	14.3ab	16.3	17.4ab	16.3	17.4ab	17.8	20.0abc
10. Metham sodium 1200l/ha + DADS 200l/ha	2.5	6.2a	9.1	12.5ab	11.1	15.5a	11.1	15.5ab	15.0	21.7abc
SED (5%)		4.87		5.96		6.97		6.71		6.69
CV%		59.9		54.2		51.8		48.9		44.9

* Data angular transformed

In the second year of this trial at Kirton without further treatment the lowest disease scores and significant disease control were recorded in plots treated with Basamid alone at both high and low rates (treatments 2 and 3). No significant control was obtained following any of the other treatments at the late August assessment date.

Table 11 Effect of treatment on yield Kirton EHS (1) spring 1987 applied treatments spring bulb onion crop summer 1989 harvest - year 2

Treatment	Yield (t/ha)	
	Total	Market-able
1. Untreated	21.2ab	20.8ab
2. Basamid 380kg/ha	37.3d	36.7d
3. Basamid 570kg/ha	31.4cd	31.1cd
4. Metham sodium 600l/ha	24.9abc	24.8abc
5. Metham sodium 1200l/ha	29.4bcd	29.1cd
6. DADS 50l/ha	17.3a	17.1a
7. DADS 200l/ha	24.5abc	24.3abc
8. Basamid 380kg/ha + DADS 50l/ha	32.4cd	32.1cd
9. Metham sodium 600l/ha + DADS 50l/ha	29.0bcd	28.6bcd
10. Metham sodium 1200l/ha + DADS 200l/ha	30.7cd	30.1cd
SED (5%)	3.68	3.56
CV%	19.3	19.0

Significant yield increases were recorded from plots treated with Basamid at both rates applied alone or at the low rate in combination with DADS, and from metham sodium plots treated with the high rate on its own (marketable yield only) or in combination with DADS. No significant total and marketable yield increases were recorded from plots treated with DADS alone or metham sodium applied at the low rate either on its own or in combination with DADS.

Table 12 Effect of treatments on disease Kirton EHS (2) Autumn 1988 applied treatments. Spring bulb onion harvest summer 1990

Treatment	Modules affected with white rot %	Trans
1. Untreated	5.8	7.2
2. Basamid 380kg/ha	8.0	10.3
3. Basamid 570kg/ha	10.2	16.2
4. Metham sodium 600l/ha	12.1	12.7
5. Metham sodium 1200l/ha	19.6	19.9
6. DADS 50l/ha	0.9	2.7
7. DADS 200l/ha	0	0
8. Basamid 380kg/ha + DADS 50l/ha	0.4	1.9
9. Metham sodium 600l/ha + DADS 50l/ha	6.4	7.8
10. Metham sodium 1200l/ha + DADS 200l/ha	0.9	3.8
SED (5%)		7.02
CV%		120.3

*Data angular transformed

Very variable white rot disease scores were recorded with no significant differences between treatments.

Table 13 Effect of treatments on yield Kirton EHS (2) autumn 1988 applied treatments spring bulb onion crop harvest summer 1990

Treatment	Yield t/ha Total	Marketable	Unmarketable
1. Untreated	47.6	46.8	0.62
2. Basamid 380kg/ha	49.5	48.0	1.15
3. Basamid 570kg/ha	48.8	46.5	1.61
4. Metham Sodium 600l/ha	48.4	47.3	0.46
5. Metham Sodium 1200l/ha	42.4	40.8	1.18
6. DADS low rate 50l/ha	56.5	55.7	0.77
7. DADS high rate 200l/ha	60.5	59.9	0.58
8. Basamid 380kg/ha + DADS 50l/ha	56.1	54.7	1.46
9. Metham Sodium 600l/ha + DADS 50l/ha	51.3	49.8	1.34
10. Metham Sodium 1200l/ha + DADS 200 l/ha	58.5	57.5	0.98
SED	6.63	6.78	0.68
CV%	18.0	18.9	94.6

No significant differences in total, marketable or unmarketable yields were recorded between treatments.

Table 14 Effect of treatments on white rot Northorpe. Spring 1987 applied treatments spring bulb onion crop summer 1988 harvest - year 1

Treatment	% Modules affected with white rot 16/6	28/6	15/7	02/8	06/9
1. Untreated	0.0	6.5bc	13.5bc	19.0bcd	34.0bc
2. Basamid 380kg/ha	0.5	3.5abc	7.5abc	9.5abcd	21.0ab
3. Basamid 570kg/ha	0.0	1.0ab	3.5ab	3.5ab	19.0ab
4. Metham sodium 600l/ha	0.0	0.0a	0.0a	0.0a	2.0a
5. Metham sodium 1200l/ha	0.0	0.0a	0.0a	0.0a	1.5a
6. DADS 50l/ha	1.0	8.0c	19.0c	26.0d	49.0c
7. DADS 200l/ha	0.5	5.0abc	18.5c	25.0cd	44.0c
8. Basamid 380kg/ha + DADS 50l/ha	0.0	3.5abc	7.5abc	8.8abc	25.5b
9. Metham sodium 600l/ha + DADS 50l/ha	0.0	0.0a	0.5a	0.5a	2.0a
10. Metham sodium 1200l/ha + DADS 200l/ha	0.5	0.5ab	0.5a	0.5a	3.5a
SED (5%)	0.5	2.64	5.3	7.62	8.54
CV%	336.0	133.0	106.0	116.0	60.0

In July, August and September, significant disease control was achieved in treatments which included metham sodium, ie metham sodium on its own or in combination with DADS. No significant differences were detected between the two rates of metham sodium, both giving a high degree of control. No significant control was achieved by the Basamid treatments. DADS did not give any control on its own and did not enhance the control when combined with sterilants.

Table 15 Effect of treatments on yield Northorpe spring 1987 applied treatments, spring bulb onion crop summer 1988 harvest - year 1

Treatment	Yield (t/ha) Total	Marketable	Unmarketable
1. Untreated	21.69a	20.18a	1.51a
2. Basamid 380kg/ha	27.65ab	26.73abc	0.92abc
3. Basamid 570kg/ha	31.11b	30.03bc	1.09abc
4. Metham sodium 600l/ha	32.81b	32.35bc	0.46ab
5. Metham sodium 1200l/ha	35.40b	34.90c	0.50ab
6. DADS 50l/ha	21.46a	19.88a	1.59bc
7. DADS 200l/ha	22.94a	20.78a	2.16c
8. Basamid 380kg/ha + DADS 50l/ha	27.27ab	25.48ab	1.80c
9. Metham sodium 600l/ha + DADS 50l/ha	33.47b	33.35bc	0.12a
10. Metham sodium 1200l/ha + DADS 200l/ha	34.06b	33.82bc	0.24a
SED (5%)	3.61	3.86	0.54
CV%	18.0	20.0	74.0

Significant total and marketable yield increases were recorded in plots which had been treated with metham sodium (either on its own or with DADS) or with Basamid alone at the higher rate.

Table 16 Effect of treatments on yield Northorpe spring 1987 applied treatments spring bulb onion crop summer 1989 harvest - year 2

Treatment	Modules affected with white rot 13/6 %	Trans	27/6 %	Trans	13/7 %	Trans	4/8 %	Trans	21/8 %	Trans
1. Untreated	1.5	4.9	3.9	8.1	8.9	14.1c	11.9	16.7c	14.9	18.8d
2. Basamid 380kg/ha	0.0	0.0	1.5	4.9	2.4	8.9bc	2.9	9.7bc	2.9	9.7bc
3. Basamid 570kg/ha	0.5	2.1	1.0	4.1	1.5	6.0ab	1.5	6.0ab	2.4	7.7ab
4. Metham sodium 600l/ha	0.0	0.0	0.5	2.0	0.5	2.0ab	1.0	4.1ab	1.0	4.1ab
5. Metham sodium 1200l/ha	0.0	0.0	0.0	0.0	0.0	0.0a	0.0	0.0a	0.0	0.0a
6. DADS 50l/ha	0.5	2.1	2.9	8.4	6.9	14.7c	9.8	17.3c	9.8	17.3cd
7. DADS 200l/ha	0.0	0.0	0.0	0.0	0.5	2.0ab	0.5	2.0ab	3.5	10.4bcd
8. Basamid 380kg/ha + DADS 50l/ha	0.0	0.0	0.5	2.0	0.5	2.0ab	0.5	2.0ab	0.5	2.0ab
9. Metham sodium 600l/ha + DADS 50 l/ha	0.0	0.0	0.0	0.0	0.0	0.0a	0.0	0.0a	0.0	0.0a
10. Metham sodium 1200l/ha + DADS 200l/ha	0.0	0.0	0.0	0.0	0.0	0.0a	0.0	0.0a	1.0	2.8ab
SED (5%)		1.76		3.21		3.22		3.68		3.93
CV%		278.0		154.1		91.4		90.0		76.3

* data angular transformed

In the second year of this trial at Northorpe without further treatment significant disease control was achieved by all treatments except DADS alone at both rates. No white rot was detected in the plots treated with metham sodium alone at the high rate (treatment 5) or in those treated with the lower rate metham sodium plus low rate DADS (treatment 9).

Table 17 Effects of treatments on yield Northorpe spring 1987 applied treatments spring bulb onion crop summer 1989 harvest - year 2

Treatment	Yield (t/ha) Total	Marketable
1. Untreated	9.2	8.8
2. Basamid 380kg/ha	15.2	14.8
3. Basamid 570kg/ha	18.2	18.1
4. Metham sodium 600l/ha	14.0	13.8
5. Metham sodium 1200l/ha	16.9	16.7
6. DADS 50l/ha	9.9	9.4
7. DADS 200l/ha	12.9	12.6
8. Basamid 380kg/ha + DADS 50l/ha	16.6	16.5
9. Metham sodium 600l/ha + DADS 50l/ha	16.9	16.8
10. Metham sodium 1200l/ha + DADS 200l/ha	18.9	18.8
SED (5%)	3.32	3.32
CV%	31.0	32.1

No significant differences in total or marketable yields were detected.

Table 18 Effect of treatments on yield Arthur Rickwood EHF autumn 1988 applied treatments. Spring bulb onion harvest summer 1990

Treatment	Yield (t/ha) Total	Market-able	Unmarketable
1. Untreated	71.1	69.9	1.22
2. Basamid 380kg/ha	67.5	65.9	1.59
3. Basamid 570kg/ha	64.6	62.6	2.02
4. Metham Sodium 600l/ha	74.8	73.8	1.04
5. Metham Sodium 1200l/ha	61.6	60.0	1.59
6. DADS low rate 50l/ha	79.0	77.3	1.65
7. DADS high rate 200l/ha	77.1	75.9	1.10
8. Basamid 380kg/ha + DADS 50l/ha	66.2	62.5	3.67
9. Metham Sodium 600l/ha + DADS 50l/ha	77.2	75.0	2.20
10. Metham Sodium 1200l/ha + DADS 200 l/ha	74.4	72.8	1.59
SED	5.88	6.12	0.82
CV%	11.7	12.4	65.4

White rot was found at a low level only in one plot in this trial. There were no significant differences in yield between any of the treatments.

Table 19 Effect of treatments on plant numbers and plant vigour Methwold Fen spring 1989 applied treatments, pickling onions harvested summer 1990

Treatment	Mean plant No/m 10.7.90	Vigour* 24.7.90
1. Untreated	116.5	3.42
2. Basamid 380kg/ha	186.6	5.25
3. Basamid 570kg/ha	193.4	6.22
4. Metham sodium 600l/ha	181.1	5.15
5. Metham sodium 1200l/ha	152.6	6.25
6. DADS 50l/ha	164.2	4.92
7. DADS 200l/ha	153.5	5.57
8. Basamid 380kg/ha + DADS 50l/ha	193.6	5.85
9. Metham sodium 600l/ha + DADS 50l/ha	172.7	6.00
10. Metham sodium 1200l/ha + DADS 200l/ha	192.0	5.75
SED	27.76	0.961
CV%	23.0	25.0

*Plots were assigned a number of between 1 and 10 according to the health and size of plants 10 = good, 1 = poor.

No significant differences between treatments were detected in mean plant numbers or vigour scores. However, the untreated plots had the lowest plant numbers and were the least vigorous.

Table 20 Effect of treatments on disease Methwold Fen spring 1989 applied treatments, pickling onions harvested summer 1990

Treatment	% Area affected with white rot*					
	26/6		10/7		24/7	
	%	Trans*	%	Trans	%	Trans
1. Untreated	33.8	33.8a	81.8	66.9d	85.0	72.2c
2. Basamid 380kg/ha	26.4	29.5a	45.8	42.5c	49.1	44.4b
3. Basamid 570kg/ha	17.2	22.9a	37.9	37.4b	40.5	39.1ab
4. Metham sodium 600l/ha	18.4	23.5a	33.7	33.6abc	39.7	37.9ab
5. Metham sodium 1200l/ha	4.3	10.0a	19.1	23.6ab	27.9	30.1b
6. DADS low rate 50l/ha	19.9	26.0a	38.1	37.9bc	45.8	42.6b
7. DADS high rate 200l/ha	11.7	19.7a	35.5	36.3bc	42.3	40.4ab
8. Basamid 380kg/ha + DADS 50l/ha	12.2	20.1a	31.4	30.6abc	37.6	37.7ab
9. Metham sodium 600 l/ha + DADS 50l/ha	8.2	16.3a	24.9	29.5abc	35.4	36.1ab
10. Metham sodium 120l/ha + DADS 200 l/ha	3.0	9.6a	9.3	17.7a	19.9	24.9a
SED		7.37		7.25		7.49
CV%		49.3		28.6		26.1

* Data angular transformed

Table 21 Effect of treatment on yield Methwold Fen spring 1989 applied treatments, pickling onions harvested summer 1990

Treatment	Yield (t/ha)			
	Total	Marketable	Unmarketable	White rot
1. Untreated	9.21a	4.56a	4.56	0.09
2. Basamid 380kg/ha	20.30bc	14.84bc	5.10	0.37
3. Basamid 570kg/ha	31.65d	26.59d	4.69	0.37
4. Metham Sodium 600 l/ha	18.37b	12.58ab	5.43	0.37
5. Metham sodium 1200l/ha	16.53ab	10.44ab	5.59	0.15
6. DADS low rate 50l/ha	16.56ab	12.29ab	3.86	0.41
7. DADS high rate 200l/ha	17.18ab	12.37ab	4.36	0.42
8. Basamid 380kg/ha + DADS 50l/ha	26.63cd	20.92cd	5.22	0.49
9. Metham sodium 600l/ha + DADS 50l/ha	17.88ab	12.58ab	4.81	0.49
10. Metham sodium 1200l/ha + DADS 200l/ha	17.06ab	10.40ab	6.41	0.25
SED	3.78	3.64	1.11	0.16
CV%	27.9	37.4	31.3	57.9

Significant total and marketable yield increases were recorded in plots treated with Basamid at both rates applied alone or at the low rate with DADS. In addition significant total yield increases were recorded in plots treated with the low rate of metham sodium applied on its own. No significant yield increases were recorded in plots treated with DADS or other treatments which included metham sodium.

Table 22 Overall effect of treatments on disease[1] and yield[3]

Treatment	% Disease incidence[1]	Trans[2]	Yield (t/ha)[3] Total	Marketable
1. Untreated	42.2	40.4	31.7	30.2
2. Basamid 380kg/ha	19.8	22.4	38.0	36.1
3. Basamid 570kg/ha	17.4	19.3	38.9	37.0
4. Metham sodium 600l/ha	20.7	21.8	36.1	34.5
5. Metham sodium 1200l/ha	13.8	15.8	33.4	21.4
6. DADS 50l/ha	30.1	29.4	35.9	34.4
7. DADS 200l/ha	21.1	23.0	38.4	37.0
8. Basamid 380kg/ha + DADS 50 l/ha	17.5	19.5	39.6	37.3
9. Metham sodium 600 l/ha + DADS 50 l/ha	17.7	18.7	38.5	36.4
10. Metham sodium 1200 l/ha + DADS 200l/ha	11.3	16.5	39.9	37.9
SED (5%)		3.67	2.15	2.19
df		81.0	135.0	135.0

1 Mean of three trials, Northorpe, Kirton EHS (I) and Methwold Fen

2 Disease data angular transformed

3 Mean of five trials

Disease results from the three sites showed that all treatments gave significant control of white rot (Table 22). The best overall control (approximately 70%) was achieved from treatments which included metham sodium at 1200l/ha either alone or in combination with DADS. However, the low rate treatment of metham sodium or treatments which included Basamid did not differ from the high rate metham sodium ones. The control from the low rate and high rate DADS treatment was 28% and 50% respectively. The combined treatments of sterilants plus DADS gave similar results to those given by the sterilants alone.

Yield results from the five sites showed that total yields were significantly increased by all treatments except metham sodium at the high rate and DADS at the low rate. Marketable yields were significantly increased by all treatments except by metham sodium alone at both rates and by DADS at the lower rate.

DISCUSSION

The effects of the treatments on weeds was assessed at four sites. Basamid consistently gave a high degree of control at all sites with no significant differences in effectiveness between the two rates. Metham sodium gave variable results; the reasons for which cannot be explained. Although DADS was not expected to have an effect on weeds, significant but inexplicable control was achieved at the Arthur Rickwood and Kirton EHS (2) sites. Possibly, the mechanical effect and subsequent polythene covering may have restricted weed germination and growth. However, this does not explain why significantly more weeds grew in the lower rate DADS treated plots at the Kirton EHS (1) site. Moreover, all control treatments were sheeted over with polythene.

The use of artificially buried sclerotia can be a very valuable guide to the effectiveness of treatments. However, in these trials variable and inexplicable results occurred. The value of this method lies in comparing the untreated controls (where all the sclerotia should remain intact and viable) and the various treatments in which the sclerotia are killed (as with the sterilants) or encouraged to germinate in the absence of an onion host (as with DADS). In this trial series, at Kirton EHS (1) and at Methwold Fen sites, no viable sclerotia were recorded from the untreated plots except for 10% at the lower depth at Methwold Fen. Low sclerotia survival was recorded from those treated with chemicals so the effectiveness of the treatments could not be compared. Such results cannot be explained except that there may have been an overall effect of eg DADS vapours over the whole trial site. Such a phenomenon has not been previously recorded. At Kirton EHS (2) and Northorpe where approximately 50% sclerotia remained viable in the untreated plots at the upper depths, the sterilants gave a high degree of control. Complete kill was recorded at the 3 depths following application of Basamid at the high rate and of metham sodium at Northorpe but this was not so at the Kirton EHS (2) site. Conversely, DADS gave excellent results at Kirton EHS (2) but produced no significant effects on sclerotia at Northorpe. These variable results cannot be explained.

The effectiveness of DADS applied in the spring could not be evaluated as little disease developed at Kirton EHS(2). A similar situation arose at Arthur Rickwood where DADS gave very encouraging results on artificially buried sclerotia but no disease occurred.

At Northorpe the sterilants gave a good kill of the artificially buried sclerotia but these results were reflected in low disease scores only in the metham sodium treated plots and not in the Basamid ones. These latter results cannot be explained. However, at this site, the use of artificially buried sclerotia indicated that DADS would have been ineffective and this was borne out in high disease scores. However, moderate to high disease was recorded at Kirton EHS (1) and Methwold Fen sites but few or no viable artificially buried sclerotia were recovered suggesting that the sclerotia had been affected adversely. Great care had been taken with storage and handling of the sclerotia not to subject them to DADS or Allium vapours at any stage.

The effects of treatments on disease control could only be evaluated at three sites, Kirton EHS (1), Northorpe and Methwold Fen. At the Kirton EHS (1) site double length plots were treated and an autumn planted module crop was planted on one half so that an early indication of the effectiveness of the treatments could be gained. However, low to moderate disease developed with no significant differences between treatments and the results bore no relationship to those obtained from the spring planted crop. Such differences in results cannot be explained.

Unfortunately the effect of autumn-applied treatments on disease control could not be assessed as little disease developed on these sites (Kirton EHS (2) and Arthur Rickwood) despite a history of white rot on both sites. A similar situation has been encountered by other workers.

No treatment gave complete control of white rot although metham sodium applied at both rates at Northorpe gave a high degree of control in the first year. The effects of these treatments persisted into the second year with no disease recorded in plots treated with the higher rate of metham sodium alone and low rate metham sodium plus DADS. The latter results can be attributed to the fact that at harvest in the first year all plants were removed including white rot affected ones thus removing inoculum for the following crop. At Methwold Fen, a site with high disease, the best treatment was that of metham sodium applied at the high rate plus high rate DADS. However, 20% of plants in these plots were affected with white rot prior to harvest giving 22% control which cannot be regarded as satisfactory. At Kirton EHS (2) no disease was detected in plots treated with DADS at the high rate and very low disease was recorded in plots treated with DADS at the lower rate and also in plots treated with high rate of metham sodium plus high rate DADS; these results are likely to reflect the low level and uneven distribution of white rot on this site as opposed to real treatment effects. Analysis of the disease data revealed no significant differences between the various treatments.

Since 1985, the use of sterilants has been compared in six trials (5 in Lincolnshire and 1 in Cambridgeshire) where reasonable levels of disease have occurred (three trials sponsored by Government funding and three HDC sponsored ones). Complete control was achieved only in one trial, at Moulton, which was treated in the autumn of 1985 and in one treatment only, that of Basamid applied at 570kg/ha. This trial continued for a second year without further treatment and the effect of the Basamid persisted into the second year.

These investigations have shown the variability in white rot control achieved with soil sterilants and that they cannot be completely relied upon.

The effects of the sclerotial stimulant DADS on disease control were disappointing with 28% and 50% control achieved overall by the low and high rates of DADS, respectively. A possible reason was that DADS was not applied in sufficient volumes. In this work, DADS was applied at 200l/ha. Other work has shown that the greater the quantity and volume the better the results. Very encouraging results were achieved at Kirton EHS with a very high degree of control with drenches of DADS of 6.25-25l/m^2 ($\frac{1}{4}$"-1"/ac). It was unfortunate that the effect of autumn-applied DADS on disease could not be made as very little disease developed in these trials. The disease scores following combined treatments of sterilants plus DADS were similar to those of the sterilants with no significant advantage resulting from the dual treatment.

Analyses of the results from all five sites showed that significant yield increases were obtained by all the sterilant treatments except for the two rates of metham sodium applied alone. This cannot be explained as these treatments gave the best overall disease control. At Arthur Rickwood, very high yields were achieved in a site with little disease but there were no significant differences between treatments, ie no growth boost was detected following application of sterilants.

The interval between treatment application and planting varied between spring and autumn trials. This was due to the persistency of DADS and its effect on sclerotial germination. Spring application of DADS could be followed by spring planting the next spring. However, it was felt that following an application of DADS in the autumn, the chemical could still be active the next spring/summer and cropping was delayed until the following year, ie 18 months after treatment.

The control of white rot remains a problem for the bulb onion growers and they will ultimately run out of disease-free land. Growers are concentrating their crops on land known to be free of white rot. The use of sterilants alone cannot be relied upon to give good disease control. DADS gave insufficient control in these trials and there was no advantage of the dual treatment applied with sterilants. It may be worthwhile evaluating different formulations of DADS, such as a granule which would not require specialist equipment and could be applied at low rates in the rotation in the absence of an *Allium* crop.

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ONION WHITE ROT CONTROL - STERILANT OR STIMULANT?

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ABSTRACT

The effects of different soil sterilants and sclerotial stimulants on white rot disease and yield were investigated. Significant disease control was obtained with the sterilants 1,3 dichloropropene, metham sodium and dazomet. Autumn-applied dazomet gave better disease control than spring treatments. Dazomet at 570 kg product/ha autumn-applied gave complete control in one trial in the two subsequent years of cropping but in another trial no significant control was achieved in the second crop. No significant differences in disease levels were found between various metham sodium and dazomet treatments applied in the spring. The sclerotial stimulant diallyl disulphide gave up to 50% disease control and in combined treatments with metham sodium and dazomet disease control was similar to that given by the sterilant alone. The effect of treatments on marketable yields was variable with significant yield increases following dazomet treatments. However, no significant marketable yield increases were recorded following spring-applied metham sodium or a low rate diallyl disulphide treatments.

INTRODUCTION

White rot disease caused by the fungus Sclerotium cepivorum remains a major disease of bulb onions in the UK. It is of increasing importance in all the main areas where the crop is grown. The majority of UK bulb onion crops are direct-drilled and in these crops fungicide treatments have been of limited value (Gladders et al., 1984). However, more recently triadimenol and tebuconazole applied as foliar sprays prior to irrigation have given good disease control in trials in Southern Germany (Krauthausen, 1990). A high degree of control was obtained in trials on module-raised bulb onions with pre-planting drenches of myclozolin and procymidone (Gladders et al., 1987). However, these two fungicides are not registered for use in the UK and therefore at present, there is no effective fungicide control of white rot in bulb onions.

The white rot pathogen can survive in the soil for many years. Treatment with partial soil sterilants based on products generating methyl isothiocyanate such as metham sodium or dazomet have given variable results (Adams & Johnson, 1983; Entwistle et al., 1985; Kerr, 1986). At Kirton Experimental Horticulture Station (EHS), autumn-applied dazomet at 380 kg product/ha, metham sodium at 300 l product/ha and 1,3 dichloropropene at 220 l product/ha and sheeted over after application with 500 g polythene gave mean reductions of 75%, 73% and 53% respectively in the number of viable sclerotia artificially buried. Only dazomet gave good disease control and increased yields. At Moulton, Lincs, metham sodium, 1,3 dichloropropene and dazomet were applied as in the previous trial and in addition dazomet at 570 kg product/ha. Only the dazomet treatments gave a good kill of artificially buried sclerotia. Moderate disease was recorded in the metham sodium and 1,3 dichloropropene treated plots, very low levels in the 380 kg product/ha dazomet plots and none in the 570 kg product/ha plots (Davies & Coley-Smith, 1986). However, no significant yield differences were recorded between treatments with 19% modules affected in the untreated plots (J M Ll Davies, unpublished).

Sclerotia of S. cepivorum only germinate in the presence of Allium host plants (Coley-Smith, 1960). The roots of these plants exude compounds which are metabolised by the soil microflora to produce a mixture of thiols and sulphides which stimulate the sclerotia to germinate (Coley-Smith & King, 1969). Sclerotia germinate only once and in the absence of an onion crop they die. Synthetic stimulants offer control opportunities. Substantial reductions in the numbers of sclerotia and disease incidence have been recorded in Australia, (Merriman et al., 1981) and Canada, (Rahe & Utkhede, 1982). The major constituents of artificial onion oil have been tested and diallyl disulphide (DADS) has proved to be the most active (Coley-Smith et al., 1981). At Moulton, Lincs, onion oil soil-injected at 500 l/ha gave some reduction in the numbers of viable sclerotia artificially buried and 36% disease control but did not significantly increase yield (Davies & Coley-Smith, 1986). This paper reviews the recent ADAS trials sponsored both by the Government and by the Horticultural Development Council (HDC).

MATERIALS AND METHODS

All the trials were located on sites in parts of fields where a severe attack of white rot had been noted in the past.

Government-funded trials

Moulton, Lincs

This trial was made to see if the effects of treatments applied in the first year (as previously reported, Davies & Coley-Smith, 1986), persisted into the second year. Metham sodium (BASF Metham Fluid 510 g/l) at 300 l product/ha, 1,3 dichloropropene (Telone 11 94% Dow Agriculture) at 220 l product/ha and onion oil (Bush, Boke & Allen, London) 500 l/ha (diluted 10X) were applied by Rumpstadt Combijet 225 soil injector on 28 October 1985. This machine was also driven through the control plots without any chemical prior to application of treatments. Dazomet (Basamid 98-99%, BASF) at 380 and 570 kg product/ha was applied using a MJF Basamid Incorporator (a spade digger with a hopper) on 5 November 1985. All plots were covered on the day of application with 500 g polythene which was removed prior to planting the first crop on 8 May 1986. The trial design was a randomised block with five replicates. Each plot measured 4 m x 1.83 m with four rows of module-raised plants. The plots were separated from each other by guard beds on each side and a 2 m wide unplanted strip at each end. The plots were located on the no fungicide half of the first year plots. Module-raised onions, cv. Hyton were planted on 5 April 1987 and all subsequent husbandry was according to farm practice. The trial was harvested on 15 October 1987 and assessments were made of disease incidence, marketable and unmarketable yields.

Kirton EHS "quarantine site" - Year 1

Using a MJF Basamid Incorporator dazomet was applied at 380 kg and 570 kg product/ha covered with 125 g polythene, or at 570 kg product/ha and covered with 500 g polythene on 7 November 1986. The untreated control plots were also dug by the Basamid Incorporator but no chemical was applied and plots were covered with 125 g polythene. A light wind blew across the trial at the time of application and some of the Basamid drifted across the plots, especially in two replicates of treatments 5 and 6. More precise application was achieved subsequently by using a hand-held wind shield. Vinclozolin (Ronilan 50% w/w, BASF) was applied pre-planting as a drench at 6.16 g product in 200 ml/tray to a duplicate set of treatments. The experiment was a randomised block design with four replicates, each plot measuring 6 m x 1.83 m. The plots were separated from each other by guard beds on each side and a 2 m wide unplanted strip at each end. The trial was isolated from other onion crops by a 2 m wide unplanted strip at the sides and headlands. Artificially-produced sclerotia of S. cepivorum were supplied by and viability tests made by Professor John Coley-Smith of Hull University. Twenty-five sclerotia mixed with sand and placed in a nylon bag were inserted in a "Netlon String", three bags to each string being spaced out so that they could be buried at depths of 2.5, 10 and 20 cm. Two strings were buried at the two ends of each plot immediately after treatment and were removed on the day of planting. Module-raised onions cv.Hyton were planted on 22 April 1987 and subsequent husbandry was according to farm practice. The trial was harvested on 29 September 1987.

Kirton EHS "quarantine site" - Year 2

This trial was a continuation of the previous trial to investigate whether the effect of soil sterilants had persisted into the second year. No further dazomet treatments were made but all other treatments were identical to those of the first year. The trial was planted on 26 April 1988 and harvested on 14/15 September 1988. All other treatments were identical to the ones of the first year.

HDC-funded trials

In five trials, treatments were applied in the spring at Northorpe, Lincs on 13 May 1987, Kirton EHS (1) on 8 May 1987 (mineral soils) and Methwold Fen, Norfolk (organic peat) on 29 March 1989 and in the autumn at Kirton EHS (2) on 7/8 November 1988 and Arthur Rickwood EHF Mepal Cambs (organic peat) on 27 October 1988. The treatments were identical in all trials and consisted of dazomet at 380 and 570 kg product/ha, metham sodium at 600 and 1200 l product/ha, DADS (Phillips Petroleum and Oxford Organic Chemicals) at 50 l/ha and 200 l/ha, dazomet at 380 kg product/ha plus DADS at 50 l/ha, metham sodium at 600 l product/ha plus DADS at 50 l/ha and metham sodium at 1200 l product/ha plus DADS at 200 l/ha. The metham sodium and the DADS treatments were applied by a Rumpstadt Combijet soil injector. Dazomet was applied using a MJF Basamid Incorporator at Northorpe and Kirton EHS and by hand at Arthur Rickwood EHF and Methwold. At sites where treatments were made by hand, plots were rotovated after application. In order to prevent contamination by DADS in other treatments, the DADS treatments were the last to be applied. All plots, including the untreated, were covered with 125 g polythene which was left on for approximately 6 months at each site. Each trial was a randomised block design with 4 replicates. The plots were separated from each other by unplanted guard beds on each side and a 2 m unplanted strip at each end. In four of the trials each plot measured 4 m x 1.83 m in a treated area of 6-10 m x 2-3 m, with four rows of module-raised plants of cv. Hyton or cv. Caribo. At Methwold three double rows of pickling onions cv. Plastro were drilled in a 1.52 m wide bed. All subsequent husbandry was according to farm practice. The trials were sown or planted in March/April and harvested in August/September. All data were subjected to analysis of variance. Treatment means followed by the same letter within any one column do not differ significantly at P = 0.05 (Duncan's Multiple Range Test).

RESULTS

TABLE 1 Effect of treatments on white rot disease and yield - Moulton

Treatment (product/ha)	% Modules affected	Yield (t/ha) Total	Marketable
1. Untreated	29.0[c]	23.6[a]	22.1[a]
2. Metham sodium 300 l	13.2[b]	26.6[a]	25.7[ab]
3. 1,3 dichloropropene 220 l	11.1[ab]	30.5[ab]	29.6[abc]
4. Onion oil 500 l	12.5[ab]	30.0[ab]	29.2[abc]
5. Dazomet 380 kg	2.1[ab]	32.0[ab]	31.6[bc]
6. Dazomet 570 kg	0.0[a]	37.0[b]	36.7[c]
SED (20 df)	5.7	3.8	3.9

At Moulton (Table 1) all the chemical treatments gave significant control of white rot. These results reflect the previous year's disease scores. The two dazomet treatments significantly increased marketable yield but only the high rate significantly increased total yield.

TABLE 2 Effect of dazomet on artificially buried sclerotia - Kirton EHS

Treatment (product/ha)	Polythene gauge	Mean no. of viable sclerotia/25 depth of burial (cm) 2.5	10	20
1. Untreated	125	17.2[b]	21.0[c]	17.4[b]
2. Untreated	125	21.6[b]	23.3[c]	21.9[b]
3. Dazomet 380 kg	125	0.75[a]	1.8[ab]	0.6[a]
4. Dazomet 380 kg	125	4.9[a]	6.1[b]	2.6[a]
5. Dazomet 570 kg	125	0.0[a]	0.0[a]	2.6[a]
6. Dazomet 570 kg	125	0.0[a]	0.0[a]	0.1[a]
7. Dazomet 570 kg	500	3.1[a]	0.0[a]	3.3[a]
8. Dazomet 570 kg	500	0.0[a]	0.0[a]	0.0[a]
SED (21 df)		3.3	2.1	2.5

TABLE 3 Effect of dazomet on white rot and yield - Kirton EHS Year 1

Treatment (product/ha)	Poly-thene gauge	Pre-planting drench	% Modules affected	Yield (t/ha) Total	Market-able
1. Untreated	125	-	52.6[b]	22.5[a]	20.3[a]
2. Untreated	125	Vinclozolin	43.6[b]	30.9[b]	26.9[ab]
3. Dazomet 380 kg	125	-	13.0[a]	44.3[cd]	41.1[d]
4. Dazomet 380 kg	125	Vinclozolin	10.0[a]	46.5[d]	43.7[d]
5. Dazomet 570 kg	125	-	17.0[a]	35.9[bc]	31.1[bc]
6. Dazomet 570 kg	125	Vinclozolin	4.6[a]	38.6[bcd]	35.6[bcd]
7. Dazomet 570 kg	500	-	6.6[a]	42.9[cd]	40.6[cd]
8. Dazomet 570 kg	500	Vinclozolin	5.6[a]	44.2[cd]	41.9[d]
SED (21 df)			8.6	3.9	4.4

In the first year at Kirton EHS moderate to high levels of white rot developed. All the dazomet treatments gave a significant kill of sclerotia at the three depths (Table 2), and significant disease control and increases in total and marketable yields (Table 3). Dazomet at 570 kg product/ha and covered with 125 g polythene gave a significant lower yield than dazomet at 380 kg product/ha and covered with 125 g polythene.

TABLE 4 Effect of dazomet on white rot disease and yield - Kirton EHS, Year 2

Treatment (product/ha)	Poly-thene gauge	Pre-planting drench	% Modules affected	Yield (t/ha) Total	Market-able
1. Untreated	125	-	26.5[a]	20.8[a]	18.9[a]
2. Untreated	125	Vinclozolin	21.5[a]	21.6[a]	21.4[a]
3. Dazomet 380 kg	125	-	22.5[a]	28.4[a]	26.8[a]
4. Dazomet 380 kg	125	Vinclozolin	14.0[a]	28.3[a]	26.5[a]
5. Dazomet 570 kg	125	-	10.5[a]	29.5[a]	27.9[a]
6. Dazomet 570 kg	125	Vinclozolin	15.0[a]	28.4[a]	27.5[a]
7. Dazomet 570 kg	500	-	17.0[a]	28.1[a]	26.2[a]
8. Dazomet 570 kg	500	Vinclozolin	22.0[a]	25.0[a]	23.6[a]
SED (21 df)			8.8	4.1	4.1

Low to moderate levels of white rot developed in the second year of the trial and no significant effects of treatments were recorded (Table 4).

TABLE 5 Effect of treatments on disease and yield - HDC funded trials

Treatment (product/ha)	% Disease incidence[1]	Ang trans[2]	Yield (t/ha)[3] Total	Marketable
1. Untreated	42.2*	40.4	31.7	30.2
2. Dazomet 380 kg	19.8	22.4	38.0	36.1
3. Dazomet 570 kg	17.4	19.3	38.9	37.0
4. Metham sodium 600 l	20.7	21.8	36.1	34.5
5. Metham sodium 1200 l	13.8	15.8	33.4	21.4
6. DADS 50 l	30.1	29.4	35.9	34.4
7. DADS 200 l	21.1	23.0	38.4	37.0
8. Dazomet 380 kg + DADS 50 l	17.5	19.5	39.6	37.3
9. Metham sodium 600 l + DADS 50 l	17.7	18.7	38.5	36.4
10. Metham sodium 1200 l + DADS 200 l	11.3	16.5	39.9	37.9
SED		3.67	2.15	2.19
df		81	135	135

1 Mean of three trials, Northorpe, EHS(I) and Methwold.
2 Disease data angular transformed.
3 Mean of five trials.

Low, moderate and high white rot disease levels developed at Northorpe, Kirton EHS(1) and Methwold sites respectively (Table 5). Little disease was recorded at the other two sites with the exception of one plot of treatment 5 at the Kirton EHS(2) site which was severely affected. Results from the three sites showed that all treatments gave significant control of white rot with the best control (approximately 70%) achieved from treatments which included metham sodium at 1200 l product/ha. The control from the low rate and high rate DADS treatments was 28% and 50% respectively. The combined treatments of sterilants plus DADS gave similar results to those given by the sterilants alone. Data from the five sites showed that total yields were significantly increased by all treatments except metham sodium at 1200 l product/ha and DADS at 50 l product/ha. Marketable yields were significantly increased by all treatments except by metham sodium at 600 l or 1200 l product/ha and DADS 50 l product/ha.

DISCUSSION

These investigations have confirmed the variability in white rot control achieved with soil sterilants. Overall, dazomet applied in the autumn gave approximately 85% while spring applications gave only 56%. No significant differences in disease control were found between the 380 and 570 kg/product/ha rates of dazomet but lower disease scores were recorded following the latter. At Kirton EHS there were no significant differences in disease control between the two thicknesses of polythene sheet used to seal the dazomet treatments. In the same trial, although there was up to 100% kill of artificially buried sclerotia this did not result in comparable disease control. However, at Moulton, following the 570 kg/product/ha rate of dazomet there was 100% kill of buried sclerotia and complete disease control (Davies & Coley-Smith, 1986). The persistency of dazomet treatments was studied in two subsequent crops at two sites. At Moulton a high degree of control was achieved with the 380 kg/product/ha rate with complete control following the 570 kg product/ha treatment. However, at Kirton EHS the control achieved in the first year did not persist into the second year. It was likely that this lack of persistence resulted from the unsatisfactory method of application. Signficant yield increases were recorded following the dazomet treatments. In the HDC sponsored trials the effect of treatments on disease control could only be evaluated at three sites. Unfortunately, the effect of autumn-applied treatments on disease control could not be assessed as little disease developed on these sites despite a history of white rot, a situation similar to that encountered by Entwistle et al., (1986). Dazomet and metham sodium gave significant disease control, although, inexplicably, no significant increase in marketable yields were detected following metham sodium treatments. The effects of sclerotial stimulants on disease control were disappointing. Onion oil at Moulton gave a mean of 46% control over two years and DADS at the low and high rates gave 28% and 50% control respectively in the HDC trials. Possibly, DADS was not applied in sufficient volume (the highest rate used was 200 l/ha) as the greater the quantity and volume the better the results (Coley-Smith et al., 1986). In higher volumes DADS gave a high degree of control (72-92%) in module-raised bulb onions with drenches of 6.25-25 l/m^2 (Davies & Coley-Smith, 1990). It was unfortunate that the effect on disease of autumn-applied DADS could not be evaluated. The disease scores following combined treatments of sterilants and DADS were similar to those of the sterilant alone with no significant advantages resulting from the dual treatment.

The control of white rot remains a problem for the bulb onion growers and they will ultimately run out of disease-free land. Growers are concentrating their crops on land known to be free of white rot. The use of sterilants alone cannot be relied upon to give good disease control. DADS gave insufficient control in these trials and there was no advantage of the dual treatment applied with sterilants. It may be worthwhile evaluating different formulations of DADS, such as a granule which would not require specialist equipment and could be applied at low rates in the rotation in the absence of an Allium crop.

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