USE OF DIALLYL DISULPHIDE FOR THE COMMERCIAL CONTROL OF *SCLEROTIUM CEPIVORUM*

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ABSTRACT

Soil treatment with diallyl disulphide (DADS) for the control of *Allium* white rot (*Sclerotium cepivorum* Berk.) was studied in two trials under commercial growing conditions. In the 1996-1998 trial two applications of DADS gave a 79% increase in yield when compared with the untreated control; the addition of three tebuconazole applications gave no extra yield. One application of DADS gave a 33% increase in yield. In the 1998-2000 trial various DADS application rates were tested. All DADS treatments resulted in a large reduction in *Allium* white rot incidence compared with the untreated control. Application of DADS gave a 57% increase in yield relative to the untreated control.

Keywords: *Sclerotium cepivorum*, *Allium* white rot, diallyl disulphide, germination.

INTRODUCTION

Allium white rot (*Sclerotium cepivorum* Berk.) is a serious fungal disease of *Allium* crops in New Zealand. It is capable of destroying up to 90% of plants in severely infested fields and, in the Pukekohe and Blenheim districts, is causing many growers to relocate farming activities to disease-free sites. Until recently, the only control options available were extended rotations and use of fungicides. There has been a decline in efficacy of most fungicides currently registered for use on onions (Tyson *et al.* 1999) and alternative control methods are urgently needed.

The fungus infects the roots and bulb of *Allium* species, forming a conspicuous white mycelial mass. Sclerotia (resting structures) formed on the rotting bulb can survive in a dormant state in the soil for long periods.

The sclerotia break dormancy and germinate as a specific response to exudates, including sulphoxides, produced by *Allium* sp. and to the breakdown products of these compounds (Coley-Smith *et al.* 1987). The fungus has no free-living stage in the soil and, while a percentage (approximately 0.5%) may first form secondary sclerotia (Merriman *et al.* 1981), the majority die unless a host is available. This characteristic offers an opportunity to reduce sclerotial numbers by stimulating their germination in the absence of the host. Natural garlic and onion oils have been used for this purpose, but results have been variable (Coley-Smith and Parfitt 1986). Synthetically produced diallyl disulphide (DADS), a natural constituent of garlic and onion oil, has been shown to be able to stimulate germination of *S. cepivorum* sclerotia in the absence of an *Allium* crop (King and Coley-Smith 1969).

This paper reports the results of the use of diallyl disulphide for the control of *S. cepivorum* in two field trials under commercial farming conditions.

METHODS

Trials were carried out over two periods (1996-98 and 1998-2000) on a commercial property at Tuakau in the Pukekohe district. Both trial sites were known, from past cropping experience, to be heavily and uniformly infested with *Allium* white rot. The DADS was applied in aqueous solution (700 litres/ha) by means of a pump driven

injection system on a modified tractor toolbar. The soil surface was compacted by a roller mounted behind the toolbar to minimise loss of DADS vapour.

Trial 1: 1996-98

The trial was carried out in a field which, in the 1995-96 season, suffered extreme losses from white rot across the whole area (approximately 3 ha). It was intended that the field be taken out of onion production but was replanted by the grower (T.A. Reynolds Ltd) specifically to evaluate the efficacy of DADS.

The treatments applied in the 1996-98 trial are shown in Table 1. Each DADS treatment (treatments 1-3) consisted of a block of 11 beds of onions, with a total area of 0.7 ha/treatment. An untreated control area (treatment 4) consisted of a further 11 beds of onions (0.7 ha). Treatment 1 received three foliar applications of tebuconazole (as Folicur 430SC) at 0.375 kg/ha (recommended label rate) during the growing season. Treatments 2-4 did not receive fungicide. Due to the commercial conditions under which the trial was carried out, the treated blocks were laid out consecutively across the field and there was no replication. The second application of DADS was made immediately after the area had been sown in a mustard cover crop. The cover crop was cultivated during the autumn and onions planted on 10 June 1997. At maturity each treatment was harvested, the onions graded in the normal commercial manner and marketable yield and market value determined.

TABLE 1: Date of treatments and rates of application of DADS (litres/ha) in Trial 1, 1996/98.

Date of treatment	Treatment			
	1	2	3	4 (control)
9 December 1996	10	10	10	Nil
2 May 1997	10	10	Nil	Nil
Tebuconazole ¹	Yes	Nil	Nil	Nil

¹tebuconazole applied monthly from six weeks after planting.

Trial 2: 1998-2000

The treatments applied in the 1998-00 trial are shown in Table 2. Each DADS treatment consisted a block of five beds of onions, with an area of approximately 0.1 ha (treatments 1-4). An untreated control area (treatment 5) consisted of a further 11 beds of onions, with an area of approximately 0.2 ha. The treatment blocks were adjacent to each other and, because of commercial considerations by the grower, there was no replication. The onions were planted on 23 June 1999. After emergence two observation plots (5 m of bed) were marked out in each of the three inner beds of each treated area. Initial plant populations were counted and the plots monitored for the presence of *Allium* white rot throughout the season.

TABLE 2: Date of treatments and rates of application of DADS (litres/ha) in Trial 2, 1998/00.

Date of treatment	Treatment				
	1	2	3	4	5 (control)
2 November 1998	5	5	10	10	Nil
23 April 1999	5	10	5	10	Nil

At maturity the trial area was harvested. As there was no difference in *Allium* white rot incidence between the four DADS treatments, onions were lifted from eleven adjacent beds in the treated area and eleven in the untreated area (0.2 ha each). The onions were commercially graded and marketable yield and market value for each area determined.

The percentages of diseased plants in individual observation plots were subjected to arc-sine transformation and analysed using analysis of variance (ANOVA) with the statistical programme Genstat. Differences between treatments were determined using Fisher's Least Significant Difference (LSD).

RESULTS AND DISCUSSION

The mustard cover crop in the area of Trial 1 germinated normally within a week of the DADS application and there was no evidence of phytotoxicity. The results from Trial 1 are summarised in Table 3. Two applications of DADS (10 litres/ha + 10 litres/ha) resulted in yield increases of over 70% compared with the untreated area. There was no further increase in yield from the use of tebuconazole in addition to the two applications of DADS. At 1998 market prices, two applications of DADS provided increased returns of approximately \$12,000/ha.

TABLE 3: Marketable yield (kg/ha), percentage increase in yield compared with untreated controls (%) and estimated returns (\$/ha) after different DADS and fungicide treatments in Trial 1, 1996-98.

No.	Treatment	Marketable yield	Increase in yield	Increase in return ¹
1	2 applications of DADS + 3 foliar sprays of tebuconazole	44,900	70.7	\$10,844
2	2 applications of DADS, no fungicide	47,200	79.5	\$12,185
3	1 application of DADS, no fungicides	35,100	33.5	\$5,131
4	Untreated (control)	26,300	-	-

¹Based on an estimated 1998 market value of \$583/tonne.

The results from the observation plots in Trial 2 are summarised in Table 4 and illustrated as disease progress curves (back-transformed treatment means) in Fig. 1. Treatment with DADS reduced disease incidence from 45% to 2.7-6.7%. The DADS treatments were not significantly different from one another. Yields for the different treatments are presented in Table 5. Two applications of DADS resulted in a yield increase of 57% compared with the untreated area. At 2000 market prices, two applications of DADS provided increased returns of approximately \$1,574/ha.

TABLE 4: Mean *Allium* white rot infection (%) and SEM, Trial 2, 1999-00.

Treatment	<i>Allium</i> white rot infection ² (%)	SEM	<i>Allium</i> white rot (back-transformed %)	
1	15.0	2.17	6.7	b ¹
2	9.4	1.51	2.7	b
3	11.6	1.40	4.0	b
4	12.2	1.68	4.5	b
5	42.2	4.23	45.2	a
Fishers LSD (P<0.05)	7.09			

¹Treatments with different letters are significantly different P<0.05.

²Arc-sine transformed values.

FIGURE 1: Cumulative *Allium* white rot infection (%) in observation plots after different DADS treatments in Trial 2, 1998-00. The values are back-transformed means.

TABLE 5: Marketable yield (kg/ha), percentage increase in yield compared with untreated controls (%) and estimated returns (\$/ha) from the combined DADS treatment blocks in Trial 2, 1998-00.

No.	Treatment	Marketable yield	Increase in yield	Increase in return ¹
1-4	DADS treatments (combined)	31,550	57	\$1,574
5	Untreated (control)	20,100	-	-

¹Based on an estimated 2000 market value of \$137.50/tonne.

All DADS treatments resulted in a large reduction in disease incidence (from approximately 45% to 5%), with a corresponding increase in yield. Statistical analysis showed a highly significant treatment effect from the use of DADS with low variability within each treated area. Unfortunately lack of replication prevented a statistical measure of variability of disease across the trial area. However, it is known from long experience of onion cropping in that site that the area is heavily and uniformly infested by *Allium* white rot (P.J. Reynolds, pers. comm.). Thus, in view of the magnitude of the differences obtained, we are confident that the results are a valid measure of treatment effects.

The results from both trials reported here demonstrate that under commercial growing conditions DADS can provide a high level of control of the disease. DADS offers an attractive control option as it results in a reduction of sclerotium populations and can be applied while a cover crop is in place. In addition to an immediate increase in return per hectare, the advantages of treatment could be expected to persist for several cropping seasons.

DADS was registered for use on onions in New Zealand in 1999, representing the first registration of DADS for *Allium* white rot control worldwide. The chemical is commonly used in the food industry as a garlic flavouring substance and the limited scale of manufacture at present results in a relatively high cost per litre. Despite the low market value of onions in 2000, which led to a much lower financial benefit from treatment in that year than in 1998, the additional return would still have covered the

cost of the chemical applied in that year. As usage increases, particularly if the compound is registered for use on onions overseas, it is anticipated that the cost/benefit ratio of the treatment will be improved.

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