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Evaluation of fungicides for the management of sclerotinia blight of peanut

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Abstract. Three trials were conducted in the Burnett region of southern Queensland, Australia, in the 1993–94 and 1994–95 seasons to determine the efficacy of fluazinam, procymidone, and iprodione for managing sclerotinia blight of peanut. Different combinations of rates, nozzle types, and spraying times were used in each trial. Two or 3 sprays of fluazinam at 0.75 and 1.0 kg a.i./ha, and of procymidone at 0.688 and 0.75 kg a.i./ha, were the most effective combinations that reduced disease incidence and increased yield. Iprodione at rates up to 0.5 kg a.i./ha did not significantly improve the yield compared with unsprayed treatments in any trial. In one trial at Tingoora in 1994–95, pre-infection treatments in which the first spray of fluazinam or procymidone was applied before symptoms appeared were more effective than post-infection treatments in which the first spray was applied soon after symptoms were seen. At J. Bjelke-Petersen Research Station (JBPRS) in 1994–95, a banded spray of procymidone at 0.688 kg a.i./ha using a single flat-fan 8004VB nozzle centred over the row significantly increased yield and reduced disease incidence compared with a spray using 3 hollow-cone nozzles (HB4-70) per row, with 1 nozzle over the row and 1 drop nozzle on each side of the row directed at the bases of the plants. At JBPRS in 1993–94, a band spray of fluazinam at 0.333 kg a.i./120 L.ha, applied with a single flat-fan 80015EVB nozzle immediately after the appearance of symptoms, was as effective in reducing the rate of disease development for 3 weeks, as was a directed application using three 80015EVB nozzles at the same time and concentration, but at 3 times the rate per area (1.0 kg a.i./360 L.ha).

Additional keywords: *Arachis hypogaea* L., fluazinam, procymidone, iprodione, *Sclerotinia minor.*

Introduction

Sclerotinia blight, caused by *Sclerotinia minor* Jagger, is a serious disease of peanut in many parts of the world (Kohn 1979; Porter 1980). In the United States it has become the most destructive disease of peanut in Virginia since its first report in 1971 (Porter and Beute 1974; Porter 1980) and it is an important disease in North Carolina, Oklahoma, and Texas. In 1982, farm income losses in Virginia alone were estimated at $US8.6 million, and annual disease losses of up to 13% were reported in years favourable for severe disease development (Brenneman *et al*. 1987*a*). Despite the use of iprodione, which was registered for use on peanuts in 1985 (Smith *et al*. 1992), losses in yield between 1988 and 1991 in Virginia averaged 6% annually, resulting in an estimated loss of $US6.6 million.

Sclerotinia minor was first reported on peanut in Australia in the late 1940s (Anon. 1948) but it was not recorded in the Burnett region of southern Queensland until the mid 1980s (Queensland Department of Primary Industries, R. G. Shivas, unpubl. data). The pathogen spread rapidly in the region after its introduction and is now one of the most serious soilborne diseases in Australia. The Burnett region produces approximately 65% of Australia's peanut crop (30 000 ha), valued at $AU19 million in 1992. In that year, when sclerotinia blight was widespread and severe in the region, the estimated total loss from the disease was $AU2 million (I. Crosthwaite, pers. comm.). Such losses have resulted in the need to develop cost-effective management strategies.

Although peanut genotypes with relatively high levels of resistance to *S. minor* have been identified (Akem *et al*. 1992), there are at present no commercial cultivars with equivalent levels of resistance being grown in Australia. Applications of fungicides will remain the primary method of disease management until such cultivars are developed.

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The dicarboximide fungicides, iprodione, vinclozolin, and procymidone, significantly reduce disease severity and increase yield in infested fields (Porter 1980; Dougherty *et al*. 1983; Phipps 1983; Brenneman *et al*. 1987*a*). However, only iprodione has been registered for the control of sclerotinia blight in the United States (Porter and Phipps 1985*a*), despite the greater efficacy of other fungicides (Smith *et al*. 1992). Brenneman *et al*. (1987*a*) reported that iprodione reduced the disease incidence by 45–55%, and Smith *et al*. (1991*a*) demonstrated that spray adjuvants such as pinolene further improved the efficacy of the fungicide. However, some isolates of *S. minor* are resistant to these fungicides *in vitro* (Porter and Phipps 1985*a*, 1985*b*; Brenneman *et al*. 1987*b*). Brenneman *et al*. (1987*b*) also reported that 2 isolates of *S. minor* with *in vitro* resistance to iprodione and vinclozolin were pathogenic to peanut in field microplots, raising doubts about the long-term effectiveness of these fungicides. Recently, fluazinam has been shown to provide higher levels of protection against *S. minor* than the dicarboximides (Smith *et al*. 1992; Phipps 1994, 1995).

Iprodione at 0.50 kg a.i./ha is the only fungicide registered for the management of sclerotinia blight on peanut in Queensland. Procymidone at 0.550–0.825 kg a.i./ha was registered for this purpose until 1998, but was voluntarily withdrawn by its marketing company. In the Burnett region, these fungicides were applied by ground and by aircraft sprays usually after infection had occurred. In recent years there have been many reports of inconsistent disease control. Preliminary investigations found no evidence for the existence of dicarboximide-resistant strains of *S. minor* (R. G. O'Brien, pers. comm.). Information was needed on the relative efficacy of registered and unregistered fungicides, timing of sprays, and the methods of application for disease control. Three trials were undertaken in the region to gather data on (*i*) the efficacy of different rates of iprodione, procymidone, and fluazinam, (*ii*) the relative effectiveness of applying fungicides before disease symptoms appear compared with spraying after symptoms are obvious, and (*iii*) differences in efficacy between application techniques.

Materials and methods

Three trials were conducted in the 1993–94 and 1994–95 seasons in the Burnett region, one in both seasons at the J. Bjelke-Petersen Research Station (JBPRS), Kingaroy, and one in 1994–95 on a grower's property near Tingoora. Both trials at JBPRS were conducted in an area where *S. minor* had not been previously found. This area was inoculated on 5 January 1994 (36 days after the 1993–94 trial was planted), with a mixture of sand and sclerotia of *S. minor* (at approximately 720 sclerotia/m of row) produced *in vitro* on sterilised oat and millet seed during the preceding 6 months. The area was inoculated again on 1 February 1995 (22 days after the 1994–95 trial was planted) with a similar sand–sclerotia mixture (approximately 224 sclerotia/m row). The Tingoora trial was conducted at a site with a history of *S. minor* infection of peanut. The soils at both sites are deep, red clay–loams or Oxisols (Anon. 1975). For weed control the soil was treated with the pre-emergence herbicide trifluralin (as Trifluralin EC, 557 g/L, Nufarm), at 0.84 kg a.i./ha, 2 weeks before planting in all trials.

A randomised complete block design was used in all trials. Seeds were planted at 70 kg/ha, resulting in approximately 60 000 plants/ha at a row spacing of 90 cm. Early leaf spot (*Cercospora arachidicola* Hori), late leaf spot (*Cercosporidium personatum* [Berk. & Curt.] Deighton), and rust (*Puccinia arachidis* Speg.) were managed at JBPRS in 1993–94 by an application of tebuconazole (Folicur 250 EC 250 g/L, Bayer Corp.) at 0.175 kg a.i./ha, 105 days after planting (DAP), and in 1994–95 by 3 applications of chlorothalonil (Bravo 500, 500 g/L, Rhône-Poulenc Australia) at 0.8 kg a.i./ha, 56, 77, and 98 DAP. Leaf spots and rust were managed at Tingoora by an application of tebuconazole (Folicur 250 EC) at 0.075 kg a.i./ha, 90 DAP. These fungicides effectively controlled foliar diseases in all trials. During 1993–94 at JBPRS, rainfall was supplemented with overhead irrigation to maintain a weekly total of at least 30 mm between 43 and 99 DAP. In 1994–95 at JBPRS, a total of 324 mm rainfall and irrigation water was recorded, with 152 mm between 64 and 85 DAP and 73 mm between 113 and 120 DAP. At Tingoora, irrigation was not applied and a total of 309 mm of rainfall was received, with 144 mm recorded between 57 and 71 DAP and 52 mm at 106 DAP.

All fungicide treatments were applied with a self-propelled sprayer whose ground speed, boom height, and pressure were adjustable. The fungicides procymidone (as Sumisclex 500 Flocol FL, 500 g/L, ICI Crop Care Australia), fluazinam (as Shirlan SC, 500 g/L, ICI Crop Care Australia), and iprodione (as Rovral Liquid SC, 250 g/L, Rhône-Poulenc Australia) were tested in the trials at JBPRS in 1993–94 and at Tingoora, whereas only procymidone and fluazinam were tested at JBPRS in 1994–95. In trials at JBPRS, the wetting agent Agral 600 was added to all the fungicide mixtures, at 55 mL/100 L spray mix in 1993–94, and at 20 mL/100 L (v/v) in 1994–95. Agral 600 was added only to the fluazinam and procymidone mixtures in the Tingoora trial at 20 mL/100 L.

Field trial 1, JBPRS, 1993–94

The cultivar Virginia Bunch was planted on 30 November 1993 in plots consisting of four 12-m-long rows. There were 3 replicates of 20 fungicide treatments and 6 replicates of the unsprayed plots. There was another treatment of 3 replicates in which plots were neither inoculated nor sprayed with fungicides for sclerotinia control. Fungicides were sprayed once or twice; the first time at 50 DAP, the second spray being applied at 78 or 105 DAP. Fluazinam was applied at 0.167, 0.333, 0.5, or 1.0 kg a.i./ha in the first spray and at 0.5 or 1.0 kg a.i./ha in the second spray. Procymidone treatments were 0.25 or 0.75 kg a.i./ha in the first spray and 0.75 kg a.i./ha in the second spray. Applications of iprodione used 0.167 or 0.5 kg a.i./ha in the first spray and 0.5 kg a.i./ha in the second spray. The first spray of all fungicides was applied when sclerotinia blight was first observed in the trial (50 DAP), as either a band spray with 1 Teejet flat-fan 80015EVB nozzle at 150 kPa directly over the centre of the row delivering 120 L/ha, or as a directed spray with three 80015EVB nozzles per row (1 nozzle over the row and 1 drop nozzle on each side of the row directed at the base of the plants) delivering 360 L/ha. There were 5 application methods × timing combinations: a band spray at 50 DAP, with or without a directed spray at 78 DAP or 105 DAP, and a directed spray at 50 DAP followed by a directed spray at 78 or 105 DAP.

The number of infected plants was counted in the 2 centre rows of each plot at 58, 78, 105, and 135 DAP. The final assessment included a disease severity rating: 0, no infection; 1, 1–33% branches infected; 2, 34–66% branches infected; 3, >67% branches infected. Pods were harvested from the plants in the middle 10 m of each of the 2 centre rows at 157 DAP, artificially dried, and weighed to determine yield.

Field trial 2, JBPRS, 1994–95

The cultivar Streeton was planted on 10 January 1995 in plots consisting of 4 rows each 10 m long. There were 4 replications of 8 fungicide treatments consisting of fluazinam and procymidone, applied at 49, 79, and 108 DAP at various rates and nozzle configurations. The first spray of both fungicides was applied when signs of sclerotinia infection were first observed. Fluazinam was applied at 0.75 or 1.00 kg a.i./ha with 3 Delavan hollow-cone nozzles (HB4-70) per row, which delivered 206 L/ha, and at 0.250 or 0.333 L a.i./ha with a single HB4-70 nozzle per row, which delivered 68.7 L/ha, all at 300 kPa. Procymidone was applied at 0.229 kg a.i./ha with a single HB4-70 nozzle or with 1 Teejet flat-fan nozzle (8004VB) in a 30-cm band over the row, and at 0.668 kg a.i./ha with 3 HB4-70 nozzles or with one 8004VB nozzle in a 90-cm band. The narrow band using the 8004VB nozzle was achieved by rotating the nozzle about its vertical axis to an angle of 30° between the plane of spray and the row. The orientations of the single hollow-cone nozzle and the 3 hollow-cone nozzles were the same as those for the 80015EVB nozzles, as outlined above for Field trial 1.

The numbers of 30-cm row segments with symptomatic plants (hereafter referred to as infection centres) at 49, 76, 92, 119, and 135 DAP, and the numbers of plants with >50% of dead stems at 135 DAP, were counted in the 2 centre rows of each plot. Plants were harvested from the middle 9 m of each of the 2 centre rows at 153 DAP and the yield was determined as described previously.

Field trial 3, Tingoora, 1994–95

The cultivar NC7 was planted on 14 December 1994 in plots consisting of four 13-m-long rows. The 12 treatments (11 fungicide treatments and an unsprayed treatment) were replicated 4 times. The first spray of fluazinam was applied either at 57 DAP (pre-infection) at 0.5 kg, 0.75 kg, or 1.0 kg a.i./ha, or at 70 DAP (post-infection) at 0.75 or 1 kg a.i./ha. All of the above treatments were applied with 3 HB4-70 nozzles per row, delivering 206 L/ha at 300 kPa. Procymidone was applied at 0.5 kg a.i./ha and 0.688 kg a.i./ha at 70 DAP using one 8004VB nozzle per row delivering 377 L water/ha at 250 kPa in a 90-cm band, or at 0.688 kg a.i./ha, at 57 or 70 DAP, using 3 HB4-70 nozzles per row. Iprodione was applied at 0.5 kg a.i./ha with 3 HB4-70 nozzles per row 70 DAP. The arrangement and orientation of nozzles was the same as outlined above in Field trial 2; a 90-cm band width was used for the flat-fan nozzle. A second spray was applied at 104 DAP for all treatments using the same fungicide and rate as that of the first spray, except that for one of the fluazinam treatments at 1.0 kg a.i./ha the second spray was procymidone at 0.688 kg a.i./ha.

The numbers of infection centres at 70, 97, 118, 142, and 161 DAP, and the numbers of plants with >50% of dead stems 142 DAP, were counted in the 2 centre rows of each plot. Plants were harvested from

Table 1. Efficacy of fungicides in controlling sclerotinia blight of peanut at J. Bjelke-Petersen Research Station, Kingaroy, in 1993–94

First spray applied at 50 days after planting (DAP) as a band (120 L/ha) with one 80015EVB nozzle per row or as a directed spray (360 L/ha) with three 80015EVB nozzles. Second spray applied at 78 or 105 DAP as a directed spray (360 L/ha) using three 80015EVB nozzles. Disease index at 135 DAP: 0, no infection; 1, 1–33% branches infected; 2, 34–66% branches infected; 3, >67% branches infected

First spray		Second spray		Disease	Yield
Rate (kg a.i./ha)	Application method	DAP	Rate (kg a.i./ha)	index (0–3)	(kg/ha)
		Fluazinam			
0.167	Banded	—	—	1.5	1567
0.167	Banded	78	0.500	1.3	2137
0.167	Banded	105	0.500	1.5	1854
0.333	Banded	—	—	1.4	1731
0.333	Banded	78	1.000	0.8	3745
0.333	Banded	105	1.000	1.5	1943
0.500	Directed	78	0.500	1.1	2334
0.500	Directed	105	0.500	1.4	1891
1.000	Directed	78	1.000	0.7	3281
1.000	Directed	105	1.000	1.2	2287
		Procymidone			
0.250	Banded	—	—	1.6	1762
0.250	Banded	78	0.750	1.4	2056
0.250	Banded	105	0.750	1.4	1674
0.750	Directed	78	0.750	0.9	3041
0.750	Directed	105	0.750	1.4	1741
		Iprodione			
0.167	Banded	—	—	1.6	1361
0.167	Banded	78	0.500	1.6	1665
0.167	Banded	105	0.500	1.6	1336
0.500	Directed	78	0.500	1.6	1633
0.500	Directed	105	0.500	1.5	1672
		Unsprayed			
—	—	—	—	1.6	1332
		Uninoculated			
—	—	—	—	0.0	4279
l.s.d. (P = 0.05)				0.2	353

the middle 12 m of each of the 2 centre rows at 167 DAP and the pod yield was determined as previously described.

Statistical analysis

In all the trials, differences between treatments in the parameters used to measure disease incidence or severity, and yield, were determined using an analysis of variance (ANOVA). Differences discussed below are significant at $P = 0.05$.

Results

Field trial 1

The non-inoculated treatment had no *S. minor*-infected plants and a mean yield of 4279 kg/ha, which was significantly higher than of all the inoculated treatments (Table 1). Fluazinam sprayed in a band at 0.333 kg a.i./ha followed by a directed spray at 1.0 kg a.i./ha at 78 DAP resulted in a significantly higher yield than all other inoculated treatments. The yields of treatments sprayed at 50 and 78 DAP with fluazinam at 1.0 kg a.i./ha and procymidone at 0.75 kg a.i./ha were significantly higher than those of the remaining inoculated treatments. None of the iprodione treatments was effective. A single banded spray of procymidone at 0.25 kg a.i./ha or fluazinam at 0.333 kg a.i./ha 50 DAP without a second spray resulted in significantly higher yields and lower disease incidence than the unsprayed treatment, but both had approximately half the yield of the best treatment. Most treatments with a second spray 78 DAP were more effective than the corresponding treatment where the second spray was applied 105 DAP (Table 1).

Table 2. Effect of banded and directed sprays applied at 50 days after planting (DAP) on the percent increase in diseased peanut plants between 58 and 78 DAP at J. Bjelke-Petersen Research Station, Kingaroy, in 1993–94

Spray applied 50 DAP as a band (120 L/ha) with one 80015EVB nozzle per row or as a directed spray (360 L/ha) with three 80015EVB nozzles per row

Rate (kg a.i./ha)	Application method	% Increase in infected plants[A]
	Fluazinam	
0.167	Banded	52
0.333	Banded	8
0.500	Directed	16
1.000	Directed	0
	Procymidone	
0.250	Banded	46
0.750	Directed	35
	Iprodione	
0.167	Banded	99
0.500	Directed	99
	Unsprayed	
—	—	95
l.s.d. (P=0.05)		32

[A]Between 58 and 78 DAP.

The relative effectiveness of banded sprays and directed sprays applied at 50 DAP in controlling disease development between 58 and 78 DAP was determined by comparing the percent increase in disease incidence during this period (Table 2). Data from all treatments, irrespective of whether or not they were sprayed a second time, were used in the analysis. The best treatments were fluazinam as a directed spray at 0.5 and 1.0 kg a.i./ha or as a banded spray at 0.333 kg a.i./ha. Procymidone provided some control, but was less effective than fluazinam, whereas iprodione was ineffective.

Sclerotinia blight developed rapidly in the inoculated, unsprayed treatment and in the iprodione treatment, and by 78 DAP almost all plants were infected (Fig.1). Fluazinam and procymidone reduced the rate of increase of the numbers of infected plants in the first 20 days after spraying, and the best, a directed spray of fluazinam at 1.0 kg a.i./ha, prevented new infections. Application of a second directed spray of fluazinam at 0.50 and 1.0 kg a.i./ha and of procymidone at 0.75 kg a.i./ha at 78 DAP reduced the rate of disease development compared with that in the control plots for another 27 days for the directed sprays. After this time the disease increased at a faster rate for most treatments. Fluazinam at 1.0 kg a.i./ha and procymidone at 0.75 kg a.i./ha applied 78 DAP stopped the development of disease for at least 27 days. The lower rate of fluazinam (0.5 kg a.i./ha) also slowed disease development, but not as much as the other 2 treatments. Procymidone sprayed at 0.75 kg a.i./ha 105 DAP also reduced the rate of increase in the numbers of infected plants, but the increase between 58 and 105 DAP was such that the disease incidence and severity in these treatments were

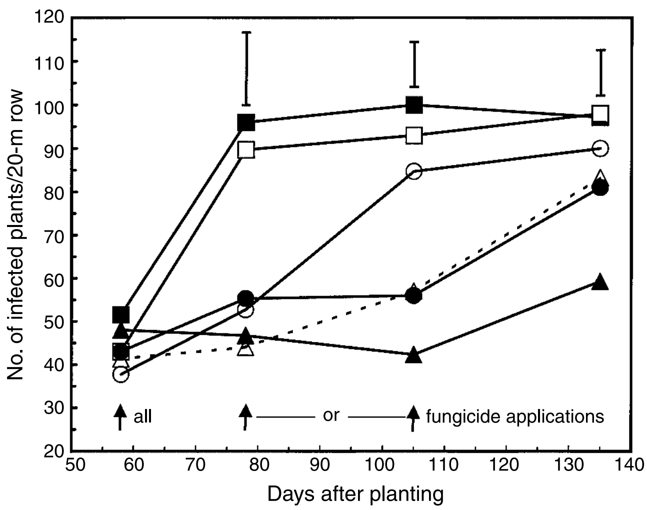

Fig. 1. Effects of selected treatments of fluazinam (--△-- 0.5, 78; —▲— 1.0, 78), procymidone (—○— 0.75, 105;—●— 0.75, 78), and iprodione (—□— 0.5, 78) (—■— unsprayed) on development of sclerotinia blight (number of infected plants) at J. Bjelke-Petersen Research Station, Kingaroy, in 1993–94. Bars represent l.s.d. (P = 0.05) values. Legend abbreviations: rate of first (50 DAP) and second sprays in kg a.i./ha, DAP of second spray. All treatments were applied with 3 flat-fan 80015EVB nozzles as a directed spray.

Table 3. Efficacy of fungicides in controlling sclerotinia blight of peanut at J. Bjelke-Petersen Research Station, Kingaroy, in 1994–95

All fungicide treatments were applied 49, 79, and 108 days after planting. The flat-fan nozzle (8004VB) delivered 377 L/ha, the single hollow-cone nozzle (HB4-70) delivered 68.6 L/ha, and the 3 hollow-cone nozzles (HB4-70) delivered 206 L/ha

Rate (kg a.i./ha)	Nozzles	Plants with >50% dead stems[A] (no./18-m row)	Infection centres[A] (no./18-m row)	Yield (kg/ha)
		Fluazinam		
0.250	1 × HB4-70	32.3	45.8	2255
0.333	1 × HB4-70	24.8	43.0	2504
0.750	3 × HB4-70	15.3	35.5	2968
1.000	3 × HB4-70	11.3	29.8	3005
		Procymidone		
0.229[B]	1 × 8004VB	15.5	40.5	2783
0.229	1 × HB4-70	45.0	52.8	1714
0.688[C]	1 × 8004VB	9.8	32.8	3143
0.688	3 × HB4-70	28.8	44.3	2572
		Unsprayed		
—	—	63.3	57.5	1276
l.s.d. (P = 0.05)		9.0	8.8	339

[A]135 days after planting. [B]Applied in a 30-cm band. [C]Applied in a 90-cm band.

always greater than the values for the procymidone at 0.75 kg a.i./ha spray applied 78 DAP.

Field trial 2

All fungicide treatments significantly increased yield and reduced the numbers of plants with >50% dead stems, and all treatments but one significantly reduced the number of infection centres compared with the unsprayed treatment (Table 3). Procymidone sprayed at 0.688 kg a.i./ha with a single 8004VB nozzle, and fluazinam sprayed at 0.75 or 1.0 kg a.i./ha with 3 HB4-70 nozzles produced the highest yields and were not significantly different from each other with respect to either disease incidence or yield. Plots sprayed with procymidone at 0.229 kg a.i./ha with the flat-fan nozzle (8004VB) adjusted to give a 30-cm band had a significantly lower mean yield than those sprayed with a 90-cm band of the same fungicide at 0.688 kg a.i./ha. Procymidone at 0.688 kg a.i./ha applied as a directed spray with 3 hollow-cone nozzles (HB4-70) was less effective than a banded spray using a single flat-fan nozzle (8004VB). For fluazinam, the treatments applied with 3 HB4-70 nozzles (0.75 or 1.0 kg a.i./ha) were significantly better than the treatments applied with 1 HB4-70 nozzle at 0.25 or 0.333 kg a.i./ha.

Sclerotinia blight developed throughout the period of the trial, with the most rapid increase in the unsprayed treatment occurring between 49 and 92 DAP (Fig. 2). By 135 DAP, the number of infection centres had nearly reached the maximum possible total of 60. All of the fungicide treatments reduced the rate of increase in infection centres in the first 28 days after the initial spray, but thereafter, disease developed at a rate similar to that of the unsprayed treatment.

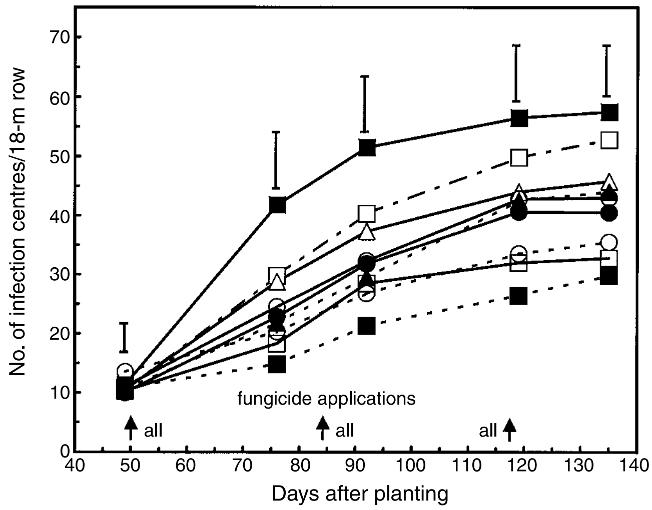

Fig. 2. Effects of selected treatments of fluazinam (—△— 0.25, 1 × HB4-70; —▲— 0.333, 1 × HB4-70; --○-- 0.75, 3 × HB4-70; --■-- 1.0, 3 × HB4-70) and procymidone (—□— 0.229, 1 × HB4-70; --▲--0.688, 3 × HB4-70; —●— 0.229, 1 × 8004VB; —□— 0.688, 1 × 8004VB) (—■— unsprayed) on development of sclerotinia blight (number of infection centres) at J. Bjelke-Petersen Research Station, Kingaroy, in 1994–95. Bars represent l.s.d. (P = 0.05) values. Legend abbreviations: rate (kg a.i./ha), number nozzles × nozzle type.

Table 4. Efficacy of fungicide treatments in controlling sclerotinia blight of peanut at Tingoora in 1994–95

All treatments were sprayed using 3 hollow-cone nozzles (HB4-70) delivering 206 L/ha except procymidone 0.500 post and 0.688 post, which were sprayed using a single flat-fan nozzle (8004VB) delivering 377 L/ha. Pre, first spray applied at 57 days after planting (DAP) before symptoms; post, first spray applied at 70 DAP after symptoms. Second spray was applied 104 DAP in all treatments

Rate (kg a.i./ha)	Time of first spray	Plants with >50% stems dead[A] (no./24-m row)	Infection centres[A] (no./24-m row)	Yield (kg/ha)
		Fluazinam		
0.500	Pre	2.3	9.5	1297
0.750	Pre	1.0	8.0	1485
0.750	Post	7.8	19.5	1278
1.000	Pre	1.5	12.3	1390
1.000	Post	10.0	21.0	1254
1.000[B]	Pre	2.0	8.0	1304
		Procymidone		
0.500	Post	11.3	26.8	1200
0.688	Pre	4.8	14.3	1349
0.688	Post	10.3	21.8	1344
0.688	Post	9.5	26.8	1210
0.500	Post	15.8	32.3	1185
		Iprodione		
0.500	Post	9.5	26.8	1210
		Unsprayed		
—	—	18.5	32.3	1112
l.s.d. (P = 0.05)		3.5	5.6	151

[A] 141 DAP.
[B] This treatment included a postinfection spray of procymidone at 0.688 kg a.i./ha at 70 and 104 DAP.

Field trial 3

Seven treatments had significantly higher yields, lower numbers of infection centres, and lower numbers of plants with >50% dead stems than the unsprayed treatment; 5 of them being treatments in which the first spray was applied before infection was evident (Table 4). Pre-infection sprays of fluazinam at all 3 rates (0.5, 0.75, and 1.0 kg a.i./ha) were effective in reducing disease incidence and increasing yield. The pre-infection spray of procymidone at 0.688 kg a.i./ha using 3 HB4-70 nozzles, and the post-infection spray of that fungicide at the same rate using a single 8004VB fan nozzle, provided control equivalent to fluazinam treatments. The post-infection spray of procymidone at 0.688 kg a.i./ha using 3 HB4-70 nozzles was not effective. The yield of peanuts treated with fluazinam at 1.0 kg a.i./ha followed by a spray of procymidone at 0.688 kg a.i./ha was not significantly different from that with 2 sprays of fluazinam at 1.0 kg a.i./ha. For the same fungicide × rate × nozzle combination, the pre-infection treatments provided better control than the corresponding post-infection treatments. Iprodione, as applied in this trial, was not effective.

In the unsprayed treatment, the number of infection centres increased throughout the season, reaching approximately half the possible maximum number (80 centres/24-m row) (Fig. 3). All of the treatments with a pre-infection spray had slower rates of disease development between 70 and 97 DAP than the treatments in which the first spray was applied after infection. The rates of disease development after 97 DAP were similar in all treatments (Fig. 3).

Discussion

Trials conducted over 2 seasons have demonstrated that fluazinam and procymidone are effective in managing sclerotinia blight of peanut in the Burnett region of southern Queensland, Australia. However, no fungicide treatment tested in any of the trials completely controlled the disease. The high efficacy of these fungicides has previously been reported in the United States (Porter 1980; Porter and Phipps 1985*a*; Smith *et al*. 1992; Phipps 1994, 1995). By contrast, in our trials, iprodione applied at the rate 0.50 kg a.i./ha registered in Australia for the control of sclerotinia blight was relatively ineffective in the 2 trials in which it was tested. At

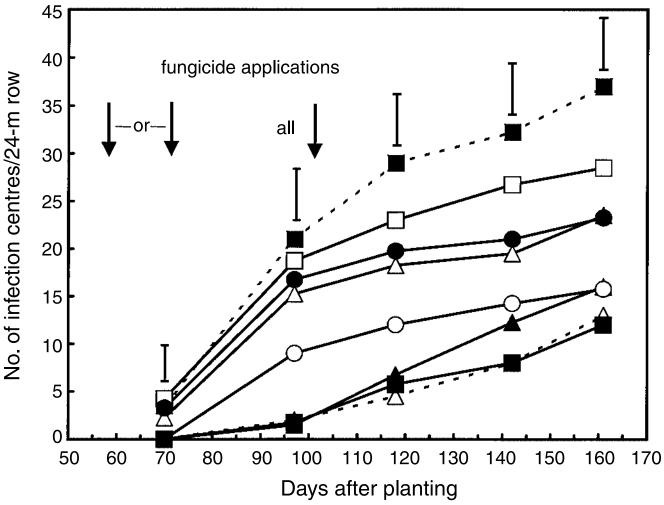

Fig. 3. Effects of selected treatments of procymidone (—□— 0.688, post; —○— 0.688, pre), fluazinam (—△—, 0.75, post; —●— 1.0, post; —▲— 1.0, pre; --△-- 0.75, pre), (—■— combination of fluazinam, 1.0, pre, and procymidone, 0.688, post) (--■-- unsprayed), on development of sclerotinia blight (number of infection centres) at Tingoora in 1994–95. Bars represent l.s.d. (P = 0.05) values. Legend abbreviations: rate (kg a.i./ha), timing of spray (pre, before symptoms; post, after symptoms). All treatments were applied with 3 hollow cone HB4-70 nozzles.

best iprodione increased yield by only 25%. Other workers (Dougherty *et al.* 1983; Phipps 1983; Brenneman 1987*a*) found that this fungicide could provide somewhat better levels of control when applied at higher rates. Based on these results, there is an urgent need for either the re-registration of procymidone, or the registration of a fungicide (such as fluazinam) with greater efficacy than that of iprodione.

The timing of fungicide applications is critical in disease control. The trial results indicate that a pre-infection application of a fungicide is more effective in reducing disease incidence and increasing yield than an application after symptoms appear (post-infection). The greater efficacy of the pre-infection fungicide application is related to its ability to restrict disease development in the first 28 days after application. The timing of subsequent fungicide applications also has an impact on the level of control achieved. Based on the results of our trials, fluazinam and procymidone have about 4 weeks activity, and delaying sprays beyond this period may result in reduced yields when infection is severe.

Band spraying with a flat-fan nozzle directly over the row, particularly when the plants are young and the canopy has not closed, is an effective method for applying fungicides for control of sclerotinia blight. Our trials indicated that a low rate of fluazinam (0.333 kg a.i./120 L.ha) is effective in suppressing the disease for at least 3 weeks after spraying. Fungicide costs can therefore be substantially reduced without affecting early disease control.

The effectiveness of fungicide sprays in disease management is related to the nozzle type, rates of fungicide, spray volume, and timing of sprays. In these trials, flat-fan nozzles delivering a high spray volume (>360 L/ha) were more effective than hollow-cone nozzles delivering a lower volume (206 L/ha), but it is not known if this is due to the higher water volume per ha, larger droplets, or a combination of both. Smith *et al.* (1991*b*) demonstrated that high volume sprays (345 L/ha) using a flat-fan nozzle resulted in a tendency towards lower disease incidences and higher yield when compared with low volume sprays (140 L/ha) using 3 hollow-cone nozzles, but the differences were not statistically significant. Flat-fan nozzles, such as 8008LP and 8010LP, are the preferred nozzle type for control of sclerotinia blight of peanut in the United States (Porter 1980; Smith *et al.* 1991*a*, 1992; P. M. Phipps, pers. comm.). Smith *et al.* (1991*b*, 1992) attributed the better performance of flat-fan 8010LP nozzles over hollow-cone D2-13 and D2-23 nozzles to the production of larger droplets which are better able to penetrate the plant canopy and reach the soil surface where infection by *S. minor* occurs. There is a need for further research on the best type and arrangement of nozzles for fungicidal management of sclerotinia blight.

In the Burnett region, fungicides for sclerotinia blight management are most commonly applied in high spray volumes by tractor-mounted boom sprays. However, farm machinery cannot be driven on the soils of the Burnett region for at least 4 days after heavy rain, by which time infection may have occurred. Application by aircraft would deliver fungicides to the targets much sooner after infection than a tractor-mounted boom sprayer, and should reduce infection levels. This method of application has been used with varying degrees of success in the past in the South Burnett region and needs to be evaluated further.

The agricultural production systems of the South Burnett region rely predominantly on rainfall, which results in highly variable yields across years, with peanut yields averaging 1.3 t/ha (Crosthwaite 1994). With a mean gross farm return of approximately $AU350/ha for peanuts, expenses must be strictly controlled. The trials reported in this paper have demonstrated that fungicides should be applied before infection has occurred to provide the maximum benefit. However, the application of fungicides before the appearance of symptoms of sclerotinia blight is regarded to be an expensive practice which will not result in increased yields if the disease does not develop. As infection by *Sclerotinia minor* is usually not seen before peg formation (6–7 weeks after planting), a pre-infection spray before this time would be difficult to justify. It is apparent from these trials that the disease can develop from pegging to maturity, so optimising the timing of sprays is critical. Several forecasting systems, based on environmental parameters with or without plant growth criteria, have been shown to be good predictors of

S. minor infection, and applications of effective fungicides at predicted infection times have been demonstrated to successfully control the disease (Phipps 1994, 1995). The effectiveness of these systems in the Burnett region will be assessed in future trials.

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