Economics and timing of fungicide application to control Sclerotinia stem rot in canola.

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ABSTRACT

In order to define the economic feasibility and most effective time for fungicide application to control Sclerotinia stem rot in Australian canola, 24 small plot trials were conducted from 2002 to 2004. In 2002, petal infestation levels were extremely low and no stem rot developed. In 2003, high percent petal infestations (59 to 99%) were recorded at all locations (except Tamworth with 2%) but very little disease was recorded (0.1 to 1.9%). In 2004, petal infestation was variable between sites (0 to 79.4%) and disease either did not develop or was very low (0 to 4.8%). Although very little disease developed in 2003 and 2004, fungicide treatments at 10 trial locations produced significantly lower stem rot levels. There were 2 treatment times in 2003 (early, 20 to 30% flowering or late, ≈ 2 weeks after early) and 3 in 2004 (early; pre rain front, ≈ 1 week after early or post rain front, ≈ 2 weeks after early). The early and pre rain front applications were significantly better than the late (post rain front) fungicide applications for reducing disease development at 7 sites. Yield was only increased in 2003 at Rutherglen (+ 0.44 t/ha in canola cultivar Rainbow, early fungicide application) and Gerogery (+ 0.46 t/ha in canola cultivar Hyola 60, late fungicide application). Low disease levels at all locations and in all years were associated with this lack of yield response. From these results, it appears a single fungicide application at early flowering was the optimum treatment for controlling Sclerotinia stem rot in seasons not conducive for disease development. However, our estimates suggest that at 10% stem rot incidence fungicides need to be below $40/ha to apply when the yield potential is 2.5t/ha and farm gate canola price is $325/t.

Key words: *Sclerotinia sclerotiorum* – canola – disease – fungicide – timing

INTRODUCTION

To date, Sclerotinia stem rot caused by *Sclerotinia sclerotiorum* has been difficult to consistently and economically control. This is because stem rot is sporadic only occurring when environmental conditions are favourable, attacks many species of broadleaf plants in rotation with canola, and has long lived survival structures called sclerotia.

Sclerotia remain viable for many years in the soil. When weather conditions are favourable, sclerotia germinate to produce apothecia. Apothecia produce thousands of air-borne ascospores that can be carried several kilometres by the wind (Adams and Ayers 1979). Spores land on canola petals and when the petals fall at the end of flowering, many lodge in the lower canopy of the crop. The spores germinate, and using the petal as a source of nutrient, the fungal mycelium grows and invades the canola plant (Anderson and Kohn 1995). The canola flowering period is therefore the critical time for infection (Rimmer and Buchwaldt 1995). Prolonged humid (wet) conditions during flowering of canola favours disease development and yield losses as high as 24% (2001) have been recorded under Australian conditions (Best Bet Canola Project, Harden Agricultural Consultants, *unpublished data*).

Worldwide, the most common method for controlling stem rot is the application of foliar protectant fungicides. Improper timing and inefficient application procedures often result in poor control. Due to the sporadic nature of stem rot in Australia it is important to determine the economic feasibility of any fungicide application. It has been considered uneconomical to apply fungicides routinely, but to be effective they need to be applied before the plant becomes infected. The best timing for protection is during flowering when the petals have just begun to senesce. Currently those fungicides registered for Sclerotinia stem rot control in Australian canola are applied at between 20 and 50% flowering. However, these recommendations are based on overseas results overseas where flowering times are much shorter than in Australia.

Rovral® liquid fungicide (250 g/L iprodione), applied at 2L/ha (≈ $62/ha) was used in these trials as it was the first fungicide registered for use on canola against *S. sclerotiorum* in Australia (Robert Griffith, Bayer CropScience, *personal communication*). Sumisclex® Broadacre fungicide (500 g/L procymidone), applied at 1L/ha (expected price ≈ $38/ha) was subsequently registered for use on canola and was included in the 2004 trials (Charles McClintock, Sumitomo Chemical Australia Pty Ltd, *personal communication*). We conducted 24 small plot trials from 2002 to 2004 to better define the most effective stage of flowering for fungicide application and the economic feasibility of applying fungicides in Australia.

MATERIALS AND METHODS

Field trials 2002: Six small-plot trials were conducted in 2002 (Table 1). Each trial had 2 canola cultivars (Hyola 60 and Rainbow) and 4 fungicide treatments using Rovral®. The Tamworth trial also had a mustard variety. The treatments were a control, early fungicide application (20 to 30% flowering), late fungicide application (≈ 2 weeks after early) and an early + late application. All trials were managed according to standard farming practices, sown with cone seeders and harvested with small-plot harvesters. Each trial was sown in a randomised block design with 3 replicates. A modified petal test (Turkington *et al.* 1991) was performed before the early Rovral® application and 20 petals/plot plated out onto Sclerotinia selective agar (SSA, ½ strength PDA containing 25 mg/L streptomycin and 25 mg/L ampicillin). In total 480 petals were plated out per location. Plants/m^2 and stem rot incidence were recorded at harvest and the percentage of plants infected with with *S. sclerotiorum* was calculated.

Table 1. Management dates for the 24 Sclerotinia fungicide trials conducted from 2002 to 2004.

Location	Yr	Managed By	Sown	Petal test	Fungicide applied 1^{st}	2^{nd}	3^{rd}	Stem rot	Yield
Rutherglen	02	DPI (Vic)	21/5	20/9	27/9	11/10	na	13/11	18/11
Henty	02	NSW Ag.	2/5	30/8	13/9	27/9	na	1/11	14/11
Junee	02	NSW Ag	15/5	20/9	26/9	11/10	na	11/11	15/11
Wallendbeen	02	NSW Ag	31/5	26/9	2/10	18/10	na	19/11	27/11
Thuddungra	02	NSW Ag	29/5	3/10	2/10	16/10	na	14/11	na
Tamworth	02	NSW Ag	4/6	20/9	23/9	9/10	na	21/11	25/11
Rutherglen	03	DPI (Vic)	3/6	2/10	30/9	16/10	na	12/11	9/12
Gerogery	03	NSW Ag	28/5	1/10	30/9	14/10	na	14/11	16/12
Henty	03	NSW Ag	7/5	23/9	22/9	7/10	na	12/11	11/12
Temora	03	NSW Ag	21/5	26/9	26/9	10/10	na	13/11	na
Dirnaseer	03	AgriTech	23/5	22/9	25/9	8/10	na	13/11	25/11
Wallendbeen	03	NSW Ag	5/5	25/9	26/9	13/10	na	6/11	15/12
Wombat	03	AgriTech	7/5	18/9	30/9	9/10	na	6/11	12/12
Thuddungra	03	NSW Ag	6/6	10/10	8/10	22/10	na	17/11	2/12
Greenethorpe	03	AgriTech	14/5	18/9	23/9	7/10	na	17/11	28/11
Tamworth	03	NSW Ag	28/5	11/9	4/9	12/9	na	1/11	1/12
Beckom	04	AgriTech	<28/5	27/9	24/9	30/9	8/10	4/11	17/11
Galong	04	AgriTech	24/5	1/10	22/9	28/9	5/10	18/11	4/12
Dirnaseer	04	AgriTech	28/5	29/9	22/9	28/9	5/10	11/11	1/12
Greenethorpe	04	AgriTech	23/5	1/10	22/9	28/9	6/10	11/11	3/12
Henty	04	NSW DPI	19/5	20/9	17/9	24/9	5/10	10/11	29/1
Lockhart	04	AgriTech	27/5	28/9	22/9	28/9	5/10	4/11	16/11
Tamworth	04	NSW DPI		22/9			na	22/11	
Wallendbeen	04	AgriTech	<28/5	1/10	28/9	5/10	13/10	17/11	na

DPI, Department of Primary Industries; **NSW Ag**, New South Wales Agriculture; **na,** not applicable

Field trials 2003: Ten small-plot trials were conducted in 2003 (Table 1). The trials were managed and data collected in the same manner as the field trials in 2002.

Field trials 2004: Eight small plot trials were conducted in 2004 (Table 1). Two trials (Henty and Tamworth) were done in the same manner as 2002. However, 6 trials (Galong, Wallendbeen, Greenethorpe, Dirnaseer, Lockhart and Beckom) were cut into existing canola fields before flowering, had 4 replicates but were otherwise managed, harvested and data collected in the same manner as 2002. Treatments were also altered; at Tamworth a mustard (Mickey) and canola cultivar (Rivette) were used, at Henty, Galong, Dirnaseer and Lockhart the canola cultivar Beacon was used; at Wallendbeen and Greenethorpe the cultivar Grace was used; and at Beckom the Clearfield cultivar 44C74 was used. The Henty trial had 4 fungicide treatments using 2 different fungicides Rovral® or Sumisclex®. Each fungicide was applied as either an early application (20 to 30 % flowering), pre rain front application (≈ 1 week after early), post rain front application (≈ 2 weeks after early) or as a full treatment with an early + pre rain front + post rain front application. The Galong, Wallendbeen, Greenethorpe, Dirnaseer, Lockhart and Beckom trials had the same treatments as Henty but, only Rovral® was applied as a full application. The petal test (160 petals per location) was done on the control plots at about 30% flowering (Table 1).

Statistical analysis: All statistical analyses (ANOVA or REML-when replications were unequal) were done using GenStat Release 4.2 or 6.1 (Rothamsted Experimental Station).

RESULTS

Field trials 2002: In 2002 conditions were dry throughout the growing season and most of NSW was officially drought declared. Very little petal infestation and no stem rot developed in any trial (Table 2). The Thuddungra trial was not harvested as it failed due to the drought.

Field trials 2003: In all locations except Tamworth high petal infestations were recorded. However, very little stem rot developed (Table 2). The early fungicide treatment at Henty (both varieties), Wombat (Hyola 60), Greenethorpe (Rainbow) and Tamworth (Hyola 60) reduced disease development in one or both canola cultivars. The early or late fungicide applications reduced stem rot at Rutherglen (Rainbow) and Gerogery (both varieties). The combination of an early and late fungicide application reduced disease at Wallendbeen in Rainbow (Table 3).

At Rutherglen the early fungicide application significantly increased the yield of Rainbow over the control by 0.44 t/ha and in Gerogery the late application significantly increased the yield of Hyola 60 over the control by 0.46 t/ha (data not presented). The Temora trial was not harvested due to hailstorm damage.

Table 2. Percent petal infestation (20 to 30% flowering) and percent stem rot incidence (mean of control plots) from the 24 trials conducted from 2002 to 2004

	Petal infestation (%)			Sclerotinia stem rot (%)		
Location	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Beckom	–	–	1.9	–	–	0
Binalong	–	–	76.3	–	–	2.22
Dirnaseer	–	86.5	15	–	0.02	2.39
Gerogery	–	61.9	–	–	0.4	–
Greenethorpe	–	97.9	9.4	–	0.2	0.01
Henty	0	98.8	79.4	0	1.9	4.84
Junee	0.3	–	–	0	–	–
Lockhart	–	–	0	–	–	0
Rutherglen	0.3	58.5	–	0	0.4	–
Tamworth	0.3	1.8	1.8	0	0.8	0
Temora	–	68.5	–	–	0.4	–
Thuddungra	0	87.1	–	0	0.3	–
Wallendbeen	10.5	77.5	36.3	0	0.1	0.01
Wombat	–	98.1	–	–	0.3	–

Field trials 2004: Petal infestation levels varied with lowest petal infestation (0%) being recorded at Lockhart and the highest (79.4%) being noted in the Henty trial. Very little stem rot was recorded before harvest, 3 sites (Beckom, Lockhart and Tamworth) had no stem rot, 2 (Greenethorpe and Wallendbeen) had extremely low levels of stem rot (0.01%) and at the remaining 3 sites (Binalong, Dirnaseer and Henty) stem rot levels ranged from 2.2 to 4.84% (Table 2).

The early and pre rain front fungicide applications significantly reduced disease development at Binalong, Dirnaseer and Henty, with the early Rovral® application being significantly better than the pre rain front Rovral® application at Dirnaseer (Table 3).

There was no significant yield benefit in applying fungicide treatments in 2004. The Wallendbeen trial was not harvested due to hailstorm damage.

Table 3. Trials where stem rot incidence was significantly reduced by a fungicide application. LSD numbers in parenthesis are transformed values. Mean stem rot data is not transformed.

	Sclerotinia stem rot (%)													
year	**2004**			**2003**										
site	**Henty**	**Dirnaseer**	**Galong**	**Rutherglen**	**Gerogery**		**Henty**		**Wallendbeen**	**Wombat**	**Greenethorpe**	**Tamworth**	
canola variety	**Beacon**	**Beacon**	**Beacon**	**Rainbow**	**Hyola 60**	**Rainbow**	**Hyola 60**	**Rainbow**	**Rainbow**	**Hyola 60**	**Rainbow**	**Hyola 60**	**Rainbow**
1	4.84 **a**	2.39 **b**	2.22 **a**	0.59 **a**	0.41 **a**	0.41 **a**	1.97 **a**	1.89 **a**	0.12 **a**	0.48 **a**	0.32 **a**	1.04 **a**	0.72 **abcde**
2	0.50 **b**	0.05 **c**	0.02 **b**	– –	– –	– –	– –	– –	– –	– –	– –	– –	
3	0.04 **b**	0.74 **c**	0.57 **b**	– –	– –	– –	– –	– –	– –	– –	– –	– –	
4	5.97 **a**	2.90 **ab**	2.43 **a**	– –	– –	– –	– –	– –	– –	– –	– –	– –	
5	0.05 **b**	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	
6	0.17 **b**	0.21 **c**	0.06 **b**	0.18 **b**	0.15 **b**	0.00 **b**	0.37 **b**	0.48 **b**	0.04 **ab**	0.22 **bc**	0.04 **bc**	0.45 **cdef**	0.56 **bcdef**
7	0.31 **b**	2.24 **b**	0.75 **b**	– –	– –	– –	– –	– –	– –	– –	– –	– –	
8	4.22 **a**	3.75 **a**	2.12 **a**	0.22 **b**	0.06 **b**	0.00 **b**	1.76 **a**	2.01 **a**	0.18 **a**	0.27 **abc**	0.21 **abc**	0.81 **abcd**	0.28 **ef**
9	0.00 **b**	0.07 **c**	0.03 **b**	0.12 **b**	0.00 **b**	0.05 **b**	0.67 **b**	1.02 **ab**	0.00 **b**	0.38 **ab**	0.09 **bc**	1.01 **ab**	0.21 **f**
LSD	**(0.6)**	**1.22**	**0.91**	**0.28**	**0.32**		**1.05**		**(0.31)**	**0.24**	**0.22**	**0.45**	

Values in the same column with the same letter are not significantly different

Treatments - **1**, Control; **2**, Early application of Sumisclex®; **3**, Sumisclex® pre rain front; **4**; Sumisclex® post rain front; **5**, Sumisclex®, early + pre rain front + post rain front; **6**, Early application of Rovral®; **7**, Rovral® pre rain front; **8**, Rovral® post rain front or late; **9**, Rovral® early + pre rain front + post rain front (or early and late).

DISCUSSION

A limited knowledge of the conditions favouring Sclerotinia stem rot development in Australia has hampered the widescale adoption of control measures. The last three seasons were not favourable for disease development but from 1998 to 2001 Sclerotinia was an important canola disease in the high rainfall zones of southern NSW.

In 2002, petal infestation levels were extremely low and no stem rot developed in any of the trials with the 2002 drought limiting crop and disease development. In 2003, high petal infestations were recorded in all locations (except Tamworth) but very little disease was recorded before harvest. Sclerotinia stem rot is favoured by wet, humid conditions. Hot and dry conditions after the early fungicide treatment are thought to have contributed to the low levels of disease development. In 2004, petal infestation was variable between sites (0 to 79.4%) and disease either did not develop or was very low (0 to 4.84%). Weather conditions in 2004 were not favourable for disease development: even where stem rot developed its incidence was low, suggesting that weather conditions were not optimal for stem rot development.

Although very little disease developed, fungicide treatments in 2003/04 significantly reduced stem rot incidence (Table 3). The early fungicide application or pre rain front application was usually better at reducing disease development than the late (post rain front) application. These results suggest that a single fungicide application at early flowering is the optimum treatment for controlling Sclerotinia but these trials will need to be repeated under high disease pressure to confirm these results.

Fungicide applications only increased yield in 2003 at Rutherglen and Gerogery. Low disease levels at all locations and in all years were associated with this lack of yield response. At Rutherglen, the early fungicide application significantly increased the yield of Rainbow over the control by 0.44 t/ha. At Gerogery the late fungicide application significantly increased the yield of Hyola 60 over the control by 0.46 t/ha. The interaction between disease development and yield in Australia is not fully understood and work is continuing in this area.

Disease levels were too low to affect yield in most of our trials. Application costs for Rovral® are about $74/ha to apply; and for Sumisclex® expected to be about $50/ha (figures include a $12 application cost). Average canola yields (t/ha) since 1996 have ranged from 0.4 to

1.9 t/ha. During the same time period, average gross returns from canola at principal markets ranged from 307 to $386/t (Wright 2004 and Lawrance *et al.* 2004).

Economic estimates, using farm gate prices between 300 and $350/t and yield potentials of 1, 1.5, 2 and 2.5 t/ha for each fungicide show that yield increases of between 5.8 and 24.7% are required to cover the cost of fungicide application (Table 4). Disease levels required to cover application costs were then calculated using the Canadian estimate that percent yield loss ≈ ½ (percent stem rot) (Morrall and Thomson 1991). These estimates showed that between 11.6 and 49.4% of canola plants would need to be infected with Sclerotinia to cover application costs (Table 4). Low disease levels from 2002 have prevented validation of the Canadian estimate under Australian conditions with Sclerotinia stem rot levels in trials not exceeding 10%. Field surveys from 1998 to 2000 found that while stem rot levels could reach 37%; its incidence was usually less than 10% (Hind *et al.* 2003). Therefore, to economically justify the use of a foliar fungicide at 10% stem rot incidence, chemical and application costs would need to be lower than the 5% yield penalty. Using a farm gate price of $325/t and the same calculations above, application costs would need to be below 16, 24, 32 and $40/ha for yield potentials of 1, 1.5, 2, and 2.5t/ha respectively.

As fungicides are not economically feasible to routinely apply to Australian canola a reliable method of disease prediction is required to economically justify their use. This would restrict chemical usage to periods when high levels of stem rot are forecast. However, as disease levels in the field are not yet predictable, Australian canola growers should carefully consider the current cost of both chemical and canola before applying fungicides

Table 4. Estimates of the percent yield increase and percent Sclerotinia stem rot incidence required to cover the cost of fungicide application in canola.

		Sumisclex® ($50/ha)						Rovral® ($74/ha)					
		Yield increase (%)			Stem rot incidence (%)			Yield increase (%)			Stem rot incidence (%)		
Farm gate price		300	325	350	300	325	350	300	325	350	300	325	350
Canola yield potential (t/ha)	1	16.7	15.4	14.3	33.4	30.8	28.6	24.7	22.8	21.2	49.4	45.6	42.4
	1.5	11.2	10.3	9.6	22.4	20.6	19.2	16.5	15.2	14.1	33.0	30.4	28.2
	2	8.4	7.7	7.2	16.8	15.4	14.4	12.4	11.4	10.6	24.8	22.8	21.2
	2.5	6.7	6.2	5.8	13.4	12.4	11.6	9.9	9.2	8.5	19.8	18.4	17.0

ACKNOWLEDGEMENTS

We would like to acknowledge: all the field units/companies for sowing and managing our trials including NSW Agriculture, Vic DPI, Agritech, Farmlink, Greenethorpe Grenfell Cropping Group, and Best Bet Canola Group; co-operating growers for hosting our trials; and the GRDC for providing the funds for this project.

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