DELAYED SOWING CAN DECREASE THE SEVERITY OF BLACK ROOT ROT OF COTTON

D. B. Nehl[1,2], A. H. Mondal[1,2,3] and C. M. Anderson[1,2]
[1] Cotton Catchment Communities CRC, Locked Bag 59, Narrabri, NSW, 2390
[2] NSW Department of Primary Industries, Locked Bag 1000, Narrabri NSW 2390
[3] Current address: 60F Albert Street, Ingleburn, NSW, 2560

Introduction

Black root rot (caused by *Thielaviopsis basicola*) has developed into a widespread, chronic disease of cotton in Australia (Nehl et al. 2004). Symptoms include slow seedling growth, dark brown to black necrosis of the root cortex and reduced yield. The pathogen survives between hosts as long-lived chlamydospores in the soil. Repetitive cropping with cotton increases inoculum density and disease severity, irrespective of rotation with non-host crops (Nehl et al. 2004). Resistant varieties are not available and control of this chronic disease is difficult.

In Australia, most cotton is sown from late September to early October, when cool conditions, favourable to black root rot, usually occur. By comparing disease severity with different sowing dates and monitoring disease progress, we showed that delaying sowing can minimise the period of time that cotton is exposed to conditions favourable for development of black root rot.

Materials and methods

In April 2000, field plots (3 × 8 m) near Narrabri NSW were either inoculated with *T. basicola*, or not. All plots were cropped with cotton in the 2000-01 season. Subsequent inoculum densities of *T. basicola* were 192 and 2 cfu/g soil in inoculated and control plots, respectively. Cotton was sown in both types of plots on 28 Sep and 17 Oct 2001, in a 2 × 2 factorial design with six replicates. Disease severity was assessed in 20 plants per plot, at 28 days after sowing (DAS) on each date. The percentage length of the tap root with characteristic blackening was assessed on a scale of 0 to 10, where 0 = no blackening, 1 was >0 and ≤ 10%, 2 was > 10 and ≤ 20%, and so on. The number of 'relatively healthy' lateral roots on each plant was assessed by counting lateral roots that had <50% of their length discoloured or blackened. Plant tops were cut at a point equivalent to soil level, bulked for each replicate plot, and placed in an oven (70°C, 48 h) for dry matter determination.

In a field infested with *T. basicola* near Moree NSW, cotton was sown on 10 Oct and 10 Nov 2003 in large plots (16 × 550 m). Disease severity on tap roots was assessed (as above) in 50 plants in each plot on 10 Nov and 11 Dec 2003, for the early and late plots respectively. Soil temperature was recorded as the mean from two temperature probes inserted horizontally along the planting line at the same depth as the seed.

In an infested field near Wee Waa, cotton was sown on 11 Oct 2003 and disease progress was monitored by assessing disease severity on tap roots (as above) in successive samples of 80 plants from each of twelve replicate plots, at 12, 19, 26 and 37 DAS. In another infested field, near Narrabri, cotton was sown on 29 Sept 2003 and disease progress was monitored by assessing disease severity on tap roots in successive samples of 10 plants from each of five replicate plots, at

15, 19, 21, 23, 27, 36, 47, 52 and 61 DAS, either with or without removal of the leaves at each sampling time.

Results

In the plots at Narrabri that had been inoculated with *T. basicola*, delaying sowing until 17 Oct 2000 decreased the severity of black root rot of cotton substantially at 28 DAS (Table 1). Disease severity in the inoculated plots, sown on 17 October, was not significantly different to the control. Development of lateral roots was decreased substantially by inoculation of the soil with *T. basicola*. However, delaying sowing in the inoculated plots resulted in lateral root growth equal to that of the uninoculated plots that were sown early (Table 1). The variation in growth of cotton in this experiment was explained, partly, by the variation in development of lateral roots (r^2 = 0.40) and partly by sowing date (Table 1). Cotton growth was not related to symptoms on tap roots (r^2 = 0.03).

Table 1. Effect of delayed sowing on black root rot of cotton, assessed at 28 days after sowing, in plots that were either artificially infested (Inoculated) or uninfested (Control) with the pathogen, *Thielaviopsis basicola*, at Narrabri NSW in 2001

	Sown 28 Sep		**Sown 17 Oct**		
	Control	**Inoculated**	**Control**	**Inoculated**	[A]Probability
Black root rot severity on tap roots (0-10 scale)	2.9b	8.2a	1.6b	4.0b	$P \leq 0.006$
Relatively healthy lateral roots (No./plant)	6.7b	1.4c	10.0a	6.0b	$P \leq 0.012$
Shoot dry mass (mg/plant)	235bc	186c	501a	305b	$P \leq 0.049$

[A]Values in rows followed by the same letter are not significantly difference by pairwise comparison of means with the Scheffe test at the stated probability (n = 6). Tap roots were scored by estimating the length with symptoms of black root rot, in deciles. A lateral root was classed as being relatively healthy if less than 50%, by length, had visible symptoms of black root rot, when dug carefully from the soil.

In the experiment at Moree in 2003, delaying sowing resulted in a very large decrease in the severity of black root rot, at one month after sowing (Table 2). Disease severity corresponded with warmer temperatures experienced during the first month after sowing, respectively (Table 1). In both experiments, yield was not compromised by the delay (data not presented).

Table 2. Decreased severity of black root rot of cotton with delayed sowing, at Moree NSW in 2003

	Sown 10 Oct	**Sown 10 Nov**	Probability
Black root rot severity on tap roots (0-10 scale)	7.6	2.2	$P \leq 0.006$
Mean soil temperature first 30 DAS (°C)	20.3	24.5	N/A

Values in rows are significantly different at the stated probability (n = 6). Tap roots were scored by estimating the length with symptoms of black root rot, in deciles. A lateral root was classed as being relatively healthy if less than 50%, by length, had visible symptoms of black root rot, when dug carefully from the soil. DAS = days after sowing.

In the field at Wee Waa in 2003, symptoms of black root rot on cotton tap roots were negligible at two weeks after sowing and then increased rapidly, peaking at around 5 weeks after sowing (Fig. 1). A similar trend was observed in the field near Narrabri (Fig. 2) and, as monitoring continued, symptoms on tap roots reached a saturation level and then declined to negligible levels by two months after sowing (Fig. 2). This decline in the level of symptoms was prevented by repeated removal of leaves.

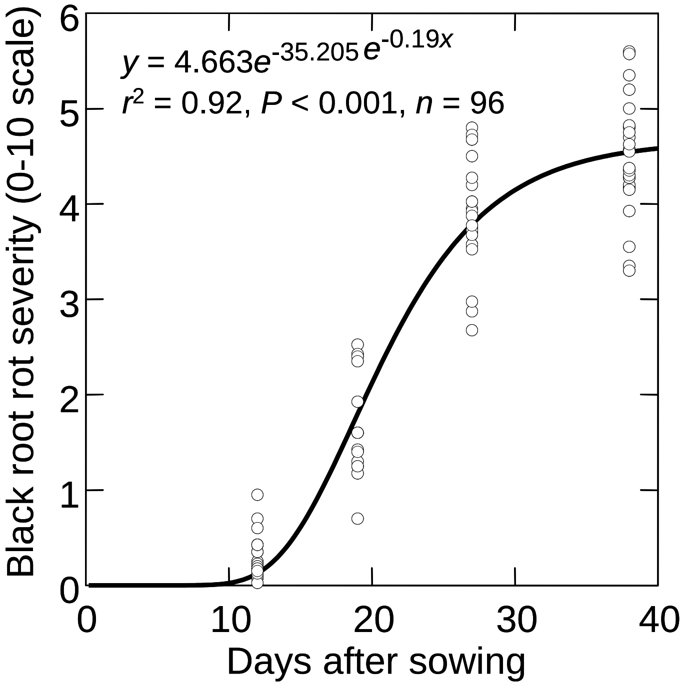

Figure 1. Progress of black root rot of cotton in a field near Wee Waa NSW, sown 11 Oct 2003.

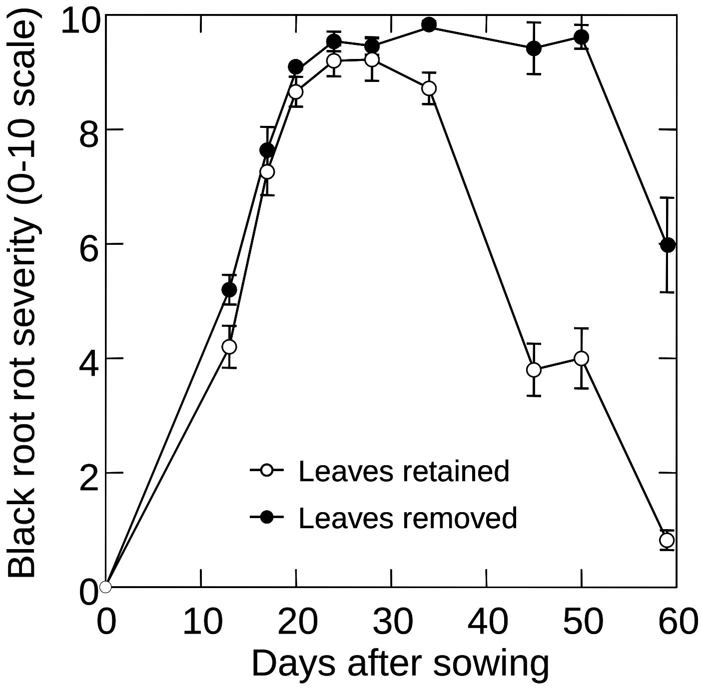

Figure 2. Progress of black root rot of cotton, with or without leaves removed at each assessment, in a field near Narrabri NSW, sown 29 Sep 2003

Discussion

Our observations of the progress of black root rot in cotton provide two critical insights into the factors affecting this disease. First, black root rot develops relatively slowly in comparison to other pathogens of seedlings, such as *Rhizoctonia* and *Pythium*. The pathogen, *T. basicola*, is not a good competitor with other fungi in the soil. While *T. basicola* can be cultured artificially in the laboratory, in the field this fungus is obliged to rely on colonisation of susceptible, living plants to survive (Hood and Shew, 1997). Even in laboratory culture, *T. basicola* is slow-growing in comparison to many other fungi. This characteristic of the fungus is reflected in the timing of the appearance of symptoms in cotton. The peak level of infection of cotton roots by *T. basicola* does not occur until three weeks after sowing. In contrast, most of the loss of cotton seedlings (pre- and post-emergent damping off), caused by *Pythium* and *Rhizoctonia*, occurs within the first three weeks after sowing and few losses occur thereafter (Nehl, unpublished data). Clearly, the seedling disease complex and black root rot operate during different stages of the cotton growth. This observation corroborates those of the annual disease surveys in NSW, which have indicated repeatedly that there is no relationship between black root rot and seedling death (Nehl et al. 2004). Clearly, black root rot and the seedling disease complex have their greatest impact on cotton at different stages in the crop.

Secondly, the peak activity of the black root rot pathogen is limited to a window of favourable environmental conditions early in the season. Usually, at around five weeks after sowing, the severity of symptoms on the tap root begins to decline, coinciding with the onset of warm conditions that favour plant growth, not infection by the pathogen. As the tap roots expand, the infected outer tissues are sloughed off and few symptoms will be visible by two months after sowing. This window of favourable conditions provides an opportunity to decrease the impact of the black root rot by delaying sowing and, therefore, decreasing the period of exposure of cotton to peak activity of the pathogen.

The potential to use delayed sowing as a tool for control of black root rot, by minimising the period of exposure to conditions favouring disease, was clearly demonstrated in the sowing-date experiments at Narrabri and Moree. However, successful exploitation of this aspect of the life cycle of the pathogen will depend upon seasonal conditions. If cool wet conditions persist through spring, then the advantage from delayed sowing may diminish and caution should be exercised if a wet spring is anticipated. The use of high-retention transgenic varieties of cotton may enable extension of the sowing window to optimise disease avoidance with less risk of compromising yield potential.

Acknowledgments

This research was funded by the Cotton R&D Corporation and NSW Department of Primary Industries. Technical assistance from Dr Om Jhorar, Ms Tracey Mor and Mr Peter Lonergan, and the generous cooperation of farmers, is gratefully acknowledged.

References

Hood ME, Shew HD (1997). Reassessment of the role of saprophytic activity in the ecology of *Thielaviopsis basicola*. *Phytopathology* **87**: 1214-1219

Nehl DB, Allen SJ, Mondal AH, Lonergan PA (2004). Black root rot: a pandemic in Australian cotton. *Australasian Plant Pathology* **33**: 87-95