Biological Control of Fusarium Wilt of Cotton Scope and prospects

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Introduction

Fusarium wilt of cotton, which is caused by *Fusarium oxysporum* f.sp. *vasinfectum* (*Fov*) is a relatively new disease in Australia. The devastating nature of the disease and the lack of effective control measures are causing serious concern in the industry.

There are now only four Australian cotton-growing areas that have not yet recorded the disease. The Australian Cotton Industry is making a concerted effort to minimise further spread of *Fov*. The different measures include keeping farm machinery and vehicles free from crop debris and soil, retaining irrigation run-off water on the farm and avoiding spillage of cotton during transport from the farm to the processing facility.

Any stress on the plant, for example water logging, appear to exacerbate the disease. There are no cotton varieties in Australia with complete resistance to Fusarium wilt. The varieties are usually divided into three susceptibility groups- least, moderately and most susceptible. Even the least susceptible varieties appear to be very susceptible in the seedling stage.

The current recommendations for managing the disease include using the least susceptible varieties, retention of crop residues on the surface for as long as possible after harvest, increased seed rate by up to 30%, control of weeds that host the pathogen and farm hygiene. The use of biocontrol agents is another tactic that can be included in this package.

Scope for biocontrol of Fusarium wilt

Several naturally occurring bacteria are antagonistic to *Fov*. These bacteria, when introduced into the root zone, can potentially interfere with the pathogenic activity of *Fov*. Research into biocontrol of cotton Fusarium wilt at the Australian Cotton Research Institute started in 1996. Through a field-based screening and selection program, we identified an effective biocontrol agent (a bacterium) against Fusarium wilt.

Performance of the biocontrol agent in field experiments

This biocontrol agent was tested, for its ability to control Fusarium wilt in a comprehensive experimental program. The field experiments were conducted in growers' fields where Fusarium wilt was known to occur. Representative results from field experiments, typical of the data we have obtained so far, are presented in Tables 1, 2 and 3. The biocontol agent increased plant survival and reduced disease severity and yield (seed cotton) losses.

Integrated disease control

Fusarium wilt was moderate in 1997-98 and severe in 1998-99 season. The results in Table 3 demonstrate that the biocontrol agent (BCA) increased yield in both seasons. However, in a severe disease season, the yield falls short of commercially acceptable levels. For example, in the 1998-99 season, Although the BCA increased yield by 65%, compared to the non-treated plots, the yield (1622 kg seed cotton per hectare) is still below the commercially acceptable level.

In order to improve disease control, we experimented with combining the biocontrol agent with other possible candidates for disease control. These candidates included potassium, plant growth hormones and systemic resistance inducers (SRI).

The results (Tables 1,2 and 3) show that the effectiveness of protection against the disease was greater when the application of the bacteria and SRI are combined.

Enhancement of biocontrol

Have we already seen the best performance of our biocontrol agent in field? Figure 1 shows the different components of the biocontrol research program. Due to the field based screening and selection we followed, we were able to find a field effective biocontrol agent in a relatively short time. So far, apart from some preliminary studies on the mechanisms underlying biocontrol, our primary focus has been on field studies. However, enhancement of disease control and development of the biocontrol method lies in our understanding of exactly how the biocontrol bacterium works. Biocontrol agents are known to operate through multiple mechanisms. Some of the commonly known mechanisms are production of anti-fungal compounds, competition for nutrients, niche exclusion and induced host plant resistance. An understanding of the mechanisms can have flow-on effects. For example, the principal biocontrol mechanism could be incorporated into the cotton plant through genetic engineering.

Further research into the mechanisms of biocontrol is essential for the future development of the biocontrol agent for better disease control.

References

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Figure 1. Schematic representation of the biocontrol research program.

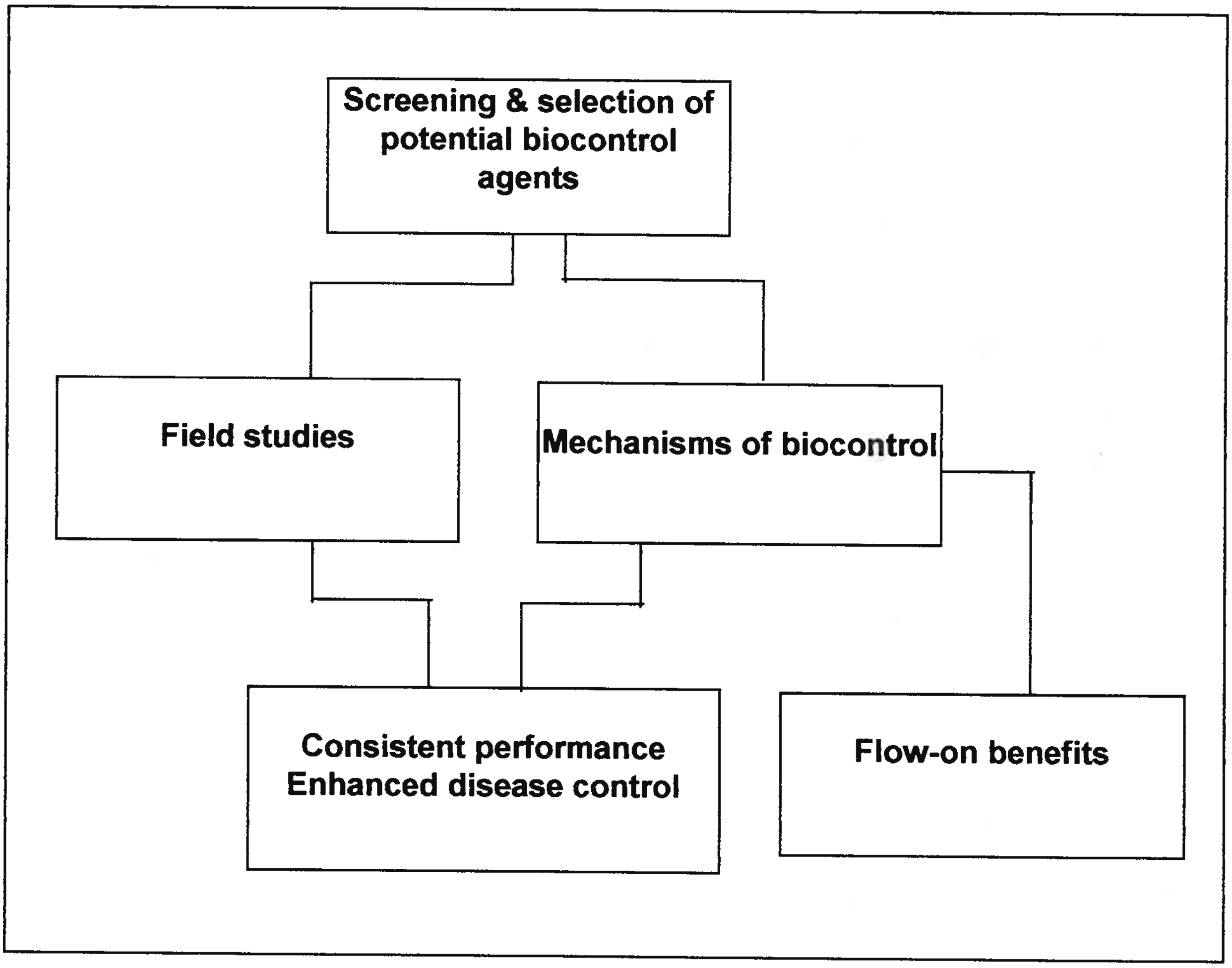

Table 1. Plant survival (plants m^{-1})

Application of biocontrol bacterium together with a chemical inducer of systemic resistance, increased plant survival. Normally ten plants per meter is considered good plant stand. However, cotton has the ability to compensate for gaps, and the compensation is greater when the gaps occur uniformly rather than in patches. In the field experiments described here, treated plots had more uniform plant stands while the non-treated plots were patchy.

Treatment	1997-98	1998-99
BCA	7.56	8.77
SRI	7.42	7.73
BCA + SRI	8.26	9.84
NT	7.51	6.64
S.E. of mean (±)	0.123	0.577

BCA – Biocontrol agent
SRI – Chemical inducer of systemic resistance
NT – Non-treated

Table 2. Disease severity index (%)

Application of biocontrol bacterium together with a chemical inducer of systemic resistance reduced severity of Fusarium wilt of cotton. The plants were rated for visual disease symptoms and vascular discolorations on a 0 (no diseases) – 4 (most disease) scale and an aggregate disease severity index calculated.

Treatment	1997-98	1998-99
BCA	41.4	43.6
SRI	46.1	42.6
BCA + SRI	34.5	38.0
NT	49.0	58.7
S.E. of mean (±)	2.71	2.29

BCA – Biocontrol agent
SRI – Chemical inducer of systemic resistance
NT – Non-treated

Table 3. Seed cotton yield (kg ha^{-1})

Application of biocontrol bacterium together with a chemical inducer of systemic resistance reduced yield losses. The yield for the treated plots was commercially acceptable in the 1997-98 season when the disease was moderate. In the 1998-99 season the disease was severe. Although the yield for the treated plots was considerably higher (upto 87%), it was still not commercially acceptable.

Treatment	1997-98	1998-99
BCA	4290	1622
SRI	4167	1315
BCA + SRI	4751	1839
NT	3267	981
S.E. of mean ($\pm$)	540.7	197.2

BCA – Biocontrol agent
SRI – Chemical inducer of systemic resistance
NT – Non-treated

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