Prospects for disease biocontrol

By Sonia Tingay, Anthony Mitchell and Dr Joe Kochman

Producing a successful crop depends on a variety of factors — including the genetics of the crop plant, the availability of nutrients and the impact of microorganisms (fungi and bacteria) in the soil. Some microorganisms are beneficial and promote plant growth while others cause diseases.

In a technique similar to Integrated Pest Management, above-ground populations of disease-causing phytopathogens can be inhibited and controlled through the use of other beneficial microorganisms. This process is referred to as biocontrol.

Naturally occurring, plant growth promoting microorganisms provide a range of functions within the soil, including supplying minerals and other nutrients to the plant in usable forms, producing phytohormones that can encourage plant growth and stimulation of the systemic resistance mechanisms of the plant (the plant's defence systems).

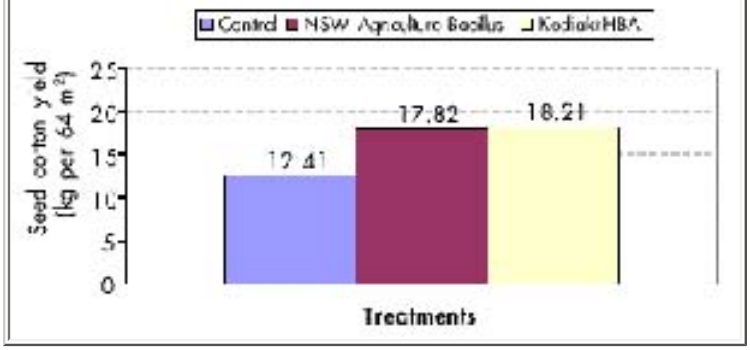
Some assist the plant indirectly by preventing pathogens from interfering with plant growth and development. Beneficial organisms may do this either by out-competing the pathogen for resources or root spaces, or by releasing antibiotics or other compounds that inhibit the growth of pathogenic strains.

As we have seen with cotton diseases such as Fusarium wilt and Verticillium wilt, phytopathogens are capable of reducing crop yields. In the worst cases the crop may not be viable. Fusarium wilt — one of the industry's 'worst-case' fungal diseases — is now affecting most cotton growing districts and has sent some growers out of cotton production.

The cotton industry has relied on plant breeding as the primary defence against diseases. Chemicals such as fungicides are not effective against all diseases, may not always be economical and are often hazardous and persistent in the environment. Some of the soil-

Biocontrol agents may offer hope for control of diseases such as Fusarium wilt.

FIGURE 1: Comparison of Biocontrol agents, small scale trial 2000–01



borne diseases are not able to be controlled by chemical means. Fungal spores, for example, are very resilient and well dispersed through the soil. Biological control agents may be an environmentally friendly alternative.

BIOCONTROL COLLECTION

Nearly 10 years ago, NSW Agriculture researchers, Drs Stephen Allen and Subbu Putcha, began collecting endophytic and rhizosphere (root zone) microorganisms from cotton plants. This collection was expected to contain potential biocontrol agents for controlling cotton diseases, particularly fungal diseases.

Initial research identified bacteria able to suppress the growth of a selection of diseases harmful to the cotton industry (Verticillium dahliae, Theilaviopsis basicola, Rhizoctonia solani and Pythium ultimum). About 29 per cent of the collection was able to suppress the growth of one or more of the pathogens in the laboratory. Several hundred of the isolates were tested in glasshouse experiments and promising strains were further evaluated in the field.

Dr Putcha went on to develop a rapid, in-field screening method to identify the most promising biocontrol agents. Of the 180 bacterial strains examined, two strains of bacteria were identified as being potentially useful.

USEFUL BACTERIA

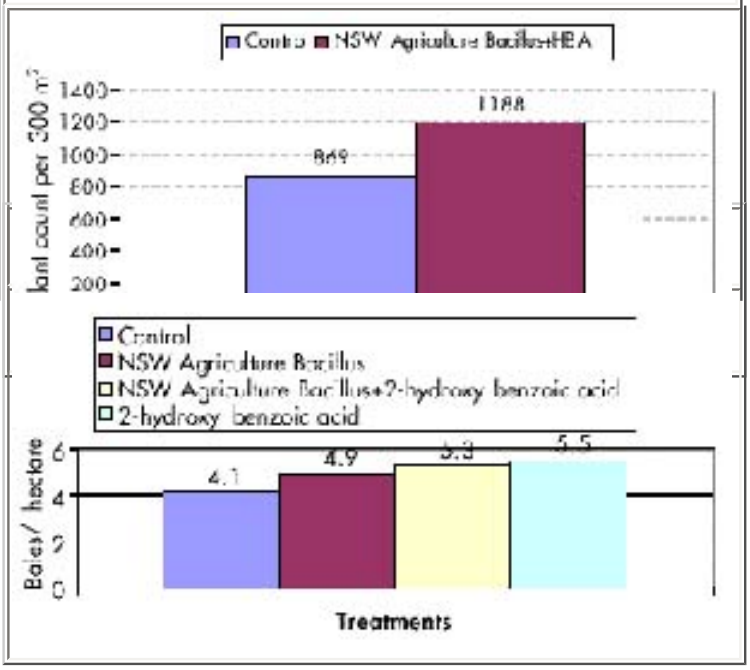
One was a Pseudomonas species and the other was of the Bacillus genus. Representatives of these genera have been previously used in commercialised biocontrol products. The strain of Bacillus isolated was shown to be potentially effective for managing Fusarium wilt.

Subbu tested this strain over a number of years in field trials, mainly on the Darling Downs. The trials included the use of a foliar spray, 2-hydroxy benzoic acid (HBA), which is an activator of the plant's defence system, and Subbu determined that the combination of soil-applied bacteria and foliar acid spray was most effective in controlling Fusarium wilt.

In the 2000–01 season, small and large scale trials were attempted in Queensland. A commercially produced formulation of Subbu's Bacillus species biocontrol agent was used in large-scale trials.

Subbu finished working on biocontrol at the end

FIGURE 2: Plant count from one large scale trial, 2000–01



of June 2001. NSW Agriculture, lead by Dallas Gibb, in conjunction with Queensland Department of Primary Industries (Joe Kochman and Anthony Mitchell), are continuing large-scale trials this season. The trials cover about 120 hectares and are located in fields infected with Fusarium on the Darling Downs.

Figures 1 to 3, from the 2000–01 season, show the performance of the Bacillus strain as a biocontrol agent against Fusarium. Figure 1 shows the in-field performance of the NSW Agriculture's Bacillus strain, which was isolated by Subbu, compared to a commercial biocontrol product named Kodiak.

Kodiak is a product registered for the control of the Fusarium fungus in the US, and contains a Bacillus subtilis strain of bacteria to inhibit the fungus. In this small-scale trial, the two strains of Bacillus, applied along with an in-furrow injection of HBA and foliar applications of HBA throughout the growing period, showed no significant difference in performance and both showed results that were significantly better than the control.

In the large-scale biocontrol trials during 2000–01, results were inconsistent for a number of reasons, including the difficulty of finding large-scale fields with a reasonably even distribution of Fusarium, some problems with trial set up and low infection levels during the past season.

There were no significant differences between control and biocontrol treatments in much of the analysed data. But this may be due to the lack of substantial levels of Fusarium wilt throughout last season. Figure 2 is an example where there was a significant difference between control and biocontrol treatments in plant count data at one trial site.

At this site, 40 per cent of plants were severely infected and there was a significant increase in plant stands in the biocontrol treatments. This season the large-scale field trials have been designed to obtain statistically valid data and should provide better data on the effectiveness of the biocontrol agents.

Figure 3 shows the performance of the foliar spray HBA against Fusarium wilt in a small-scale trial in 2000–01. Last year's result suggests that the spray alone works well — but this contrasts with previous years' data. The relative efficacy of acid spray alone, Bacillus strain alone and spray

plus bacterial application are being further assessed in large-scale trials this season.

IMPORTANT ROLE?

Biocontrol has a potentially important part to play in disease control, particularly in the short to medium term until plant breeders are able to produce resistant varieties. Further research into useful strains of bacteria for biocontrol needs to continue.

It may be possible to genetically engineer strains to over emphasise the anti-pathogenic traits or to transfer traits between strains. It may even be possible to create a bacterial biocontrol agent capable of defending cotton against the major fungal diseases affecting the industry. It is also important to begin looking at the ecological impact of introduced organisms, particularly as pure strains in concentrated forms in the soil environment.

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