GREEDY SCALE AND THE FUNGUS *FUSARIUM STILBOIDES*

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Consumer demand for residue-free food and a less polluted environment is increasing in a number of countries. This pressure has reawakened interest in non-polluting methods of pest and disease control in horticulture such as parasitoids, predators, resistant cultivars, and more benign chemicals.

On organically produced kiwifruit (*Actinidia deliciosa*) in New Zealand, *Bacillus thuringiensis* can be used to control lepidopteran larvae but control of scale insects (greedy scale, *Hemiberlesia rapax* and latania scale, *Hemiberlesia lataniae*) remains difficult. Oil and soap sprays, parasitoids, and post-harvest dipping, brushing, and cool storage of fruit have been, or are being, evaluated (Steven pers. comm.).

Considerable research has been conducted over the years on the use of fungi to control insects. Evans and Prior (1990) reviewed the current status of entomopathogenic fungi worldwide. In New Zealand, Jackson (1990) has listed the fungus-insect pest relationships observed, most of which are from pastoral insects, while Prestidge and Willoughby (1990) have reported promising results with a fungus for the control of the garden weevil *Phlyctinus callosus* on asparagus. Sedentary colonies of scale would appear to be ideal targets for fungal attack. In the present study, populations of greedy scale were sampled for the presence of fungal pathogens which might provide an alternative to conventional chemicals for scale control.

Scale insects which had died from no obvious cause were removed from leaves on sprayed and unsprayed kiwifruit vines in five orchards in Auckland and the Bay of Plenty. To obtain pure cultures of the fungi present, scale bodies were plated onto prune agar for 1 week with subsequent subculturing on to potato dextrose agar for 1 month. All the plates were held under ultra-violet light at room temperature. The isolated pathogens were then identified.

The fungus most frequently isolated from dead scales occurred in two types. Each type was physically described and its growth rate on agar determined at various temperatures. To prove pathogenicity a micro-organism must have been isolated from the host, cultured, reapplied to, and then recovered from, dead hosts (Koch's postulate). To investigate pathogenicity, a culture suspension of the fungus was applied to unsprayed, scale-infested, kiwifruit vines 5 times in each of two seasons by 'Solo' sprayer. Assessments were made throughout each season.

Various fungi and bacteria were isolated from the dead scales collected during the survey. The fungi included aeroflora such as *Penicillium* sp., *Cladosporium* sp., *Trichoderma* sp., *Glomerella* sp.; known plant pathogens such as *Phomopsis* sp. and *Alternaria* sp., and insect pathogens such as *Beauveria bassiana* and *Fusarium larvarum*. The incidence of these insect pathogens was low. A higher incidence of other *Fusarium* spp. was recorded, including the species: *oxysporum*, *lateritium*, *culmorum*, *avenaceum*, *concolor*, *equiseti*, *solani*, *sambucinum*, *semitectum* and *stilboides*.

The species frequently present at all five survey sites was *F. stilboides* which had not previously been recorded from New Zealand. The identification was confirmed by Dr C. Booth, Commonwealth Mycological Institute, U.K. Bugnicourt (1939) stated that *F. stilboides* caused canker disease on coffee, had been isolated from tea and citrus plants and had been found on three armoured scales. These were coconut scale, *Aspidiotus destructor*, San Jose scale, *Quadraspidiotus perniciosus* (also found infected in our survey) and greedy scale.

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In New Zealand, *F. stilboides* was found to consist of two colony types. Type 1 had a peach basal colony colour, floccose peach/white mycelium and sporodochia sometimes in rings whereas Type 2 had a blue/peach basal colour, greyish/white mycelium with sporodochia in rings or at random. Both types produced only macroconidia which narrowed at each end, had a pointed or beaked apical cell and a distinct foot cell could be present. Both types had similar growth rates over the 7-32 °C range and, at the optimum temperature of 24 °C, growth was 14-20 mm after 4 days.

The bodies of mature scales killed by this fungus were port wine-black in colour, shrivelled and shortened but moist and tar-like. This appearance was distinctive. Bodies of young scales were dry and shrivelled with a deep brown coloration. Dead crawlers had a port wine-brown colour, were depressed in shape and could be 'glued' to the body of the mother scale.

All live scale stages, including eggs and crawlers, were found, by plating, to be infected on both sprayed and unsprayed leaves. The application of inoculum increased the level of infection by seven to fourteen times in live scale instars and from 3.6 to 46.1% and 12.8 to 33.3% for the 2 trials, respectively, for all scales. There was a three to fourfold increase in mortality of immature scale stadiums (from 8 to 30% and 3.3 to 10.1%), but no increase in mortality of maturing or mature scales compared to those on the untreated control leaves.

A complex mixture of enniatins, analogues of the beauvericin produced by the insect pathogen *Beauveria bassiana*, are the active compounds produced by *Fusarium stilboides*. They are known insecticides (J.F. Grove, pers. comm.) apparently of low mammalian toxicity (Bright, pers. comm.) but they may also be phytotoxic (Gaumann *et al* 1960). We recorded some insect mortality but no phytotoxicity in the field trials.

In conclusion, while we have demonstrated *F. stilboides* to be a pathogen of greedy scale, it did not consistently cause significant mortality in the population in the field trials. Further work is suggested on the selection of pathogenic isolates and the type, concentration, and insecticidal activity against scale insects of the enniatins produced.

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