SETTLEMENT OF ARMoured SCALE INSECTS ON FRUIT OF COMMERCIAL *ACTINIDIA* SPP.

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ABSTRACT

The proportion of greedy (*Hemiberlesia rapax*) and latania (*H. lataniae*) scale insect crawlers (Hemiptera: Diaspididae) that settled on fruit of commercial kiwifruit cultivars *Actinidia arguta* cv. K2D4, *A. chinensis* cv. Hort16A and *A. deliciosa* cv. Hayward was quantified at intervals from 20% to 100% final fruit size. In all three cultivars, the proportion of settled crawlers increased as the fruit matured. The settlement of greedy scale was greater than latania on Hort16A fruit, with minimal differences between scale species on other cultivars. Comparisons of scale settlement with scale phenology found fruit of K2D4 was vulnerable to settlement from the first summer generation, with second-generation scale mainly infesting Hayward fruit. Hort16A fruit can be infested by both generations. Implications of these findings for the pest status of scale insects, and customisation of the industry pest-monitoring system (KiwiGreen®) for new varieties, are discussed.

Keywords: armoured scale insect, kiwifruit, phenology, resistance, monitoring.

INTRODUCTION

The two primary armoured scale insect pests of kiwifruit (*Actinidia* spp.) are greedy scale, *Hemiberlesia rapax* (Comstock), and latania scale, *H. lataniae* (Signoret) (Hemiptera: Diaspididae) (Steven 1990). After 1 January for Hort16A and 10 January for Hayward, armoured scale insects are currently managed by spraying with mineral oil or organophosphate insecticides when the infestation of leaves with live scale insects exceeds a threshold of 4%, as recommended by the KiwiGreen® industry pest-monitoring system. This threshold was developed from work on the Hayward cultivar (Steven et al. 1994; Steven 1997) and has since been extended to Hort16A.

Preliminary observations suggest that there is variation in the susceptibility of Hayward and Hort16A to greedy and latania scale (Blank et al. 2000). Furthermore, recent evaluation of *Actinidia* germplasm, held at the HortResearch Te Puke Research Orchard, has revealed considerable differences in the relative susceptibility of germplasm to armoured scale insects (Hill et al. 2003). Understanding the mechanisms of resistance is important for the selection of kiwifruit cultivars with resistance to armoured scale insects and improving the management of armoured scale insects on kiwifruit.

The objective of this study was to examine scale insect crawler settlement in relation to fruit maturity, and the phenology of crawler production on three commercial cultivars of kiwifruit, *A. arguta* (Sieb. Et Zucc.) Planch. Ex Miq. cv. K2D4, *A. deliciosa* (A. Chev.) C.F. Liang et A.R. Ferguson cv. Hayward, and *A. chinensis* Planch cv. Hort16A.

METHODS

Scale crawler settlement on kiwifruit

Fruit were taken from K2D4, Hort16A and Hayward vines at the Te Puke Research Orchard during the 2003/04 season, when estimated to be 20%, 40%, 60% and 100% of final fruit size. The timing of each harvest was based on fruit development data from previous seasons (B. Snelgar, unpubl. data). The actual fruit size at the time of sampling,

expressed as a percent of final fruit weight, was obtained by dividing the fruit weight at the time of sampling by the mean weight of the fruit in the 100% fruit weight sample.

On the dates of harvest, eight fruit were picked at random from fruiting laterals closest to the leader, from each of ten vines for each of the three varieties. The 80 fruit collected from each cultivar were weighed and split into two groups of 40 for inoculation with scale insect crawlers from two scale species. The Hayward, Hort16A and K2D4 vines used were 21, 8 and 6 years old respectively. All vines were trained on T-bar structures, and grown using standard kiwifruit management practices.

Greedy and latania scale insect crawlers (<24 h old) were obtained from laboratory cultures. Rearing method was adapted from DeBach & White (1960). Four crawlers of the same species were transferred, using a paintbrush, within the same vicinity of approximately 10 mm² on the side of each fruit. Each inoculated fruit was placed on absorbent paper, covered with an inverted plastic pottle and kept at 21°C ± 2°C. Relative humidity was not controlled and fluctuated between 60–78%. Seven days after inoculation, the number of white caps (first instar scale insects) on each fruit was counted with the aid of headband magnifiers (OptiVisor[®], 10 dioptries magnification). Thus the data collected consisted of settlement rates from each scale species on three cultivars of kiwifruit. Scale insect settlement was expressed as a percentage for each scale insect species. Confidence limits (95%) for percentage crawler settlement were calculated using exact formulae for upper and lower limits for binomial probability distributions (Colquhoun 1971).

Scale crawler phenology

Scale crawler activity was recorded by trapping the mobile life stage under bands of clear all-weather tape (24 mm wide) each fortnight between 5 November 2003 to 30 June 2004 (Hill et al. 1986). Bands were applied to the two leaders from each of six Hort16A vines, seven K2D4 vines, and six Hayward vines; the same vines used for fruit sampling. Scale crawler density (crawlers per cm per day) was calculated for each kiwifruit cultivar and sampling period, by dividing the total crawlers captured by the total length of the band, by the number of days sampled. It was not possible to distinguish greedy and latania scale crawlers morphologically, therefore data may be a mixture of both.

RESULTS

Scale crawler settlement on kiwifruit

Percentage crawler settlement of both scale species increased with fruit size on the three kiwifruit cultivars (Fig. 1). Settlement was consistently under 50% when the fruit were 20% of final size, increasing to between 60% and 85% on mature (100% sized) fruit. Data for crawler settlement on Hayward fruit at 60% of final size were omitted due to an error in data collection. Percentage settlement of latania scale was slightly higher than that of greedy on K2D4 fruit (Fig. 1a). Settlement of latania scale on Hort16A fruit was consistently lower than that of greedy, with the difference less obvious as the fruit matured (Fig. 1b). There was no apparent difference in crawler settlement between the two scale species on Hayward fruit (Fig. 1c).

FIGURE 1: Proportional settlement of greedy (solid symbol) and latania (open symbol) scale insects on K2D4 (A), Hort16A (B) and Hayward (C) as a percent of final fruit size. Vertical bars denote 95% confidence intervals.

Scale crawler phenology in relation to scale crawler settlement on kiwifruit

In Figure 2, scale crawler phenology is compared with crawler settlement on fruit (and by implication fruit size – see Fig. 1). The density of emerging crawlers on the three varieties follows an approximate bimodal pattern through the growing season (Fig. 2), coinciding with two annual generations of armoured scale on kiwifruit (Blank et al. 1996). K2D4 fruit were available for settlement by the first generation of scale crawlers between December and February (Fig. 2a). The fruit become increasingly more vulnerable to crawler settlement throughout January and February, as shown by the increasing proportion of crawler settlement in the laboratory trial (Fig. 2a). K2D4 fruit are harvested in early March thereby avoiding exposure to settlement from most of the second generation of scale crawlers. Hort16A fruit, harvested in April/May, are available for settlement by crawlers of both generations (Fig. 2b). Hayward fruit, which are harvested in May but set approximately one month after Hort16A (Blank et al. 2000), largely avoid settlement by scale crawlers from the first generation (Fig. 2c). The mean abundance of scale crawlers on Hort16A and K2D4 vines was much lower than on Hayward (Fig. 2).

FIGURE 2: Proportional settlement of greedy (square) and latania (triangle) scale insects on K2D4 (A), Hort16A (B) and Hayward (C) in relation to crawler phenology on the vine (histograms). Note the difference in Y-axis scales between the three plots.

DISCUSSION

Hayward fruit are substantially shielded from infestation by the first generation of scale crawlers by virtue of their later fruit set and the relatively low percentage settlement of crawlers on small fruit in January and February (Fig. 2c). By comparison, Hort16A fruit are exposed to settlement by first generation greedy scale crawlers (Fig. 2b). Latania scale has low settlement success on small fruit of Hort16A and this will limit its ability to infest fruit in the first generation between December and February. Previous observations of scale insects on the fruit of Hayward and Hort16A at Kerikeri and Te Puke have suggested that these cultivars differ in their susceptibility to the two main armoured scale insect species. Hayward fruit were infested by both species, while Hort16A fruit were infested mainly by greedy scale (Blank et al. 2000). These observations may be explained by the poor settlement success of the latania scale on immature fruit (Fig. 1b), and possibly by the unpalatability of other plant parts to latania scale.

It is evident from this study that the biology of greedy and latania scale insects is different on Hayward and Hort16A. Observed differences in scale-plant interactions, coupled with the variation in plant phenologies (e.g. fruit set on Hort16A occurs approximately 30 days before Hayward), suggest that the KiwiGreen® monitoring system developed for Hayward (Steven et al. 1994; Steven 1997) needs to be modified for

each new kiwifruit cultivar. In addition, alternative monitoring systems based on scale phenology should be explored for cultivars that do not use the KiwiGreen® monitoring system, e.g. K2D4.

The lower abundance of scale crawlers on Hort16A and K2D4 compared with Hayward is likely to be, in part, related to the conditions within an orchard, such as the age of the vines, since scale populations tend to build up on older vines. In addition, previous work has shown that shelter species that are highly susceptible to greedy and latania scale can act as a reservoir of infection for fruit by crawler wind dispersal (Blank et al. 1987). However, in most orchard situations without susceptible shelter there is no strong relationship between proximity to shelter and scale incidence (Blank et al. 1999).

This study initially hypothesised that crawler settlement was related to fruit hairiness, which declines as the fruit develops. Accordingly, hair density on Hayward and Hort16A fruit was measured as the fruit grew. The discovery that crawler settlement increases with fruit size on all three varieties, including the hairless K2D4 (Fig. 1), implies that crawler settlement is influenced by factors other than hair density, therefore results relating to hair density have not been presented here. The overall scale insect infestation rate on fruit is presumably related to the overall population density of the scale on the vine, which in turn must be related to the inherent susceptibility of the plant to the insect. More detailed study is required on the constitutive resistance of kiwifruit plants to scale insects.

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