MANAGING BRONZE BEETLE, *EUCOLASPIS BRUNNEA*, IN ORGANIC APPLE ORCHARDS

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ABSTRACT

Bronze beetle (*Eucolaspsis brunnea*) is threatening the viability of New Zealand's organic apple industry. This study investigated the efficacy of organic insecticides against bronze beetle, trialled adult emergence traps, measured fruit damage caused by adult feeding and sampled larvae in the soil. Laboratory bioassays of ten organically acceptable insecticides failed to identify an effective product to control adult bronze beetle. Emergence trapping on two orchards showed that bronze beetle emergence peaked during November. Bronze beetle damage on cv. Royal Gala apples was highly variable among the 12 orchards surveyed, and ranged from 2 to 43% immediately before harvest. Royal Gala apples had much more damage when inspected in field bins than cv. Braeburn apples. Soil sampling suggested that most bronze beetle larvae are found 51-150 mm below the soil surface during autumn.

Keywords: bronze beetle, organic apple production, Chrysomelidae.

INTRODUCTION

Bronze beetle (*Eucolaspsis brunnea* (F.), Coleoptera: Chrysomelidae) is an endemic New Zealand beetle, which has recently become a significant pest in organic apple orchards. Historically bronze beetle was a major apple pest during the 1920s and 1930s, although as early as 1862 it had reached plague proportions, had defoliated various trees and "sounded like rain" as the beetles dropped on leaves (Lysaght 1930; Miller 1971). The use of organochlorine insecticides resulted in bronze beetle becoming rare in apple orchards (Clearwater & Richards 1984). Since the widespread introduction of integrated fruit production (IFP) management systems for apples, bronze beetle has remained a minor pest causing no economic damage in conventional production.

Feeding by adult beetles on flowers and fruitlets can result in severely distorted fruit or raised scab-like blemishes (Lysaght 1930; Miller 1971). Feeding on more mature fruit typically creates a cavity adjacent to the stalk with distinct chewing marks around the edges. Bronze beetle feeding on apple leaves causes a shot-hole effect but does not result in economic damage. The larvae feed on the small roots of grasses (Miller 1971; Kay 1980).

This study was the first year of on-going research to develop management strategies for the control of bronze beetle in organic orchards and comprised four parts. Firstly, the efficacy against adult bronze beetle was tested of organically acceptable products, including pyrethrum and garlic, which is commonly used by orchardists. Secondly, emergence traps were trialled as a monitoring tool for bronze beetle adults. Thirdly, bronze beetle damage to apples was quantified to provide an accurate assessment of the problem and finally, soil was sampled to determine more precisely where bronze beetle larvae occur.

METHOD

Insecticide bioassays

Bronze beetle adults were collected from an organic orchard in Hawke's Bay by shaking leaf and fruit clusters to dislodge beetles so they fell onto a plastic plate, from which they were aspirated into collection vials. Bronze beetle were anesthetised with carbon dioxide, and then 2 ml of insecticide (Table 1) or water (control) was applied to them by Potter spray tower. Both sides of an apple leaf were similarly sprayed. When dry, the leaf was placed inside a Petri dish with 15 sprayed bronze beetle. Derris dust was applied differently, the insecticide was not sprayed or dusted directly on to the beetles. Instead a pre-weighed leaf was coated in the dust, the excess was shaken off and the leaf re-weighed so an application rate /g of leaf could be calculated. There were four replicate Petri dishes per treatment. Since the bronze beetle were sprayed over two days, those treated on the second day had been stored overnight at 8°C and so a second water control was included in the bioassay. Mortality was assessed after holding the bronze beetle for 24 and 48 h at 20°C. Beetles were deemed to be dead when no movement was observed when they were prodded.

TABLE 1: Organic treatments applied to bronze beetle and apple leaves in a laboratory bioassay.

Product	Concentration and formulation	Application rate (a.i./litre)
NeemAzal™ -TS	1% azadirachtin EC	0.05 g
Surround®	950 g/kg kaolin WP	30 g
BettaCrop Pyrethrum & Garlic	12 g/litre pyrethrum EC	0.24 g
BettaCrop Pyrethrum & Garlic	12 g/litre pyrethrum EC	0.48 g
Entrust™	800 g/kg spinosad WP	0.048 g
Entrust™	800 g/kg spinosad WP	0.96 g
Watkins Derris Dust	5 g/kg rotenone dust	0.37 mg/g[1]
Celatom Diatomite	diatomaceous earth	10 g
Moana Fish Protein		1 ml
McGregor's Copper	500 g/kg copper oxychloride WP	2 g
Pyradyne	5.4 g/litre pyrethrum in oil	0.014 g
McIlhenny's Tabasco Sauce	pepper sauce	50 ml

[1]mean rate (a.i. mg/g of apple leaf).

Adult emergence

Bronze beetle adults were collected as they emerged from the soil using upturned 9 litre black plastic bucket traps (270 mm diameter) with a 60 mm circular hole in the base. A Petri dish base with an equivalent hole was glued to the bucket. This enabled a Petri dish lid smeared with Tanglefoot® to be placed on top of the base and held with Blu-Tack™. Each trap was positioned within 1 m of the base of an apple tree within the tree row. Twenty traps were deployed on 14 October 2005 and spread throughout a cv. Royal Gala block in each of two organic apple orchards with a history of bronze beetle damage in Hawke's Bay. The traps were inspected weekly and the beetles caught were counted and removed until 5 January 2006 when trapping ceased.

Fruit damage

The within-tree location of bronze beetle damage was assessed in 12 organic Hawke's Bay cv. Royal Gala apple orchards in February 2006. Fifty apples were examined for the presence or absence of damage within each of the bottom, middle and top fruiting tiers (approx. 0.9, 1.8 and 3 m above ground) of five trees in each orchard. The incidence of bronze beetle damage to cv. Royal Gala and cv. Braeburn apples at harvest was measured on eleven and seven orchards respectively. Samples of 100 apples of each cultivar were inspected for the presence of bronze beetle damage in each of ten field bins per orchard during the main harvest pick.

Soil samples

Soil from two orchards (one of the 12 surveyed for damage and an additional one), both with high levels of bronze beetle damage to fruit, was sampled under cv. Royal Gala trees by extracting 80 mm soil cores with a soil corer. Ten samples were collected per orchard on three occasions throughout a block and less than 1 m from the base of apple trees. The first and second samples were to a depth of 150 mm, while the final samples on 30 March were 200 mm deep. An additional set of samples (30 March) was collected from the centre of the grassed alleyway (i.e. between the tractor tracks) opposite the tree sampled. Soil cores were dissected by hand and any bronze beetle larvae found were counted.

Data analysis

Fruit damage data were arcsine transformed, and damage levels at different heights or differences due cultivar were compared by ANOVA, followed by Tukey's HSD where appropriate using Mintab statistical software. The effect of cultivar was analysed only where both varieties were sampled on a single orchard.

RESULTS AND DISCUSSION

Insecticide bioassays

None of the products tested was effective against adult bronze beetle in the laboratory bioassay (Table 2). The best products were pyrethrum and garlic, and Entrust™, both at twice the label rate. While Potter tower bioassays are not directly comparable to field applications of insecticides these results suggest that none of these products kills many bronze beetle. However, growers may be achieving some measure of control with pyrethrum and garlic, even at the most commonly used rate of 1% and 20 litre/ha, by temporary knock-down and anti-feeding effects, both of which were observed in the bioassays. Pyrethrum, rotenone and Entrust treatments were observed to inhibit mating and feeding. The difficulty of controlling adult bronze beetle is that, because of the long period of emergence, multiple applications of a persistent product are required. Therefore historically insecticides such as DDT and chlorpyrifos were very effective (Clearwater & Richards 1984). Currently IFP growers have several options for bronze beetle control including thiacloprid which is active against beetles. However, the insecticide options for organic growers are very limited.

TABLE 2: Mean percentage mortality (± SEM) of bronze beetle 24 and 48 h after exposure to organically acceptable products.

Treatment	% mortality 24 h	% mortality 48 h
Control 1	0.0 ± 0.0	3.5 ± 2.0
Control 2	1.7 ± 1.7	3.3 ± 1.9
NeemAzal™-TS	3.3 ± 1.9	3.3 ± 1.9
Surround®	0.0 ± 0.0	3.3 ± 3.3
BettaCrop Pyrethrum & Garlic	1.5 ± 1.5	3.3 ± 1.9
BettaCrop Pyrethrum & Garlic × 2	3.3 ± 1.9	20.0 ± 3.8
Entrust™	1.8 ± 1.8	0.0 ± 0.0
Entrust™ × 2	0.0 ± 0.0	18.3 ± 3.2
Watkins Derris Dust	1.7 ± 1.7	8.1 ± 6.3
Celatom Diatomite	0.0 ± 0.0	6.8 ± 2.7
Moana Fish Protein	0.0 ± 0.0	6.7 ± 0.0
McGregor's Copper	0.0 ± 0.0	0.0 ± 0.0
Pyradyne	5.0 ± 3.2	8.3 ± 3.2
McIlhenny's Tabasco Sauce	0.0 ± 0.0	0.0 ± 0.0

Emergence

The main bronze beetle emergence from November to December (Fig. 1) was consistent with the reported period of adult activity (Lysaght 1930; Miller 1971; Clearwater & Richards 1984). Within the orchards sampled, bronze beetle emergence probably started earlier in October because beetles were caught during the first week of trapping. The longevity of adult bronze beetle is unknown, although Lysaght (1930) kept them alive in the laboratory for up to eight weeks. The present data suggest they can live for at least one month in the field, as large populations were observed in orchard D during late December, despite very little emergence during December. The mean density (± SEM) of adult bronze beetle emerging from the soil in the zone where the bucket traps were located was 172 ± 24/m^2 and 113 ± 23/m^2 respectively for orchards C and D.

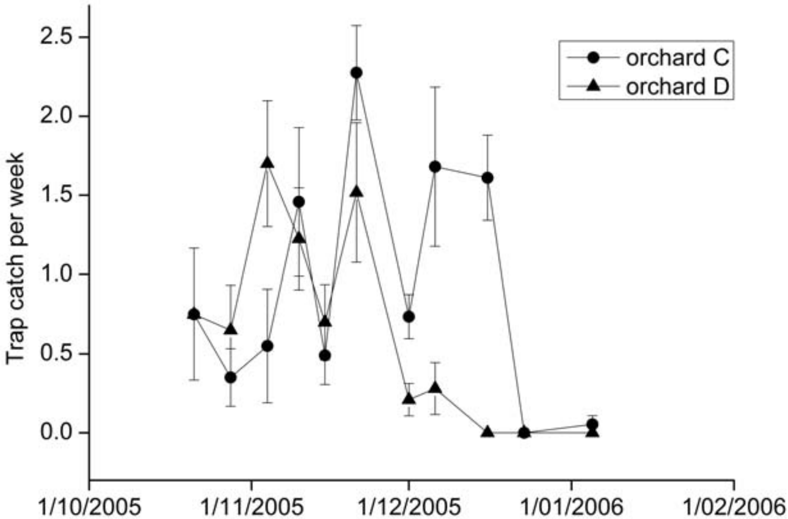

FIGURE 1: Mean (± SEM) bronze beetle trap catch per week in two Hawke's Bay organic apple orchards during 2005-2006.

Fruit damage

Bronze beetle damage to cv. Royal Gala apples was highly variable between the 12 orchards surveyed, and incidence ranged from 2.0±0.56 to 43±11% (overall mean/tree ± SEM) immediately before harvest. Apples on all parts of the tree were damaged by bronze beetle (Fig. 2), with a significant effect of tree height (P=0.001). Damage to the top tier was lower than to either the bottom or middle tiers of the trees, which were damaged equally severely (P=0.05). These data may underestimate bronze beetle damage as some damaged apples may have been selectively removed during thinning, although during the 2006 season there was very little thinning because of a lower than normal fruit set.

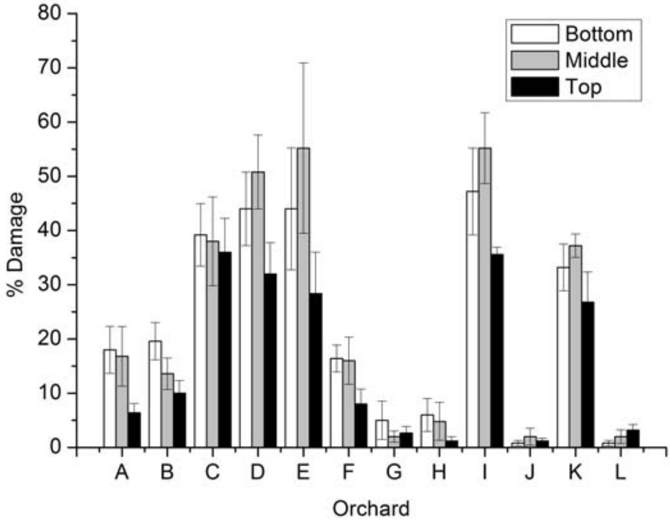

FIGURE 2: Mean (± SEM) percentage fruit damaged by bronze beetle for the bottom, middle and top apple tree tiers from 12 Hawke's Bay organic apple orchards during 2006. Fifty fruit were taken from each tier of five trees in each orchard.

There was also considerable variation in bronze beetle damage at harvest recorded during inspection of field bins (Table 3), from none to as high as 33%. Most growers instructed their pickers to avoid picking fruit that was obviously damaged by bronze beetle and which would be rejected for export. Hence the bronze beetle damage assessed in bins was lower than the on-tree assessments. Royal Gala had significantly ($P<0.001$) more damage (range 1.3 to 32.8%) than cv. Braeburn (range 0 to 8.5%). This finding is reinforced by grower observations and may result from management practices whereby cv. Royal Gala is more likely to have clusters of multiple fruitlets, which provide an ideal environment for bronze beetle.

TABLE 3: Mean (± SEM) percentage of bronze beetle damaged organic apples in field bins in Hawke's Bay in 2006

Orchard	Royal Gala	Braeburn
A	2.29 ± 0.68	2.30 ± 0.47
D	32.10 ± 4.88	8.5[1]
E	3.40 ± 1.81	2.2[1]
F	11.75 ± 2.80	1.30 ± 1.09
G	11.60 ± 2.63	0.00 ± 0.00
H	8.00 ± 5.81	0.00 ± 0.00
I	32.78 ± 4.12	
J	8.80 ± 2.48	1.50 ± 1.36
K	1.33 ± 0.37	0.00 ± 0.00
L	2.70 ± 1.49	0.10 ± 0.10
M	9.50 ± 2.46	

[1]Due to a mistake in data recording, only the total was recorded, not the values for individual replicates. This means the SEM could not be calculated.

Soil samples

Most bronze beetle larvae were found between 51 and 150 mm below the surface and their abundance increased in later samples (Table 4). Small larvae may have been present but undetected in earlier samples. Samples from the alleyway of orchard D (30 March 2006) contained only one bronze beetle larva. Despite orchard O having high levels of bronze beetle damage, only one larva was found on 30 March 2006. However, these soil sampling results should be regarded as preliminary as there is only one season's data and larvae were found at only one orchard.

TABLE 4: The total number of bronze beetle larvae found at different depths for ten soil cores per sampling date at organic apple Orchard D in Hawke's Bay during 2006.

Date	0-50 mm	51-100 mm	101-150 mm	150-200 mm	Total
23 February	0	0	1	–	1
9 March	0	2	15	–	17
30 March	5	15	16	4	40

CONCLUSIONS

Bronze beetle is threatening the viability of some organic apple orchards in Hawke's Bay. Yet other orchards are unaffected and sometimes there is great variation between blocks on the same orchard. Adult bronze beetle are difficult to control with the 'soft' insecticides available to organic growers. Entomopathogenic micro-organisms (such as *Beauveria bassiana* and *Bacillus thuringiensis* subsp. *tenebrionis*) with activity against larval bronze beetle might prove a better control option for bronze beetle, and should be investigated. Before DDT, the primary method of bronze beetle control was soil cultivation (Lysaght 1930), which has been successfully used with other coleoptera (Gednalske & Walgenbach 1984). Clearly the larvae appear to be too deep in the soil during autumn for insecticidal control, but late instar larvae and pupae move much closer to the surface during early spring (Lysaght 1930). Therefore cultivation within the tree row in spring may also be an effective control strategy.

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