A CARBOSULFAN INSECTICIDE TO PROTECT PINE SEEDLINGS FROM *HYLASTES ATER* (COLEOPTERA: SCOLYTIDAE) DAMAGE

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ABSTRACT

A controlled release granular carbosulfan pesticide was tested for efficacy against *Hylastes ater* damage of *Pinus radiata* seedlings in second-rotation forests in the central North Island. Our study involved control seedlings and seedlings treated with 10 g or 15 g carbosulfan granules per seedling. Seedling mortality ranged from 0 to 8% at the five sites. When seedling mortality was high (8%), mortality was reduced to 0.7% and 0% for carbosulfan granules applied at 10 g/seedling and 15 g/seedling respectively. While seedling mortality in the five sites was low, a large proportion of seedlings were damaged (38 to 83% of untreated seedlings) by *H. ater*. Untreated seedlings were damaged more frequently and with greater severity than treated seedlings. The results indicate that carbosulfan should protect *P. radiata* seedlings from damage caused by *H. ater* when used at the recommended field rate.

Keywords: *Hylastes ater*, carbosulfan insecticide, *Pinus radiata*, seedling mortality.

INTRODUCTION

Hylastes ater Paykull (Coleoptera: Scolytidae) is a European bark beetle that was first recorded in New Zealand in 1929 (Clark 1932). It is now well established in all exotic pine plantations and breeds in stumps, roots and logs of *Pinus* species (Milligan 1978). The adults attack and can kill young pine seedlings. Despite initial concerns, *H. ater* has not been regarded as a significant pest in New Zealand. However, recent changes in forest management have meant that *H. ater* has become more important (Reay & Walsh In press). For example, current establishment practises mean that fewer seedlings are being planted. Therefore replanting may be necessary at low levels of seedling mortality to ensure that there will enough trees at harvesting. In addition, an increased number of sites with populations of *H. ater* are being planted as the fallow time between harvesting and planting decreases. In the past, sites were left unplanted for longer periods so beetles left when food resources were exhausted, often before seedlings were planted. Finally, seedlings are becoming more expensive as quality increases.

Carbosulfan has been shown to protect conifers seedlings for three years against bark beetle and weevil attack in Europe (Lemperière & Julien 1989; Mrlina et al. 1994; Heritage et al. 1997). This pesticide is marketed as a controlled-release insecticide with a single application at planting time. This is the first study designed to test the efficacy of this pesticide to protect *P. radiata* seedlings from *H. ater* damage in New Zealand.

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METHODS

Five sites were selected from three second-rotation *P. radiata* forests in the central North Island, New Zealand, thought likely to be “at risk” of *H. ater* damage. The bark of 10 stumps in each site was removed to confirm that *H. ater* larvae were present. Two sites were selected in Kinleith and Kaingaroa Forests and one site in Te Wera Forest (Taranaki). The trials were laid out in a randomized, complete block design. Each trial consisted of seven replicate blocks, each containing three treatments. Blocks were separated from each other by two rows of “buffer” seedlings. The treatments were control, 10 g/seedling and 15 g/seedling of granules containing carbosulfan (Marshal suSCon®, 100 g ai/kg). The pesticide was applied to the roots of the seedlings after they were placed in the planting hole but before the tree was “firmed in”. Each treatment consisted of one row of 100 seedlings. Sites were sampled for evidence of *H. ater* related mortality and damage as described below:

Damage Assessment

H. ater damages seedlings on the root collar below the soil. Therefore it was necessary to remove some seedlings from the ground to investigate levels of sub-lethal damage. One-year after planting, every second seedling was destructively sampled from each row, until 20 seedlings were sampled. For each seedling sampled, evidence and severity of damage were recorded as follows:

- 0 = No evidence of *H. ater* damage. No evidence of feeding activity was observed on the root collar or the roots of seedlings.
- 1 = Mild *H. ater* damage. Small pits or spots of resin around the root collar or on roots indicating a minor attempt by *H. ater* to feed.
- 2 = Moderate damage by *H. ater*. Moderate damage was recorded when either many feeding attempts were observed or when there was evidence of one or two sustained feeding attempts, such as, when feeding activity resulted in the removal of an area of bark greater than 1 cm².
- 3 = Severe damage by *H. ater*. Severe damage was recorded if ring barking or multiple feeding wounds covering the root collar and stem of the seedling by *H. ater* were observed.

Mortality

A mortality survey was undertaken at one year following planting. All dead seedlings in each treatment were removed from the ground and inspected for evidence of *H. ater* damage. Mortality was attributed to *H. ater* only if severe damage was evident on a dead seedling.

Statistical analysis

Data collected on the incidence of damage by *H. ater* were analysed using chi-square tests to investigate differences between treatments. Analyses of variance (ANOVA) were used to compare mean mortalities and the severity of *H. ater* damage between treatments. Pair-wise multiple comparisons were conducted using Duncan’s multiple range test to determine which pairs differed from one another.

RESULTS

Mortality as a result of *H. ater* damage

All seedlings that died after being damaged by *H. ater* did so within the first year of planting. Overall, mean mortality was significantly different between treatments ($P < 0.001$). While seedling mortality was generally low, untreated seedlings were killed more often by *H. ater* than seedlings treated with carbosulfan (Fig. 1). Seedling mortality as a result of *H. ater* feeding damage was highest in Site 5, with 8% mortality. Mortality due to *H. ater* was not significantly different between seedlings treated with 10 g or 15 g carbosulfan granules (Fig. 1). Levels of mortality differed between the sites ($P < 0.001$).

Sub-lethal feeding damage to seedlings by *H. ater*

H. ater damaged untreated seedlings with greater frequency than those treated with the pesticide ($\chi^2_{(2)} = 271.783$, $P < 0.001$, Fig. 2). On average, 83% of untreated seedlings

FIGURE 1: Seedling mortality in *P. radiata* treated with 0, 10 or 15 g carbosulfan granules/seedling. Means within each site with different letters are significantly different at $P < 0.05$; bars = SE.

in Site 5 showed evidence of *H. ater* damage. Mean incidence of damage on untreated seedlings in other sites ranged from 38% (Site 4) to 75% (Site 1). Overall, there was no significant difference in the proportion of seedlings damaged between the two rates of carbosulfan ($\chi^2_{(1)} = 0.435$, $P > 0.05$). However, in Site 5 fewer seedlings treated with 15 g carbosulfan granules were damaged than seedlings treated with 10 g carbosulfan granules (Fig. 2). There was a significant difference in the number of seedlings damaged between sites ($\chi^2_{(4)} = 169.778$, $P < 0.001$).

FIGURE 2: Incidence of damage by *H. ater* one year after treating *P. radiata* seedlings with 0, 10 or 15 g carbosulfan granules/seedling. Means within each site with different letters are significantly different at $P < 0.05$; bars = SE.

Severity of sub-lethal feeding damage on seedlings

Overall, *H. ater* damaged untreated seedlings with greater severity than treated seedlings ($P < 0.001$, Fig. 3). Untreated seedlings in Site 5 suffered the greatest damage with a mean severity of damage of 1.8 (Moderate). There was no significant difference in damage between seedlings treated at the two rates of carbosulfan (Fig. 3). There was a significant difference in damage levels between sites ($P < 0.001$).

FIGURE 3: Severity of damage by *H. ater* one year after treatment of *P. radiata* seedling with 0, 10 or 15 g carbosulfan granules/seedling. Means within each site with different letters are significantly different at $P < 0.05$; bars = SE.

DISCUSSION

Carbosulfan provided significant protection to *P. radiata* seedlings from *H. ater* damage. The treatment of seedlings with carbosulfan reduced the incidence of tree mortality and damage by *H. ater*. These results are consistent with studies in other countries evaluating the effectiveness of carbosulfan to protect seedlings from bark beetle and weevil attack (Lemperière & Julien 1989; Mrlina et al. 1994; Heritage et al. 1997).

The amount of sub-lethal seedling damage by *H. ater* was substantial in this study, despite overall low levels of seedling mortality. A similar observation was made by Reay & Walsh (In press) in a survey of seedling mortality and damage by *H. ater* in 60 sites in the central North Island. This indicates that many seedlings survive after being damaged by *H. ater*. Most studies documenting attack by *H. ater* only describe levels of seedling mortality (Clark 1932; Boomsma & Adams 1943; Neumann 1987; Ciesla 1988). Damage by *H. ater* may result in increased levels of mortality if seedling health is compromised by other factors, such as drought or frost.

Sub-lethal *H. ater* damage may be significant to the forestry industry through losses in value, since sub-lethal damage may influence seedling growth rates or allow invasion by pathogens. Reay et al. (In press) found that sub-lethal damage by *H. ater* made seedlings vulnerable to invasion by sapstain fungi, and these fungi were isolated from half of severely damaged seedlings. Staining fungi are of significant economic concern to the New Zealand forest industry because *P. radiata* wood is very susceptible to staining.

The results show significant differences in the incidence of seedling damage between untreated and treated seedlings. The high incidence of damage on untreated seedlings

and the relatively low incidence of damage on treated seedlings indicates that carbosulfan may have had a repellent effect on *H. ater*. The benefits of protecting seedlings from contact with *H. ater* may be properly appreciated when the effects of sub-lethal damage, such as invasion by pathogens or compromised seedling health, are fully understood. Application of carbosulfan also reduced the severity of *H. ater* feeding damage since feeding beetles die when the pesticide is taken into their gut (Heritage et al. 1997). Seedling damage is less severe because feeding activity ceases soon after it is initiated. Reducing the severity of seedling damage by applying carbosulfan may provide other benefits, such as minimising invasion by fungal pathogens.

It is concluded that carbosulfan granules may be used to protect *P. radiata* seedlings from damage caused by *H. ater* when used at the recommended field rate of 10 g granules/seedling.

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