CARBARYL FOR CONTROL OF BLACK VINE WEEVIL (*OTIORHYNCHUS SULCATUS* (F.)) ON RHODODENDRONS

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SUMMARY

Carbaryl was evaluated for black vine weevil (*Otiorynchus sulcatus* (F.)) control in potted rhododendrons in a commercial nursery. One, two or three spray applications of carbaryl at 120 g/100 litres water were made after adult emergence in early summer with 2 weeks between repeat applications. Adult weevil survival was significantly reduced by double and triple applications of carbaryl but larval establishment was not affected. Leaf damage was reduced in all carbaryl treatments. Carbaryl residue levels decreased rapidly within 4-5 days after the first application, but less rapidly with each successive spray. Residue levels declined more quickly on plants watered overhead than on soil surface watered plants.

INTRODUCTION

Black vine weevil (BVW), *Otiorynchus sulcatus* (F.), is a ubiquitous pest which feeds on a wide variety of plants. Rhododendrons, azaleas, *Taxus* sp and other ornamental shrubs as well as herbaceous plants such as *Primula* sp, and cyclamens seem to be particularly favoured in nursery stocks. Adult weevils feed on the foliage of plants causing notching of the leaf margins, and larvae feed on the roots inflicting severe root pruning, damage to the root crown and sometimes girdling or ring barking at the soil surface. Larval damage is far more serious than adult feeding, but larvae have proved to be the more difficult to control with insecticides (eg. Parrella and Keil 1984). Potential for larval control using parasitic nematodes in late summer has been demonstrated (Barratt *et al* 1989) and this combined with insecticidal control of adults in spring may provide a satisfactory integrated management system for nurseries.

Barratt and Ferguson (1987) screened a number of insecticides in a laboratory bioassay and found that carbaryl gave highest mortality of adult BVW (80%). It was recommended from this work that carbaryl be tested in nursery conditions for BVW control, with applications over a 30-40 day period between adult eclosion and the onset of oviposition. Research in the USA has generally found carbaryl to be ineffective in controlling BVW (eg Nielson and Montgomery 1977; Nielsen 1983). However, Nielsen *et al* (1975) noted that 'carbaryl has acted as a stomach poison in successful field trials conducted by others' (unspecified). Helson (1974) recommended carbaryl for BVW control in New Zealand.

The trial described here was designed to evaluate carbaryl for BVW control on nursery stock rhododendrons, and to determine the number of applications required to maintain adequate residue levels on the foliage to give control under different watering regimes.

METHODS

Treatments

The trial was carried out during November-December 1987 in the shade house of a commercial nursery using BVW-free 1-year-old rhododendron cuttings 15-20 cm high in 25 cm diameter polythene planter bags with five plants per bag. Plants were sprayed to run off with carbaryl (Ispray Carbaryl 80W) at 120 g/100 litres water mixed with surfactant (Multifilm X-90) at 25 mls/100 litres using a 'Solo' knapsack pressurised sprayer. Treatments replicated six times were as follows:

Proc. 42nd N.Z. Weed and Pest Control Conf.

1. Untreated
2. Carbaryl applied once (11 November 1987), 1 week after the beginning of adult emergence.
3. Carbaryl applied twice, 1 and 3 weeks (26 November 1987) after the onset of adult emergence.
4. Carbaryl applied three times, 1, 3 and 5 weeks (11 December 1987) after the onset of adult emergence.

In each treatment BVW adults were not introduced to plants until after the first carbaryl application had dried on foliage. The adults were contained on the treated plants using mesh bags covering each plant. Because of this it was not possible to water plants using overhead sprinkler irrigation, so two further sets of six replicates of the four carbaryl treatments (as above) were established without weevils. One of these received water to the soil surface (as did the plants with weevils added) and the other set were subjected to normal overhead sprinkler irrigation.

BVW pupae were collected from infested plants in the nursery and held in the laboratory until adults emerged. In an attempt to approximate the field emergence pattern and not bias results towards high mortality levels, the weevils were introduced gradually to the plants over a 5 day period (11-16 November 1987) with six weevils in total added to each plant. Plants watered by overhead sprinklers received water each day in one or two periods of 1-2 hours duration. Three rain gauges were used to check for uniformity of watering from the sprinkler over the area covered by the plants. All plants were subjected to the same natural rainfall although the gauze bags may have reduced the amount of rain reaching those plants with weevils. Air and soil temperatures were recorded during the trial between 10.00 and 11.00 am at 2-3 day intervals.

Assessments

Samples of the tank mix of carbaryl were kept from each spray date, frozen and transported to Ruakura for analysis. Each sample was allowed to thaw at 23 °C, then mixed thoroughly and an aliquot removed and diluted 100-fold with methanol-water (1:1). A subsample of this solution was used for analysis by high performance liquid chromatography (HPLC)

Carbaryl residues on leaves were measured by taking samples of two leaves per plant from all treatments from the time when the first carbaryl treatment was applied and then twice weekly until 2 weeks after the final spray had been applied. Two 18 mm diameter leaf discs were cut from each leaf to give four leaf discs per plant. To reduce the number of analyses required, the six replicates were paired to give three residue samples per treatment at each sampling date. Discs were stored between sheets of grease-proof paper, placed in plastic bags and frozen as soon as possible after collection. Samples were transported to Ruakura and stored at -20 °C until analysed. For analysis, each set of eight leaf discs (four discs from each of two replicates) was placed in a vial with 20 ml of methanol-water (80:20). These extraction mixtures were allowed to stand at ambient temperature for 2 h with mixing at 30 min intervals. An aliquot was then removed for analysis by HPLC using reversed-phase analysis and detection at a wavelength of 222 nm. Recovery tests showed that this procedure extracted at least 80% of the extractable carbaryl residue from the leaf discs.

Two weeks after the final carbaryl application, three of the six replicate plants from each treatment which had weevils added were destructively sampled. The number of surviving BVW adults and the number of BVW larvae were recorded and these data were analysed by fitting generalised linear models using a binomial distribution with a logit link for adults and a Poisson distribution with a log link for larvae. The proportion of damaged leaves was calculated and the percentage leaf area loss of damaged leaves was visually estimated. In late February the remaining plants were sampled for BVW larvae.

The nursery in which the trial was conducted sprayed all their susceptible stock with carbaryl at 120 g/100 litres water at the time we recommended, i.e. 1 week after the beginning of adult emergence.

RESULTS AND DISCUSSION

The total amount of water recorded by the three rain gauges between 20 November and 24 December 1988 in the overhead sprinkler treatment varied between 2209 and 2812 mm. This included rainfall as well as that supplied by the sprinkler. Average mid-morning air temperature was $17.9 \pm 1.4^\circ\text{C}$ and soil temperature at 50 mm depth, $14.6 \pm 1.0^\circ\text{C}$ on the days recorded during the trial period.

Carbaryl residues

For the first, second and third treatment dates, the carbaryl levels in the tank mix subsamples as determined by analysis were 78.4, 104 and 100.7 g/100 litres respectively. These were lower than the expected level of 120 g/100 litres. However, it was observed that the carbaryl powder settled very quickly and the tank mix samples may not have been taken immediately after thorough tank shaking. It does indicate the need for continuous agitation of the mixture when using carbaryl.

The analysis of carbaryl residues on the leaf disc samples showed that levels fell rapidly during the 3-4 days after spraying (Fig 1). This fall off in residue levels became less pronounced with each successive application and may suggest a reduction in leaf growth dilution effects as the trial progressed. The carbaryl residues on plants which were irrigated by overhead sprinklers declined more rapidly and to a lower level than their hand-watered equivalents. This suggests that the carbaryl was washed off to some extent by overhead watering.

Fig. 1: Carbaryl residues ($\mu\text{g}/\text{cm}^2$) on leaf discs sampled at intervals after single, double or triple applications to rhododendrons.

Adult BVW survival and larval numbers

The retrieval rate of weevils was not high even in the unsprayed treatment where 55% of weevils were found alive and only 61% of weevils were recovered in total. Some dead weevils were found in a badly disintegrated state, but it is not clear whether others escaped or died and were not found. There were significantly fewer surviving adults in the x2 and x3 carbaryl treatments compared with the untreated plants (Table 1). The single treatment did not significantly reduce the number of surviving weevils.

The numbers of larvae extracted from the plants in December were low and there was no significant treatment effect (Table 1). In late February when the remaining three replicates were sampled the numbers of larvae found were very low and bore no relation to treatment. The reasons for such poor larval establishment even in untreated plants were not clear.

TABLE 1: BVW adult survival (of the six introduced to each plant), foliar damage and larval establishment in rhododendrons after carbaryl treatment

Treatment	BVW		% leaves undamaged	% leaf area loss of damaged leaves
	Adults* (proportion surviving ± SE)	Larvae* (no. per pot ± SE)		
untreated	0.56 ± 0.10	2.3 ± 0.9	29.8	26.3
carbaryl x 1	0.28 ± 0.10	5.0 ± 1.3	38.4	11.9
carbaryl x 2	0.06 ± 0.05	5.0 ± 1.3	56.6	13.7
carbaryl x 3	0.06 ± 0.05	6.0 ± 1.4	61.5	11.9
SEM			10.1	1.9

* Values predicted by model

Foliar damage

A significantly lower proportion of the leaves of plants which received three carbaryl treatments were damaged by BVW compared with untreated plants. Of those leaves which were damaged, the percentage leaf area loss was reduced in all carbaryl treatments, although there was no relationship between the number of carbaryl applications and degree of leaf injury.

The nursery reported no damage from BVW in their rhododendrons and other stock which had been sprayed as recommended.

CONCLUSIONS

Carbaryl may have a role in nurseries for BVW control. Although no control of ensuing larvae was demonstrated in this trial, two applications of carbaryl reduced adult survival. This combined with biological control of larvae in late summer might form the basis of a satisfactory integrated management system for BVW control in nurseries.

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