EFFECTS OF HOST PLANT CHARACTERISTICS ON SPRAY DEPOSITION

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ABSTRACT

Previous studies have shown that the effect of *Bacillus thuringiensis* var. *kurstaki* (Btk) on painted apple moth (PAM; *Teia anartoides* Walker) efficacy varies significantly depending on the host plant species. This study tested the hypothesis that host plant architecture influenced deposition of aerially applied Btk and its consequent efficacy against PAM. Laboratory experiments demonstrated that the architecture of six host plants had a significant influence on Btk dose per unit leaf area and dose per unit leaf weight. However, the large host plant effect on PAM mortality from Btk could not be explained in terms of variation in the amount of spray intercepted.

Keywords: *Bacillus thuringiensis,* spray deposition, canopy architecture, host plant interaction, painted apple moth, *Teia anartoides*.

INTRODUCTION

At the beginning of any pest eradication operation requiring aerial application of a pesticide, a decision must be made on the appropriate application rate. Previous studies have shown that painted apple moth (PAM) mortality from a given dose of Btk is strongly influenced by host plant species (B. Richardson, unpubl. data). The selected dose and the timing and frequency of spray applications are all factors that will have a huge influence on the success of a pest eradication operation. Therefore understanding the factors that may be causing the variation in pest mortality when a given dose of Btk is applied to different host plants is important for optimising a pest eradication operation.

One factor that could contribute to the observed host plant effect on pest mortality is the canopy architecture of the different plant species. Previous studies have shown that for a given set of spray application characteristics, plant architecture and leaf area density can have a large influence on the amount of spray deposition and its distribution through the canopy (Richardson & Newton 2001; Richardson & Thistle 2006).

Therefore, experiments were conducted to determine whether differences in spray deposition per unit foliage area on a range of PAM host plant species explained the strong Btk dose/host plant interaction.

MATERIALS AND METHODS

Test species

Spray deposition was measured on six PAM host plant species that had varying foliage architecture, viz. *Pinus radiata*, *Acacia mearnsii*, *Paraserianthes lophantha*, *Sophora microphylla*, *Corynocarpus laevigatus* and *Nothofagus solandri*.

Measuring deposition

For each test species, 15-20 samples of foliage (branch segments) were taken from 1-5 trees immediately prior to applying the spray treatment. Samples were taken from current year's foliage during summer and were approximately 20 cm in length. As far as possible, each sample was visually representative of a typical foliar element of that species. Once collected, the cut stem of each branch segment was placed in conical flasks filled with water to keep the samples hydrated.

Prior to spraying, plant samples were placed upright in florist's blocks and sprayed separately. To measure the actual rate of Btk applied, a horizontal mylar sheet (147 × 106.5 mm) was sprayed before the first and after every fourth plant sample. All spray applications were made using a calibrated belt tracksprayer. Btk (as Foray 48B) was applied at 5 litres/ha using an Ulva+ (Micron Sprayers Ltd.) controlled droplet applicator set at 13,500 rpm during spraying. The volume median diameter (VMD) of the applied droplet spectrum was approximately 115-130 µm. VMDs were calculated by measuring the crater diameter, created by the impaction of droplets onto a magnesium oxide covered microscope slide (Matthews 1979).

The amount of Btk deposited on sprayed plants was determined by excising all leaves from the plants and then rinsing them with a known volume of distilled water to remove the Btk. The amount of Btk in the washings was determined by measuring light absorbance at 262 nm using a spectrophotometer (PG Instruments Ltd, T70) and comparing the measured value with dilution standards. Recovered Btk from each sample was adjusted to account for differences in application rate, based on analysis of deposition on mylar sheets. Following calculation of leaf area, normalised deposition per unit leaf area was estimated.

Leaf area measurements

Absolute leaf area is the actual one-side area of all leaves in the sample being sprayed. It is an important measurement because absolute leaf area represents both the amount of leaf area available for PAM consumption and the area over which spray deposition can be distributed. Absolute leaf area of excised leaves from test plant samples (other than pine needles) was measured with either the LI-3100 (Licor, Nebraska, USA) or by photographing the leaves and using image analysis software (V++, Digital Optics Ltd.) to determine their area. For pine needles, which have a 3-dimensional structure, the total surface area and half the total surface area were calculated using the techniques of Beets (1977).

Following leaf area measurements, oven dry weights were obtained for each plant sample.

Analysis

For each plant species, Btk deposition was calculated both per unit leaf area and per unit leaf mass. Analysis of variance and least significance difference tests were used to test whether there were differences in deposition. These results were then compared with the nominal dose needed to kill 50% of PAM larvae (LD_{50}) measured using standard bioassay techniques (e.g. Richardson et al. 2005). If the interaction between host plant species and Btk efficacy is due to differential deposition on different plant species, then there should be a strong correlation between measured deposition and LD_{50}.

RESULTS AND DISCUSSION

Canopy architecture effects

Analysis of variance and least significant difference tests (Table 1) showed that there were significant differences between species in terms of spray deposition per unit leaf area or per unit weight and leaf density.

That there were differences in dose received per unit leaf area is not surprising. The probability of interception depends on the gap fraction within a canopy (the proportion of space between foliage elements) on a plane normal to the droplet trajectory (Richardson & Newton 2001). In turn, gap fraction depends on the area density, distribution, orientation and inclination of foliage elements. Simple observation of the different types of foliage indicates large differences in their basic architecture. For example, there are the large, planar and more-or-less horizontal leaves of *C. laevigatus*, the highly clumped needle and fascicle structure of *P. radiata* and the complex and sensitive double compound leaves of *A. meansii and P. lophantha*.

TABLE 1: Spray deposition per unit leaf area and per unit leaf weight and leaf density for six plant species that are hosts to painted apple moth.

Species	No. plants	Deposition per unit leaf area (µl/cm^2)	Deposition per unit leaf weight (µl/g)	Leaf density (g/cm^2)
P. radiata	10	0.0412 d[1]	2.1 d	0.0196 a
A. mearnsii	15	0.0653 a	4.2 bc	0.0161 b
P. lophantha	15	0.0691 a	4.6 ab	0.0152 b
S. microphylla	15	0.0306 c	3.3 c	0.0092 c
C. laevigatus	10	0.0434 b	5.8 a	0.0076 d
N. solandri	15	0.0172 d	4.4 bc	0.0039 e

[1]Values in a column followed by the same letter do not differ significantly (P=0.05).

The different ranking of plant species in terms of dose per unit leaf weight reflects the dose received per unit leaf area for each leaf type and the respective leaf density (Table 1). Previous work has shown that PAM mortality on a given species is strongly related to droplet density (Richardson et al. 2005). However, when comparisons are made between species, leaf mass also is an important factor. The relative importance of dose per unit leaf area and dose per unit leaf mass depends on whether PAM larvae consume the entirety of the lamina or whether they simply graze on the leaf surfaces. Observation indicates the former is most common; hence dose per unit leaf mass is probably the most important factor.

The critical test of the importance of results from this experiment is whether the observed Btk/host plant interaction can be explained by differences in actual deposition between the species. There was no significant correlation between the LD_{50} of Btk on each test species and either actual deposition per unit leaf area (P=0.95) (Fig. 1) or deposition per unit mass (P=0.25) (Fig. 2).

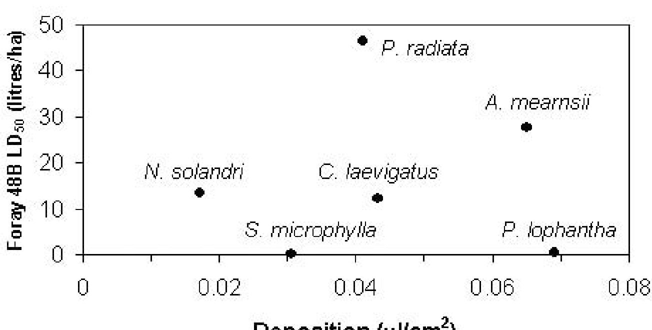

FIGURE 1: Relationship between actual Btk deposition on test plants (amount per unit leaf area), following application of a standard dose, and the LD_{50} of each test plant.

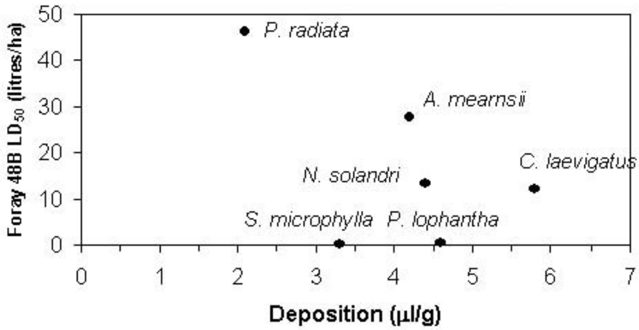

FIGURE 2: Relationship between actual Btk deposition on test plants (amount per unit leaf dry weight), following application of a standard dose, and the LD_{50} of each test plant.

The conclusion from these results is that, while there are species specific differences in deposition for a given application rate, the Btk/host plant correlation is not dependent on foliage architecture factors that lead to species specific differences in deposition for a given application rate. More simply, the large host plant effect on PAM mortality from a given dose of Btk cannot be satisfactorily explained in terms of variation in the amount of spray intercepted by different foliage types.

CONCLUSIONS AND RECOMMENDATIONS

Plant architecture had a significant influence on dose per unit leaf area and dose per unit leaf weight. However, the large host plant effect on PAM mortality from a given dose of Btk cannot be explained in terms of variation in the amount of spray intercepted by different foliage types. Based on this finding it is clear that more work is needed to identify the mechanism of the Btk efficacy/host plant interaction.

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