EVALUATING TARGETED AERIAL SPRAYING FOR INSECT CONTROL

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ABSTRACT

The main target zones in early plans for eradicating painted apple moth (PAM) (*Teia anartoides*) in Auckland, New Zealand, were narrow riparian strips of vegetation and steep gullies. However, there were concerns that achieving high levels of *Bacillus thuringiensis* var. *kurstaki* (Btk) deposition in these riparian areas, with minimal drift onto residential areas, would be difficult. This is because, with a combination of small droplets and high release heights, there would be considerable downwind movement of the spray cloud. The concept of targeting riparian strips was evaluated using an aerial spray application simulation model. Results indicated that targeted spraying is not a practical proposition, at least where small droplets are used and high release heights are required. The only solution would be to build larger target areas around the riparian strips. For targeted spraying to become a practical proposition, techniques must be developed for achieving efficacy using much larger spray droplets.

Keywords: aerial spray models, deposition, drift, targeted spraying, *Teia anartoides*.

INTRODUCTION

The painted apple moth (PAM) (*Teia anartoides* Walker), a native of Australia, was first found in the west Auckland suburb of Glendene in May 1999. This species has been recorded feeding on and damaging a wide range of host plants, including *Acacia* spp., radiata pine (*Pinus radiata* D. Don), pip and stone fruit trees and some native species. In October 2001, the Ministry of Agriculture and Forestry (MAF) decided to supplement ground-based attempts at eradication of PAM by using aerial application of *Bacillus thuringiensis* var. *kurstaki* (Btk), formulated as Foray 48B. The conventional aerial application method for an operation of this kind is to release a cloud of small droplets along a succession of evenly-spaced swaths, producing a "blanket" of spray deposits. With this method, the likelihood of significant skips (areas that receive low doses of Btk or that are missed completely) is relatively low. However, MAF's original plan for the PAM eradication project was to only spray Btk insecticide over the narrow riparian margins between the Whau estuary and adjacent residential areas where the moth larvae were most concentrated. Although Btk has a very low mammalian toxicity, this approach would limit the extent to which residential areas might be exposed to the insecticide.

The riparian zones comprise narrow, meandering strips of vegetation up to about 30 m tall, and often the main target species are in the understorey. Also there are many obstacles in the spray zones, such as overhead power lines or individual tall trees. A combination of small droplets to maximise efficacy (B. Richardson, unpubl. data) and high release heights, is known to result in considerable downwind movement of the spray cloud. Therefore, to deposit the spray on a narrow strip of vegetation the aircraft is required to release the spray upwind from the target area. This technique, known as swath displacement, is the horizontal offset distance between the flight line and the target area.

This paper presents results from a study to determine whether aerial spraying of discrete riparian areas with small droplets is a practical proposition for applying insecticide for insect control.

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METHODS

An evaluation of targeted spraying was undertaken using SpraySafe Manager 2 (SSM2), a GIS-based aerial spray application decision support system (Ray et al. 1999; Schou et al. 2001). Field data for the modelling study were taken from a spray trial undertaken in a flat, recently mown paddock in Murupara. This site simulated the important characteristics of the Auckland riparian strips. A 200 m long line, containing one significant bend, was marked using bright yellow plastic tape to indicate the edge of the target zone. Meteorological measurements taken on site included wind speed and direction using a Gill x, y, z, anemometer, and temperature and relative humidity (Skye Instruments), all at 2 m above the ground.

The pilot of a Jet Ranger helicopter was asked to fly flight lines, with a nominal spray release height of 20 m and flying speed of 111 km/h, as if he was trying to target a spray zone that had its edge defined by the yellow tape. Prior to approaching each flight line the pilot was relayed a specific swath displacement, from which to judge his flight path. Actual flight line locations, release heights and speeds were subsequently evaluated using data from the aircraft's global position system (GPS) and spraying system. In total, 14 comparisons were made between requested and actual swath displacement, using a range of nominal displacement values from 0 – 70 m, with seven lines flown either side of the marked target zone. The consequences of errors in the pilot's ability to fly to the requested specifications were determined using SSM2.

RESULTS AND DISCUSSION

In the 14 test flights described above, the requested release height was 20 m. Actual release height varied between 11 and 44 m, with a mean of 26.4 m (SD 10.8 m). However, these figures were influenced by data from the last three flight lines when the pilot flew at heights of between 39 and 42 m. These excessive heights may have been related to strong gusts of wind (up to 30 km/h) during the last few flight lines. These gusts were much higher than the recommended maximum wind speed for the PAM operation (12 km/h). If the last three runs are omitted, mean release height was 20.4 m (SD 6.2 m). In subsequent analyses, only the smaller values for release height variability were used.

Actual mean swath displacement values were consistently higher than the requested values (Fig. 1a). On average, for swath displacement values less than 30 m the actual displacement was just over twice what was requested. With higher displacement values the proportional error decreased. As would be expected, the variability in swath displacement along an individual flight line increased as actual swath displacement increased (Fig. 1b). Under standard spraying conditions, where the aircraft is flying straight, parallel lines using some form of GPS track guidance, the level of variation would probably be reduced. Under the trial conditions, which simulated the proposed Auckland PAM operation, the pilot had to judge the appropriate displacement from an irregular target zone boundary.

The mean flying speed over the tests of 115 km/h (SD 6.5 km/h) was close to the requested value of 111 km/h with a range of 107-124 km/h.

Meteorological variables

As mean wind speed increased its standard deviation also increased (data not shown), but at a relatively slow rate. The standard deviation of wind direction was relatively unaffected by wind speed.

Implications of variability

Previous work has demonstrated that predictions of spray deposition from the SSM2 system are reliable as long as inputs are accurately quantified (Bird et al. 2002; Ray et al. 1999; Richardson et al. 1995). However, using mean values for important variables can be misleading unless results are interpreted with care (Richardson et al. 2001). The trial results provided information on the level of variability of important spray application variables. SSM2 was used to evaluate the effect of this variability on swath displacement.

Droplet size, wind speed, and release height are among the most important factors influencing spray deposition and drift (Teske et al. 1996). Of these factors, droplet size

FIGURE 1: Relationships between (a) requested swath displacement and actual mean swath displacement based on GPS data (1:1 line indicated for reference); and (b) mean swath displacement and the standard deviation (sd) of swath displacement.

TABLE 1: Modelled swath displacement values calculated for two droplet sizes and a range of wind speeds and release heights. The results presented are for the mean condition and plus or minus one standard deviation.

Scenario	Droplet VMD (μm)	Wind speed (km/h)	Release height (m)	Swath displacement (m^2)
<i>Small drops, low wind</i>				
- 1 SD ¹	140	4.0	31.5	81
Mean	140	3.2	45.0	119
+ 1 SD	140	4.8	58.5	223
<i>Small drops, high wind</i>				
- 1 SD	140	10.0	31.5	146
Mean	140	8.0	45.0	314
+ 1 SD	140	12.0	58.5	558
<i>Large drops, low wind</i>				
- 1 SD	220	4.0	31.5	18
Mean	220	3.2	45.0	41
+ 1 SD	220	4.8	58.5	80
<i>Large drops, high wind</i>				
- 1 SD	220	10.0	31.5	67
Mean	220	8.0	45.0	181
+ 1 SD	220	12.0	58.5	263

¹SD = standard deviation.

²Swath displacement calculated using SSM2.

is more-or-less constant throughout an operation but wind speed and release height vary depending on the prevailing meteorological and flying conditions, respectively. Consequently, variability was only modelled for release height and wind speed. The first step was to use SSM2 to determine the swath displacement assuming a set of four mean conditions (two droplet sizes and two wind speeds) (Table 1). Then, based on variability observed in the trials, the calculation was repeated using the mean conditions $\pm$ one standard deviation. Droplet spectra used in the simulation had volume median diameters (VMDs) of either 140 μ m and 220 μ m. Laboratory tests (B. Richardson, unpubl. data) indicated that efficacy was greater with the smaller size. However, larger droplets would be less prone to drift.

The swath displacement values calculated for mean conditions would normally be the basis for defining an operational swath displacement. However, when variability was included in the analysis, the swath displacement values differed considerably from the mean (Table 1). Under the “worst” case condition tested, with small droplets, high wind speed and high release height, a mean swath displacement of 314 m would be required. If variability of wind speed and release height are added to the analysis, the required swath displacement ranged from 146 to 558 m. Even under the “best” case condition tested, large droplets and a low wind speed, the range in swath displacement values was from 18 to 80 m. The calculations represented in Table 1 do not include variability resulting from the pilot’s ability to fly a specified swath displacement and to accurately maintain this position. Incorporating this factor would have increased the swath displacement ranges represented in Table 1.

CONCLUSION

Results indicated that targeted aerial spraying is not a practical proposition, at least where small droplets are used and high release heights are required. Measurements indicated that it is difficult for an experienced agricultural pilot to judge swath displacement even under favourable conditions. Therefore it is not conceivable that a pilot would be able to judge displacements of up to several hundred metres for meandering strips. The only solution would be to build larger target areas around the riparian strips, which would effectively be approaching the conventional blanket spray application method. For targeted spraying to become a practical proposition, techniques must be developed for achieving efficacy and the required degree of coverage using larger spray droplets.

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