Pyronyl Crop Spray Effective in Controlling Larvae of the Asian Tiger Mosquito (*Aedes albopictus* [Skuse] [Diptera: Culicidae]) in Non-Circulating Hydroponic Nutrient Solution

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Abstract. One to two ppm of Pyronyl Crop Spray (Pyronyl) effectively controlled larvae of the Asian tiger mosquito *Aedes albopictus* (Skuse). The mean LT_{99} was 35.8 hrs for 1.0 ppm and 2.3 hrs for 2.0 ppm Pyronyl. Pyronyl concentrations of 0, 0.062, 0.125 and 0.25 ppm resulted in similar time to the LT_{99} (greater than 200 hrs). Pyronyl mixed in the nutrient solution at 1.25, 2.5 and 5.0 ppm did not reduce the mean head weight of lettuce grown in the nutrient solution for 5 weeks. Pyronyl at these concentrations did not affect root weight at 1.25 and 2.5 ppm, but a slight reduction in root weight was observed at 5.0 ppm. Based on these results, Pyronyl is an effective compound for commercial non-circulating hydroponic lettuce growers to use against *A. albopictus*. Growers typically add approximately 4.0 L of nutrient solution per plant, utilizing this approximation, 1.0 ml of Pyronyl solution per 125 plants would provide *A. albopictus* control.

Introduction

Non-circulating hydroponic production of vegetable crops, especially lettuce, has flourished in Hawaii over the past years since its development by Kratky (1993). These systems, however, utilize the principle of stagnant, non-aerated, nutrient solution that has proven to be an excellent breeding site for the Asian tiger mosquito, *Aedes albopictus* (Skuse). Since growers typically enclose hydroponic greenhouses with screen-netting to deter migrating insect pests, *A. albopictus* populations rise very rapidly once introduced into the greenhouse area. The recent appearance of Dengue Fever and West Nile disease in Hawaii have furthered the concern and need for controlling this primary mosquito vector.

In previous papers, we have reported control of *A. albopictus* larvae with *Bacillus thuringiensis israelensis* (*Bti*) impregnated in an organic vermiculite carrier (VectoBac G) when added directly into the nutrient solution (Furutani and Arita-Tsutsumi, 2002a; 2002b). A single full dose of VectoBac G, however, significantly decreased lettuce head weight when grown in the nutrient solution. Splitting the application into 2 half-doses, a split-application, resulted in lettuce head weights similar to the control. While VectoBac G is effective in controlling *A. albopictus* larvae, it is not registered for hydroponic use.

Pyronyl Crop Spray (Pyronyl), Prentiss Incorporated, C.B. 2000, Floral Park, NY 11001) is a combination of 6% pyrethrins and 60% piperonyl butoxide. Pyronyl is currently labeled for use on hydroponically grown vegetables and is also labeled for use as a water system treatment (nutrient solution treatment) to control aquatic dipteran larvae.

Nearly all hydroponic systems utilize either a circulated or an aerated nutrient solution to grow crops and mosquitoes are not usually a problem in these systems. In Hawaii, however, most growers are utilizing the recently developed non-circulating hydroponic system where the nutrient solution remains stagnant. Plants grown in stagnant nutrient solutions have proven to be very sensitive to petroleum compounds when added to the nutrient solution (Furutani and Arita-Tsutsumi, 2002b). The purpose of this experiment is to determine the effective Pyronyl dose for *A. albopictus* larvae and its phytotoxicity on lettuce when grown in a stagnant nutrient solution.

Materials and Methods

Determination of LT_{50} and LT_{99}. Larvae were collected from 5 gallon buckets that were set outdoors in the Puna, Hawaii area. Ten mosquito larvae (wigglers) were transfered to 1.0 liter glass jars (Ball jars) containing 500 ml of 0, 0.062, 0.125, 0.25, 0.5, 1.0 or 2.0 ppm Pyronyl Crop Spray (Pyronyl), Prentiss Incorporated, C.B. 2000, Floral Park, NY 11001. The Pyronyl solution was made by first preparing a stock solution of 1,000 ppm Pyronyl in a 1.0 liter volumetric flask (1.0 ml Pyronyl/L). The 2.0 ppm Pyronyl solution was made from the 1,000 ppm stock solution (2.0 ml of 1,000 ppm Pyronyl/L). The 2.0 ppm Pyronyl solution was then serially diluted to derive the other concentrations. Jars were then covered with absorbent paper towels, with small perforations for air exchange, secured with screw-down metal rings provided with the Ball jars. Ball jars were set on a lab bench at 22 ± 3 C. Each treatment consisted of 5 replicate jars. Mosquito mortality was recorded at 2, 24, 48, 120, and 144 hrs after treatment. Time-mortality regression equation; and hrs to LT_{50} and LT_{99} along with the 95% fiducial limits for each concentration was estimated by probit analysis using Minitab Statistical Software Release 13, Minitab Inc.

Pyronyl phytotoxicity on lettuce. Clear, four-liter polycarbonate containers (containers for bottled drinking water) were modified for use as hydroponic tanks. The containers were double wrapped with black polyethylene plastic (6 mm thick) to block the entrance of light. The containers' spout was fitted with a net pot as described by Kratky (2002) in the suspended pot method of non-circulating hydroponics.

The nutrient solution was prepared by mixing 1.2 g 10-8-22 Universal Sump Tank Formula (Chem-Gro, Hydro-Gardens, Inc., Colorado Springs, CO) per L of water. Pyronyl treatments were 0, 1.25, 2.5, and 5 ppm Pyronyl in the nutrient solution prepared as described above. The nutrient solution containing Pyronyl was then added to each container until 2 cm of bottoms of the net pots were submerged in the solution. Each treatment consisted of 7 replicates arranged in a completely randomized design.

'Green Mignonette Manoa' lettuce, *Lactuca sativa* L. seedlings were prepared by sowing seeds 0.25 cm deep into seedling trays filled with a standard potting mix (Pro-mix, Ontario, Canada). The seedlings were grown in the greenhouse for 12 days before transplanting into net pots containing a 1:1:1 mixture of peat: vermiculite (no. 2 grade): horticultural perlite (medium grade). The plants were grown in a polycarbonate-covered greenhouse. No additional nutrient solution was added. Lettuce heads were harvested just above the surface of the media and weighed after 5 weeks. Roots extending beyond the net pots were harvested, dried in a drying oven and weighed. Fresh head weight and root dry weight from each Pyronyl treatment were statistically analyzed with oneway ANOVA using Minitab Statistical Software Release 13, Minitab Inc.

Results and Discussion

The time-mortality regression equations are presented in Table 1. Regression coefficients were highly significant ($P = 0.01$) for all treatment levels except for the 2.0 ppm Pyronyl treatment which was significant at $P = 0.05$. The LT_{50} and LT_{99} and 95% fiducial limits are also presented in Table 1.

Table 1. Time-mortality regression equation, hours to LT_{50} and LT_{99}, and 95% fiducial limits for *Aedes albopictus* larvae exposed to various concentration of Pyronyl Crop Spray.

Pyronyl concentration (ppm)	Time-mortality regression equation	Regression Coefficients R^2 values	Hours to LT_{50}	95% fiducial limits		Hours to LT_{99}	95% fiducial limits	
				upper	lower		upper	lower
2.0	Y = 4.3320 + 0.1223X	0.408*	1.6	49.38	–46.10	2.3	42.21	–37.61
1.0	Y = 3.3763 + 0.1219X	0.724**	10.3	13.36	7.68	35.8	46.47	29.47
0.5	Y = 2.7869 + 0.0568X	0.846**	36.7	42.97	31.74	88.1	109.68	74.90
0.25	Y = 2.6360 + 0.0230X	0.794**	95.9	112.43	83.50	221.7	272.60	189.40
0.125	Y = 2.4338 + 0.0181X	0.853**	130.5	146.18	118.38	260.0	310.41	228.10
0.0625	Y = 2.5213 + 0.0154X	0.748**	142.5	116.53	125.99	309.7	387.39	263.10
0.0	Y = 2.6402 + 0.0144X	0.755**	147.1	174.98	128.52	330.9	421.74	277.65

Significant at *P = 0.05 or **P = 0.01. Each treatment concentration consisted of 5 replications with 10 larvae per replication. Larvae mortality was measured at 0, 2, 24, 48, 120, and 144 hrs after Pyronyl Crop Spray treatment.

Table 2. Mean head and root weights (g) of 'Green Mignonette Manoa' lettuce at different concentrations of Pyronyl.

Pyronyl concentration (ppm)	Fresh head wt. (g)	Root dry wt. (g)
0	131 $\pm$ 32 NS	1.6 $\pm$ 1.0 NS
1.25	153 $\pm$ 37	1.6 $\pm$ 0.9
2.5	162 $\pm$ 36	2.2 $\pm$ 1.6
5.0	139 $\pm$ 23	1.2 $\pm$ 0.3

NS Means within columns not significant by F test at P = 0.05. Each treatment concentration consisted of 7 replicate containers with 1 lettuce plant per container.

Pyronyl concentrations of 0.062, and 0.125 resulted similar time to $LT_{50,}$ (greater than 130 hrs). One and 2.0 ppm Pyronyl concentrations caused 50% mortality in 10.3 and 1.6 hrs, respectively. One-half and 0.25 ppm Pyronyl concentration resulted in 50% mortality at, 36.7 and 95.9 hrs, respectively. More than 100 hours were required to attain LT_{50} with more dilute Pyronyl concentrations. More than 200 hours were required to achieve LT_{99} mortality at Pyronyl concentrations of 0, 0.062, 0.125 and 0.25 ppm. However at 0.5, 1.0 and 2.0 ppm concentrations of Pyronyl, the LT_{99} mortality was greatly reduced to 88.1, 35.8 and 2.3 hrs, respectively.

Lettuce-head and root dry weight after 5 weeks at different concentrations of Pyronyl are presented in Table 2. The mean head weight of the control was 131 $\pm$ 32 g. Mean lettuce head weights were higher in the 1.25, 2.5 and 5 ppm Pyronyl treatments then in the control, but differences were not significant. At 1.25 ppm, the root mean weight was the same as the control (1.6 g). At 2.5 ppm Pyronyl, the mean root weight was higher (2.2 g). However, mean root weight was slightly lower (1.2) at 5.0 ppm Pyronyl concentration. Results for the root weights among treatments were not significant.

The results show that Pyronyl is a very effective in controlling *A. albopictus* larvae. Two ppm Pyronyl effectively killed all larvae within 3 hrs. This concentration did not reduce the mean head and root weights of lettuce as compared to the control. Growers typically add around 4 L of water per plant. Thus, 1 ml of Pyronyl solution per 125 plants would provide control of *A. albopictus* larvae. Since Pyronyl is labeled for hydroponically grown vegetables and for application in the nutrient solution and is effective at low concentrations, it provides an option for growers of hydroponic crops to control *A. albopictus* larvae in stagnant nutrient solutions.

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Literature Cited

Furutani, S.C. and **L. Arita-Tsutsumi.** 2002a. Use of *Bacillus thuringiensis israelensis* and methoprene to control Asian tiger mosquito, *Aedes albopictus* (Skuse) (Diptera: Culicidae), in non-circulating hydroponic tanks. *Proc. Hawaiian Entomol. Soc*. 35:113–119.

Furutani, S.C. and **L. Arita-Tsutsumi.** 2002b. Split-application of *Bacillus thuringiensis israelensis* to control Asian tiger mosquito, *Aedes albopictus* (Skuse) (Diptera: Culicidae), without reducing lettuce head weight in non-circulating hydroponics. *Proc. Hawaiian Entomol. Soc*. 35:125–128.

Kratky, B.A. 1993. A capillary, noncirculating hydroponic method for leaf and semi-head lettuce. *HortTechnology* 3: 206–207.

Kratky, B.A. 2002. A simple hydroponic growing kit for short-term vegetables. University of Hawaii, College of Tropical Agriculture and Human Resources publication HG-42.