Selective Toxicity of Pirimicarb, Carbaryl and Methamidophos to Green Peach Aphid, (*Myzus persicae*) (Sulzer), *Coleomegilla maculata lengi* (Timberlake) and *Chrysopa oculata* Say.[1,2]

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ABSTRACT

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The selective toxic insecticidal properties of pirimicarb, carbaryl and methamidophos to the green peach aphid, *Myzus persicae* (Sulzer), and its predators, *Coleomegilla maculata lengi* (Timberlake) and *Chrysopa oculata* (Say) were studied. Pirimicarb was less toxic than carbaryl and methamidophos to *C. maculata* and *C. oculata* and more toxic to aphids. The selectivity ratio for pirimicarb indicating selectivity favoring the predators was ca. 4000:1.

Introduction

The green peach aphid, *Myzus persicae* (Sulzer), is an important pest of Irish potatoes. Infestations decrease yields by reducing plant growth (Mackauer and Way 1976) and vectoring virus diseases. The aphid's ability to cause damage at low population densities and its tendency to spread widely present especially difficult control problems. Presently insecticides are needed and will continue to be used in the forseeable future to regulate green peach aphid populations on potatoes. The strategy behind integrated pest management systems is to use as many methods as available to keep the pest population below economic status. The rationale behind integrated techniques is optimization of the cost benefits to pest control. Generally these allow reduced applications of insecticide. Integrated techniques may also diminish the chances of an insect species developing resistance to an insecticide. Total reliance on a toxicant would tend to concentrate those individuals containing genes for resistance. However, pests subjected to a series of control methods would have the tendency to maintain a diverse gene pool in the population, lessening the chances of concentrating the resistant gene. Considering the costs of developing and producing new chemicals, the judicious use of chemicals along with natural enemies can serve a dual purpose: reducing the quantity of chemical needed and retaining the chemical's efficacy. Thus efforts to develop selective insecticides are needed to enhance the impact of natural enemies in an integrated pest management program.

The dose mortality response provides a relatively precise means of assessing the effects of insecticides on beneficial and pest species of insects. *Coleomegilla maculata lengi* (Timberlake) is a predominant coccinellid species found on potatoes in central Pennsylvania and *Chrysopa oculata* (Say) is one of the most abundant lacewing species. The larvae and adults of *C. maculata lengi* and *C. oculata* feed on a variety of soft-bodied insects including aphids. The objective of this study was to quantify the selective toxic properties of pirimicarb, methamidophos and carbaryl on adult *C. maculata lengi*, 2nd instar larvae of *C. oculata* and apterous adult *M. persicae*.

Materials and Methods

Experimental insects were laboratory reared in mass. Predators were maintained in an environmental chamber at 24±2°C and 70-80% RH and constant illumination. Pea aphids, *Acrythosiphon pisum* (Harris), were given daily in amounts corresponding with the predators' food requirements.

Second instar *C. oculata* larvae, 5 days old, and 3-14 day old *C. maculata lengi* male or female adults, were used for dose mortality tests. Green peach aphids were maintained on radishes and Chinese cabbage at 20±3°C, 16L:8D photoperiods and 75-80% RH. The mean weights (mg) were obtained prior to testing. *C. maculata lengi* males, 13.59±.25; *C. maculata lengi* females, 17.75±53; *C. oculata* 2.81±25; *M. persicae*, .56±12.

Insecticides were diluted in acetone from technical grade material (purity of 98-100%). A microapplicator fitted with a calibrated 0.25 ml tuberculin syringe and a 28 gauge hypodermic needle was used to apply each insecticide. One μl was applied to the abdominal sternites of the predators and 0.25 μl to the dorsum of *M. persicae*. The doses applied to each insect for the toxicants were as follows: *M. persicae*; pirimicarb, 0.000075—0.00075; methamidophos, 0.0025—0.25, carbaryl 0.002—0.025; *C. oculata:* pirimicarb, 0.5—50, methamidophos 0.007—0.09, carbaryl 0.03—0.14; *C. maculata lengi:* pirimicarb, 13—60, methamidophos 0.02—.8, carbaryl 0.05—.5. The coccinellids and chrysopids were held stationary during dosing by vacuum pressure. *M. persicae* were dosed according to a modified method prescribed by the F.A.O. (1970). Aphids were treated while feeding on Chinese cabbage leaf disks attached to a 1.3 × 2 cm Kraft® paper expanded honeycomb cell, Hexacell®. Treated insects were held at 24±1°C and 60-80% RH.

Mortality was determined 24 h after treatment for *M. persicae* and 48 h for *C. maculata lengi* and *C. oculata*. Moribund and dead insects were combined in estimating mortality. The dose mortality response curves were obtained from means of each replicate. A minimum of 5 doses containing from 270 to 470 insects were used to establish the response. Treatments were replicated 2-11 times with a total of 20-100 insects/dose. A minimum

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of 100 and an average of 200 insects were treated within the 95% confidence limit of the LD_{40}-LD_{60} concentrations. No apparent difference in the response of male or female *C. maculata lengi* adults to the insecticides was observed. The data were subjected to probit analyses (Daum 1970) to determine dose mortality response.

Results and Discussion

The dose mortality responses of green peach aphids, *C. maculata lengi* and *C. oculata* to primicarb, methamidophos and carbaryl are contained in Table 1 and Figure 1. Pirimicarb was the most toxic compound against *M. persicae*; LD_{50} on 0.4 μg/g. Although predators were most susceptible to methamidophos, pirimicarb was relatively nontoxic to *C. maculata lengi* and *C. oculata*. Carbaryl was significantly more toxic to *C. maculata lengi* than to the aphid and chrysopid species (Fig. 1C). Comparison of the LD_{50}s of each insecticide to the 3 species indicated pirimicarb was ca.: 1) 17 and 65 times more toxic than methamidophos and carbaryl to *M. persicae*; 2) 57 and 200 times less toxic than carbaryl and methamidophos to *C. oculata*; 3) 390 and

Table 1.—Relative toxicities of 3 insecticides applied topically to apterous adult *M. persicae, C. maculata lengi* adults and 2nd instar *C. oculata* larvae.

Insecticide	LD_{50} μg/insect	LD_{50} μg/g	95% Confidence limits of LD_{50}	Slope of dosage mortality line ± standard error
Carbaryl				
M. persicae	.013	26.09	21.61–32.59	1.57 0.20
C. maculata	.066	4.24	3.75–4.67	3.17 0.41
C. oculata	.083	28.76	23.28–33.68	2.05 0.29
Methamidophos				
M. persicae	.004	6.92	5.86–7.85	2.63 0.43
C. maculata	.049	3.10	2.82–3.38	4.46 0.58
C. oculata	.022	8.19	6.62–9.96	2.32 0.28
Pirimicarb				
M. persicae	.0003	.54	.33–.49	1.51 0.22
C. maculata	25.59	1639.78	1510.48–1814.71	3.71 0140
C. oculata	4.50	1612.18	1106.37–2326.11	1.15 0.16

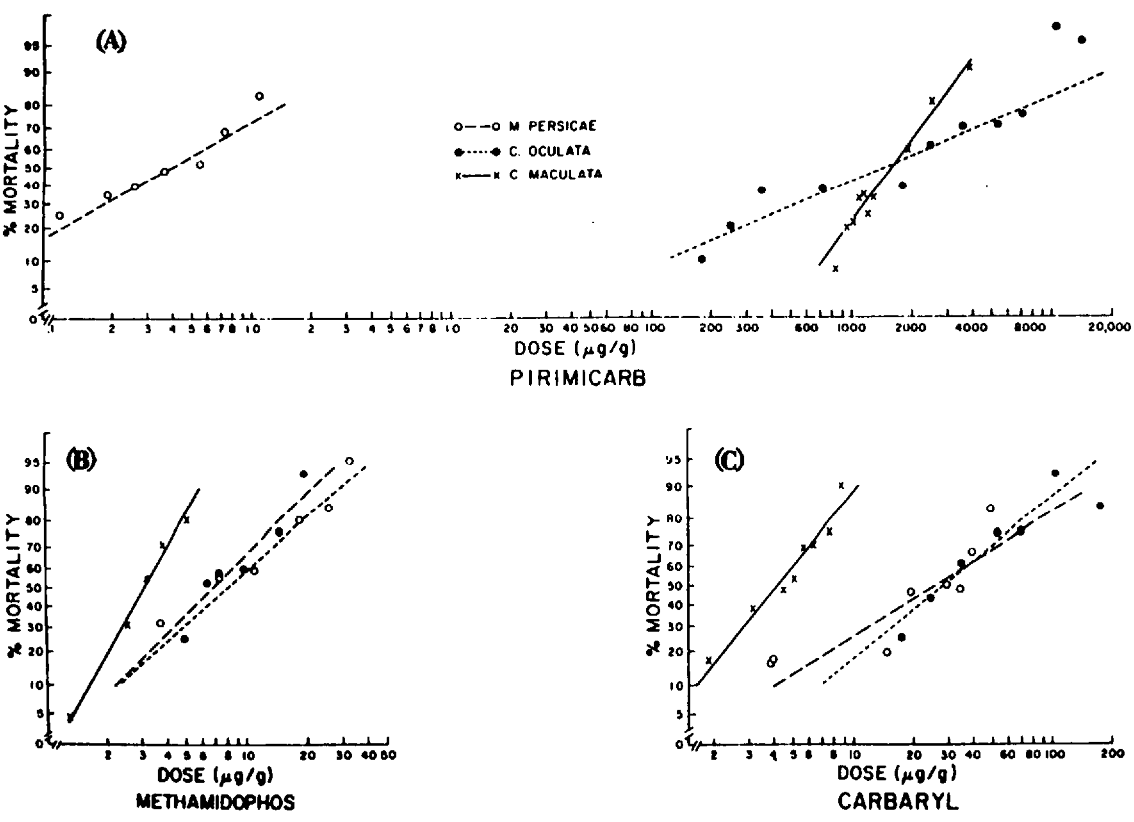

FIG. 1.—Dose mortality curve for the topical application of pirimicarb (A), methamidophos (B) and carbaryl (C) to *C. maculata lengi* adults, *C. oculata* 2nd instar larvae and *M. persicae* non-winged adults. Data points are means of all observations.

530 times less toxic than carbaryl and methamidophos to *C. maculata lengi*.

The selectivity ratio (SR) (Metcalf 1972) was used to determine the relative toxicities of the insecticides tested against aphids to natural enemies. The SR is defined as the LD_{50} of the nontarget organism divided by the LD_{50} of the pest. An SR value of less than one indicates selectivity favoring the pest, and a value of more than one represents selectivity favoring the predator. SRs were obtained from comparison of *C. maculata lengi* adults and *C. oculata* 2nd instar larvae to *M. persicae* adult apterae. Pirimicarb was overwhelmingly selective for green peach aphid (Fig. 1A). SR values were greater than 4030 for *C. maculata* and 4099 for *C. oculata*. Carbaryl and methamidophos had SR values for *C. maculata lengi* less than one, indicating greater toxicity to the coccinellids than to the aphids. Methamidophos was about 3 times as selective as carbaryl to *C. maculata lengi*. Carbaryl and methamidophos had nearly equal toxicity to *C. oculata* larvae and green peach aphids; SRs were 1.2 and 1.1, respectively (Fig. 1C, B).

The selective properties of pirimicarb have been demonstrated with other beneficial arthropod species. Under laboratory conditions, pirimicarb was highly toxic to *M. persicae* but nontoxic to *C. carnea* (Stephens), *Encarsia formosa* (Gahan) and *Phytoseiulus persimilis* (Athias-Heuriot) (Helgesen and Tauber 1974). It was moderately toxic to the aphid parasite *Diaretiella rapae* (McIntosh) (DeLorme 1976). Pirimicarb effectively controlled *M. persicae* on peppers, and *Coccinella septempunctata* (L.) adults were capable of bearing 5 times the normal dose of the insecticide (Laska 1972). The material controlled the melon aphid, *Aphis gossypii* (Glover), on cucumber without adversely affecting population of *P. persimilis* (Gould 1971). While pirimicarb has been found to be relatively harmless to many beneficial arthropod species, including bees, it is toxic to syrphid flies (Baranyovits 1970).

Relatively little information about selectivity of methamidophos is available. Methamidophos is considered moderately high in toxicity to honey bees (Atkins et al. 1970). Because it is a broad spectrum insecticide, beneficial arthropod species would probably be harmed. This study indicates that such is the case.

Carbaryl has been reported destructive to many beneficial insect species. Carbaryl was highly toxic to adults and larvae of *Hippodamia convergens* Guerin-Meneville under field conditions (Stern et al. 1960). The LD_{50} value for *C. maculata lengi* adults, .07 μg/beetle. Carbaryl was highly destructive to parasitic Hymenoptera, *Chrysopa* spp., *Nabis* spp. and *Geocoris* spp. (Shorey et al. 1962), and it is exceptionally toxic to honey bees (Strang et al. 1968). Even though carbaryl is highly toxic to beneficial insect species, it is ineffective in controlling green peach aphids (Smilowitz unpublished data). Shorey (1961) attributed the rapid green peach aphid population buildup on peppers sprayed with carbaryl to the elimination of aphidophagous natural enemies. The fact that the green peach aphids topically treated with carbaryl were somewhat susceptible may be attributed to laboratory and field biotype differences. In contrast to field populations of *M. persicae*, the laboratory colony was not subjected to any insecticidal selection for 2 years.

Foliar sprays, including pirimicarb, carbaryl and methamidophos, may be used to attain potato pest control. Pirimicarb and methamidophos are recommended for the control of aphids on potatoes, and carbaryl and methamidophos are recommended for the control of other potato insect pests. Whereas pirimicarb was ca. 17 times more toxic than methamidophos in this study, methamidophos provided slightly better control of green peach aphids in potato fields than pirimicarb (Bacon et al. 1976). However, application technology may cause differences found between laboratory and field tests. Pirimicarb was found to be most effective when applied during cool periods when winds were at a minimum. Otherwise the high vapor pressure resulted in rapid dissipation (Smilowitz, unpublished data). In addition, if foliar sprays are needed to control green peach aphids on potatoes, pirimicarb, in contrast to methamidophos, should conserve coccinellid and chrysophid natural enemies, and thus, a selection pressure which should delay development of resistance in *M. persicae* populations is preserved.

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