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Host Plant Affects Response of Colorado Potato Beetle to a Pyrethroid Insecticide

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Abstract. **The abundance of Colorado potato beetle (CPB) (*Leptinotarsa decemlineata* Say) larvae and their response to the pyrethroid insecticide fenvalerate were compared among three crop hosts, eggplant (*Solanum melongena* L.), potato (*S. tuberosum* L.), and tomato (*Lycopersicon esculentum* Mill.). Generally, fewer larvae were observed on tomato and eggplant than on potato. Percent reduction of CPB larval populations by fenvalerate was often greater on eggplant and potato than on tomato. Percent defoliation was greater on eggplant and potato than on tomato. Eggplant and potato yields increased as larval populations were reduced by fenvalerate, but tomato yield was unaffected by fenvalerate treatment. Chemical name used: cyano (3-phenoxyphenyl) methyl-4-chloro-α-(1-methylethyl) benzeneacetate (fenvalerate); butyl-carbityl 6-propylpiperonyl (piperonyl butoxide).**

The Colorado potato beetle (CPB) is the most important insect pest of potato, tomato, and eggplant in the mid-Atlantic region of the United States (3, 4), and can completely defoliate each of these hosts unless checked. Insecticides have become less effective for controlling CPB as beetle populations in these areas have developed resistance to all classes of insecticides (3), although compounds that synergize activity, e.g., the mixed-function oxidase (MFO) inhibitor piperonyl butoxide (PB), have extended the useful lifetime of some insecticides (8).

Interactions between host plants and pests may affect arthropod responses to pesticides. The capacity of an arthropod to use a host substrate may depend on its capacity to sequester or detoxify toxic constitutents (11). If similar metabolic pathways are used for detoxification of certain host compounds and insecticides, then an insect's response to a pesticide may depend on the composition of the host substrate (1, 2, 7, 11, 12).

In the field, host effects on pest metabolism may contribute to differences in pesticide efficacy among host crops, such as those described by Silcox et al. (8). Investigating grower reports and field observations suggesting that protection against CPB by the use of pyrethroids was better on tomato than on eggplant, Silcox et al. (8) assayed field-collected CPB larvae from each crop. Unexpectedly, CPB from tomato were more tolerant of the pyrethroid permethrin than were CPB from eggplant. This difference disappeared when PB was added, suggesting that enhanced MFO activity was responsible for the greater permethrin tolerance of CPB collected from tomato (5, 8). What, then, could explain the perception of easier CPB control on tomato? We speculated that a) there were simply fewer CPB on tomato to begin with than on eggplant or potato; or b) equivalent numbers of CPB cause less damage to tomato foliage or have less effect on tomato yield; or, c) the LD_{50} assay was an anomalous result and did not reflect actual field pest control results.

Our objectives in conducting this work were to compare CPB abundance among tomato, potato, and eggplant in the field; to compare the response of CPB to fenvalerate, a pyrethroid insecticide, among these three crops; and to assess the impact of the pesticide treatment and CPB abundance on percent defoliation and yield of each crop.

The experiment was conducted at two locations in 1984, Bridgeton and New Brunswick, N.J., and at Bridgeton again in 1985. Seed potatoes of 'Katahdin' were planted in mid-April, and 'Rutgers 39' tomato (Harris Seeds) and 'Harris Special Hibush' eggplant were transplanted to the field in mid-May. The design was a split plot, with fenvalerate treatment as the main plot and crop species as the subplot. Main plots were arranged in a latin square design with four replicates of fenvalerate treatments at 0, 0.05, 0.1, and 0.2 $kg \cdot ha^{-1}$. Each subplot consisted of three rows 7.6 m long with 0.5 m between rows. There were 2.0 m between main plots. Within rows, tomatoes and eggplants were planted at 0.5 m and potatoes at 0.3 m. Subplots were treated with a tractor-mounted three-row boom sprayer calibrated to deliver 590 $liters \cdot ha^{-1}$ at 275.8 kPa operated at 3.2 $km \cdot hr^{-1}$. All three rows of each subplot were treated, but observations were made only on the center row.

In 1984, percent defoliation was estimated visually before and after each pesticide treatment at New Brunswick, and at four times during the season at Bridgeton. CPB larvae were counted on each plant in the center row of each subplot immediately before and within 24 hr after the fenvalerate treatments were applied. Thus, observations were made on ≈15 plants per subplot (60 plants per treatment) of tomato or eggplant and 25 plants per subplot (100 plants per treatment) of potato before and 24 hr after every treatment. At New Brunswick, treatments were applied 20 June and 19 July 1984, and observations were made before and within 24 hr after each of these dates. At Bridgeton, treatments were applied 15 and 28 June and 21 July, and observations were made before and 1 day after each date. Percent reduction of the larval population was calculated as [(number before − number after)/number be-

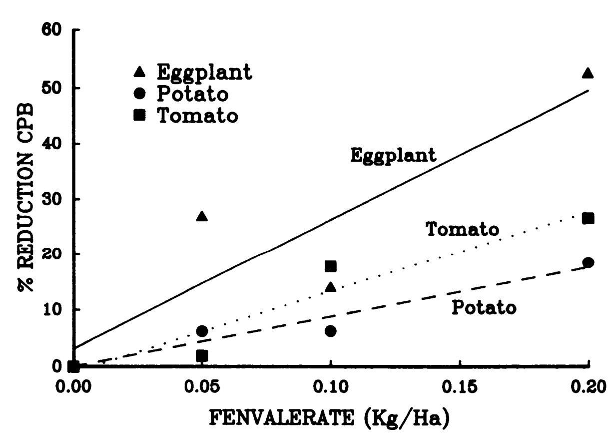

Fig. 1. Regression of percent reduction (%R) of Colorado potato beetle (CPB) larval population on fenvalerate (Fv) concentrations applied to eggplant, potato, and tomato at Bridgeton, N.J. 1985. Eggplant (▲): %R = 3 + 229Fv, r = +0.88*; Potato (●): %R = 0 + 86Fv, r = +0.97**; and Tomato (■): %R = −1 + 141Fv, r = +0.95*.

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Table 1. Average number of Colorado potato beetle (CPB) larvae per plant before each insecticide treatment date and averaged over all dates ($\overline{X}$), on eggplant, potato, and tomato at New Brunswick (NB) and Bridgeton (Btn), N.J., and percent reduction of CPB larval population in response to fenvalerate at 0.2 kg·ha^{-1} on each crop at NB and Btn in 1984 and at Btn in 1985.[z]

	No. CPB Larvae per Plant								Percent reduction of CPB					
	NB, 1984			Btn, 1984				Btn,	NB, 1984		Btn, 1984			Btn.
Crop	20 June	19 July	$\overline{X}$	15 June	28 June	21 July	$\overline{X}$	1985	20 June	19 July	15 June	28 June	21 July	1985
Eggplant	10 b	9 b	9 b	5 b	5 a	4 a	5 b	11 ab	41 a	18 a	71 a	49 a	20 a	52 a
Potato	27 a	29 a	28 a	23 a	7 a	3 a	11 a	18 a	10 b	9 a	60 a	48 ab	34 a	18 b
Tomato	3 b	3 c	3 c	5 b	1 a	2 a	3 c	5 b	9 b	0 a	62 a	18 b	0 b	26 ab

[z]Within each column, means separated by Duncan's multiple range test ($P = 5\%$) or by Student's t test ($P = 5\%$) on percent reduction adjusted for controls.

fore]·100. In 1985 at Bridgeton, fenvalerate treatments were made on 20 and 26 June, CPB observations were made only before and 1 day after the 26 June treatment, and percent defoliation was determined on three dates from early to late July. Crop yields were determined at the end of each season at Bridgeton only.

CPB larval abundance, percent defoliation, percent reduction of the larval population (transformed to arcsin), and yield were analyzed by general linear model (GLM) analysis of variance (Statistical Analysis Systems) in relation to replicate, crop, fenvalerate rate, crop within fenvalerate level, and interactions among these variables. At New Brunswick, CPB counts were made separately for young (first to second instar) and older (third to fourth instar) larvae, so that percent reduction also could be analyzed in relation to the effect of larval maturity. At both locations, crop species means for percent reduction were adjusted for CPB population changes in the control plots by subtraction of any reduction of CPB in the control plots for each species from the percent reduction of CPB in treatment plots. Adjusted percent reduction also was regressed on fenvalerate treatment levels for each crop.

More CPB larvae were found on potato than on eggplant or tomato at New Brunswick and, at the beginning of the season, at Bridgeton (Table 1). Averaged over the 1984 season, more larvae were found on potato than on eggplant, and more on eggplant than on tomato at each location (Table 1). Potato plants also had more larvae than tomato, with eggplant intermediate at Bridgeton in 1985.

The response of the larval population to fenvalerate differed among the crops following the initial pesticide treatments at New Brunswick, as indicated by significance of the crop × fenvalerate interaction ($p \leq 0.001$). Percent reduction of CPB larvae did not differ among crops at the low rates of fenvalerate, but was greater on eggplant than on tomato or potato at the highest rate (Table 1). There was no significant interaction of larval stage with crop species and/or treatment. By 19 July at New Brunswick, fenvalerate efficacy was reduced to 0% reduction on tomato and to < 20% on eggplant and potato at even the highest rate (Table 1). There were no significant differences among crops in percent reduction following the 19 July treatment.

At Bridgeton, percent CPB reduction in response to fenvalerate did not differ among crops in the earliest 1984 treatment (Table 1). However, percent reduction began to differ among the crops on 28 June and by 21 July was significantly greater on eggplant and potato than on tomato (Table 1). Percent reduction was also greater on eggplant than potato, with tomato intermediate, at Bridgeton in 1985. Percent reduction of the CPB larval population increased with fenvalerate concentration on all three crops in 1985, but the interaction of fenvalerate rate (FV) × crop was significant ($R^2_{Model} = 0.69$, $P \leq 0.01$; $P_{Crop \times FV} \leq 0.01$). The response to fenvalerate was about two to three times greater on eggplant than on tomato or potato, as indicated by the slopes from regression of percent reduction on fenvalerate rate (Fig. 1).

Percent defoliation was less for tomato than for the other two crops throughout the season in 1984 and 1985 (Table 2). Toward the end of the 1984 season, percent defoliation was greatest on potato, followed by eggplant, and least on tomato at both locations. Defoliation was positively correlated with the number of larvae present on each crop at New Brunswick ($r = 0.42$, 0.44, and 0.65 for eggplant, potato and tomato, respectively; $P \leq 0.001$ for each) and at Bridgeton ($r = 0.65$, 0.55 and 0.73 on eggplant, potato and tomato, respectively; $P \leq 0.05$ for each). At New Brunswick, percent defoliation on 19 July declined with increasing strength of the fenvalerate treatments on eggplant ($r = -0.26$, $P \leq 0.01$) and potato ($r = -0.48$, $P \leq 0.001$), but was not correlated with fenvalerate rate on tomato ($r = -0.02$, $P > 0.10$). At Bridgeton, percent defoliation averaged over all dates declined with fenvalerate rate on each crop ($r = -0.75$, -0.83, and -0.59 on eggplant, potato, and tomato, respectively; $P \leq 0.05$ for each), with no significant difference among crops in the rate of response to fenvalerate concentration (by $P > 0.10$ for the crop × fenvalerate interaction).

Crop yields were obtained each year at Bridgeton. The relationship of yield to fenvalerate did not differ significantly between years ($P_{year \times FV} > 0.10$ for each crop), so yield was averaged over both years and regressed on fenvalerate concentration. Eggplant and potato yields increased with fenvalerate rate, but tomato yield did not (Fig. 2). In 1984, yield was negatively correlated with percent defoliation of potato, eggplant, and tomato ($r = -0.87$, -0.68, and -0.52 for potato, eggplant, and tomato, respectively; $P \leq 0.05$ for each), and also increased with percent reduction of CPB larvae on eggplant ($r = 0.66$, $P \leq 0.01$) and potato ($r = 0.69$, $P \leq 0.01$), but was not significantly correlated with CPB reduction on tomato ($r = -0.10$, $P > 0.10$). In 1985, yield declined as percent defoliation increased on eggplant ($r = -0.54$, $P \leq 0.05$) and potato ($r = -0.92$, $P \leq 0.001$), but did not vary with percent defoliation of tomato ($r = -0.28$, $P > 0.05$). Only eggplant yield increased in relation to percent reduction of CPB in 1985 ($r = 0.59$, $P \leq 0.05$ for eggplant; $r = 0.06$ and 0.32 for potato and tomato, respectively, $P > 0.05$ for each).

The results indicate that CPB occurred in greater numbers on potato than on tomato. The numbers of CPB larvae on eggplant were generally equal to those on tomato or intermediate to those on potato and tomato. Percent reduction of CPB by fenvalerate on eggplant was either greater than or at least equal to that on tomato and potato, and the response to increasing fenvalerate rates was greater on eggplant than on tomato and potato. Furthermore, although eggplant and potato yields were directly related to percent CPB reduction by fenvalerate, tomato yield was not, suggesting little effect of this small CPB population on tomato performance.

The lower efficacy of fenvalerate on tomato compared to eggplant in the present work supports the results of Silcox et al. (8), indicating greater tolerance to a pyrethroid by CPB on tomato than on eggplant. Crop differences in fenvalerate efficacy could be related to intergeneric variation in secondary compounds, e.g., glycoalkaloids, which have been shown to confer host-plant resistance to some pests of the Solanaceae (6, 9, 10). Alternatively, efficacy could be associated with differences in spray coverage or reten-

Table 2. Percent defoliation by Colorado potato beetle (CPB) on eggplant, potato, and tomato at New Brunswick (NB) and Bridgeton (Btn), N.J. in 1984, and at Btn in 1985, averaged over all plots.[z]

	Percent defoliation						
	NB, 1984		Btn, 1984				Btn,
Crop	20 June	19 July	3 July	23 July	3 Aug.	13 Aug.	1985
Eggplant	32 a	62 b	52 a	45 a	47 b	40 b	33 a
Potato	41 a	81 a	48 a	48 a	56 a	57 a	37 a
Tomato	25 b	1 c	10 b	14 b	12 c	8 c	4 b

[z]Within each column, means separated by Duncan's multiple range test, $P = 5\%$.

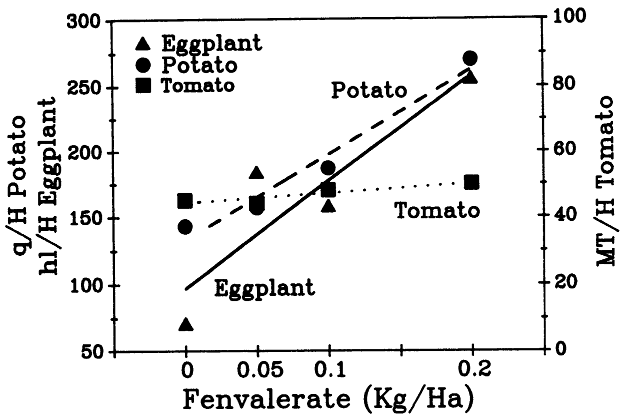

Fig. 2. Regression of average 1984 and 1985 combined yield (Y) of eggplant (hl/H), potato (q/H) and tomato (t/H) on fenvalerate (Fv) concentrations applied to each crop at Bridgeton, N.J. Eggplant (▲): Y = 97 + 807Fv, $r = +0.903^{*}$; Potato (●): Y = 132 + 654Fv, $r = +0.98^{**}$; and Tomato (■): Y = 45 + 0.1Fv, $r = +0.54^{NS}$.

tion on the foliage, which were not examined in this study. Regardless of cause, fenvalerate was often less effective in reducing the CPB population on tomato than on eggplant, and had little effect on tomato yield. Thus, the perception of improved CPB control by fenvalerate on tomato is more likely due to the lower abundance of CPB larvae on this crop and to the lack of effect on small CPB populations on tomato yield, rather than to increased fenvalerate efficacy. However, this experiment may not be representative of crop differences in CPB control where large monocrop acreages are grown and CPB population size may be greater on tomato and eggplant, or in cases where another pesticide is employed.

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Asparagus Crown Response to Dikegulac

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Abstract. **Dipping asparagus crowns (*Asparagus officinalis* L.) in 300 ppm dikegulac (Atrinal) solution significantly reduced the time of emergence and the height of asparagus shoots without affecting their fresh and dry weights. The number of shoots at complete emergence was not affected by the dikegulac treatment, but thereafter a significant increase occurred. Of the concentrations tested (0, 200, 300, and 400 ppm), 300 ppm was the most effective. After the top was cut off, the dikegulac treatment did not affect the time of emergence of the second shoots, but it did continue to increase their number. Chemical name used: 2,3:4,6-bis-*O*-(1-methylethylidene)-α-L-*xylo*-2-hexulofuranosonic acid (dikegulac).**

Technical advances have been made in direct seeding and seedling methods of establishing asparagus fields. However, crown transplanting is still used extensively. Due to "positional dominance", emergence of shoots is progressive and may continue late into the fall, until the bud growth is stopped by low temperature. By analogy to apical dominance, in positional or lateral dominance, the presence of shoots on rhizomes, tubers, or crowns suppresses the emergence of proximal dormant buds.

Depending on the number of buds present, the age of the plants, and the environment, five to 15 shoots or more may emerge from the crown. The sequential emergence of shoots is particularly strong during the harvest period. This growth characteristic makes the harvesting time-consuming and labor-intensive. It also represents one of the constraints to mechanical harvesting. Therefore, a chemical that would stimulate simultaneous emergence of asparagus shoots has great potential for practical use. Wittwer and Bukovac (14) suggested the use of gibberellins (GA) to overcome positional dominance in asparagus. Tiburcio (11), using GA drenches at 10 ppm, obtained an increase in number, diameter, weight, and length of new shoots, but, in another study, soaking the crowns in 1000 ppm KGA (Gibrel) solution did not increase the number of shoots per crown under field conditions (6). Benson (1) reported that (2-chloroethyl)phosphonic acid (ethephon) drenches were ineffective in overcoming positional dominance in asparagus. However, dipping the crowns in 750 to 1000 ppm of ethephon increased the number of shoots per crown (6). Dipping sweet potato roots in ethephon solutions also increased the number of shoots per root, thus suggesting the elimination of positional dominance (12, 13). Dikegulac, a commercially available systemic growth regulator, was effective in inhibiting apical dominance in pecans (7), azalea (3, 10), and cane cuttings of *Dracaena fra-*

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