COMPARISON OF CONVENTIONAL AND BIOLOGICAL CONTROL INTENSIVE PEST MANAGEMENT PROGRAMS ON EGGPLANT IN NEW JERSEY

GEORGE C. HAMILTON AND JAMES LASHOMB
Department of Entomology, P.O. Box 231, Cook College
Rutgers University, New Brunswick, NJ 08903

ABSTRACT

Adoption of biological control and Integrated Pest Management programs by growers depends on adequate control of pests while remaining cost effective. Some New Jersey eggplant growers follow a biological control intensive pest management (BCIPM) program, utilizing the egg parasitoid *Edovum puttleri* Grissell for the control of Colorado potato beetle. This study evaluates the profitability of the BCIPM program based on comparisons of planting and insecticide application costs, and yield information from conventional and BCIPM growers during the 1993 and 1994 growing seasons. On average, BCIPM growers utilized less insecticide and made fewer applications than conventional growers to control Colorado potato beetles. Differences for the control of aphids, eggplant flea beetles, and two-spotted spider mites were less

evident. Each year, BCIPM growers harvested increased levels of higher quality fruit when compared with conventional growers, while incurring similar production costs. These differences resulted in higher per hectare crop values, increased monetary returns, and a more environmentally friendly production system for BCIPM growers.

Key Words: Eggplant, Colorado potato beetle, *Edovum puttleri*, BCIPM, profitability

RESUMEN

Los granjeros adoptan programas de control biológico e integrado de plagas cuando dichos programas producen un adecuado control de las plagas a un costo efectivo. Algunos productores de berenjena de New Jersey siguen un programa intensivo de control biológico e integrado, utilizando el parasitoide de huevos *Edovum puttleri* Grissell para el control del escarabajo de la papa de Colorado. En este estudio se evalua la rentabilidad del programa de manejo integrado, sobre la base de comparaciones de costo de plantación, aplicación de insecticidas y rendimiento, en granjeros convencionales y en granjeros que aplican el programa de manejo integrado para el control del escarabajo de Colorado. Las diferencias en el control de áfidos, crisomélidos, y ácaros de dos manchas fueron evidentes. Cada año, los granjeros que utilizaron el programa de manejo integrado aumentaron la producción de frutos de alta calidad en comparación con los granjeros convencionales, incurriendo en los mismos costos de producción. Los granjeros con manejo integrado tuvieron más altos valores de producción por hectárea y mayor rentabilidad, además de un sistema producción ambientalmente más sano.

New Jersey is a major producer of vegetables in the United States. In 1990, 404.7 hectares of eggplant (*Solanum melongena* L.) were planted with yields averaging 848.11 kg per hectare (NJ Dept. Agriculture 1991). Of the eleven most common vegetables grown in New Jersey during 1990, eggplant ranked second in total dollar value ($2,188,000). The use of pesticides is also correspondingly high (Hamilton & Meyer 1992). This use pattern represents primarily insecticides applied to control the major insect pest in eggplant, the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), and various fungicides. Feeding by larval and adult Colorado potato beetles can result in significant plant injury and yield losses (Cotty & Lashomb 1982).

Conventional control of Colorado potato beetles on eggplant and potato has been accomplished by weekly applications of insecticides. Beginning in the 1970's, this led to resistance by Colorado potato beetles to nearly all of the chemicals available (Forgash 1985). Despite the development of new insecticides, this situation further intensified during the 1980's. In response, a biological control intensive pest management program (BCIPM) was developed utilizing the egg parasitoid *Edovum puttleri* Grissell (Lashomb 1989). The program relies on bi-weekly scouting of fields, six weeks of parasitoid releases, and limited insecticide usage to maintain Colorado potato beetle populations below economically damaging levels. To date, the program has been implemented by the New Jersey Department of Agriculture on 10% of New Jersey's total eggplant acreage.

To gain acceptance of any pest management program, growers must have confidence that it will work and be cost effective (Headley 1975). The BCIPM program has been shown to effectively control Colorado potato beetles (Lashomb 1989), but a profitability comparison with conventional practices has not been conducted. This study provides the cost/return information needed to make this comparison.

MATERIALS AND METHODS

In 1993 and 1994, all growers participating in the eggplant BCIPM program (10 in 1993; 8 in 1994) and seven conventional growers were asked to participate in the study. Conventional growers were selected based on their geographic proximity to BCIPM growers and the forecast of planting 'Harris Special' eggplant (industry standard). Each year prior to planting, growers provided the numbers of hectares of 'Harris Special' eggplant that would be grown and agreed to supply application records [date, pest(s) treated for, material and rate used, total amount applied, and number of hectares treated] for all insecticides applied during the growing season. Growers also agreed to provide harvest information, i.e., number of boxes packed per hectare by grade class (#1, #2, and large) for each harvest date.

Production Costs

Standard production costs per hectare for plant material ($220.20), fertilizer ($46.97), lime ($9.70), supplies ($408.12), and labor ($563.03—planting, fertilizer and lime applications, and harvesting) were obtained from information developed by Dhillon & Latimer (1986) for New Jersey eggplant production. Standard costs for BCIPM growers also included a $40.47 per hectare charge for the parasitoid. This charge is mandatory for growers in the program and is assessed to cover the cost of parasitoid rearing, weekly parasitoid-releases (2,700 per ha), and bi-weekly scouting of fields.

Cost data for the insecticide applied each year were developed from information (dollars per kg AI) supplied by 3 local pesticide distributors. Product costs were calculated on a per hectare basis for azinphos methyl ($3.31—Guthion®, Bayer, Kansas City, MO), *Bacillus thuringiensis tenebrionis* (Btt) ($5.66—M-One®, Mycogen, San Diego, CA; $8.01—Novodor®, Novo-Nordisk, Franklinton, NC), cryolite ($0.89—Kryocide®, Elf Atochem, Philadelphia, PA), endosulfan ($2.72—Thiodan®, FMC, Philadelphia, PA), esfenvalerate ($82.55—Azana XL®, E.I. Dupont, Wilmington, DE), fenbutatin oxide ($18.06—Vendex®, E.I. Dupont, Wilmington, DE), methomyl ($4.54—Lannate L®, E.I. Dupont, Wilmington, DE), mevinphos ($10.16—Phosdrin®, Amvac Chemical, Los Angeles, CA), oxamyl ($5.87—Vydate L®, E.I. Dupont, Wilmington, DE), PBO ($4.91—Butoxide®, Fairfield American, Frenchtown, NJ), permethrin ($24.05—Ambush®, Zeneca, Wilmington, DE; $38.25—Pounce®, FMC, Philadelphia, PA), pyrethrins/rotenone ($10.22—Pyrellin®, Webb Wright Corp., Ft. Myers, FL), and rotenone ($2.30—Rotenox®, Fairfield American, Frenchtown, NJ). Labor costs associated with the application of insecticides were set at $15 per hectare per application (Dhillon & Latimer 1986).

Seasonal eggplant prices were determined using weekly pricing data for the years 1980 to 1994 obtained from the New Jersey Department of Agriculture, Agricultural Statistics office. Using this information, mean market prices were set at $8.00 per box for #1 fruit, $4.00 per box for #2 fruit, and $6.00 per box for large fruit.

Statistical Analysis

The data collected each year were analyzed using analysis of variance (ANOVA). Mean separation tests (LSD; $P \leq 0.05$) were conducted to determine differences between the two farming regimes (SAS 1994). An economic analysis, using per hectare costs and returns, was conducted to assess the differences in profitability between each system.

Results and Discussion

A total of 19.83 (1.98 ha per grower) and 14.73 (2.10 ha per grower) hectares were grown by BCIPM and conventional growers, respectively, in 1993. Comparable acreages were again grown by both groups the following year (BCIPM—22.87 ha, 2.87 ha per grower; conventional—21.04 ha, 2.99 ha per grower).

Conventional growers applied a total of 52.81 kg AI per hectare of insecticide/acaricide in 1993 and 17.84 kg AI per hectare in 1994 (Table 1). Growers in the BCIPM program utilized lower total amounts each year, applying 30.50 kg AI per hectare and 14.07 kg AI per hectare in 1993 and 1994, respectively. These materials were applied to control four pests: Colorado potato beetle; green peach aphid, *Myzus persicae* (Sulzer); eggplant flea beetle, *Epitrix fuscula* Crotch; and two-spotted spider mite, *Tetranychus urticae* (Koch). Each year, the amount applied to control Colorado potato beetles were higher for conventional growers. Conventional growers also applied higher amounts to control aphids, flea beetles and two-spotted spider mite than BCIPM growers in 1993 but applied similar amounts in 1994. The difference in the total amounts applied is due to the types of insecticides used. The data show that conventional growers apply a wider variety of materials, while BCIPM growers restricted their applications for Colorado potato beetle control to primarily the use of rotenone and PBO. Rotenone and PBO are less harmful to *Edovum puttleri* than other available insecticides (Hamilton et al., in press) and are recommended once parasitoid releases are begun.

BCIPM growers made significantly fewer applications (about 2.0 during parasitoid releases) and treated significantly fewer hectares to control Colorado potato beetle than conventional growers (Table 2). BCIPM growers also applied less active ingredient, both in terms of seasonal amounts and amounts per hectare. The total seasonal costs associated with these applications were significantly lower for BCIPM growers each year; however, the per hectare costs were significantly lower in 1994 only. Unlike the applications made to control Colorado potato beetles, those made to control aphids, flea beetles, and mites varied between years. BCIPM growers made more applications and applied more material per hectare in 1993 but treated less acreage using less material per hectare in 1994. Both years, BCIPM growers treated less acreage and applied lower total amounts. The cost of these applications was also different. Each year, while the total cost incurred by conventional growers was higher, the per hectare costs were lower.

BCIPM growers experienced higher yields than conventional growers, harvesting significantly more #1 and #2 eggplants in 1993 and 1994 (Table 3). Conventional growers, however, produced more large fruit. The difference in yields of #1 and #2 fruit indirectly suggests that BCIPM growers produced higher quality fruit. Grade levels in eggplant are determined by several factors including fruit size, fruit color and the absence of damage. Visible feeding damage as small as one bite to the flesh or calyx of the fruit causes a fruit to be culled. Less frequent occurrence of culling in BCIPM fields due to reduced Colorado potato beetle populations would explain the yield differences observed. The higher number boxes produced per hectare by BCIPM translated into gross profits for BCIPM growers as well. Each year the per hectare crop value was significantly higher for BCIPM growers (+$521.40 in 1993, +$442.27 in 1994).

Standard costs (i.e., plant material, fertilizer, etc.) for the two programs were assumed identical except for the added cost incurred by BCIPM growers for scouting and rearing/release of the parasitoid (Table 4). Total insecticide costs (AI and labor costs) were different each year between the two groups. In 1993, BCIPM growers spent $92.00 more per hectare than conventional growers; however, in 1994 BCIPM

TABLE 1. TOTAL INSECTICIDE USAGE PER HECTARE AND NUMBER OF APPLICATIONS BY CONVENTIONAL AND BCIPM GROWERS, 1993 AND 1994.

		Kg AI Applied per Hectare				Number of Applications			
		1993		1994		1993		1994	
Species[1]	Insecticide	Conventional	BCIPM	Conventional	BCIPM	Conventional	BCIPM	Conventional	BCIPM
CPB	*B.t.t.*	15.21	0.00	5.65	0.00	4.0	0.0	11.0	0.0
	cryolite	12.21	0.00	1.34	0.00	2.0	0.0	2.0	0.0
	endosulfan	6.87	0.22	0.58	0.32	13.0	1.0	6.0	2.0
	esfenvalerate	0.18	0.01	0.03	0.00	2.0	1.0	6.0	0.0
	oxamyl	6.11	2.19	1.63	1.01	10.0	2.0	18.0	7.0
	permethrin	0.15	0.02	0.21	0.00	6.0	2.0	8.0	0.0
	PBO	2.84	6.23	2.52	2.57	15.0	40.0	16.0	16.0
	rotenone	5.23	19.47	4.05	8.49	7.0	38.0	13.0	18.0
GPA	methomyl	0.00	0.45	0.00	0.00	0.0	2.0	0.0	0.0
	mevinphos	2.34	0.00	0.00	0.00	3.0	0.0	0.0	0.0
	pyrethrins/rotenone	0.12	0.00	0.00	0.00	1.0	0.0	0.0	0.0
EFB	azinphos methyl	0.13	0.41	0.13	0.43	2.0	2.0	5.0	3.0
TSSM	fenbutatin oxide	1.42	1.50	1.70	1.25	2.0	2.0	4.0	5.0
	Total	52.81	30.50	17.84	14.07	67.0	90.0	89.0	51.0

[1]CPB=Colorado potato beetle; GPA=green peach aphid; EFB=eggplant flea beetle; TSSM=two-spotted spider mite.

TABLE 2. EFFECT OF COLORADO POTATO BEETLE CONTROL PROGRAM ON INSECTICIDE USAGE AND APPLICATION COSTS, 1993 AND 1994.

Year[1]	Program	Applications per Grower (±SE)	Hectares Treated per Growers (±SE)	Kg AI Applied: Seasonal Amount per Grower (±SE)	Kg AI Applied: Amount per Hectare (±SE)	Total Cost[2] per Grower, Dollars (±SE)	Cost per Hectare[2], Dollars (±SE)
Colorado potato beetle							
1993	Conventional	11.8(3.5) a	85.4(28.0) a	150.7(62.9) a	17.4(7.1) a	1,858.4(672.8) a	148.4(33.6) a
	BCIPM	6.8(1.1) b	26.5(9.2) b	55.8(20.9) a	13.3(2.5) a	575.3(200.1) b	151.4(25.9) a
1994	Conventional	9.3(2.2) a	34.9(12.7) a	48.2(14.9) a	7.4(1.6) a	1,148.4(391.7) a	164.6(49.0) a
	BCIPM	3.8(0.8) b	17.2(5.3) b	35.4(9.9) a	6.2(0.6) a	370.0(111.6) b	67.0(7.1) b
Other Insects and Mites							
1993	Conventional	2.8(0.8) a	11.6(4.2) a	17.1(7.1) a	2.0(0.3) a	331.3(230.1) a	47.5(10.3) b
	BCIPM	3.6(1.9) a	5.3(2.3) a	10.2(4.5) a	5.5(2.0) a	254.4(112.3) a	136.8(50.4) a
1994	Conventional	2.8(1.1) a	9.9(4.9) a	11.8(4.3) a	1.9(0.9) a	300.8(118.4) a	44.3(18.3) a
	BCIPM	1.6(0.2) a	5.3(1.7) a	5.3(1.7) a	1.7(0.4) a	187.8(58.5) a	48.3(9.4) a

[1]ANOVA performed on transformed (SQRT[x+1]) data. Nontransformed means reported. Means by year and insect group within the same column followed by the same letter are not significantly different ($P \leq 0.05$; LSD). n=10.

[2]Costs include the price of active ingredient (AI) per kg and labor to apply material.

TABLE 3. EFFECT OF COLORADO POTATO BEETLE CONTROL PROGRAM ON YIELD AND CROP VALUE, 1993 AND 1994.

Year[1]	Program	Number of Boxes per Hectare (±SE)			Number of Boxes per Hectare (±SE)	Value per Hectare (±SE)
		#1's	#2's	Large		
1993	Conventional	333.1(86.4) b	49.2(18.2) b	8.7(5.8) a	391.0(42.4) a	2,902.47(299.2) b
	BCIPM	381.8(126.3) a	99.1(26.5) a	0.0(0.0) a	480.9(86.8) a	3,423.87(690.4) a
1994	Conventional	268.5(56.7) b	46.7(10.9) b	19.6(7.1) a	334.8(37.1) a	2,450.21(269.1) b
	BCIPM	300.5(81.5) a	77.2(25.6) a	8.3(8.3) a	386.0(71.0) a	2,892.48(594.5) a

[1]ANOVA performed on transformed (SQRT[x+1]) data. Nontransformed means reported. Means by year within the same column followed by the same letter are not significantly different ($P \leq 0.05$; LSD). n=10.

TABLE 4. PROFIT/LOSS ANALYSIS FOR CONVENTIONAL AND BCIPM GROWERS, 1993 AND 1994.

	Cost-Value (dollars) per Hectare			
	1993		1994	
Item	Conventional	BCIPM	Conventional	BCIPM
Costs				
Standard	1,250.02	1,290.49	1,250.02	1,290.49
Insecticides	195.90	288.20	208.90	115.30
Total	1,445.92	1,578.69	1,458.92	1,405.79
Crop Value	2,902.47	3,423.87	2,450.21	2,892.48
Profit	1,456.55	1,845.18	1,041.10	1,486.69

growers spent $93.60 less. Using the costs and crop values calculated for the 1993 and 1994 growing seasons, an analysis of profit or loss showed that BCIPM growers made a greater profit than conventional growers. The profit level was 27% and 43% higher in 1993 and 1994, respectively.

A valuable outcome of an effective IPM program can be a reduction in pesticide usage (Pedigo 1996). This effect has been documented for IPM programs in several other crops including anturiums and tomato (Hara et al. 1990; Trumble & Alvarado-Rodriguez 1993). The data reported here show that this reduced insecticide use is occurring with the BCIPM program for eggplant. Overall, 42.2% and 21.1% more pesticides were applied by conventional growers in 1993 and 1994, respectively. Accordingly, growers in the BCIPM program on average treated their crop 42.4% and 59.1% fewer times in 1993 and 1994, respectively, for Colorado potato beetle control than conventional growers.

In determining the benefits of an BCIPM program, yield levels and costs must be evaluated. If reducing pesticide usage results in reduced profitability, growers will have little incentive to adopt a new program (Rajotte 1993). This study provides evidence that an advantage, other than reduced pesticide levels, is gained by participating in the BCIPM program. Each year, BCIPM growers produced more fruit per hectare and experienced higher net profits (value of fruit at harvest minus production cost) when compared to conventional growers. Trumble & Alvarado-Rodriguez (1993) report similar results for an IPM program developed for tomatoes. Their program, which uses intensive sampling, parasitoid releases, and selective use of pesticides, resulted in higher net profits ($304-$579 per ha) when compared to standard control practices.

The differences in the input (i.e., standard costs, scouting, insecticides, etc.) and profits shown between the two programs would not justify using conventional practices as opposed to enrollment in the state BCIPM program. The data indicates that growers involved in the state BCIPM program can spend less time and money on pesticide applications and incur higher returns on their investment.

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