A Comparison of Eggplant Grown Under Conventional and Biological Control Intensive Pest Management Conditions in New Jersey

George C. Hamilton, Ph.D.
Specialist in Pesticides

Rutgers Cooperative Extension
P.O. Box 231, Cook College,
Rutgers University, New Brunswick, NJ 08903

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EXECUTIVE SUMMARY

EGGPLANT is a major vegetable crop in New Jersey ranking second or third in total dollar value per acre. Each year, the Colorado potato beetle (CPB), *Leptinotarsa decemlineata* (Say), is the key pest problem in eggplant with significant plant injury and yield loss occurring due to feeding by both larvae and adults. Traditionally, control of CPB is accomplished by utilizing insecticides. However, during the 1980's, resistance to many commonly used insecticides began to develop. In response to this, a successful biological control intensive pest management program (BCIPM) to control CPB was developed by Rutgers University and the New Jersey Department of Agriculture utilizing the egg parasitoid, *Edovum puttleri* Grissell.

Growers' acceptance of the program has been good and control of the beetle has been documented. To date, however, an input/output comparison, necessary to evaluate cost effectiveness between it and conventional control practices, has not been conducted. The objective of this project was to develop this information by comparing the practices of conventional and BCIPM growers during the 1993 and 1994 growing seasons.

To conduct the study, growers enrolled in the 1993 and 1994 eggplant BCIPM program were compared to those of seven conventional growers. Participating growers in each group were then asked to provide data on the number of acres grown and all applications of insecticides. Growers were also asked to provide harvest information. This information was then evaluated and used to create a cost effectiveness comparison.

Overall, conventional and BCIPM growers applied similar amounts of pesticides each year. What types of pesticide were applied, however, differed between the two groups. Conventional growers applied more fungicides and insecticides while BCIPM growers applied more herbicides and fumigants. Each year, conventional growers also made more applications utilizing a wider variety of materials to control CPB than BCIPM growers.

Analysis of the yield information showed that the number of boxes harvested per acre was comparable between the two groups. In 1993, BCIPM growers harvested slightly more fruit than conventional growers with the opposite situation occurring in 1994. However, the data showed that BCIPM growers yielded more higher quality fruit each. Due to this, the value of the BCIPM grower's crop is estimated to be higher each year.

Examination of the costs involved showed that overall BCIPM growers incurred lower production costs. Again, as with applications, the distribution of these costs varied. Conventional growers spent more on insecticides while spending less on herbicides and fungicides. Despite these differences, the profits on a per acre basis were comparable between the two groups with BCIPM growers having higher profits both years.

The data shows that the two systems are comparable, both in terms of the inputs placed into the system and the outputs realized. Based on this data, the BCIPM program is a cost effective venture for eggplant growers.

INTRODUCTION

NEW JERSEY is a major producer of vegetables in the United States. Each year approximately 1,000 acres of eggplant are planted with yields averaging 140 cwt. per acre (NJ Dept. of Agriculture 1991). Of the eleven major vegetables grown in New Jersey, eggplant ranks second or third in total dollar value per acre. In light of eggplant's value, the use of pesticides is correspondingly high (Hamilton and Meyer, 1992). This usage pattern represents primarily insecticides applied to control the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) and various fungicides. The Colorado potato beetle (CPB) is the key pest in eggplant. Feeding by both larvae and adults can result in significant plant injury and yield losses (Cotty and Lashomb, 1982).

Traditionally, control of CPB is accomplished by applying insecticides using a calendar based program. During the 1980's, the use of calendar programs led to resistance by CPB to many of the insecticides available (Forgash 1985). In response to this, a biological control intensive pest management program (BCIPM) was developed utilizing the egg parasitoid, *Edovum puttleri* Grissell (Lashomb 1989). This program has been implemented on limited acreage by the New Jersey Department of Agriculture utilizing bi-weekly field scouting for insect problems, and six weeks of parasitoid releases to maintain CPB populations below economically damaging levels. While the program does not discount the use of pesticides when necessary, it can result in significant reductions in the number and type of sprays applied.

To gain acceptance of any pest management program, growers must have confidence that it will work and be cost effective (Headley 1975). While this program has been shown to effectively control CPB, an input/output comparison between it and conventional control practices has not been conducted. This comparison is needed in order to decide whether such a program is both beneficial and cost effective. The objective of this project was to develop input/output information from both conventional and BCIPM growers for the 1993 and 1994 growing seasons.

MATERIALS AND METHODS

For the purposes of this study all growers who enrolled in the 1993 (10 growers) and 1994 (8 growers) eggplant BCIPM program were asked to participate in this study.

In May of each year, conventional growers were interviewed regarding their standard production practices and their willingness to participate in the study with the understanding that all information would remain anonymous. Conventional growers were selected based on their proximity to BCIPM growers, the number of acres being grown, and the variety planted. Minimizing the differences between these criteria was important. To assure valid comparisons, growers in each group needed to experience relatively the same levels of beetle pressure each year. Using this information, seven growers who practice conventional CPB control methods were asked to participate in the study each year. Once selected, the variety of eggplant grown and the number of acres planted was recorded for each grower in the two groups.

Participating growers in each group were then asked to record information throughout the growing season for all pesticide applications that were made. Each year this information was recorded for all insecticide applications targeting both CPB and other insect pests, and all fungicide and herbicide applications. In 1994, this

information was also recorded for any fumigant applied prior to planting. For each application the data recorded by growers included the date of application, the pest(s) treated for, the material used (common chemical name and trade name), the rate utilized, the total amount applied, and the acreage treated.

Harvest information was collected by requiring growers to record yield information on each date that eggplant was harvested. This information included the harvest date, the total number of fruit harvested, and the total number of boxes packed. Fruit quality information was also recorded. This was accomplished by asking growers to record the number of boxes packed in each grade class. Three standard grade classes are utilized by growers: #1, #2 and large with #1 fruit being the highest quality.

Standard production costs were obtained by modifying information developed by Dhillon and Latimer (1986) for New Jersey vegetable production. These data included costs for fertilizer and lime, plant material, supplies and labor costs associated with planting and the application of lime, fertilizer and pesticides. Standard costs for BCIPM growers also included a per acre charge for scouting and release of the parasitoid. Cost data for the pesticides applied by both groups was developed from price information obtained from local pesticide distributors. For this information, local distributor prices were determined to be the best gauge of the actual cost to growers. To estimate the seasonal eggplant prices, weekly pricing data from 1980 to 1994, was obtained from the New Jersey Department of Agriculture - Agricultural Statistics office and averaged over the 14 year period for each grade classification.

The data collected was then analyzed to determine the differences in pesticide use between the two farming regimes each year (SAS 1994) including the total acreage treated, the total amounts of active ingredient applied, and the number of applications made. The amount of active ingredient applied by type of material, i.e. insecticides, fungicides, etc. the pest(s) treated for, and individual compound used was also determined on a per acre basis. Harvest information was evaluated based on the total number of boxes harvested, the total number of boxes harvested per acre, and the total number of boxes within each grade class harvested. Following this, an economic analysis was conducted to assess the differences in profitability between each system.

RESULTS

A total of 49 acres (4.9 acres/grower) and 56.5 (7.1 acres/grower) of eggplant were grown as part of the state BCIPM program during 1993 and 1994 respectively. In 1993 and 1994, conventional growers grew a total of 36.4 acres (5.2 acres/grower) and 52.0 acres (7.4 acres/growers), respectively. While a greater number of acres were grown in the BCIPM program in 1993 and 1994, comparisons of the data were considered valid due to the similarity in the number of acres grown per grower. Each year, all growers participating in the study grew the 'Harris' variety of high bush eggplant. This variety is the industry standard in New Jersey.

Overall, conventional growers treated 753.4 acres with 1,295.0 lb. of active ingredient in 1993 and 1,003.0 acres (7,988.3 lb. a.i.) in 1994. Growers in the BCIPM program utilized similar amounts in 1993, applying 1,271.1 lb. a.i. (729.4 acres) in 1993 but substantially lower amounts in 1994 (6,804.9 lb. a.i.; 643.5 acres). On a per acre basis, however, BCIPM growers (1993 - 25.0 lb. a.i.; 1994 - 120.4 lb. a.i.) used less material than conventional growers (1993 - 35.6 lb. a.i.; 1994 - 153.6 lb. a.i.) both years. The usage pattern by type of material applied is presented in Table 1. The data indicate that conventional growers applied more fungicides, fumigants and insecticides each year but less herbicides. The application of miticides by conventional growers was lower in 1993 (46.4 lb. a.i. vs. 66.0 lb. a.i.) and slightly higher (66.0 lb. a.i. vs. 63.8 lb. a.i.) in 1994.

Table 1. Overall Pesticide Usage in Conventional and BCIPM Programs during 1993 and 1994 by Type of Material Applied.

	lb. a.i. Applied			
	Conventional		BCIPM	
Type	1993	1994	1993	1994
Fungicides	457.7	374.5	360.7	359.6
Fumigants	---	4,324.8	---	4,461.0
Herbicides	55.9	46.3	112.0	1,299.8
Insecticides	735.0	3,241.9	688.4	668.1
Miticides	46.4	66.0	66.0	63.8

When specific active ingredients were examined, the amounts of copper (339.1 lb. a.i.) and maneb + Zn (92.0 lb. a.i.) used by conventional growers in 1993 for disease control were higher than for BCIPM growers (Table 2). BCIPM growers did apply copper (166.3 lb. a.i.) in addition to high amounts of metalaxyl (108.0 lb. a.i.) in 1993 to control foliage and fruit diseases. Conventional growers utilized primarily copper (187.9 lb. a.i.) and maneb (131.3 lb. a.i.) for diseases in 1994. BCIPM growers, however, applied more copper (223.3 lb. a.i.) than conventional growers and slightly less maneb (124.0 lb. a.i.) in addition to metalaxyl (12.3 lb. a.i.).

Table 2. Fungicide Usage by Conventional and BCIPM Growers in 1993 and 1994.

	lb. a.i. Applied			
	Conventional		BCIPM	
Type	1993	1994	1993	1994
Chlorothalonil	0.0	37.4	0.0	0.0
Copper	339.1	187.9	166.3	223.3
Maneb	0.0	131.2	9.6	124.0
Maneb/Zn	92.0	0.0	76.8	0.0
Metalaxyl	26.6	18.0	108.0	12.3

Growers in both programs applied the same herbicides: chlorthal dimethyl, napropamide, and paraquat (Table 3). In both 1993 and 1994, the amounts of napropamide (58.0 lb. a.i., 39.8 lb. a.i.) and chlorthal dimethyl (54.0 lb. a.i., 1,260.0 lb. a.i.) used were higher for BCIPM growers. Paraquat (10.34 lb. a.i.) was used by conventional growers only in 1994.

Table 3. Herbicide Usage by Conventional and BCIPM Growers in 1993 and 1994.

	lb. a.i. Applied			
	Conventional		BCIPM	
Type	1993	1994	1993	1994
Chlorthal dimethyl	15.0	0.0	54.0	1,260.0
Napropamide	40.9	36.0	58.0	39.4
Paraquat	0.0	10.3	0.0	0.0

Insecticide usage specifically for CPB control was higher for conventional growers each year (Table 4). In 1993 the overall level of use by both groups was low, however, conventional growers applied more insecticides for CPB control (657.3 lb. a.i. vs. 602.7 lb. a.i.). In 1994, the level used by conventional grower was higher than that applied by BCIPM growers (3,317.9 lb. a.i. vs. 582.9). Conventional growers utilized a wide range of materials for CPB control each year including *Bacillus thuringiensis tenebrionis*, endosulfan, cryolite, oxamyl, permethrin and rotenone. The use of insecticides for CPB control by the BCIPM growers can be divided into two subgroups, pre and post parasitoid release. Prior to release, growers were allowed to apply any material they chose. After release of the parasitoid, they are encouraged to use rotenone alone or in combination with the synergist piperonyl butoxide (PBO). Even with the wide range of materials allowed to be used prior to releases, rotenone was by far the most utilized materials by BCIPM growers each year. This level of use was higher than that for conventional growers (388.8 vs. 106.9) in 1993 but considerably lower than conventional growers in 1994 (2,583.0 lb. a.i. vs. 414.4 lb. a.i.). The use of other materials prior to releases included endosulfan, esfenvalerate, oxamyl and permethrin in 1993 and oxamyl only in 1994. This usage each year, however, was much lower than the usage by conventional growers.

Table 4. CPB Insecticide Usage by Conventional and BCIPM Growers, 1993 and 1994.

	lb. a.i. Applied			
	Conventional		BCIPM	
Type	1993	1994	1993	1994
B.t.k.	149.8	262.0	0.0	0.0
Endosulfan	66.7	27.0	9.8	0.0
Esfenvalerate	2.8	1.6	0.5	0.0
Cryolite	198.0	62.0	0.0	0.0
Oxamyl	89.8	75.4	74.5	51.0
Permethrin	1.8	9.9	0.9	0.0
PBO	41.4	117.0	128.3	117.5
Rotenone	106.9	2,583.0	388.8	414.4

Insecticide/miticide usage for the control of aphids, flea beetles and mites each year is presented in Table 5. BCIPM growers applied slightly more pesticides than conventional growers to control these pests in 1993. Conventional growers utilized approximately the same level of azinphos methyl for flea beetle control as BCIPM growers each year. The use of fenbutatin oxide each year by BCIPM growers for mite control was almost double that of conventional growers in 1993 but essentially the

same in 1994. Conventional growers also used mevinphos and pyrethrin/rotenone mixes for in 1993 and methomyl in 1994 for aphid control where BCIPM growers did not.

Fumigant usage in 1993 by either group was nonexistent, however, in 1994 metam sodium was applied as preplant application by both groups (Figure 1). In addition, one BCIPM grower applied methyl bromide (1,176.0 lb. a.i.).

Table 5. Other Insecticide Usage by Conventional and BCIPM Growers, 1993 and 1994.

	lb. a.i. Applied			
	Conventional		BCIPM	
Type	1993	1994	1993	1994
Azinphos methyl	4.4	18.0	6.0	21.8
Fenbutatin oxide	46.4	66.0	79.4	63.4
Mevinphos	23.0	0.0	0.0	0.0
Methomyl	0.0	20.0	0.0	0.0
Pyrethrins/ Rotenone	4.0	0.0	0.0	0.0

When the number of applications per grower is examined for the different types of materials applied, overall, conventional growers made more applications than did BCIPM growers each year. The number of herbicide applications was essentially the same between the groups in 1993 (0.9 vs. 1.0). In 1994 conventional growers made twice as many herbicide applications as BCIPM growers (1.14 vs. 0.63). Conventional growers applied fungicides an average of 4.1 times each year while BCIPM growers made 4.6 and 4.8 applications in 1993 and 1994, respectively. Overall, each year conventional growers made more insecticide applications than BCIPM growers. The number of insecticide applications specifically made for CPB control was higher each year in the conventional group. In 1993 this group applied insecticides targeting CPB 13.3 times. In 1994 the number of applications was 9.1. BCIPM growers on the other hand applied CPB insecticides 4.6 times in 1993 and 3.9 times in 1994. It should also be noted that BCIPM growers, on average, only made 2.4 applications in 1993 and 2.6 applications in 1994 for CPB control once the parasitoid release program was begun. These post release applications were made to control larval populations that had reached threshold levels and were necessary to allow the parasitoid to key on eggmasses without allowing economic damage to occur.

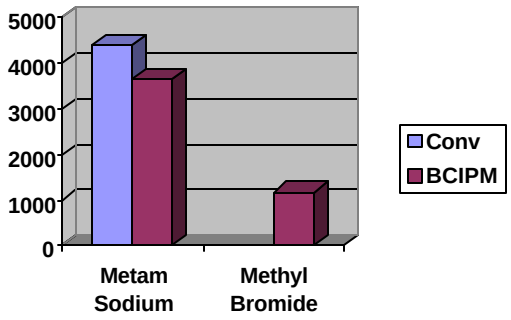

Figure 1. Fumigant Usage by Conventional and BCIPM Growers, 1994.

Applications made for aphids or flea beetles, 1.1 and 1.0 in 1993 and 1994 respectively, were higher for conventional growers than for BCIPM growers (1993 - 0.1, 1994 - 0.4). Examination of the applications made for mite control show that BCIPM growers made more than twice as many applications than conventional growers in 1993 (1.8 vs. 0.7). In 1994, miticide applications by conventional and BCIPM growers were essentially identical (0.57 vs. 0.63).

In order to assess the profitability of the two systems data were collected on the number of

boxes of fruit per acre that each grower harvested throughout the season. Overall, conventional growers in 1993 harvested a slightly lower number of boxes per acre (859.8 boxes) than did BCIPM growers (887.0 boxes). Division of the data into the three standard grading categories (#1, #2 and large) found that conventional growers, on a per acre basis, harvested 848.7 boxes of #1 fruit, 11.1 boxes of #2 fruit and no boxes of large fruit. BCIPM growers harvested 877.2 boxes of #1 fruit, 8.8 boxes of #2 fruit and 1.0 boxes of large fruit. In 1994 a similar pattern was seen. Conventional growers yielded a average of 729.0 boxes/acre (#1 - 719.3 boxes, #2 - 9.6 boxes, and large - 0.1 boxes), while BCIPM growers yielded 732.5 boxes/acre (#1 - 725.6 boxes, #2 - 6.6 boxes, and large - 0.3 boxes). This difference in the number of #1 fruit between the two programs is important. The fact that BCIPM growers produced 28.5 more #1 boxes of fruit per acre in 1993 and 6.4 more boxes per acre in 1994 is direct evidence that BCIPM growers are producing larger amounts of higher quality fruit. Using this harvest information each year and assuming an average seasonal price of $8.00, $4.00, and $6.00 per box for #1, #2 and large fruit, respectively, the total seasonal per acre value of the crop realized by conventional growers was $6,834.00 in 1993 and $5,793.40 in 1994. The per acre crop value for BCIPM growers was $7,058.80 in 1993 and $5,833.00 in 1994.

The test of a good BCIPM program is a reduction in pesticide usage. The data shows that this is occurring with the state-run BCIPM program for eggplant. In determining the benefits of a program, however, costs must also be evaluated. If while reducing pesticide usage, overall costs of production are increased, growers will have little incentive to adopt a new program.

Table 6. Non-pesticide Production Costs for Conventional and BCIPM Growers.

	Cost ($)/Acre	
Item	**Conventional**	**BCIPM**
Lime	22.00	22.00
Fertilizer	175.00	175.00
Plant Material	875.00	875.00
Supplies	1,355.00	1,355.00
Labor	538.15	370.75
Release Program	----------	100.00
Total	2,965.15	2,897.75

The costs of production excluding the cost of pesticide material are listed in Table 6. Standard production costs per acre were adapted from data derived for peppers (Dhillon and Latimer, 1986). The standard costs of producing eggplant were identical with the exception of labor costs, which includes average labor costs each year for the application of pesticides, and the cost of releasing parasitoids ($100.00/A). Despite the added cost of the release program, BCIPM growers spent less per acre than conventional growers in terms of standard costs.

Pesticide costs each year were very different between the two programs. Conventional growers spent a total of $348.01/A and $907.75/A in 1993 and 1994, respectively (Table 7). While BCIPM growers spent higher amounts in 1993 ($353.89/A) and lower amounts in 1994 ($739.01/A), the distribution of costs varied. Conventional growers spent 36% less per acre in 1993 and 96% less in 1994 on herbicides than BCIPM growers. Conventional growers also spent 53% less per acre in 1993 and 84% less in 1994 on fungicides. However, the same growers spent 61.1% more per acre in

1993 and 732.9% more in 1994 on insecticides. In terms of the cost to control CPB, conventional growers spent 99.6% and 255.4% more per acre than BCIPM grower in 1993 and 1994 respectively. Fumigants were utilized by both groups in 1994 only. Again, conventional growers spent 24% more on fumigants.

Table 7. Pesticide Costs for Conventional and BCIPM Growers, 1993 and 1994.

	Cost ($)/Acre			
	Conventional		BCIPM	
Item	**1993**	**1994**	**1993**	**1994**
Weed Control	11.25	9.17	17.49	222.91
Disease Control	83.42	10.77	179.18	68.93
Insect Control				
CPB	185.13	415.09	92.75	11.68
Other Insects	68.21	56.87	64.47	44.65
Fumigants	------	415.85	------	390.84
Total	348.01	907.75	353.89	739.01

Using these cost Tables and the crop values for the 1993 and 1994 seasons an analysis of profit or loss was determined. This analysis is presented in Table 8. On a per acre basis, growers in the BCIPM program realized a $3,806.88 profit during 1993 while conventional growers obtained a profit of $3,520.84. In 1994, a profit of $2,196.24/A was made by BCIPM growers as opposed to a profit of $1,920.50/A by conventional growers. Overall, BCIPM growers made less than 8.1% more per acre than conventional growers in 1993 and 14.4% more in 1994. The difference in profit between the two programs would not justify not using conventional practices as opposed to being enrolled in the state BCIPM program. By being involved in the state BCIPM program, the data shows that growers can spend less time and money on pesticide applications and still incur similar returns on their investment.

Table 8. Profit/loss Analysis for Conventional and BCIPM Growers, 1993 and 1994.

	Cost-Value($)/Acre			
	Conventional		BCIPM	
Item	**1993**	**1994**	**1993**	**1994**
Costs				
Standard	2,965.15	2,965.15	2,897.75	2,897.75
Pesticides	348.01	907.75	353.89	739.01
Crop Value	6,834.00	5,793.40	7,058.52	5,833.00
Profit/Loss	3,520.84	1,920.50	3,806.88	2,196.24

CONCLUSIONS

Overall, 5.5% and 17.4% more pesticides were applied by conventional growers in 1993 and 1994, respectively. Excluding fumigants in 1994, fungicides and insecticides made up the bulk of the materials applied by this group each year. However, growers in the BCIPM program on the average treated their crop 34.6% less for CPB control than conventional growers in 1993 and 42.9% less in 1994.

Overall, standard costs were lower for BCIPM growers each year. This reduction in standard costs was due in part to the reduced labor costs involved with making pesticide applications. These costs in 1993 were offset by a 1.7% increase in pesticide costs. In 1994, however, a 22.8% decrease for BCIPM growers was seen.

Overall, BCIPM growers yielded more boxes of fruit per acre in both 1993 and 1994 (887.0 and 732.5, respectively). The level of high quality fruit produced by BCIPM growers was also higher each year (1993 - 3.4%; 1994 - 1%). BCIPM growers made more profit than conventional growers both years.

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