SUSTAINABLE AGRICULTURE RESEARCH AND EDUCATION PROGRAM AND AGRICULTURE IN CONCERT WITH THE ENVIRONMENT

FINAL REPORT **DATE OF REPORT: MARCH 10,1992**

PROJECT TITLE: Eggplant: A model system for integrating biological control of Colorado potato beetle and Verticillium wilt.

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GRANT NUMBER: LNE 89-15 Funding Period 1989-1991.

FUNDING TO DATE:

Organisations	SARE or ACE Funding	Non-Federal Match Funds	Other Federal Match Funds
NJAES	$19,000 for both	111,000	0
NJDA		118,000	

Abstract

Data collected on spray regimes used by farmers for protecting eggplant from the Colorado potato beetle prior to implementing the Biological Control Intensive Pest Management Program shows that we have reduced sprays from 15-20/year to one/ year after the release season starts. The savings are at least $100/acre/year for just the cost of insecticides alone. The assumption is that all insecticides are equally effective the one (oxymyl) where the savings is 100/year is among the least effective today. Development of a production budget is mostly complete but must be validated and improved. Not included in the benefits is the fact that higher quality fruit are harvested from the BCIPM fields. We hypothesize that higher luster occurs because insecticide carriers could interfere with xanthophyll production.

The sequential sampling plan we have developed has cut scouting costs dramatically and increased the number of acres scouted/day/person.

Findings: The Biological Control Intensive Pest Management Program in eggplant (BCIPM) is designed around a six week release schedule of 2,000 *Edovum puttleri* parasitic wasps released/acre/week on each participating farm. The wasps are parasitic on Colorado potato beetle eggs (*Leptinotarsa decemlineata*) for they lay their eggs within the beetles eggs. In addition, the wasp kills, with a selective sting, those beetle eggs that she does not lay her eggs in. The sum of the combined oviposition and selective sting results in 99% of eggs within a Colorado potato beetles eggmass to die.

Within this program we reduced insecticide applications from 15-20 for the season, to one spray at the beginning of the release period on participating growers farms. The average benefits are at least $100/acre for each farm. Receptivity of the program by the participating farmers has been very positive. These growers, at the outset, were very skeptical about the prospects for protecting their crop from the Colorado potato beetle. One-acre demonstration plots on each farm showed the farmers that the wasp was capable of suppressing the beetle population and that the crop would develop on time and with high quality fruit. One reason that the demonstration plots were so successful is that the farmer did not have all of his prospective eggplant revenues for the year tied up in the study. Our experience has shown that for new participating farmers the one-acre test plot is mandatory, because of the fear of potentially lost receipts from allowing higher than normal (for them) populations of the beetle in the crop is too much all at once. In addition, since the wasp is so tiny (about 2 mm long) it takes an individual farmer at least 2 years to develop the confidence that it will be successful on that farm. In short, the education/acceptance process for each grower is at least 2 years. Commonly after the 2 year period a grower will ask us to take over all their acreage which ranges up to $200,000 in gross receipts. General responsiveness among vegetable growers is increasing rapidly, for some farmers are now angry with their county agents for not including them in the program when it began. The limiting factor for expansion of the program is a lack of a draw-down account for hiring more personnel for mass rearing and more field scouts. Growers on expanded acreage are agreeing to fee-for service in ensuing years.

The eggplant production budget reflects the start up costs for the farmer, the actual costs of insecticides applied, and the estimated costs of delivering the program. Table 1 shows the average estimated costs to the farmer for producing and managing the crop. Table 2 shows six differing insecticide use pattern scenarios of labeled insecticides for protecting the eggplant crop from the Colorado potato beetle . We determined the costs by interviewing growers about their prior insecticide delivery strategies and found that they had been spraying 15-20 times/season; often with mixtures of more than one insecticide. Included within each estimated scenario are two sprays for green peach aphid for which the BCIPM program has eliminated the need. The preclusion of sprays for green peach aphid is from the buildup of natural enemies, such as ladybird beetles and green lacewings, once sprays for Colorado potato beetle stops.

We calculated the in-season costs on a minimum of 15 sprays without mixtures of differing insecticides. The last scenario is the Biological Control Intensive Pest Management program in eggplant.

Nested within this benefit is a *generally higher quality* fruit that come from BCIPM fields. Data gathered independently by three farmers showed conclusively that more # 1 fruit are harvested from BCIPM fields. In general, the luster of these fruit is deeper. The lack of luster in conventionally grown fruit may come from interference of xanthophyll production by carriers in the insecticides.

We must point out that two of the insecticides used in the scenarios, esfenvalerate and oxymyl, are generally losing there effectiveness against Colorado potato beetle, which will result in increased number of sprays applied by the farmers in coming years. This general loss of efficacy has severe implications on the economic return to the farmer through increased insecticide costs and more time spent spraying. The latter takes time away from the most important activity- Marketing. The loss of insecticide efficacy has spurred more grower interest in the program.

We have established a 10 year data set base on weekly eggplant prices from the Vineland NJ Fresh vegetable auction and will conduct break-even analysis for each of the participating farmers for the total production budget using BCIPM and conventional insecticide treatments. Fig.s 1-2 shows weekly cumulative receipts for eggplant from four of the participating growers in 1991. The range of revenue generated from eggplant sales was from \$14,000 to \$18,000/ acre. Each tic mark reflects a picking date. We have no reliable tested estimates on picking costs, so we will be determining those costs in that in the upcoming year.

We have done an archival analysis of beetle and parasitism data from all farms participating in the program for the past 3 years. By putting all data from each farm on the same scale we can now search for patterns in the beetle populations and wasp reproduction. Figures 3-5 represent results from 1 farm where we have had total control of the farmers acreage from 1989-1991. Two patterns emerge: (1) beetle populations have declined over the past 3 years and by the middle of July wasp reproduction in the field provides females to new eggs in a ratio of 2-3:1. This firmly establishes the negative effect that the wasp is exerting on the Colorado potato beetle population because of reproduction of the wasp in the field following release. Likewise on this farm fourth instar larval equivalents all remained below the economic threshold. Use of larval equivalents is a method which puts all feeding stages on a relative basis. For instance small larvae represent 1/3 of a large larvae and adults equal 1.25 fourth instar larvae.

We met with the participating growers in late Fall 1991. All farmers were enthusiastic about the results, especially with their sharply reduced insecticide bill and less time spent spraying The farmers uniformly want this project to continue especially since we have reduced the number of sprays following release of the wasp to one. In 1989, the average sprays following release was 3. A complete production budget will allow us to accurately assess the benefits derived from this program and determine a fair cost for delivering the program to the farmer.

Figure 6 shows the decision making tool that we have developed for determining the need to spray, which is a Sequential Sampling Plan. This statistically reliable sampling method is widely used in pest management for rapidly classifying insect populations in to non-damaging or soon-to-be damaging populations. In general, this sampling decision guideline reduces decision making time in the field by at least 50% with no loss of precision. For this program, we have developed two sampling plans. The first plan is to classify eggmass populations in to high or low. The economic injury level of 1 eggmass/plant is intended to prevent the eggmass count from rising higher than the tri-weekly release of the wasp can actively search out and oviposit. In addition, larvae hatching from one eggmass is about 30, which is high enough density to seriously defoliate a plant. Populations of eggmasses exceeding the economic injury level usually occur early in the season before parasitism is very high.

The second sequential sampling plan is for determining Colorado potato beetle larvae and adult populations population densities to ensure that they do not rise to levels that will defoliate the plant and retard fruit maturation or harm fruit directly by beetles chewing on them. This method rapidly classifies beetle populations into ones that do not need to be sprayed or ones that do. We have extensively tested this plan on historical data sets and find that it has one weakness. We have little data from high beetle populations which weakens our determination of when sampling can stop. Simply put, the regression has few data points at the higher densities so the plan has a harder time classifying the most damaging populations. The data do not allow us to approach satisfactory probability levels. This present plan requires the sampler to enumerate more plants to make a statistically reliable decision which in turn result in higher sampling costs.

In 1992 we have sufficient funding for extending the program to the present participants. This represents demonstration on about 40 acres. The acreage will be increased from 26 acres in 1991. The pattern for extending the program has been for the new farmers to have a 1 acre test plot on ther farm for 1-2 years. If at the end of two years, the farmer likes the program then we will take on more acreage on that farm. The learning curve by the farmer takes at least that long to understand our methods and the reliability of complete plant protection by the effects of the wasps killing beetle eggs. In most cases, after 2 years the farmer approaches us to take on the balance of his eggplant acreage. With a fund from which we could draw, we could increase the acreage, have the farmers pay from the program and replenish the monies to run the program the following year. Lack of funds for expansion is our most serious hinderance for program expansion. The participating county agents have all commented that there are many farmers who would join our program if it were to expand.

The objectives for integrating biological control of *Verticillium* wilt yeilded non-satisfactory results for economic plant protection. If it to be useful in the future more research on *Talormyces* must be done.

B. The eggplant acreage (1,000) in New Jersey is concentrated on the flat outer coastal plain in the southestern part of the state and is predominantly sandy loam in texture with nearly 0% organic matter. As a result of this concentrated acreage of eggplant, delivery of the program is much easier. Also, the crop is not planted until the frost-free date has passed so daily temperatures are ideal to promote parasitic activity by the wasp. The maritime climate allows a long growing season (frost-free to frost is at least 6 months. As a result, at least 80 different vegetable crops are grown in this area with an average of 30 on each farm. To deal with the variability among crops the vegetable farmer may have as many as ten differing tractors each designated for a specific purpose. For pesticide delivery, they use either a high pressure boom sprayer or modified air blast sprayer. Where possible, most growers use black plastic mulch on raised beds with drip irriigation. Some farmers apply fertilizers delivered through the drip system. The rotation cycles represent changing of crops with little fallowing of land. What rotations are done are for avoidance of soil-borne pathogens such as *Verticillium* wilt. All of the crops on the New Jersey vegetable farms are hand-harvested which requires a large summer labor pool. Most farms contract with the same migrant crews each year with occasional hiring of day labor for crops that are behind in the picking schedule. The social structure is classical small family farm with ususally 3-7 different family members actively participating in management decisions, each with their own specific responsibility. At least 90% of these farms are within 1hr drive of the cooperative vegetable auction. The estimated receipts of the auction are $100,000,000/year. These crops are pesticide(fungicide and insecticide) intensive because nearly all is sold to the fresh market buyers.

C. Tables 1 and 2. show economic analysis to date of the eggplant production and benefits of the program relative to a single factor insecticide approach. It is clear that the program is cost-effective relative to pre-existing practices.

D. Dissemination of findings. Nine scientific publications have resulted from various parts of the project with three more submitted and four more in preparation. In addition, I have given 6 talks on the Colorado potato beetle and *Edovum puttleri* to the general assembly at the New Jersey Vegetable Grower Association meeting. These talks were specifically designed to acquaint the growers with biological control in general and the evolution of the program. We have also had several groups from the USDA tour the demonstration areas and visit with participating growers. We also find that the cooperators are disseminating results at the auction by telling other growers the benefits of the program.

E. Producer involvement: This past year we have instituted an annual meeting of all cooperators NJAES, NJ Dept of Agriculture and farmers to update each other on benefits and detractions of the program. In this forum we were able to clear up misconceptions of the program and lay the ground work for future participation in the program.

Potential Contributions and Practical Applications.

A. Wide adoption of this practice severely restrict further development of insecticide resistance by the beetle in eggplant. This crop is considered by the insecticide industry to be an orphan because of its small nation-wide acreage. That being the case new insecticides may not be labelled on the crop because the benefits to the company do not outweigh labeeling costs. Also, in the case of re-registration of old compounds, many companies are not going to conduct the toxicity studies that are required. This is the case with rotenone. The compound is manufactured by a French company as a piscicide and if forced to re-register they are going to drop their label. Interestingly, the beetle or any other insect has never shown resistance to this compound.

B. This project has shown that biological control can be used in some fashion in the production of fresh vegetables. This production system has been regarded as a low possibility for biological control because the appearance criteria by the consumer results in high pesticide loads.

Areas Needing Additional Study:

Two highly important areas of exploration are improved mass rearing techniques for the beetle and the wasp and more foreign exploration for natural enemies of the beetle.

Table 1. A preliminary budget for producing eggplant in New Jersey

Cost of materials	Rate/acre	Price/unit	$ cost/acre
Lime	1 ton	22.00	22.00
Fertilizer	1 ton	175.00	175.00
Transplants	3500	0.25	875.00
Plastic mulch	2 rolls	87.50	175.00
Picking basket	50 baskets	7.00	350.00
Packing boxes	1000	0.83	830.00
subtotal			2427.00
Insecticides			
Na aluminoflouride	45.00	1.85 lb	83.25
Endosulfan	0.17	31.00 gal	5.27
Esfenvalerate	0.08 gal	120.00	9.60
Methomyl	0.50 gal	36.50 gal	18.25
Oxymyl	0.50 gal	55.00 gal	27.50
Piperonyl butoxide	0.13 gal	86.50 gal	11.25
Rotenone	0.64 gal	40.00 gal	25.60
Bacillus thuringiensis			
subtotal			199.62
Biological control (E. puttleri rearing and dispersal)	12,000 for season	0.01/ wasp	120.00
Scouting	0.80 hrs/acre	6.00/hr	4.80
subtotal			124.80
Labor			
seasonal	2.00	5.63	12.39
Pesticide application	1.00	7.38	8.12
Harvesting	1.25	5.63	139.34
Packout	1.50	13.01	98.04
Market transport	4.00	7.38	32.47
subtotal			290.36
Cost of macinery and equipment			1150.00
Land costs			100.00
General overhead			125.00

Magagement fee (7%)	184.90
Selling charge (3% of gross	2100.00

Total cost/ acre	65.91.68
Growing cost/acre	2856.92
Harvesting and marketing cost/acre	3734.76

Table 2. Estimates of seasonal cost of insecticides applied in 6 different scenarios. Each scenario is based on a 20 week spray season. With one application/week/.

Insecticide and /or Biocide	1	2	3	4	5	6*
Na aluminoflouride	1332.00					
endosulfan	10.54	10.54	10.54	10.54	10.54	
esfevalerate	38.40	38.40	192.00	38.40	38.40	
methomyl	36.50	36.50	36.50	36.50	36.50	
oxamyl		440.00				
piperonyl butoxide	44.98	44.98	224.90	179.92	44.98	44.98
rotenone				409.60		102.40
Bacillus thuringiensis					340.20	
Edovum puttleri						120.00
Scouting						96.00
subtotal	1,462.4	570.42	463.94	674.96	470.62	363.38

Each scenario is one in which farmers could take for a season. Many farmers use mixtures of insecticides in the same tank, which we did not include here. Two of these scenarios using esfenvalerate and oxymyl oar conservative in the rate applied since both are losing effectiveness rapidly. In addition. during mid season some growers indicate that they often spray twice/week. The endosulfan and methomyl costs are for the 2 sprays appied on the conventional acreage for green peach aphid. In the biological control program the need for these are eliminated because of the tremendous build-up of predators. The estimates for each scenario are for insecticide costs alone. Costs of application and tractor usage are not included nor is the time gained for other activities. Another benefit not calculated is that havrvest schedules do not have to be altered in the biological control program for reentry time or preharvest interval.

* This is calculated for a six week release season (2,000/week for 6 weeks) and a ten week scouting season. Wasp release begins about 1 month post planting they and are released by the scouts.

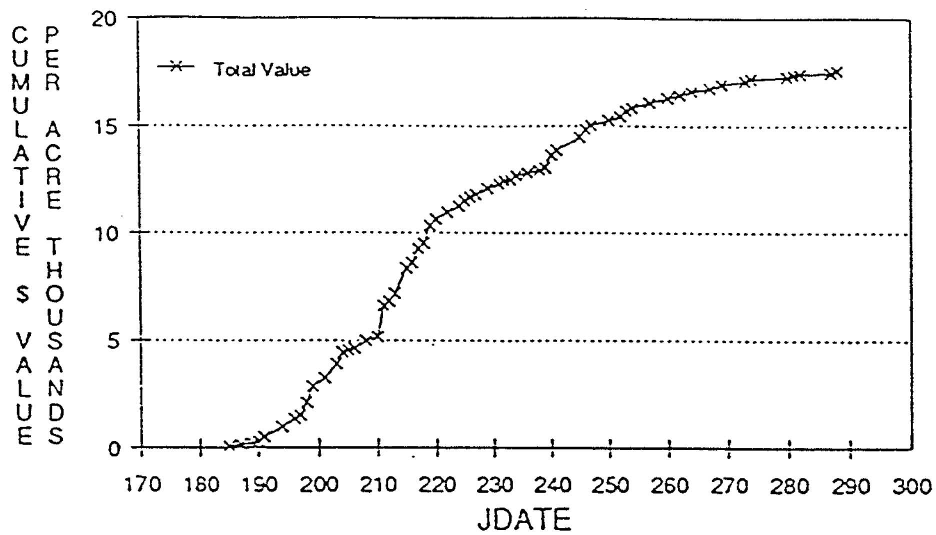
Figure Captions:

Figures 1-2. Cumulative weekly dollar return from 4 eggplant fields currently in the Biological Control Intensive Pest management Program.

Figures 3-5. Parasitism of Colorado potato beetle eggs in eggplant fields and estimated number of females emerging in the field from 1989-1991.

Figure 6. Graphical sequential sampling plans for classifying high and low populations of Colorado potato beetle eggmasses and classifying feeding stages adults and larvae into damaging or non-damaging populations.

1991 Value Data
State CPB IPM Program



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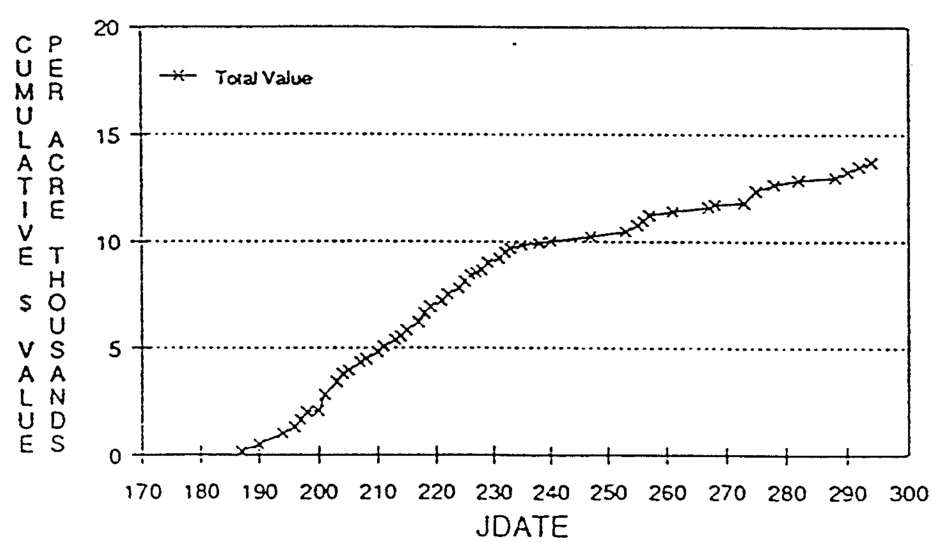
1991 Value Data
State CPB IPM Program



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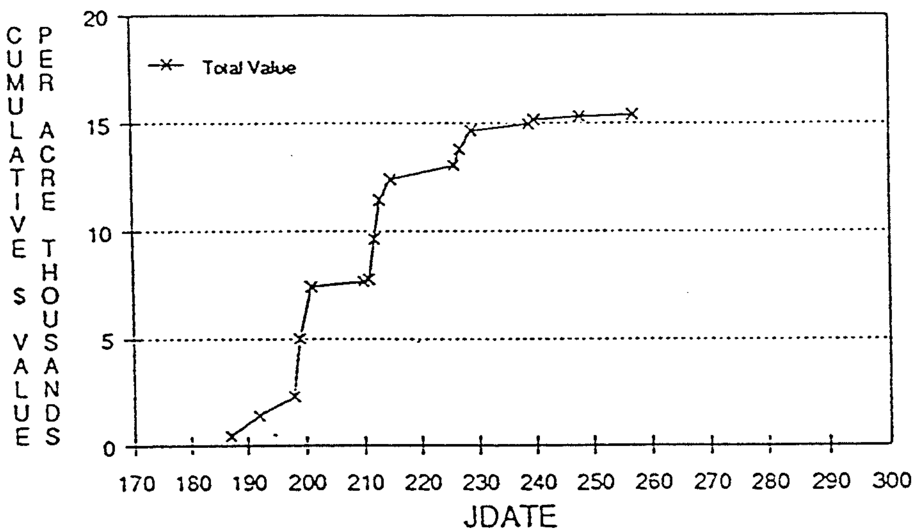

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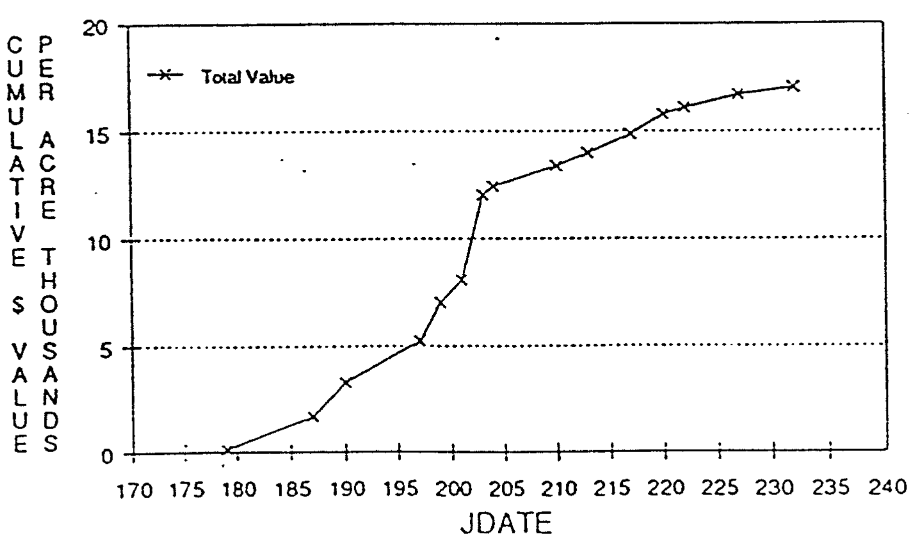
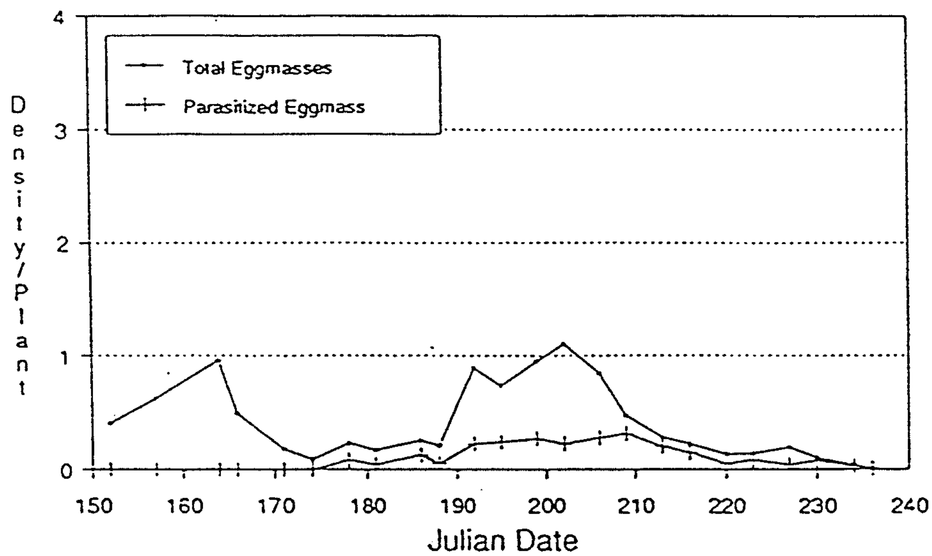


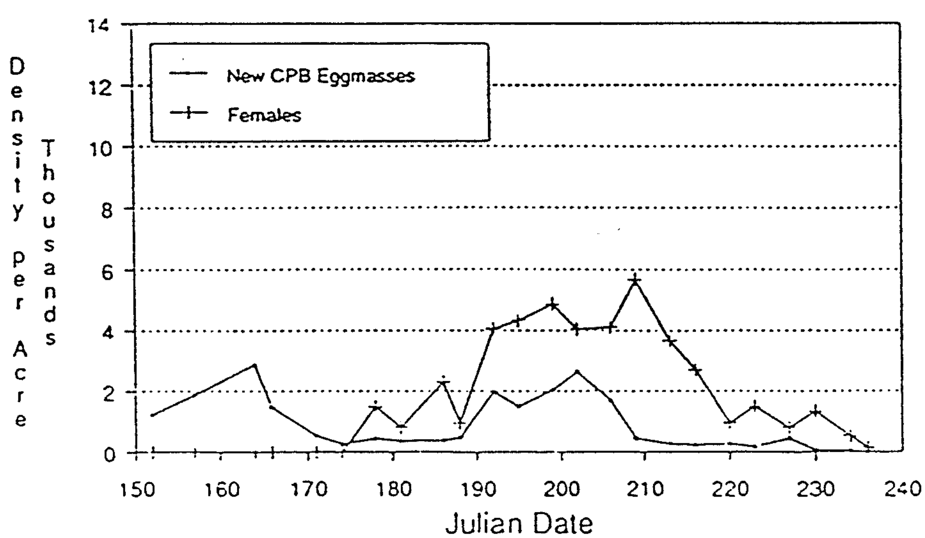
GV291.CHT

Field Parasitism
T. 1989



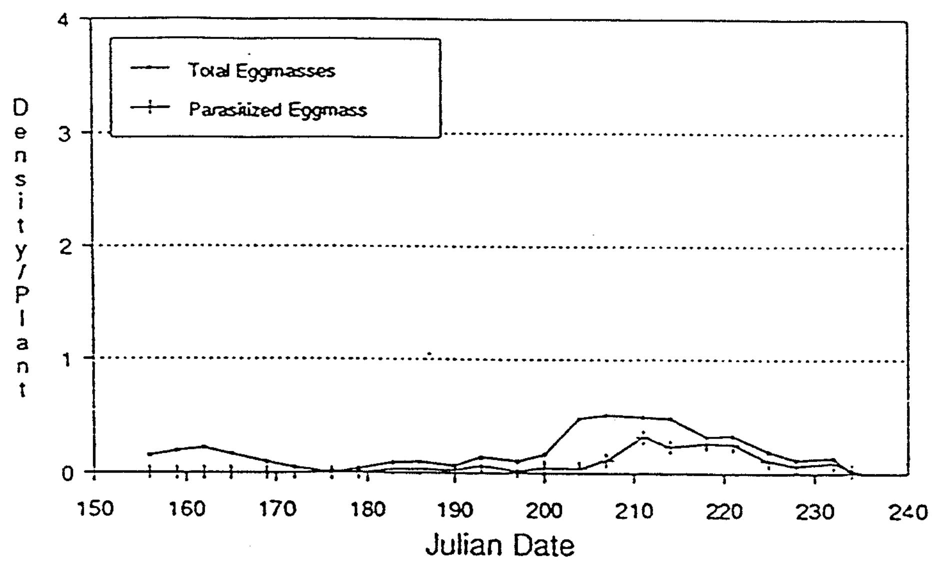
TAREGG89

Female EP vs New Eggmasses
T. 1989



TEGGS89

Field Parasitism
T. 1990



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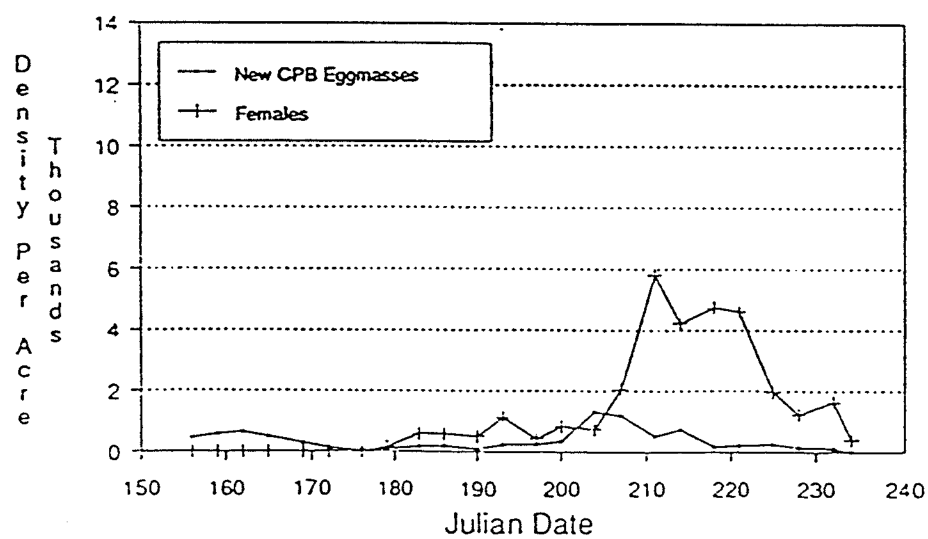
T. 1990



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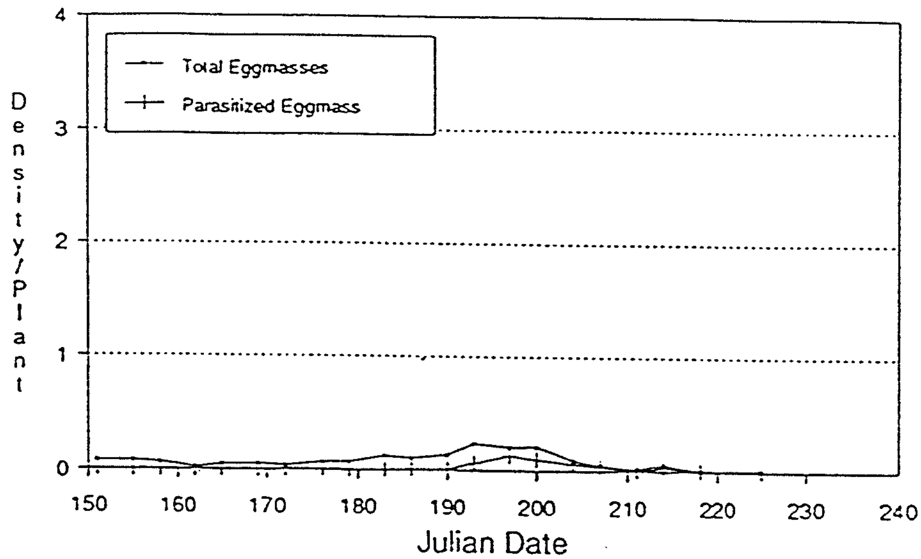
Field Parasitism

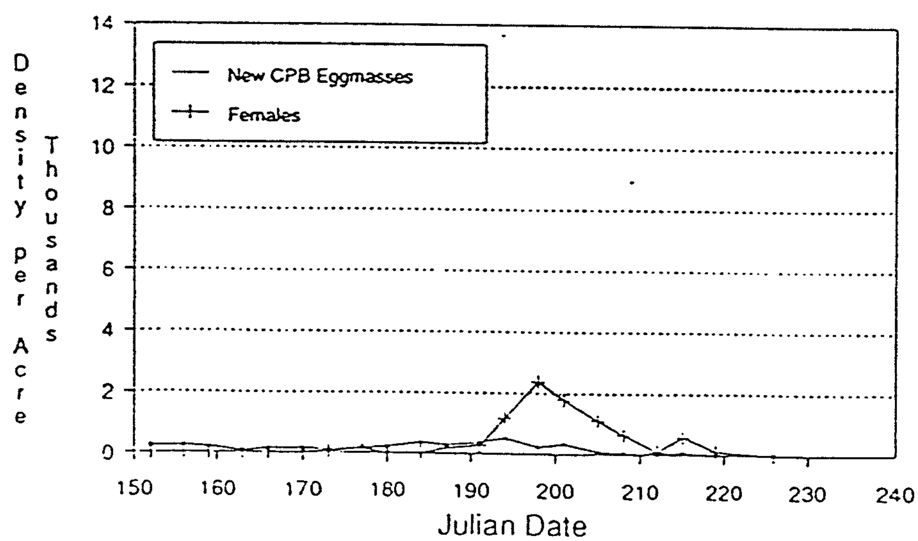
T. 1991



TAREGG91

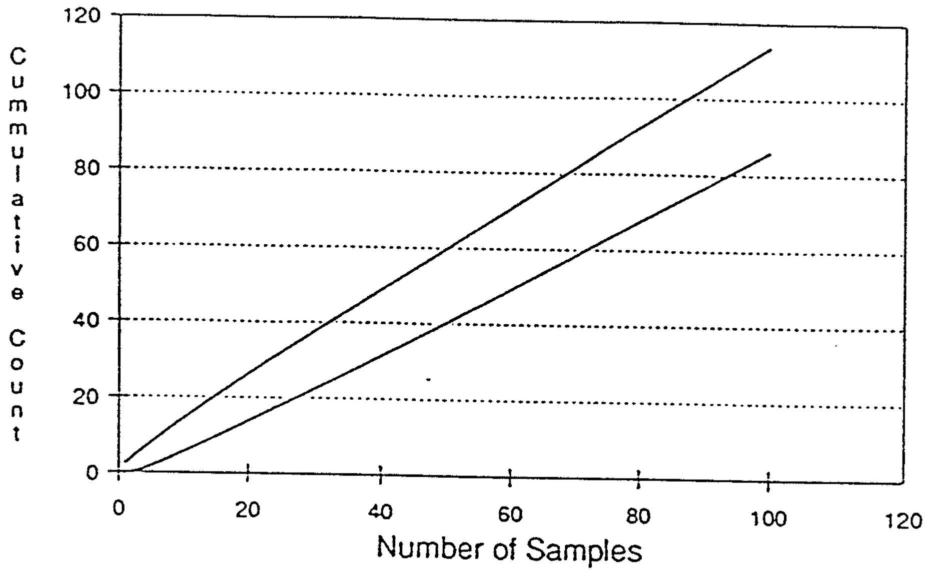
Female EP vs New Eggmasses

T. 1991



TEGGS91

Sequential Sampling Stop Lines
CPB Eggmasses (ET = 1)



Data from 1988 - 1990

Sequential Sampling Stop Lines
Adults and Larvae (ET = 8)