Control of Insect Pests on Broccoli in Southern Texas: A Comparison Between Synthetic Organic Insecticides and Biorational Treatments[1]

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ABSTRACT Biorational and synthetic organic insecticide application regimes were evaluated for management of key pests of broccoli in southern Texas. Broccoli plants were grown in small replicated plots and pests were managed either under a regime of synthetic organic insecticides or biorational techniques (*Bacillus thuringiensis* and/or fatty acid soap applications and inundative releases of *Chrysoperla carnea*). Effectiveness of treatments was evaluated by comparing insect populations and number of broccoli heads harvested from plots. The biorational and synthetic organic insecticides were equally effective in controlling lepidopterous pests but the biorational regime required a greater number of applications for effective control. Neither inundative releases of *C. chrysoperla* eggs and larvae nor applications of a fatty acid soap were effective in reducing aphid populations. Applications of synthetic organic insecticides were effective when applied solely for aphid control or as a control for lepidopterous larvae.

KEY WORDS Insecticide, diamondback moth, cabbage looper, aphids, broccoli.

Brassicaceous crops including broccoli, cabbage and cauliflower are grown on approximately 19,000 acres in southern Texas and are worth approximately $45 million (Anonymous 1985). A major production limitation is the insect pest complex that feeds on the crops including the lepidopterous pests diamondback moth (*Plutella xylostella* L.), cabbage looper (*Trichoplusia ni* (Hübner)), beet armyworm (*Spodoptera exigua* (Hübner)) and the aphids, green peach aphid (*Myzus persicae* (Sulzer)), turnip aphid (*Lipaphis erysimi* (Kaltenbach)), cabbage aphid (*Brevicoryne brassica* (L.)) (Cartwright et al. 1987). These pests may reduce yield by limiting plant production or by damaging and contaminating the product, thus resulting in heads graded as non-marketable.

Application of synthetic organic insecticides to the brassicaceous crops has historically been the major management tool for controlling insect pests. However, recent public concern about the use of the synthetic organic insecticides and their effect on human health and the environment has resulted in a demand

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for vegetables grown without the use of these materials. Additionally, diamondback moth populations in North America have become resistant to insecticides (Magaro and Edelson 1990). Therefore, alternative management tools are being developed and many are currently being marketed (Endersby and Morgan 1991).

Research was initiated to determine whether available alternatives to synthetic organic insecticides can effectively be used to produce a marketable broccoli crop under the intense insect pest pressure existing in sub-tropical southern Texas.

Materials and Methods

Broccoli, 'Southern Comet,' was direct seeded in raised beds at the Texas Agricultural Research and Extension Center, Weslaco, on 8 October 1987 (fall crop), 27 January 1988 (spring crop) and 23 September 1988 (fall crop). Experimental plots were four beds wide (1 m centers) and 16.5 m long. Two rows were planted to each bed and plants were thinned to 15 cm spacing within and between rows. A randomized complete block experimental design was used with five blocks and three treatments.

Insect pests were sampled at approximately seven-day intervals by examining five plants per plot and recording presence of diamondback moth, cabbage looper, beet armyworm, and aphids (green peach aphid, turnip aphid, cabbage aphid). Treatment decisions were based on mean number of lepidopterous larvae or aphids of all species as recorded during sampling within plots for the various treatments. Decisions to treat all replicates of plots for a treatment were based on thresholds of 0.3 larvae/plant or 10 aphids/plant (Cartwright et al. 1987, Flint 1985). Treatments consisted of 1) untreated plots, 2) applications of biorational materials (i.e., *Bacillus thuringiensis* for lepidopterous larvae and plot inoculations with *Chrysoperla carnea* Stephens eggs or applications of a fatty acid soap for aphid control), and 3) applications of commonly used synthetic insecticides (endosulfan for lepidopterous larvae and methamidophos for aphids).

Applications of *B. thuringiensis* (Dipel 2X, Abbott Laboratories, Chicago, IL), fatty acid soap (Safer Insecticidal Soap, Mycogen Inc., San Diego, CA), methamidophos (Mobay, Kansas City, MO) and endosulfan (FMC Corp., Philadelphia, PA) were made with a tractor mounted sprayer at a rate of 93.6 liters of total solution per ha at 2.8 kg/cm^2. The spray boom was equipped with TX-10 hollow cone nozzles mounted at 25 cm intervals and directed straight down over the tops of plants. Rates used were: Dipel 2X, 0.5 kg/ha; Safer Insecticidal Soap, 1% by volume solution; methamidophos and endosulfan, 1.0 kg (AI)/ha.

Inoculations of plots with *C. carnea* eggs were made by manually distributing eggs over the two center beds in the biorational plots. Eggs were ordered from the supplier (Rincon-Vitova, Oak View, CA) on the same day on which surveys indicated aphid numbers were above threshold. The eggs were distributed in the plots late in the afternoon of the day on which they were received.

Yield was determined by cutting off mature broccoli heads approximately 2.5 cm below the bottom of the head. Harvests were made at approximately seven-day intervals as is common in commerical production in south Texas. All mature heads were cut from plants in 3 meters within a single row selected from each of the two center beds in the plots and taken to the laboratory on each harvest date. Head diameters and weights were measured and then heads were examined visually to record presence of insects or insect damage. Mature heads less than 10 cm in diameter or with noticeable damage or insect contamination were judged not marketable.

Pest population data were pooled across dates and analyzed for each species using analysis of variance (SAS, Proc GLM) and Duncan's multiple range test (Duncan 1975) for mean separation. Aphid population data were transformed to $\log_{10}$ (aphid + 1) prior to analyses (Southwood 1980) and non-transformed means are reported. Yield data were summed across dates and subjected to analysis of variance and Duncan's multiple range test for mean comparisons (Duncan 1975).

Results

Fall 1987. Pest sampling was initiated 18 November and continued through 21 December. Harvests were initiated 22 December and continued through 12 January.

Lepidopterous larval populations during the fall cropping season were above threshold levels in all plots on each survey date and therefore pesticide applications (20, 25 November, 3, 10 and 18 December) were made after each survey. The synthetic insecticides and *B. thuringiensis* significantly reduced numbers of larvae compared to the untreated plots (Table 1). *B. thuringiensis* and the synthetic insecticides were effective in reducing total number of lepidopterous larval populations to less than one per plant.

Aphids (primarily cabbage aphids), were not abundant and synthetic insecticide applications in those plots treated for lepidopterous larval control maintained the aphid populations below 10 per plant throughout the season and no additional aphicides were applied.

B. thuringiensis is a specific lepidopterous larvicide and had no effect on aphid populations. *C. carnea* eggs were ordered from the commercial supplier when aphid populations reached a level above 10/plant on 11 December in the biorational treatment plots. Eggs arrived on 16 December and were released at a rate of 123,500/ha in the biorational treatment plots. Aphid populations remained above the threshold on the following survey date (18 December). Because of the delay involved in ordering, receiving and inoculating plots with eggs, no additional order was made after December 16 even though aphid numbers were greater than 10/plant on December 18.

Inoculation of plots with eggs had no discernable effect on aphid populations and by the end of the season there were no significant differences in numbers of aphids in the biorational treatment plots relative to the untreated plots. Aphid numbers were significantly lower in the synthetic pesticide plots relative to both the biorational and untreated plots (Table 1).

Broccoli was harvested on 29 December, 1, 12, and 19 January. No differences in yield of broccoli heads were noted among treatments in terms of mean number of heads per plot for data summed across harvest dates (Table 1). A significantly larger number were judged marketable (free of insect contamination

Table 1. Mean number of lepidopterous larvae and aphids per plant and mean number of mature heads and marketable heads per plot for broccoli grown in Weslaco, TX.

Treatment	Larvae per plant	Aphids per plant	Number of Heads Total	Number of Heads Marketable
Fall 1987				
chemical	0.4 a	2.1 a	20.6 a	18.0 a
biorational	0.5 a	7.7 b	22.2 a	15.6 ab
untreated	1.1 b	6.7 b	23.6 a	14.4 b
Spring 1988				
chemical	1.6 a	57 b	11.0 a	0.8 a
biorational	1.7 a	150 a	2.4 b	0 b
untreated	2.5 a	160 a	6.6 b	0 b
Fall 1988				
chemical	0.4 ab	13 b	64.8 a	30.3 a
biorational	0.2 a	1486 a	36.5 b	0.5 b
untreated	0.6 b	366 a	31.5 b	2.0 b

and greater than 10 cm in diameter) from the synthetic pesticide plots relative to the untreated plots (Table 1). The greater abundance of aphids and larvae in the untreated plots resulted in a reduction in marketable heads relative to the synthetic insecticide treated plots.

Spring 1988. Surveys of plants in the spring crop were initiated 9 March and continued through 19 April. Plots were harvested on 26 April through 17 May. Lepidopterous larval populations were above threshold in all plots on all sampling dates after 21 March. Applications of insecticides were made to plots to control lepidopterous larvae on 30 March, 7, 13, and 20 April. *B. thuringiensis* and endosulfan treatments were not effective in reducing larval populations below those noted in the untreated plots (Table 1).

Aphid populations (70% cabbage aphid, 30% green peach aphid) were above threshold on the first date of surveys. Synthetic insecticide applications were initiated on 10 March. *C. carnea* eggs were ordered from the commercial supplier on 9 March, arrived on 14 March and plots were inoculated at a rate of 123,500/ha. Aphid numbers did not decline in the biorational plots and a second order for eggs was placed 19 April. The eggs arrived 24 April and plots were inoculated at a rate of 246,000/ha.

Synthetic insecticide applications reduced aphid populations in comparison to the untreated and biorational plots (Table 1). Inoculation of plots with *C. carnea* eggs did not result in aphid population reductions.

Mean number of heads from plots treated with synthetic insecticides was greater than in the other treatment plots (Table 1). Lepidopterous larval population abundance did not differ among treatments but aphid numbers were lower in the synthetic insecticide treated plots. Indications are that aphid abundance had a negative impact on production of heads. Number of marketable heads was extremely low across treatments due to the large numbers of diamondback moth larvae in all plots. Heads contaminated with aphids and/or diamondback moth larvae or smaller than 10 cm in diameter were graded nonmarketable.

Fall 1988. Surveys were initiated 2 November and continued through 23 December. Harvests were conducted on 10 and 17 January, 1989. Applications of a fatty acid soap were substituted for releases of *C. carnea* as conducted in the previous trials due to the ineffectiveness of the releases in controlling aphid populations. Five applications of synthetic insecticide were made to the chemical control plots during the season. A total of eight applications (four each of soap and *B. thuringiensis*) were made to the biorational treatment plots during the season.

The number of lepidopterous larvae was significantly lower in the biorational treatment plots compared with the untreated plots (Table 1). The number of aphids (primarily cabbage aphids) was significantly lower in the synthetic insecticide treatment plots relative to both the biorational treatments and untreated plots.

Mean number of heads harvested and judged marketable were significantly greater in the synthetic insecticide treatment plots. Plants and heads from the biorational treatment and untreated plots were severely contaminated with aphids (Table 1).

Discussion

The broad spectrum insecticides, endosulfan and methamidophos, were effective in reducing aphid populations each season. Results indicate that *B. thuringiensis*-based insecticides such as Dipel 2X can be used to effectively manage the lepidopterous pest complex of species in brassicaceous crops. The aphid species complex was not effectively controlled in the Lower Rio Grande Valley using inundative releases of *C. carnea* or applications of a fatty acid soap. Large numbers of aphids on plants during two of the seasons appear to have reduced the number of mature heads formed on plants by up to 50% in addition to reducing size of heads and causing significant contamination of those heads formed.

The biorational management regimes evaluated in this study were more costly than the use of synthetic organic insecticides primarily due to the increased number of applications of Dipel 2X needed to control the lepidopterous larvae. Cost of materials may fluctuate over time and is dependent on suppliers, thus it is difficult to compare cost of *B. thuringiensis* materials with costs of materials such as endosulfan or methamidophos. However, the cost of actual application (equipment, labor, time) should be the same for either and increased numbers of applications will increase total costs. Additionally, more marketable heads were harvested in the synthetic organic insecticide plots due to effective management of the aphid complex. This increase in production plus the decreased number of applications, increased the cost effectiveness of the synthetic organic insecticide regime.

There are indications that aphid population pressure on brassicaceous crops in southern Texas will limit the effectiveness of management solely with biorational treatments unless other, more effective treatments are developed. If releases of predators are used and are effective in reducing aphid populations, growers will have to contend with the problem of predator larvae and pupae being present on and contaminating the marketable product. Market and FDA constraints are such that few insect parts, whether resulting from pest infestations or predator populations, are tolerated in fresh or processing market-bound vegetables.

In summary, commercially available biorational techniques are not cost competitive for management of the entire pest complex on brassicaceous crops in southern Texas. It may be possible to increase the level of management and inputs of biological materials to achieve effective control; however, the increased cost would have to be recouped through higher market prices for the end product or through enhanced yield.

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