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Diamondback Moth, *Plutella xylostella* (L.), control studies on cabbage in St. Kitts

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Diamondback moth (DBM) (*Plutella xylostella* (L.)) insecticide efficacy and population dynamics studies were conducted in St. Kitts 1985 - 1987. Experiment station and "on-farm" trials were conducted in addition to monitoring small farmers cabbage crops for DBM and *Apanteles plutellae* population levels. Permethrin, *Bacillus thuringiensis* (Berliner), and pirimiphos-methyl, controlled DBM adequately. Peaks in A. *plutellae* parasitism coincided with a predominance of 4th instar larvae. The presence of high parasite populations delayed the time to first spray. A relative growth rate analysis of DBM populations indicated that growth rates are correlated to percent A. *plutellae* parasitism. It is hypothesized that parasitism levels exceeding 25-35% may control DBM populations.

Keywords: *Plutella xylostella*; Cabbage; *Apanteles plutellae*; St. Kitts; Population dynamics.

Introduction

The diamondback moth (DBM), *Plutella xylostella* (L.) is a cosmopolitan pest of crucifers. (Talekar et al., 1985). In the Caribbean, the DBM is well distributed and is a particularly serious pest of cabbage (Cook 1985). Alleyne (1978) reports that the DBM is the chief pest of cabbage in Barbados, while Yaseen et al. (1977) reported a similar situation in Trinidad. It is not unusual for an entire crop of cabbage to be destroyed by this insect in St. Kitts/Nevis.

Alam (1982 a & b) reports annual percent *A. plutellae* parasitism levels ranging from 17.9 - 68.9% in Barbados during the years 1971 - 1982. Van Driesche (1983) has determined that, percent parasitism alone, serves as a poor indicator of actual parasite impact unless host and parasite phenologies are described at the time of sampling. Yaseen et al. (1977) report *A. plutellae* parasitism levels of DBM feeding on cauliflower in Trinidad, increasing from zero to a maximum of 22.2% over a 3 week period after a release of 100 *A. plutellae*.

Much research still needs to be conducted on the dynamics of A. *plutellae* and DBM in integrated pest management programmes for cabbage. The authors are unaware of any Caribbean studies that have actually monitored a cabbage crop and its associated pest complex from seedling to harvest. The dynamics of the DBM/parasite system are complex and the effects of spray treatments compound problems when one intends to assess the ability of a *A. plutellae* to control DBM populations.

For the past two years, the St. Kitts Manufacturing Corporation/Caribbean Agricultural Research and Development Institute, Integrated Pest Control Unit (SSMC/CARDI-IPCU), has been conducting

DBM control studies "on-farm" and at CARDI's experiment station in St. Kitts. The objectives of these studies have been to determine:

1) The efficacy of selected insecticides for control of the St. Kitts DBM biotype;
2) The population dynamics of the DBM during the course of a typical cabbage crop
3) The pest/parasite interactions of the DBM and *A. plutellae*.

We believe that the DBM is regulated by *A. plutellae* under certain conditions. However, an integrated pest management approach must provide a suitable environment and enhance the parasite's ability to regulate DBM levels.

Materials and Methods

Three DBM control experiments were conducted during 1985 -1987. In addition, several small farmers' cabbage plots were monitored for DBM and parasite levels during the course of an entire crop. Experiments 1 and 2 were conducted at CARDI's experiment station. Both experiments consisted of 3 treatments replicated 4 times in a RCB design. Plot sizes were 2.3m x 3.2m and 2.3m x 2m for Experiments 1 and 2, and contained 35 and 25 plants respectively. Experiment 3 was conducted "on-farm" using a 4 x 4 RCB design. Plots were 3.7m x 3.2m and contained 56 plants each.

Diamondback moth and *A. plutellae* populations were monitored weekly for the entire cabbage crop in all experiments. Population estimates were derived from 10 randomly selected whole-plant counts in each plot. At each count, all stages of the DBM were recorded. Percent parasitism (%PA) was calculated using Van Driesche's (1983) formula:

$$\%PA = P/(H + P),$$

where P = number live *A plutellae* cocoons and
H = number DBM larvae (all stages)

Insecticides were applied by knapsack sprayer when populations averaged 2-3 DBM/head. In addition, in Experiment 3, a blanket treatment of malathion was used to control cabbage aphids, *Brevicoryne brassicae* (L). Yield measurements were taken for all experiments and in Experiment 2, a visual damage assessment was performed by an unbiased observer.

Regular monitoring was conducted in three commercial cabbage crops to gather additional data on pest/parasite interactions. At each site, 45 cabbage plants were randomly selected and pest/parasite levels recorded from approximately 1 - 2 weeks post-transplant, until harvest.

Results

Table 1 provides summarized results of average post-spray DBM/head counts for all experiments. In Experiment 1, insecticide treatments were applied twice. Pirimiphos-methyl, *Bacillus thuringiensis* (Berliner) and permethrin gave the best control, with post-spray counts of 0.8. 1.2 and 2.0 DBM/head, respectively. Diazinon was also selected for further evaluation.

The top performing insecticides from Experiment 1 plus cartap and PP-321 (Karate) were evaluated in Experiment 2. A total of three spray treatments were applied in this experiment. Pirimiphos-methyl, *B. thuringiensis* and permethrin were again top performers, with average post-spray counts of 0.5, 1.7, and 2.1 DBM/head, respectively. Cartap also provided excellent control with a post-spray average of 0.4 DBM/head. Karate, did not give good control.

Pirimiphos-methyl, *B. thuringiensis* and permethrin were retested "on-farm" in Experiment 3. Average post-spray populations were 0.8, 0.3 and 1.2 DBM/head, respectively, while Carbaryl, the standard "on-farm" control treatment, had a significantly higher post-spray average of 1.7 DBM/head.

Table I Efficacy of various insecticides for the control of *Plutella xylostella* diamondback moth on cabbage. Average of post application pest levels.

Compound	Rate (kg. ai/ha)	DBM population (counts/head) Expt 1	Expt 2	Expt 3
Bacillus thuringiensis (var. Berliner) (3.2% wp)	0.84	1.2(±0.1)[1]a[2]	1.7(±0.5)ab	0.3(±0.04)a
Carbaryl 80% SP	2.2	-	-	1.7[3](±0.4)b
Cartap 50% SP	0.5	-	0.4(±0.1)a	-
Deltamethrin 2.5 EC	0.017	3.1(±0.3)b	-	-
Diazinon 60 EC	1.4	2.4(±0.2)ab	3.0(±0.2)bc	-
Fenvalerate 2.4 EC	0.2	2.1(±0.2)ab	-	-
Karate 70% w/v	0.35	-	9.4(±2.1)d	-
Malathion 5 EC	2.1	2.0(±0.4)ab	-	-
Permethrin 50% w/v	0.2	2.0(±0.4)ab	2.1(±0.4)ab	1.2(±0.3)ab
Pirimiphos-methyl	0.5	0.8(±0.2)a	0.5(±0.1)a	0.8(±0.2)ab
Control (no insecticide)	-	3.3(±0.4)b	4.3(±0.7)c	-

1) S.E. given in ( )
2) Means in same column followed by different letters are significantly different (Fisher's Protected LSD Test, $P < 0.05$).
3) Control for "on-farm" trial

DBM pest/parasite population dynamics

Experiments 1 - 3: Populations of *A. plutellae* and DBM were present early in Experiments 1 and 3 (Figs. 1 and 3 respectively). Maximum percent parasitism was observed in these experiments 3 to 4 weeks after transplanting. In Experiment 2, *A. plutellae* was not recorded until 5 weeks after transplanting (Fig. 2) when DBM populations were beginning to increase rapidly and insecticide treatments were initiated. DBM populations were kept in check by *A. plutellae* up to 6 weeks in Experiment 1. The relatively high percent *A. plutellae* parasitism levels in Experiments 1 and 3 kept DBM populations under control for a longer period and delayed the time to first spray for up to seven weeks.

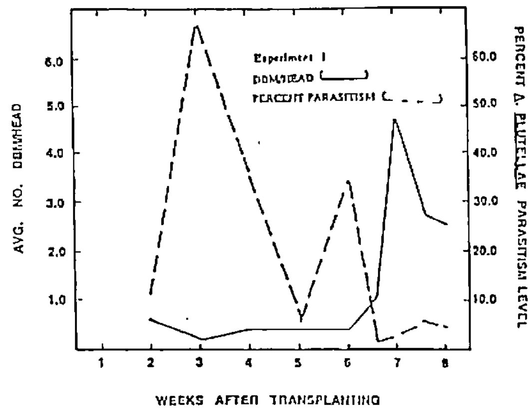

Figure 1 Percent parasitism and DBM/Head populations for insecticide-free control plots in Experiment 1

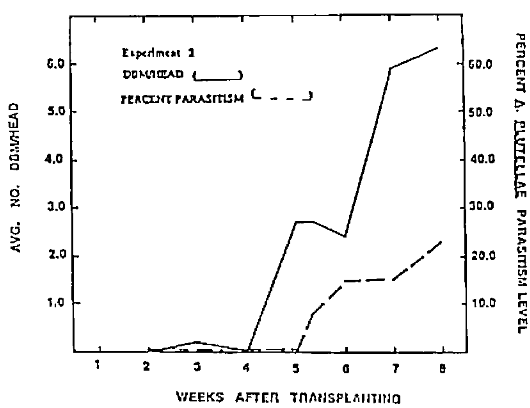

Figure 2 Percent parasitism and DBM/Head populations for insecticide-free control plots in Experiment 2

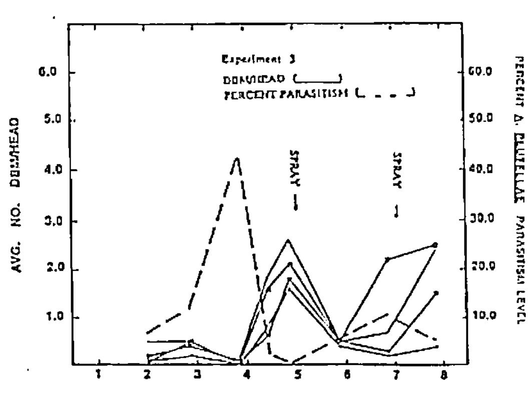

Figure 3 Percent parasitism and DBM/Head populations for all treatments in Experiment 3

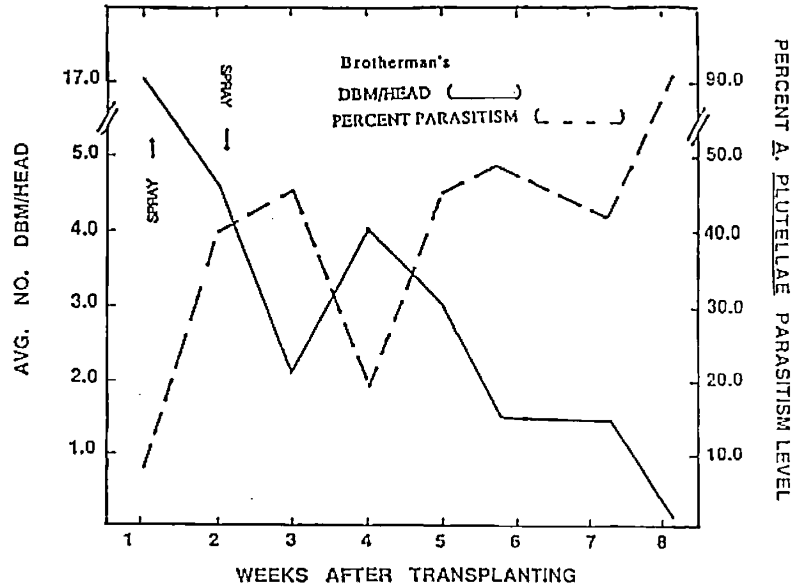

Figure 4 Percent parasitism and DBM/Head population levels at Brotherman's Farm, Green Acres, St. Kitts

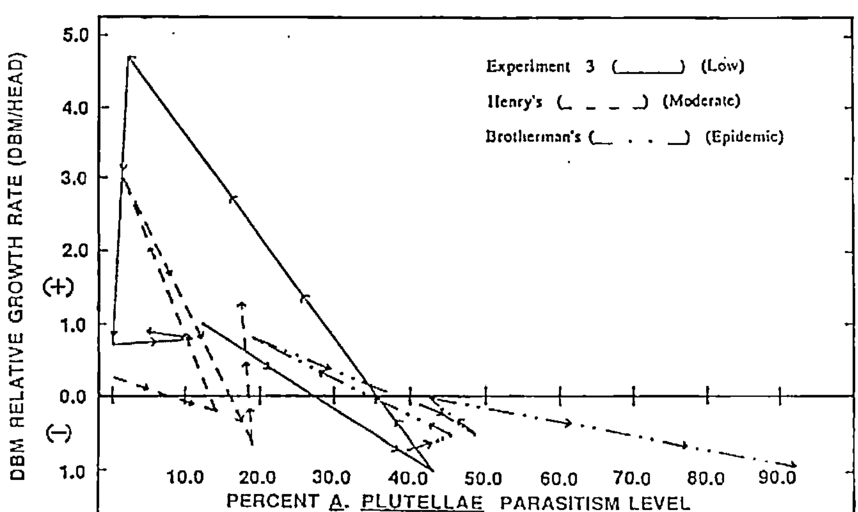

Figure 5 Results of a DBM relative growth rate analysis vs. percent *A. plutellae* parasitism. Analyses calculated for 3 sites. Points above the zero line represent increasing populations while those below are decreasing

Peaks in parasitism typically coincided with a predominance of 4th instar DBM larvae and fresh pupae since it is during this stage that *A. plutellae* larvae emerge from their host to pupate. Percent parasitism levels were highest when DBM populations were low (Figs 1 and 3) where a single *A. plutellae* pupa significantly affects the parasitism level. After the initial peak, parasitism levels generally declined due to a gradual increase in DBM numbers. As a second 4th instar DBM cohort began to appear, percent parasitism increased once again (Fig 1 - Week 6). Spray treatments in Experiment 3 may have prevented a similar occurrence in this trial. The decline in percent parasitism toward the end of Experiment 1 (Fig. 1) was probably due to a combination of similar factors since spray treatments were initiated in surrounding plots on 18 March (Week 7).

On-farm Studies: DBM and *A. plutellae* populations in commercial cabbage crops typically behaved in a manner similar to those in Experiments 1-3. Peaks in *A. plutellae* parasitism coincided with 4th instar DBM larvae, and populations that had low *A. plutellae* populations at the initiation of the crop, typically developed greater pest populations.

At one site (Brotherman's, Fig. 4), DBM populations were high approximately 3 weeks after transplanting, while parasitism was less than 10%. Two sprays of permethrin were applied within a 10-day period to reduce DBM levels, which were suppressed to approximately 2.2 DBM/head. Parasitism subsequently rose to ca. 45% 1 week after sprays were concluded. This peak in parasitism coincided with a flush of 4th instar DBM larvae. Parasitism subsequently averaged 48.2% and peaked at 92.0% during the next 5 weeks of the cabbage crop, while population declined to less than 1.0 DBM/head. Yield from this crop was unfortunately, very low due to the severe damage inflicted during the first few weeks of the crop.

DBM relative growth rate analyses

Berryman (1985) indicates that populations of two different species coexisting within the same geographic area (e.g. the DBM and *A. plutellae* in a cabbage field) may be viewed as two separate population systems which interact with each other, so that the numbers of one population modify the favourability of the environment for the other. By analyzing the growth rates of the competing populations, it is possible to determine the negative effects that each has upon the other and to estimate the equilibrium positions about which the populations fluctuate. These techniques can be used to determine the approximate parasitism levels that are required to maintain a pest population in check.

Percent parasitism plotted against the DBM relative growth rate (RGR) (= rate of DBM increase per capita) yields an additional measure of the significance of *A. plutellae* in regulating DBM populations. Figure 5 contains a plot of the DBM RGR vs. % parasitism for 2 farmer's cabbage plots and Experiment 3. The RGR was calculated as:

$$RGR = H_t - H_{(t-1)}/H_{(t-1)} \quad \text{(Berryman, 1985)}$$

where H is the DBM population/head at times t and (t-1),

The magnitude of the RGR determines the rate of increase or decrease of the DBM population. By plotting RGR vs. percent *A. plutellae* parasitism at time t, one obtains an estimate of the parasitism level that is required to maintain DBM populations at a zero growth rate (RGR = 0).

A visual, "best fit" line for Figure 5, suggests zero RGR is attained at approximately 30% parasitism by *A. plutellae*. Figures 1-4 support this value as they show that percent parasitism levels exceeding 30% typically resulted in a decline in DBM populations. The results therefore suggest that if *A. plutellae* parasitism levels can be maintained above 25 - 35%, adequate DBM control will result.

Conclusions

Our studies have shown that *B. thuringiensis*, cartap, permethrin and pirimiphos-methyl provide adequate control of the DBM in St. Kitts/Nevis. However, it is likely that persistent use of these compounds will lead to the development of insecticide resistance in the near future. Already, we have lost a number of insecticides for the control of DBM in the Caribbean and continued use of these compounds will contaminate our fragile environments further.

A. plutellae is distributed throughout the Caribbean, can readily establish itself and is easy to rear and release. Our studies indicate that sustained percent parasitism levels of 25-35% can control DBM populations. The Asian Vegetable Research and Development Center (AVRDC) has reported similar results in Taiwan where releases of *A. plutellae*, *Diadegma eucerophage* (Hortsman), and *B. thuringiensis*, gave effective DBM control without the use of chemical insecticides in cabbage (AVRDC, 1985). Further, DBM control studies should be conducted in the region to test the hypotheses needed for establishing an effective biological control program that incorporates *B. thuringiensis*, limited use of chemical insecticides at reduced rates, and parasites for the control of the DBM.

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