INTERACTION OF *COTESIA MARGINIVENTRIS* PARASITIZATION AND FIELD APPLIED *BACILLUS THURINGIENSIS*, THIODICARB, AND THEIR COMBINATION ON TOBACCO BUDWORM MORTALITY AND PARASITOID EMERGENCE

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Abstract

Bacillus thuringiensis var. *kurstaki* and thiodicarb were evaluated in field tests to determine the effect on *Heliothis virescens* larvae and the parasitoid *Cotesia marginiventris*. Tests were conducted using *B. thuringiensis* rates and thiodicarb rate, independently and in combination, as recommended for resistance management in Arkansas. Results indicate that neither *B. thuringiensis* nor thiodicarb, alone or in combination, provide acceptable control of late second to early third instar *H. virescens* larvae (< 32%). However, thiodicarb and thiodicarb/*B. thuringiensis* mixes provided significantly greater control of *H. virescens* than did *B. thuringiensis* application alone. In addition, no significant advantage was determined for tank mixes as compared to thiodicarb application alone. Parasitization was only observed to increase early mortality in conjunction with the application of *B. thuringiensis*. Neither insecticide applied independently nor in combination had a significant impact on the emergence of *C. marginiventris* from *H. virescens*. Overall, while results indicate poor control of *H. virescens*, findings indicate no detrimental effect on the parasitoid population at rates suggested for resistance management.

Introduction

Pyrethroid resistance in *Heliothis virescens* (F.), the tobacco budworm, is now a common occurrence in cotton production (Luttrell et al 1987, Mullins et al. 1991 and Plapp et al. 1990). In 1992, pyrethroid resistance for *H. virescens* was reported to be as high as 38% in Arkansas, 58% in Louisiana and 77% in Mississippi (Elzen 1992). While there are numerous non- insecticidal means of preventing or delaying resistance development (i.e. early crop maturity and adequate field scouting), insecticides are and will continue to be an important component of any pest management strategy. Two of the more commonly recommended insecticides for resistance management, particularly in early season cotton, are *Bacillus thuringiensis* var *kurstaki* and thiodicarb, usually in tank mix combinations. However, one must also consider the role of natural enemies in controlling populations of the tobacco budworm and the impact of insecticide use on these natural enemies.

Cotesia marginiventris (Cresson) (Hymenoptera: Braconidae) is one of the most common parasitoids encountered in Arkansas cotton fields. Atwood et al. 1995 determined increasing rate of host mortality for *H. virescens* and decreased parasitoid emergence for *C. marginiventris* relative to increasing concentrations of both *B. thuringiensis* and thiodicarb. However, these tests were conducted with continuous insecticide exposure in semisynthetic diet. As shown by Dulmage (1978), Ali and Watson (1982) and Fast and Regniere (1984), lepidopterous larvae may recover from initial doses of *B. thuringiensis.* As both thiodicarb and *B. thuringiensis* are commonly applied as a tank mix, there is also a need to evaluate the combined effect of these insecticides on parasitoid survival, particularly as would occur under field conditions. To this end, tests on field treated cotton were conducted during 1995 to evaluate the independent and combined effectiveness of *B. thuringiensis* and thiodicarb, at rates commonly recommended in Arkansas, against late second instar *H. virescens* and to determine the impact of these insecticides on the emergence of the parasitoid *C. marginiventris*.

Materials and Methods

Laboratory colonies of *H. virescens* and *C. marginiventris* were established from *H. virescens* larvae collected in Forman and Rydell, AR during the summer of 1993. *Heliothis virescens* larvae served as hosts for *C. marginiventris.* Host larvae were reared on a standard semisynthetic diet (Burton 1969). Insecticides used in these tests were *B. thuringiensis* (Javelin WG, Sandoz Crop Protection) and thiodicarb (Larvin 3.2, Rhone-Poulenc).

Tests were conducted at the Agriculture Experiment Station Research Farm of the University of Arkansas in Fayetteville, AR (Washington Co.). Small plot tests were conducted as a randomized complete block design with five replicates. Plots consisted of a single row, 15 m in length, with 2-row buffers between sides of treatments and 5 m buffers between replicates. Spray dates for each replicate were as follows: 1) August 9, 2) August 12, 3) August 18, 4) August 27 and 5) September 2. Replicates 1, 2, 3, and 4 were all located in the same field. However, as the cotton in the initial field began cutting out, replicate 5 was located in a second field which had been planted at a later date.

Insecticide concentrations used in these tests were those commonly recommended for *H. virescens* control in Arkansas. *Bacillus thuringiensis* rates were 0.56 and 1.12 kg product/ha (0.5 and 1 lb product/acre) and thiodicarb rate was 0.14 kg AI/ha (0.125 lb AI/acre). Each insecticide-rate was tested individually and in combination. A sixth treatment consisted of an untreated control. In addition, each treatment was evaluated alone

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and in combination with parasitization by *C. marginiventris* for a total of 12 experimental treatments.

Insecticide application was made using a CO_2 powered backpack sprayer at a pressure of 2.8 kg/cm^2. Treatments were applied in a volume of 94.6 liters/ha using 2 nozzles (TX-6) per row. All applications were made in the late afternoon to minimize effect of thermal inversion.

One hour after treatment, 100 primary squares were picked from each treatment and placed in labeled plastic bags for transportation to the laboratory. Squares were placed individually in 30-ml plastic soufflé cups to which had been added a moistened filter paper disk. A parasitized or non-parasitized *H. virescens* larva was then placed in each cup. For each replicate, 20 late second instar *H. virescens* were placed on semisynthetic diet in 36 wax-lined paper cups (266 ml) the previous day. Six larval cups were used for each treatment with half being provided with two female and two male *C. marginiventris* for parasitization. A total of 50 parasitized and 50 non-parasitized larvae were used for each treatment.

Heliothis virescens larvae were allowed to feed on the treated squares for 48 hours, after which time mortality readings were obtained and each larva transferred to individual 30-ml soufflé cups containing semisynthetic diet. Mortality for *H. virescens* was also recorded on day 7 and 16 after initial exposure to the treated squares and emergence of *C. marginiventris* was recorded on day 16. Data were analyzed using proc GLM (SAS 1988) with mean separation by LSD.

Results

***Heliothis virescens* Mortality**

Mortality for *H. virescens* was observed to range from 2.0 to 21.7% for non-parasitized larvae and 5.6 to 20.2% for parasitized larvae two days following insecticidal exposure (Fig. 1). Parasitization had no significant impact on early *H. virescens* mortality. Similarly, no significant difference in *H. virescens* mortality was noted in relation to *B. thuringiensis* rate. Conversely, significantly greater mortality was observed in non-parasitized and parasitized larvae exposed to treatments which included thiodicarb as opposed to *B. thuringiensis* alone treatments.

Seven days after exposure to insecticide, significantly greater mortality was observed for parasitized larvae (19.2 to 30.6%) and non-parasitized larvae exposed to thiodicarb or thiodicarb/*B. thuringiensis* combinations (25.8 to 28.8%) as compared to larvae exposed to *B. thuringiensis* alone (6.0 to 10.8%) (Fig. 2). In addition, significantly greater larval mortality was noted for parasitized larvae exposed to *B. thuringiensis* as compared to non- parasitized larvae. Regardless of state of parasitization, mortality from *B. thuringiensis* exposure did not significantly differ from the untreated control.

Mortality for *H. virescens* 16 days after insecticidal exposure significantly illustrates the impact of parasitization (Figure 3). Mortality for parasitized larvae ranged from 93.2 to 96.4% with mortality from insecticide exposure not differing significantly from the experimental control. In contrast, mortality for non-parasitized larvae was significantly less than that for parasitized larvae, ranging from 22.6 to 32.8%. Again, significantly lower *H. virescens* mortality was noted for larvae exposed to *B. thuringiensis* alone as compared to larvae exposed to thiodicarb and thiodicarb/*B. thuringiensis* mixes. However, insecticidal mixes were not significantly more effective against *H. virescens* than thiodicarb alone.

***Cotesia marginiventris* Emergence**

Parasitoid emergence from *H. virescens* larvae was observed to range from 66.4 to 74.5% (Fig. 4). No significant difference in *C. marginiventris* emergence was noted in relation to insecticide treatment and emergence did not differ from the untreated control.

Discussion

Insecticides recommended for pyrethroid resistance management of *H. virescens* in Arkansas appear to have negligible effect on late second to early third instar *H. virescens* or its parasitoid *C. marginiventris*. Atwood et al (1995) determined increasing *H. virescens* mortality associated with increasing *B. thuringiensis* and thiodicarb concentrations in laboratory investigations. However, it must be considered that their tests provided continuous exposure to the insecticides. Greater mortality may have occurred in the current test with longer insecticide exposure. However, Ali and Young (1993) determined a decrease in *B. thuringiensis* activity at identical application rates against first instar *H. virescens* in field tests, showing less than 23 and 31% of the initial activity after 3 days. Therefore, it is doubtful if longer exposure to *B. thuringiensis* treated squares would have significantly increased larval mortality.

These findings indicate the importance of field monitoring to target first instar *H. virescens* larvae in a resistance program incorporating *B. thuringiensis* application. Negligible control of late second to early third instar *H. virescens* was noted regardless of insecticide or insecticidal combination used or *B. thuringiensis* rate. In contrast, Atwood et al. (1985) determined an increase in *H. virescens* mortality as a result of delay in initial thiodicarb exposure. Therefore, it is impossible to rule out a similar field effect of delayed exposure to thiodicarb. Additional investigations would be required to evaluate this hypothesis.

Three conclusions can be drawn from this investigation. These are 1) neither *B. thuringiensis* nor thiodicarb provide adequate control of late second instar *H. virescens*, 2) thiodicarb and thiodicarb/*B. thuringiensis* combinations provide significantly greater control as opposed to *B. thuringiensis* applied alone, however, mixes are no more effective than thiodicarb alone 3) neither exposure to *B. thuringiensis* or thiodicarb in conjuction with parasitization significantly increased *H. virescens* mortality over that observed for non-parasitized larvae. However, additional investigations are warranted to determine the impact of recommended treatments on other parasitoids endemic to Arkansas cotton fields. Overall, findings indicate that *H. virescens* larvae parasitized prior to insecticide application have the ability to survive and thereby maintain field populations.

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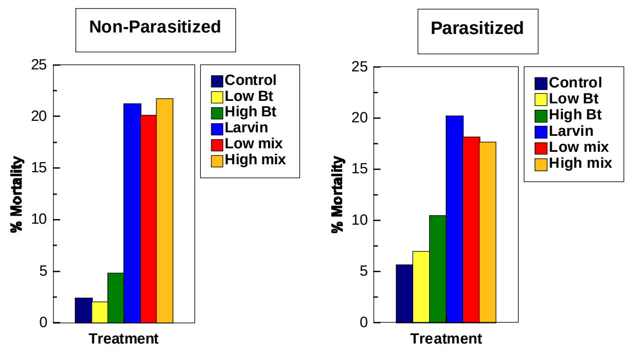

Figure 1. Morality in H. virescens exposed to Bt and thiodicarb, alone and in combination, two days after exposure.

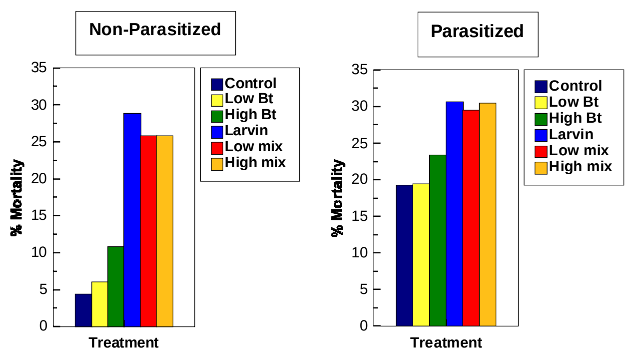

Figure 2. Morality in H. virescens exposed to Bt and thiodicarb, alone and in combination, seven days after exposure.

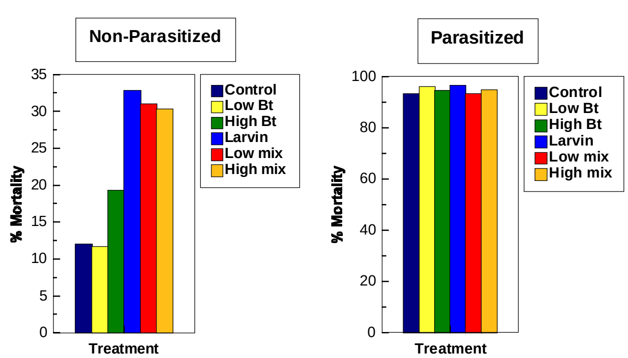

Figure 3. Morality in H. virescens exposed to Bt and thiodicarb, alone and in combination, 16 days after exposure.

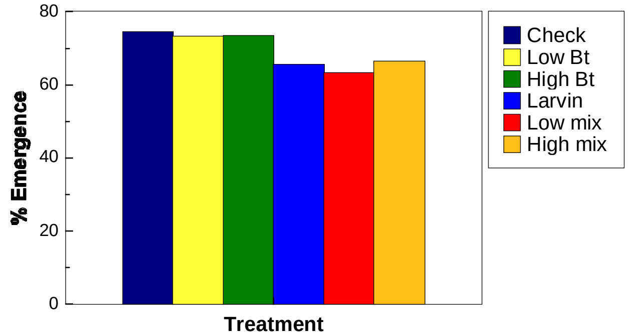

Figure 4. Emergence of C. marginiventris 16 days after host exposure to Bt and thiodicarb, alone and in combination.