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Acephate and Spinosad Impact on Parasitoids of *Heliothis virescens* (F.) (Lepidoptera: Noctuidae) on Tobacco in South Carolina[1]

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J. Entomol. Sci. 41(4): 399-402 (October 2006)

Key words tobacco budworm, tobacco, parasitoids, *Heliothis virescens*

The budworm/bollworm complex, consisting of *Heliothis virescens* (F.) and *Helicoverpa zea* (Boddie), are among the most damaging of pest complexes affecting agricultural crops in the southeastern U.S. To prevent, or at least reduce, the losses caused by these insect pests, insecticides are used to supplement natural biological control agents that include predators and parasitoids of tobacco budworm populations on tobacco. Insecticides are the most essential tool to the control of harmful insects (Atwood et al. 1997, J. Entomol. Sci. 33:136-141) and are generally necessary for successful tobacco production. Foliar insecticides are sprayed an average of 4X to 6X per season on tobacco in South Carolina (Manley, unpubl. data).

For years, the organophosphate acephate was the predominant insecticide used on tobacco. In general, the organophosphate insecticides tend to be nonselective, broad-spectrum insecticides, harmful to both the pests and beneficial arthropods (Plapp and Bull 1978, Environ. Entomol. 7:431-434; Plapp and Vinson 1977, Environ. Entomol. 6:381-384; Wilkinson et al. 1979, J. Econ. Entomol. 72:473-475). In recent years spinosad, a Naturalyte product, has been labeled for lepidopteran larvae control on tobacco and has provided a suitable addition to the products available for tobacco budworm control. Spinosad is thought to be less harmful to beneficial arthropods than acephate, although studies have been predominantly with predators rather than parasitoids (Boyd and Boethel 1998a, Environ. Entomol. 27:154-160; 1998b, J. Econ. Entomol. 91:401-409).

Although insecticides are usually necessary, natural control of the budworm, through parasitism, remains an important component of budworm control on tobacco.

[1]Received 07 March 2006; accepted for publication 25 August 2006; technical contribution no. 5096 of the Clemson University Experiment Station.

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In some years nearly 50% of all budworms may be parasitized, with the primary parasitoids being *Cardiochiles nigriceps* Viereck, *Campoletis sonorensis* (Cameron), and *Pristomeris spinator* (F.), in that order of importance (Johnson and Manley 1983, J. Georgia Entomol. Soc. 18:1-6; Manley et al. 1991, J. Agric. Entomol. 8:169-178). Of those, *Cardiochiles* is by far the most important on tobacco. The purpose of this preliminary research was to examine the differential effects of acephate and spinosad on parasitoids of the tobacco budworm on tobacco in a field situation.

These studies were conducted during 3 growing seasons (2001, 2002, and 2004) and modified, as necessary, to conform to the conditions of the respective year. Although similar studies were attempted in 2003, tobacco budworm populations were so low that after initial treatment there was not enough of a rebound in the budworm population to determine incidence of parasitism. It should be noted that whereas untreated checks were used on the Pee Dee Research and Education Center (PDREC), no untreated plots were used in grower fields as they were unwilling to absorb the losses due to insects.

The test was conducted in 3 locations in 2001. The first was in Marion Co., on the farm of Walter Legette. At that location, there were two treatments: (1) Tracer® 4SC (spinosad, Dow AgroSciences, Indianapolis, IN) @ 108 ml/ha foliar spray (= 50 g AI/ha) as needed for lepidopteran larvae, based on scouting, and (2) Orthene® 75S (acephate, Valent USA, Walnut Creek, CA) @ 1.12 kg/ha foliar spray (= 0.84 kg AI/ha) as needed for lepidopteran larvae, based on scouting. Each treatment was replicated 3 times in a randomized, complete block design. Each plot was 8 rows of tobacco and 73 m in length (0.07 ha). Tobacco (var. 'Speight H20') was transplanted on 12 April 2001. No at-planting insecticide was used. The test was scouted weekly for insects, beginning on 24 April, according to standard Clemson University scouting practices (Manley et al. 1988, Clemson Univ. Ext. Bull. 129, 22 p.).

Tobacco budworms were collected on 8 June, when scouting determined that 12% of the plants were infested. Ten to 20 budworms of any size were collected from each plot, placed in individual clear plastic creamer cups (30 mL) containing artificial diet (Vanderzant and Adkisson Insect Wheat Germ Diet plus Vanderzant Vitamin Fortification-U.S. Biochemical Corporation, Cleveland, OH), transported to the laboratory at the PDREC, Florence, SC, and reared to pupation or parasitoid emergence as described by Manley et al. (1991). Following larval collection, plots were sprayed by tractor on 15 June. Application was with three nozzles per row, at 2.8 kg/cm^2, and with 234 L total volume per ha. Larvae were again collected on 26 June.

The second location was in Darlington Co., on the farm of Craig Gandy. Treatments were identical. Each plot consisted of four rows of tobacco, 158 m in length (0.07 ha). Tobacco (var. 'K-326') was transplanted on 19 April. No at-planting insecticide was used, and plots were scouted weekly for insects, beginning on 26 April.

Tobacco budworms were collected as previously described on 5 June, when scouting determined that 8% of the plants were infested. Plots were sprayed as previously described on 14 June. Larvae were collected again on 27 June.

The third location was at the PDREC. At that location, there were 3 treatments, each replicated 2 times in a randomized complete block design. The first 2 treatments were identical to those in the other locations. The third treatment was an untreated check. Each plot consisted of 4 rows of tobacco, 37 m in length (0.02 ha). Tobacco (var. 'K-346') was transplanted on 20 April. No at-planting insecticide was used, and plots were scouted weekly for insects, beginning on 26 April.

Tobacco budworms were collected by previously described methods on 11 June, when scouting determined that 28% of the plants were infested. The plots were sprayed on 12 June as previously described. Larvae were collected again on 28 June.

The test was repeated in 2002 using the same 3 locations as in 2001. However, at the Marion Co. location, the budworm population never rebounded enough after the initial insecticide treatment to make a second larval collection for comparison.

At the Darlington Co. location there were 3 treatments, each replicated 2 times in a randomized, complete block design. Each plot consisted of 8 rows of tobacco, 66 m in length (0.06 ha). Tobacco ('K-326') was transplanted on 12 April and plots were scouted weekly for insects, beginning on 23 April. The 3 treatments were: (1) Orthene® 97PE @ 0.84 kg/ha as a transplant water treatment, plus Orthene® 97PE @ 0.84 kg/ha as a foliar spray, as needed, based on scouting; (2) Admire® 2FL (imidacloprid) @ 30 ml/1000 plants as a transplant water treatment, plus Tracer® 4SC @ 67 g AI/ha as a foliar spray, as needed, based on scouting; and (3) Platinum® 2SC (thiamethoxam) @ 24 ml/1000 plants as a transplant water treatment, plus Tracer® 4SC @ 67 g AI/ha as a foliar spray, as needed, based on scouting.

Larvae were first collected on 16 May when the tobacco budworms infested 15% of the plants. The field was sprayed later that day. A second collection was made on 29 May when 7.5% of the plants were infested. The field was sprayed on 5 June. And, a third collection was made on 20 June when 5% of the plants were infested. Larvae were treated as in 2001.

Collections were made in 2002 from 2 different fields at the PDREC. These collections were made only following treatments, and were part of research being undertaken by other scientists at the PDREC.

A collection was made from the first field (designated as the northwestern field) on 19 June. The plots in this field were treated on 10 and 17 June and the treatments were: (1) Orthene® 97PE @ 0.84 kg AI/ha; (2) Tracer® 4SC @ 108 ml/ha (= 50 g AI/ha); and (3) an untreated check. Larvae were collected from the second field (designated as the southeastern field) on 10 July, following treatment on 28 June. Treatments were the same as in the other field.

In 2004, the test was conducted in a single location in Dillon Co., on the farm of Johnny Gasque, Jr. There were two treatments, each replicated 4 times in a randomized, complete block design that included one untreated check. Each plot consisted of 8 rows of tobacco, 46 m in length (0.04 ha). Tobacco (var. 'NC 71') was transplanted on 27 April. All of the tobacco was treated with Admire® (imidacloprid, Bayer Corp., Kansas City, MO) in the greenhouse, according to label instructions. The test was scouted weekly for insects, beginning on 28 April. The treatments were: (1) Tracer® 4SC @ 108 ml/ha, as needed, based on scouting, and (2) Orthene® 97PE @ 0.84 kg AI/ha, as needed, based on scouting; plus one untreated check plot.

A larval collection was made on 10 June when 27% of the plants were infested. The plots were sprayed later that day. A second collection was made on 24 June when 22% of the plants were infested.

Rates of parasitism for each year were subjected to analysis of variance using SAS 9.1 (SAS Institute, Inc., 2002-2003, Cary, NC). Means were compared using LSD (0.5).

Rate of parasitism varied greatly from plot to plot, as well as from treatment to treatment, but all were comparable with results of previous studies (Johnson and Manley 1983, Manley et al. 1991). Most of the budworms were first or second instar. And, nearly all of the parasitoids were *C. nigriceps*, although some *Campoletis* and

Pristomeris were collected. In 2001 in Darlington Co., parasitism increased after treatment (1% and 19% with acephate and spinosad, respectively). In Marion Co., parasitism decreased after treatment (17% and 18% with acephate and spinosad, respectively). And at the PDREC, it was -19%, +1%, and -23% with acephate, spinosad, and untreated, respectively. Insecticide treatment did not appear to impact the rate of parasitism, as the greatest decline was in the untreated check at the PDREC.

Rate of parasitism also varied greatly in 2002. It is interesting to note that in the Darlington Co. test, the rates of parasitism were higher for all treatments following insecticide application (by 22%, 24%, and 14% for acephate/acephate, imidacloprid/spinosad, and thiamethoxam/spinosad, respectively). At the PDREC, the posttreatment rates of parasitism were 27%, 50%, and 30% in one field and 38%, 30%, and 58% in the other field, with acephate, spinosad, and untreated, respectively. Interestingly, the untreated check had the highest rate of posttreatment parasitism in one field, and the lowest in the other.

Rates were still varied in 2004, although not as greatly as in the two prior years. Following treatment, parasitism increased by 3%, was unchanged, and increased by 6% for acephate, spinosad, and the untreated.

Tillman and Mulrooney (2000, J. Econ. Entomol. 93:1638-1643) reported that spinosad was highly toxic to all parasitoid species that they tested. However, they applied the insecticides topically to the parasitoids. Our aim was to determine the effects of acephate and spinosad treatment to field populations of parasitoids of the tobacco budworm on tobacco. We found that neither of these insecticides is particularly deleterious to the tobacco budworm parasitoids under field conditions. In some instances the rates decreased after treatment. However, in other instances the rates actually increased after treatment. The latter might be explained by the fact that a similar number of parasitoid wasps would be attacking a reduced number of hosts. Although this is only a preliminary study, it appears that growers should select their tobacco insecticides on the basis of efficacy versus target pests, and that concerns over the fate of nontarget parasitoids are unwarranted.