2003 BELTWIDE COTTON CONFERENCES, NASHVILLE, TN – JANUARY 6-10

POPULATION DYNAMICS OF HELIOTHIS VIRESCENS IN A MULTIPLE CROP SYSTEM

Mark R. Abney, Clyde E. Sorenson, and J.R. Bradley Jr.
Department of Entomology
North Carolina State University
Raleigh, NC

Abstract

Studies were conducted to evaluate the population dynamics of the tobacco budworm (TBW), *Heliothis virescens* (F.), in a host-plant rich agroecosystem in North Carolina. Commercial cotton and tobacco fields in the central coastal plain of NC were monitored in 2001 and 2002 for tobacco budworm larval development. A small plot trial was designed in 2002 to further elucidate the importance of cotton, tobacco, soybeans, and peanuts as hosts for *H. virescens*. Results of field evaluations indicate that the presence of tobacco in the North Carolina agroecosystem dictates budworm occurrence both spatially and temporally. Production of *H. virescens* from cultivated crops other than tobacco in commercial fields and small plots was minimal. Tobacco in NC may serve as an important refuge for both *Bt* and conventional insecticide resistance management.

Introduction

The tobacco budworm, *Heliothis virescens* (F.), is considered a pest of tobacco and is a very serious pest of cotton in the United States. The larvae of this insect feed directly on the harvestable portion of both crops and may reduce cotton yields if not controlled. Chemical control of *H. virescens* has been complicated over the years by the development of resistance by the insect to many classes of insecticides. Resistance originally developed in tobacco budworm to the chlorinated hydrocarbons, and control failures have since been reported following applications of certain carbamate and organophosphate insecticides (Sparks et al. 1993). Pyrethroid insecticides first became commercially available in the late 1970's and are generally efficacious and cost effective tools for the management of many insect pests in many crops. However, the development of resistance by the tobacco budworm to pyrethroids has had a major impact on cotton insect pest management in many parts of the United States. Pyrethroid resistance management is of particular concern in North Carolina because of the importance of this class of insecticides in cotton in the state. North Carolina presents a unique case in that resistance development by tobacco budworm has occurred much slower here than in many other states (Sparks et al. 1993).

The tobacco budworm is a polyphagous feeder capable of developing on a number of cultivated and wild host plants, though its host range varies from region to region (Barber 1937, Neunzig 1969, Sudbrink and Grant 1995). Primary hosts in North Carolina are tobacco and cotton; only limited numbers of insects have been reported to develop on uncultivated plants in the state (Neunzig 1963). The availability of cotton suitable for tobacco budworm development has declined in recent years with the advent of new insect management tools. The cotton acreage in North Carolina is made up of an increasing proportion of transgenic varieties containing a gene that codes for the production of *Bacillus thuringiensis* endotoxin; these plants represent a dead end for *H. virescens* development because of the high toxicity of *Bt* to tobacco budworms. The impact of widespread planting of *Bt* cotton on the overall tobacco budworm population is unknown. Soybeans are common in North Carolina and are capable of supporting *H. virescens* development (Sheck and Gould 1993, Dietz et al.1976), but relatively few individuals are found in soybeans in the field (Dietz et al.1976). The extent to which cotton, soybeans, peanuts, and wild hosts contribute to overall tobacco budworm numbers in the state is likely to be small compared to the impact of tobacco. Nevertheless, these plants may be of importance as refuge areas for tobacco budworm development as they are, with the exception of the inherent toxicity of *Bt* cotton varieties, infrequently treated with insecticides for *H. virescens*.

Nearly one million acres of cotton and more than one hundred fifty thousand acres of tobacco were planted in North Carolina in 2001 and 2002. Though much of the state's cotton acreage is planted to *Bt* cultivars, non *Bt* cotton and tobacco still represent a major potential nutrient resource for *H. virescens* production. Given the abundance of cultivated host plants and the relatively low tolerance for insect damage in both cotton and tobacco, the development of resistance by the tobacco budworm to insecticides in North Carolina has surprisingly been much slower and less pronounced than in many other cotton producing states. Reasons for this phenomenon are not fully understood but are probably linked to the structural differences associated with the North Carolina agroecosystem. Pyrethroid resistance developed in the Mid-South due to repeated use of pyrethroids on successive generations of budworms in cotton crops within the growing season. In North Carolina budworms have typically been exposed to materials like pyrethroids during only one generation annually. The only significant exposure to pyrethroids currently experienced by tobacco budworms in North Carolina occurs in late July-early August when pyrethroid applications are made to cotton for control of the cotton bollworm, *Helicoverpa zea*. The presence of an abundant preferred host (tobacco) in the state may effectively limit oviposition of *H. virescens* in cotton thus reducing the need for chemical control in that crop. Ramaswamy et al. (1987) proposed that damaging populations of tobacco budworm occur in cotton only because of the abundance of the plants in what they termed a "no choice" situation. While alternative hosts may be rare in many cotton producing states, they often abound in North Carolina thus minimizing the impact of the "no choice" scenario and reducing the number of *H. virescens* developing in cotton. Understanding the population dynamics of this serious pest in North Carolina's diverse agricultural environment is a key step in developing sound insecticide resistance management strategies in the state.

It is critical that comprehensive, research based resistance management plans be implemented in North Carolina in order to delay or prevent the development of resistance by the tobacco budworm to established and novel insecticide chemistries. The ultimate focus of this research is the identification and quantification of biological, ecological, and environmental conditions that might impact the rate of insecticide resistance development by *H. virescens* in the host-rich agricultural environment of the state. The distribution, abundance, and phenology of host plants, the presence and frequency of insecticide resistance genes in budworm populations, and the selection pressure that tobacco budworm populations are likely to experience must all be determined. The work presented here was designed to evaluate the temporal and spatial distribution and abundance of tobacco budworms in agronomic hosts in eastern NC.

Materials and Methods

Work was conducted in 2001 and 2002 to quantify the seasonal distribution of tobacco budworm larvae within a mixed tobacco/cotton agroecosystem in the central coastal plain of North Carolina. Eleven tobacco and five non-*Bt* cotton fields in 2001 and ten tobacco and six non-*Bt* cotton fields in 2002 were selected from a commercial farming operation spanning a three county area consisting of Pitt, Wilson, and Edgecombe Counties. Tobacco fields were sampled for tobacco budworm presence twice weekly beginning in late May and continuing until stalk destruction in September. Cotton fields were sampled twice weekly from mid June until plants were no longer suitable for tobacco budworm development in mid-September. One hundred whole tobacco/cotton plants were randomly selected for evaluation in each field on each sampling date. Heliothine larvae were collected and placed in vials containing 75% ethanol pending identification to species. Larvae were returned to the laboratory where they were measured and identified; determinations were based on larval keys presented in Neunzig (1969). Measurements were used to determine the approximate age of larvae based on correlations between larval size and age reported in Neunzig 1969.

Because routine insect management practices on a commercial farm may interfere with the inherent suitability of a crop for tobacco budworm oviposition and larval development, a small plot study was established in 2002 at NC State University's Central Crops Research Station in Clayton NC. This test was designed to evaluate peanuts, soybeans, and cotton as alternate hosts for *H. virescens* in a more controlled, insecticide free environment. Tobacco, cotton, peanuts, and soybeans were planted in one-tenth acre plots in a randomized complete block design with four replicates. Tobacco budworms were sampled in cotton by examining fifty randomly selected whole plants from the middle four rows of each eight-row plot. Forty whole plants from the center two rows of each eight-row tobacco plot were likewise sampled for the presence of larvae. Six row meters from the middle four rows of each soybean plot were sampled with a one-meter beat sheet. Sampling in peanuts was conducted by taking fifteen sweeps through the center four rows of each plot with a 15" diameter sweep net. Crop phenology was recorded and plots were sampled weekly for presence of tobacco budworm larvae. Sub-samples of larvae collected from each plot were returned to the laboratory for species identification.

Results and Discussion

Heliothis virescens was more abundant than *Helicoverpa zea* in tobacco throughout the growing season in 2001 and 2002, though larval densities varied considerably between sample dates. (*Helicoverpa zea* data are not presented here.) Two distinct peaks in larval density were observed in tobacco in both years of the study (Figures 1and 3). High early season budworm densities in tobacco in 2001 were controlled with a single acephate application (Orthene 97PE at .37lbs AI per acre). Larval numbers in tobacco were reduced significantly after topping (flower bud removal) in late June and early July in both years. Tobacco budworm larvae were rare in the study cotton fields in 2001 (Figure 2), and total heliothine larval densities never exceeded 5% infested plants in any of the fields sampled. Few late instar larvae of either species were found in cotton in 2001 indicating low survival in that crop. Conservative insecticide treatment thresholds employed by producers contributed to the low numbers of larvae observed in cotton and tobacco in 2001. No tobacco budworm larvae were recovered from cotton in 2002. Cotton in the sample area in 2002 was severely drought stressed and was likely unfavorable for oviposition for much of the growing season. Results show that both *H. virescens* and *H. zea* may be present in cotton and tobacco throughout the growing season in North Carolina. Nevertheless, our data shows that tobacco budworm production in conventional non-*Bt* cotton is limited. Current refuge strategies designed to manage *Bt* resistance in lepidopterous pests assume adult insect production from non-*Bt* cotton. The apparent lack of *H. virescens* development in cotton in NC increases the importance of tobacco as a refuge for *Bt* resistance management in the state.

As expected, results from small plot alternate host studies indicate a strong oviposition preference by tobacco budworm females for tobacco over the other crops tested. Tobacco budworm densities in untreated tobacco plots approached 4000 larvae per acre in two separate peaks occurring in late June and early August (Figure 4). Production of *H. virescens* larvae in alternate crop hosts was minimal. Tobacco budworm larvae were collected from cotton on only three sample dates; densities of

250 larvae per acre were calculated for each of the three dates. Less than 10% of total heliothine larvae observed in cotton plots were identified as *H. virescens*; the remainder of the larvae collected were *Helicoverpa zea*. These results support the idea that tobacco budworm utilization of cotton is determined largely by the proximity of a more attractive host. No tobacco budworm larvae were collected from soybean or peanut plots on any of the sampling dates. This result is consistent with previous work showing little tobacco budworm production from soybeans in NC. The importance of peanuts for tobacco budworm production is unknown, but results here indicate limited utilization of the crop by the insect when tobacco is available.

The presence of tobacco culture appears to dictate both spatial and temporal occurrence of tobacco budworm in NC agroecosystems. The close association between this pest and its preferred host is likely responsible for the minimal tobacco budworm problem experienced in cotton in the state. Tobacco may have also played an important role in slowing the development of insecticide resistance in NC populations of tobacco budworm. Pyrethroid insecticides are not labeled for use in tobacco; subsequently, the crop has provided a significant refuge for tobacco budworm production. Today, tobacco continues to serve as an important refuge for pyrethroid and also for *Bt* resistance management in tobacco budworm.

Acknowledgements

The authors express sincere gratitude to the NSF Center for Integrated Pest Management and the North Carolina Tobacco Foundation, Inc. for partial funding of this research. Thanks are also due to Alan Stephenson, David Nichols, Travis Edmonds, Drew Covington, and Sarah Arpin for technical assistance.

References

Barber, W.B. 1937. Seasonal availability of food plants of two species of *Heliothis* in eastern Georgia. J. Econ. Entomol. 30:150-158.

Dietz L.L., J.W. Van Duyn, J.R. Bradley Jr., R.L. Rabb, W.M. Brooks, and R.E. Stinner. 1976. A guide to the identification and biology of soybean arthropods in North Carolina. North Carolina Agricultural Research Service: Tech. Bul. No. 238. 264 pp.

Neunzig, H.H. 1969. The biology of the tobacco budworm and the corn earworm in North Carolina. North Carolina Agricultural Experiment Station. Tech. Bu. No. 196. 76 pp.

Neunzig, H.H., 1963. Wild host plants of the corn earworm and the tobacco budworm in Eastern North Carolina. J. Econ. Entomol. 56:135-139.

Ramaswamy, S.B., W.K. Ma, and G.T. Baker. 1987. Sensory cues and receptors for oviposition by *Heliothis virescens*. Entomol. exp.appl. 43: 159-168.

Sheck, A.L., and F. Gould. 1993. The genetic basis of host range in *Heliothis virescens*: larval survival and growth. Entomol. Exp. Appl. 69: 157-172.

Sparks, T.C., J.B. Graves, and B.R. Leonard. 1993. Insecticide resistance and the tobacco budworm: Past, present, and future. Rev. Pestic. Toxicol. 2: 149-183.

Sudbrink Jr., D.L., and J. Grant. 1995. Wild host plants of *Helicoverpa zea* and *Heliothis virescens* (Lepidoptera: Noctuidae) in eastern Tennessee. Environ. Entomol. 24: 1080-1085.

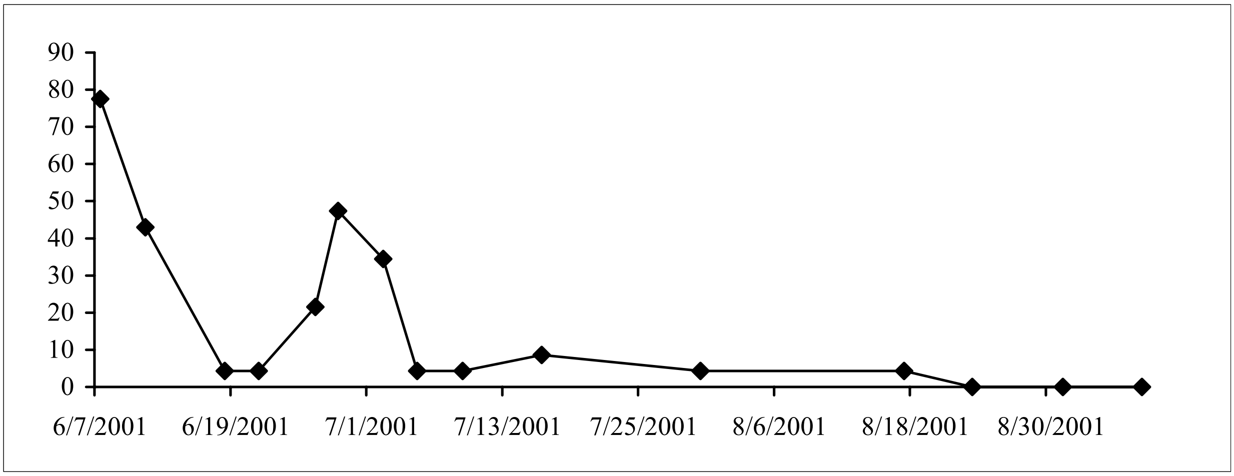

Figure 1. Density of *Heliothis virescens* larvae per acre by sample date in commercial tobacco in the central coastal plain of NC in 2001. Topping of tobacco plants was initiated on 20 June and was completed by 1 July.

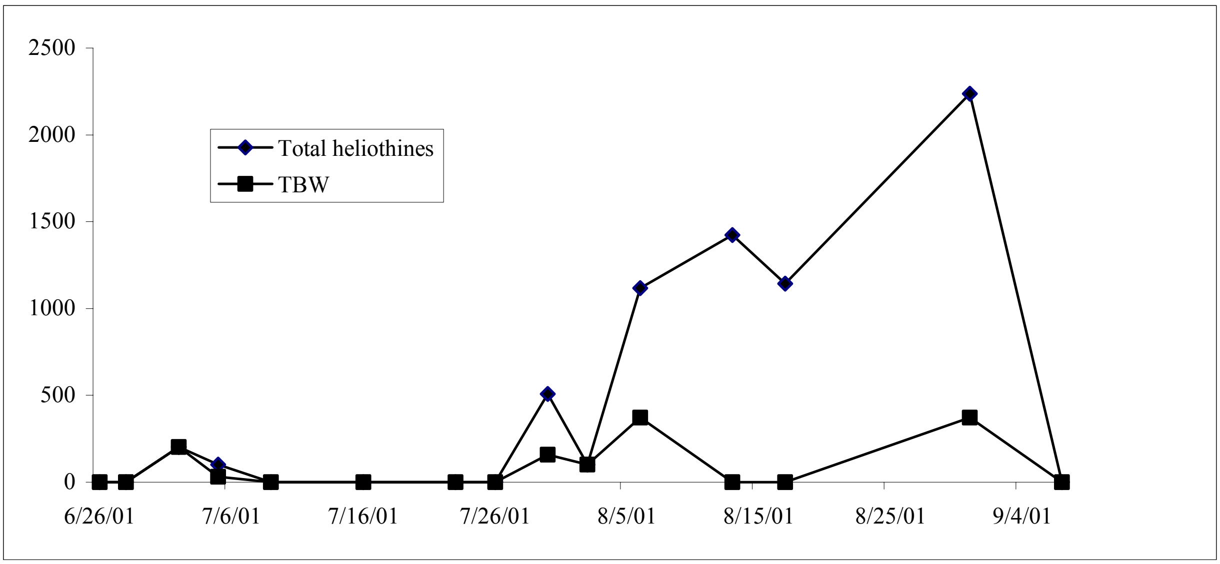

Figure 2. Density of total heliothine and *H. virescens* (TBW) larvae per acre by sample date in commercial cotton fields in the central coastal plain of NC in 2001.

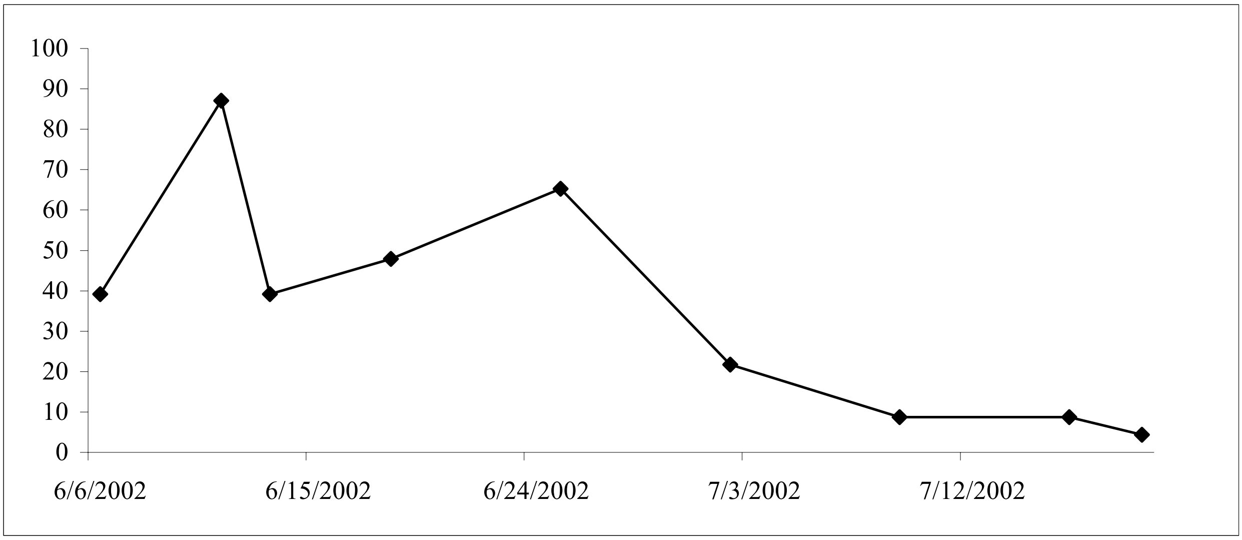

Figure 3. Density of *Heliothis virescens* larvae per acre by sample date in commercial tobacco in the central coastal plain of NC in 2002. Topping of tobacco plants was initiated on 13 June and was completed by 24 June.

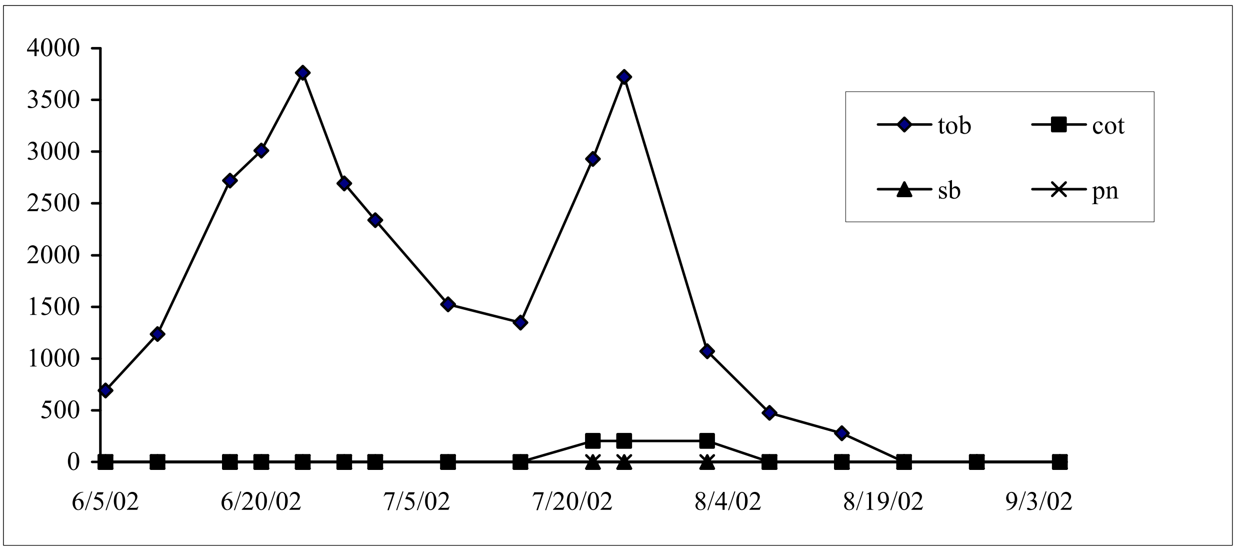

Figure 4. Mean number of *H. virescens* larvae per acre in small plot evaluations of alternate crop hosts by sample date in the central piedmont of NC in 2002. Legend key: tob= tobacco, cot= cotton, sb= soybeans, pn= peanuts.