DISTRIBUTION OF *HELICOVERPA ZEA* (BODDIE) AND *HELIOTHIS VIRESCENS* (F.) IN COTTON/SOYBEAN LANDSCAPES

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Abstract

Experiments were conducted in 2013 to determine the distribution of oviposition patterns for bollworm, *Helicoverpa zea* (Boddie) and tobacco budworm, *Heliothis virescens* (F.) in cotton and soybean landscapes. Screen cages were used encompassing three rows of cotton and an adjacent three rows of soybean. Paired adult male and female *H. zea* were released in each cage when both cotton and soybean had reached optimum bloom, soybean at R2 and cotton in the 3rd – 4th week of bloom. Methods were repeated with *H. virescens*. Oviposition was recorded in relation to crop and location on the plants. *H. zea* and *H. virescens* eggs were found to be distributed in both cotton and soybean. There were significant differences in the proportion of eggs laid on soybean between *H. virescens* and *H. zea*. In contrast to past knowledge, these preliminary data suggest that *H. virescens* may have a preference of soybean over cotton, while *H. zea* appears to oviposit on both crops equally when both crops are at full bloom.

Introduction

The bollworm, *Helicoverpa zea* (Boddie), is one of the most polyphagous and economic pests in production agriculture throughout the United States (Luttrell and Jackson 2012). In 1995, transgenic insecticidal cotton (Bollgard®, Monsanto Company) was approved for use by the U.S. Environmental Protection Agency (US EPA, 1998). Bollgard cotton contained a gene from the soil bacterium *Bacillus thuringiensis* Berliner (Bt) that coded for the production of Cry1Ac, a crystalline toxin, that protects against certain lepidopteran pests including bollworm, tobacco budworm, and pink bollworm (Liu et al. 2001, Shelton et al. 2002). To defend against evolving resistance to Bt cotton, a structured refuge of non-Bt cotton was required to be planted to produce susceptible lepidopteran pests. Bollgard cotton provided virtually complete control of *H. virescens* however it only gave limited control of *H. zea* because of naturally high tolerance for most Bt proteins (Gould 1998). Bollgard II® cotton (Monsanto Company) was commercially introduced in 2003 expressing two Bt proteins (Cry1Ac + Cry2Ab) followed by Widestrike™ cotton (Dow AgroSciences, Indianapolis, IN, USA) in 2005 that expresses the (Cry1Ac and Cry1F) Bt toxins. Dual gene Bt cottons significantly improved the efficacy against *H. zea* and continue to provide exceptional control against *H. virescens*.

The possibility of Bt resistance evolution in *H. zea*, *H. virescens*, and *P. gossypiella* has been demonstrated in the lab (Luttrell et al. 1999, Burd et al. 2003). However, Bt-resistance alleles in *H. zea* field populations have not increased (Burd et al. 2003, Jackson et al. 2006). Previous research showed that non-cotton crop hosts provide a sufficient contribution of susceptible individuals to the *H. zea* population in the Mid-South and Southeast regions of the U.S. to justify a natural refuge. Therefore, the natural refuge concept was adopted and implemented in the U.S. in 2006 for dual gene Bt cottons only. Currently, 95% of cotton planted in the Mid-South and Southeast regions of the United States is planted with Bt cotton varieties (Williams 2012).

Recently, cotton acres throughout the Mid-South and Southeast regions of the U.S. have declined substantially. Corn and soybean acreage has increased in these areas as a result of economics. Additionally, the pest status of bollworm, *H. zea* (Boddie), in soybean has increased (Musser et al. 2010). As a result, there is growing interest from producers and industry to have commercial access to transgenic soybean varieties that express the Bt toxins to help assist management against lepidopteran pests. Presently, soybeans are valued as a key host in the natural refuge. *Bacillus thuringiensis* has been a tremendous resource in cotton and corn but the potential for resistance development when insects encounter the same toxins in multiple crops is a concern. Research is needed to determine if the introduction of Bt soybeans into the southern U.S. will present an unacceptable risk to the sustainability of Bt in other crops.

Materials and Methods

Bollworm population were collected from crimson clover, *Trifolium incarnatum*, in Starkville, MS during March 2013and tobacco budworm populations were collected from chickpea, *Cicer arietinum*, in Stoneville, MS during June 2013. Collections were made by taking several sweeps with a sweep net. Sweep nets were then emptied and bollworm and budworm larvae were removed. Larvae were placed on diet in Mississippi State University rearing facilities. Bollworm and tobacco budworm colonies were maintained at 26.7˚C +/- 2˚C with a humidity level of 60% at a photoperiod of 16:8 hour (light: dark). Once larvae pupated, the pupae were sexed by suture identification and separated. Populations were maintained and allowed to reach physiological maturity.

Four screen cages 6.1m by 6.1m were erected over three rows of cotton and an adjacent three rows of soybean planted on 96.5cm beds. Cages were replicated four times. Soybeans were planted four weeks after the cotton to simulate double crop soybeans where most lepidopteran pressure is usually found. This was also done to ensure that both crops would be at full bloom simultaneously. Twenty five pairs of adult male *H. zea* and female *H. zea* were released in each cage when both crops had reached optimum bloom (soybean at R2 and cotton in the 3^{rd} – 4^{th} week of bloom). These methods were repeated with *H. virescens*. Cages were sampled three days after infestation. Sampling was conducted by removing plants from 1.5m of row from the center row of cotton and center row of soybean. Once removed, plants were transported to the laboratory and visually examined to count the number of eggs present and the location of the egg on the plant.

Results and Discussion

Eggs from *Helicoverpa zea* and *Heliothis virescens* were laid in both cotton and soybean (Fig. 1 and 2). Significant differences were observed in species and crop but interactions were not significant. *H. virescens* were found to lay a significantly higher number in soybean than cotton. No significant differences were found in eggs laid by *H. zea* in cotton and soybean. Significant differences were found in the number of eggs laid between *H. virescens* and *H. zea*. In contrasts to past knowledge, in this study *H. virescens* demonstrated a preference of soybean over cotton. However, *H. zea* showed no crop preference. For both species, soybean appears to be a key host during the bloom stage. Further research is planned to further elucidate the relationship between oviposition preference and crop development.

Figure 1. Distribution of *Heliothis virescens* eggs in cotton and soybean converted to eggs per acre. Statistics based on log transformed data.

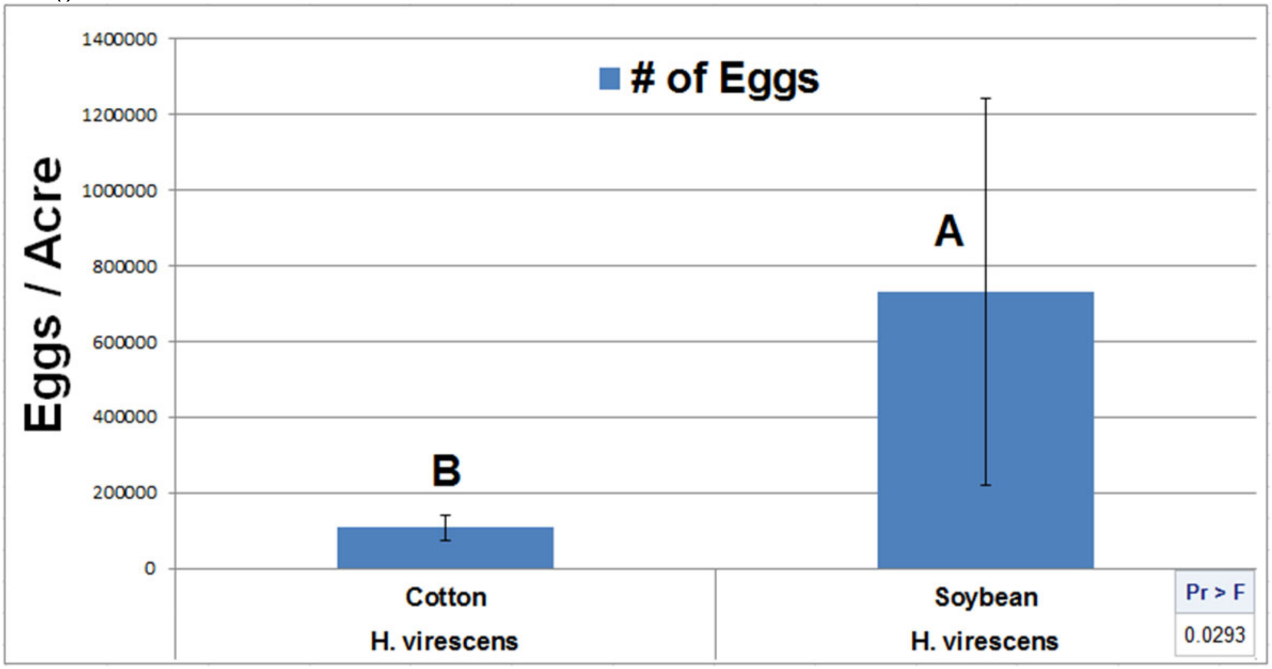
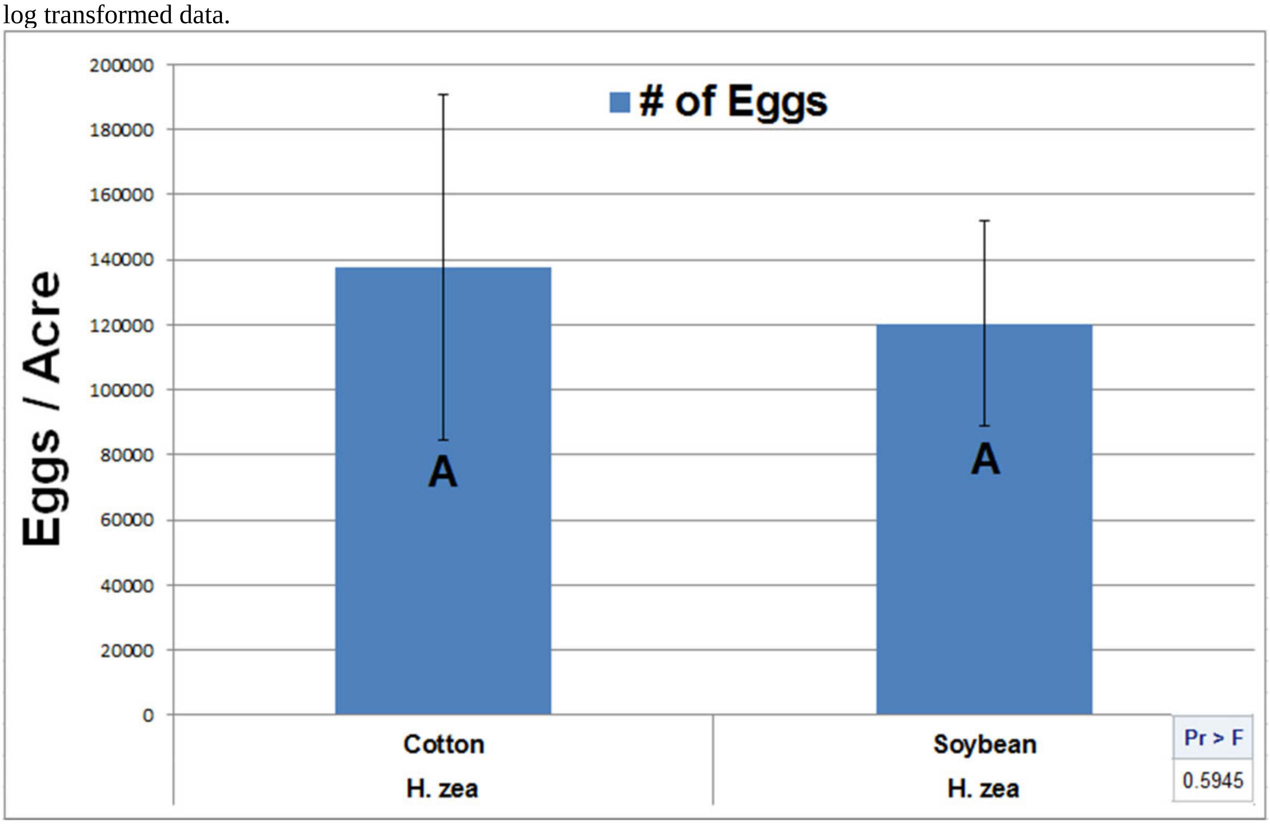


Figure 2. Distribution of *Helicoverpa zea* eggs in cotton and soybean converted to eggs per acre. Statistics based on log transformed data.



References

Burd, A. D., F. Gould, J. R. Bradley, J. W. Van Duyn, and W. J. Moar. 2003. Estimated Frequency of Nonrecessive Bt Resistance Genes in Bollworm, Helicoverpa zea (Boddie) (Lepidoptera: Noctuidae) in Eastern North Carolina. Journal of Economic Entomology 96: 137-142.

Environmental Protection Agency. 1998. The Environmental Protection Agency's White Paper on Bt Plant-Pesticide Resistance Management, no. 739-S-98-001. Washington, DC, USA.

Gould, F. 1998. Sustainability of transgenic insecticidal cultivars: integrating pest genetics and ecology. Annual Review of Entomology 43: 701-726.

Jackson, R. E., F. Gould, J. R. Bradley, and J. W. Van duyn. 2006. Genetic Variation for Resistance to <i>Bacillus thuringiensis</i> Toxins in <i>Helicoverpa zea</i> (Lepidoptera: Noctuidae) in Eastern North Carolina. Journal of Economic Entomology 99: 1790-1797.

Jackson, R. E., J. R. Bradley, J. Van Duyn, B. R. Leonard, K. C. Allen, R. Luttrell, J. Ruberson, J. Adamczyk, J. Gore, D. D. Hardee, R. Voth, S. Sivasupramaniam, J. W. Mullins, and G. Head. 2008. Regional assessment of Helicoverpa zea populations on cotton and non-cotton crop hosts. Entomologia Experimentalis et Applicata 126: 89-106.

Kogan, J. 1978. A bibliography of Heliothis zea (Boddie) and H. virescens (F.) (Lepidoptera:Noctuidae) / Jenny Kogan ... [et al.], Urbana : International Soybean Program, College of Agriculture, University of Illinois at Urbana-Champaign, 1978.

Liu, Y.-B., B. E. Tabashnik, T. J. Dennehy, A. L. Patin, M. A. Sims, S. K. Meyer, and Y. Carrière. 2001. Effects of Bt Cotton and Cry1Ac Toxin on Survival and Development of Pink Bollworm (Lepidoptera: Gelechiidae). Journal of Economic Entomology 94: 1237-1242.

Luttrell, R. G., and R. E. Jackson. 2012. *Helicoverpa zea* and Bt Cotton in the United States. GM Crops and Food: Biotechnology in Agriculture and the Food Chain 3: 213-227.

Luttrell, R. G., L. Wan, and K. Knighten. 1999. Variation in Susceptibility of Noctuid (Lepidoptera) Larvae Attacking Cotton and Soybean to Purified Endotoxin Proteins and Commercial Formulations of Bacillus thuringiensis. Journal of Economic Entomology 92: 21-32.

Musser, F. R., G. M. Lorenz, S. D. Stewart, and A. L. Catchot, Jr. 2010. Soybean Insect Losses for Mississippi, Tennessee, and Arkansas. Midsouth Entomologist 4: 22-28.

Shelton, A. M., J. Z. Zhao, and R. T. Roush. 2002. Economic, ecological, food safety, and social consequences of the deployment of Bt transgenic plants. Annual Review of Entomology 47: 845.

Williams, M. R. Year. Published. Cotton insect losses, pp. 1413-1416. *In*, Beltwide Cotton Conference, 3-6 January 2012, Orlando, FL. National Cotton Council of America, Memphis, TN.