Dispersal and Avoidance Behavior of Western Bean Cutworm When Exposed to Bt Maize

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Introduction

- *Striacosta albicosta* is a noctuid moth (Fig. 1).
- Economic damage is caused by feeding on maize and dry beans (Figs. 2a,b).
- It is endemic to the western part of the United States, but has expanded eastward since 1999 (Fig. 3).
- Quantitative yield loss can be 248 to 1000 kg/ha (1).
- Genetically modified maize expressing *Bacillus thuringiensis* (*Bt*) targeted to control WBC is planted extensively.
- Avoidance to Bt maize by pests has been observed (2).
- Characterization of this behavior is important, as it can help explain variability in efficacy and influence the design of resistance management strategies.

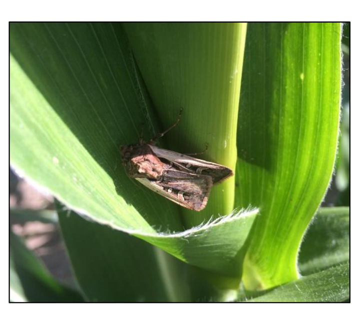


Fig. 1. WBC Moth

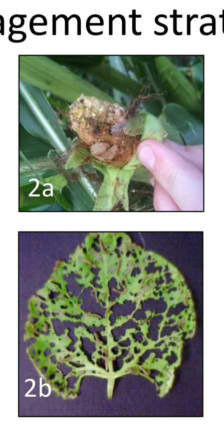


Fig 2. Feeding damage on maize (a) and dry bean (b)

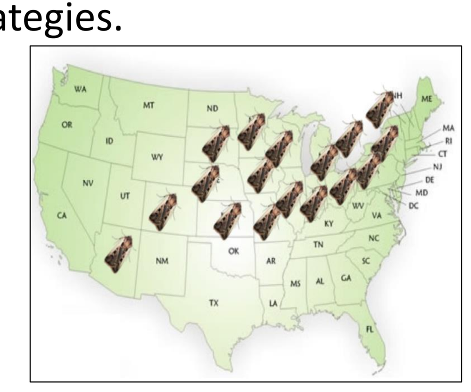


Fig 3. Expansion of WBC

Research Objectives

Determine whether *S. albicosta* presents avoidance behavior to Cry1F and Vip3A maize

Materials and Methods

On-plant neonate dispersal behavior

Plants were placed inside cages as shown in Fig. 4. One egg mass was placed on the top leaf of the plant and number of eggs recorded. 24h after hatching the plant was dissected. Recovered neonates were categorized as: 1) Tassel, 2) Upper leaves, 3) Lower leaves, 4) Silk, 5) Off plant, and 6) Dead. Experiments were held at room temperature at 22 ± 2 °C, 30 ± 20% r.h., and L14:D10 photoperiod.

Food choice experiment

Experiments were performed in 60 mm × 15 mm Petri dishes. Leaf and tassel tissue of both Bt (Cry1F or Vip3A) and non-Bt plants were randomly assigned in each section for the choice experiment. Leaf and tassel tissue of a single plant type were placed in the dish for the no-choice experiment (Fig. 5). One larva was transferred per dish and the position of the larva and mortality was recorded every 30 minutes for 9h. Behavior was categorized as: 1) on Bt tassel, 2) on isoline tassel, 3) on Bt leaf, 4) on isoline leaf, 5) off plant, 6) dead, or 7) missing.

Silking behavior

Neonates were exposed to Cry1F, Vip3A, or non-Bt maize leaves for 24h. Neonates were then placed on maize plants in the field with matching Bt traits. Each neonate was transferred to the center of the top side of a leaf and observed for 15 min for silking and/or other activities. A total of 50 neonates were tested for each plant type.

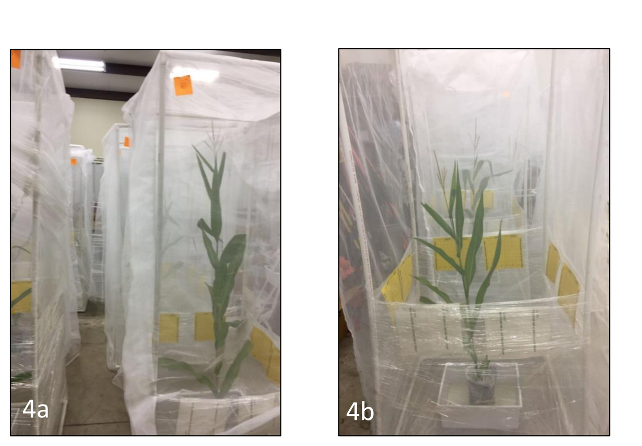


Fig. 4. a and b Larval dispersal cages

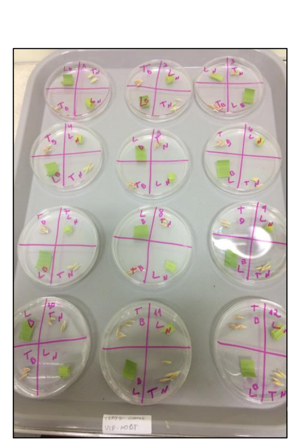


Fig. 5. Food choice experiment

Results 1 - On-plant neonate dispersal behavior

The majority of the larvae moved toward upper leaves in all treatments, 54% of vip3A, 59% of Cry1F, and 57% of non-Bt. Tassel was the second plant region where larvae moved the most, similar results between Vip3A and Cry1F but less occurrence for non-Bt plants. Approximately 17% of larvae moved to the silks on non-Bt plants, a behavior rarely observed on Vip3A plants (<1%) and only 3% on Cry1F plants. 24% of the larvae moved away from the plant when exposed to Vip3A, compared to 11 and 9%, respectively, for Cry1F and non-Bt (Fig. 6). Mortality was not observed on non-Bt plants and at very low levels on Vip3A (1.46%) and Cy1F (3.70%).

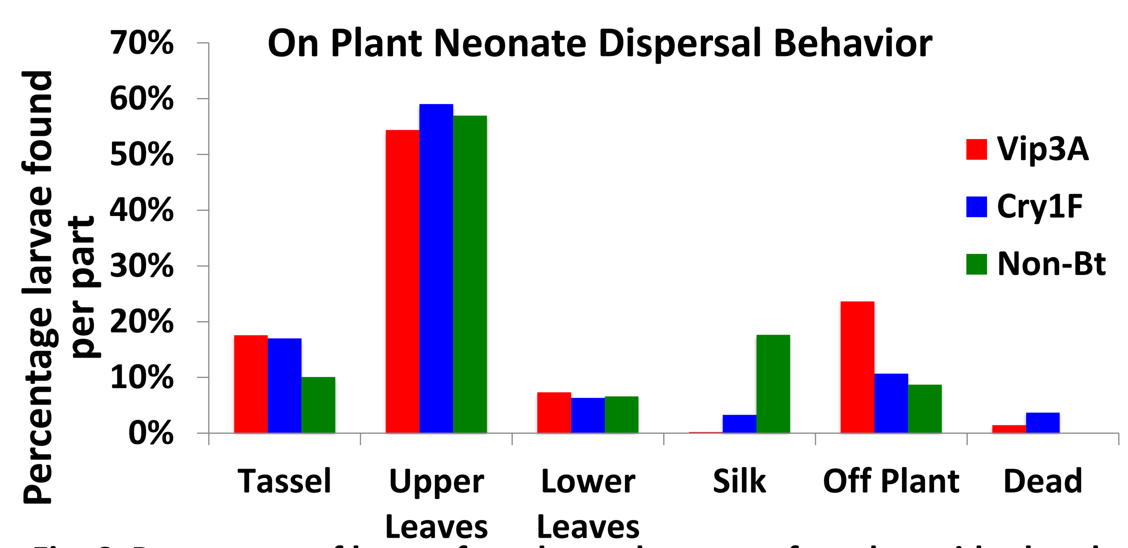


Fig. 6. Percentage of larvae found per plant part, found outside the plant and dead

Results 2 – Food choice experiment

Choice: The majority of larvae spent more time on Bt leaf tissue and non-Bt tassel, differing from non-Bt leaf tissue and from Bt tassel. There was a high occurrence of off tissue for both trials, resulting in larvae spending more time off tissue than on any tissue (Fig. 7). No choice: Larvae spent more time on tassel tissue. Time spent on leaf tissues was similar among the three treatments. Larvae spent more time off tissue on Vip3A (Fig. 8).

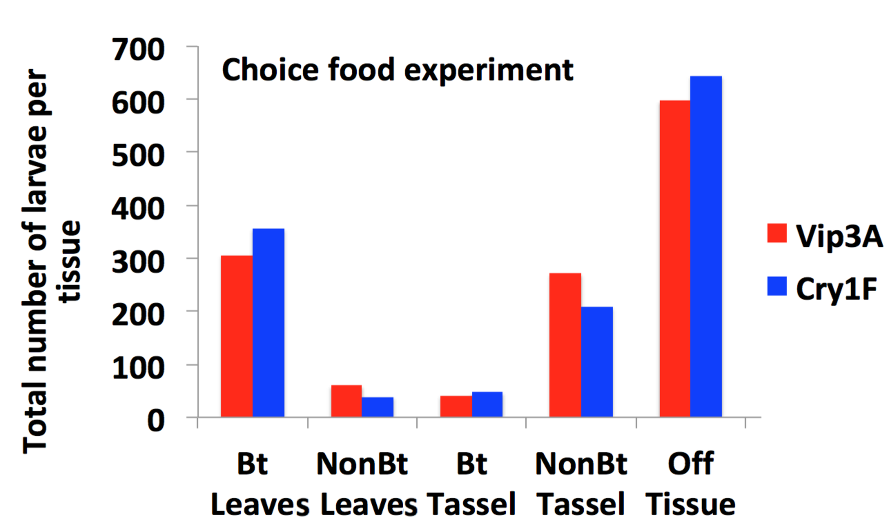


Fig. 7. Total number of larvae per plant tissue on choice trials

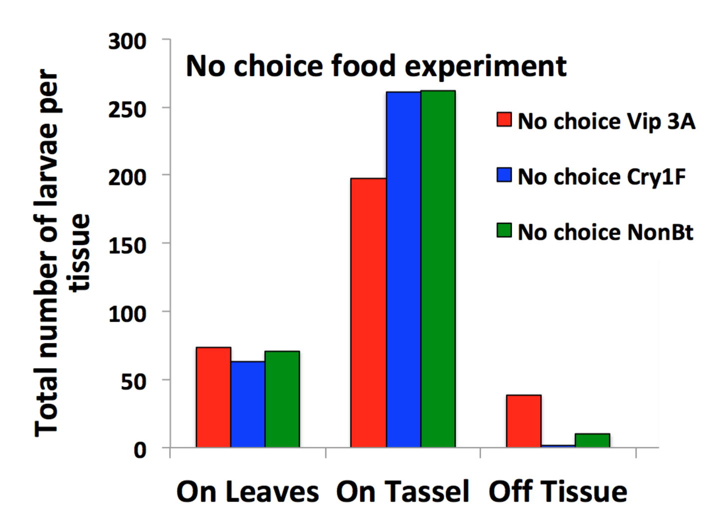
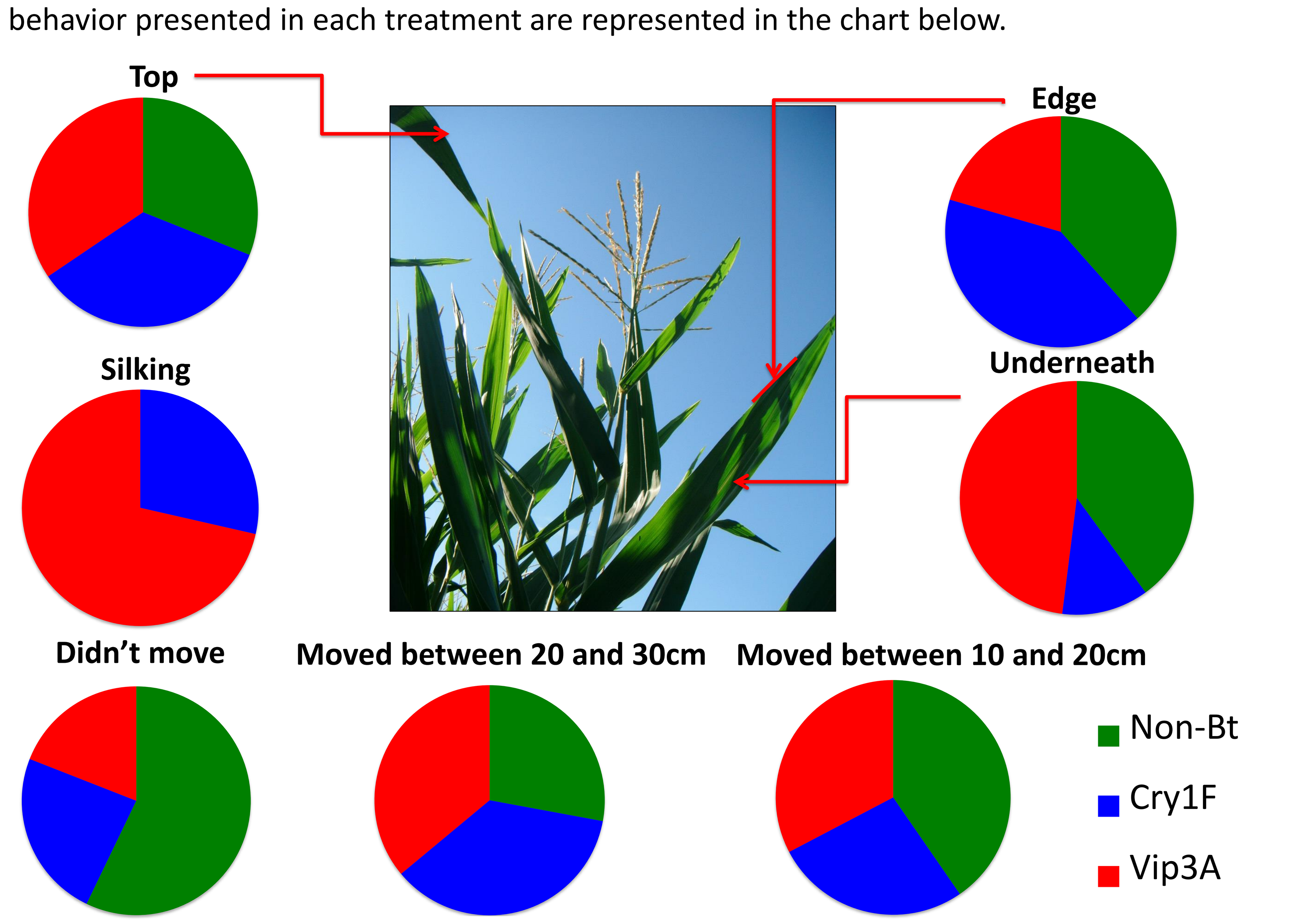


Fig. 8. Total number of larvae per plant tissue on no choice trials

Results 3 – Silking behavior

Silking behavior was observed only 5 times in Vip3A and 2 times in Cry1F, indicating that the majority of the larvae did not silk. Feeding behavior was observed only on non-Bt. Additional behavior presented in each treatment are represented in the chart below.



Results Summary

- On non-Bt plants, larvae moved more to the plant silk region when compared to Vip3A and Cry1F.
- When exposed to Vip3A, larvae abandoned plants more often than from Cry1F and non-Bt plants.
- For choice trials, larvae spent more time on tassel tissue.
- For choice trials, larvae spent more time on Bt leaf and non-Bt tassel tissues. Off plant behavior was more predominant than other locations for both treatments.
- Silking behavior was observed only 5 times for Vip3A, 2 times for Cry1F and zero times for non-Bt.
- For on plant movement behavior there was no difference among treatments for larvae remaining on the top of the leaf. There was more occurrence of larvae on the edge for non-Bt and Cry1F.
- The majority of larvae on non-Bt plants did not move.
- For distance moved by larvae, all treatments were similar.

Discussion and Conclusion

Movement data for lepidopteran pests is very limited (3). Previous studies on non-Bt maize shows that WBC exhibits non-directional movement in field experiments (4). However, our preliminary results suggest that *S. albicosta* may present avoidance behavior to *Bt* toxin, especially to Vip3A. Further studies investigating larval movement in the field are necessary to understand the potential for larval movement among plants expressing Bt toxins. Such information can be used to improve resistance management strategies and help delay the development of resistance and/or behavioral adaptation.

Significance

Understanding larval movement and preferences can help improve components of IPM. Furthermore, the development and implementation of IRM strategies, such as refuge placement and deployment of seed mixtures, can also be improved when larval movement is well understood.

Future Directions

Develop further field experiments including Bt and non-Bt plants, and include other pests from the maize Lepidoptera pest complex.

Acknowledgments

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