The impact of spray application methodology on the development of resistance to cypermethrin and spinosad by fall armyworm Spodoptera frugiperda (J. E. Smith).

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ABSTRACT
The development of resistance to an insecticide under various type of application methods has yet to be reported in the literature. Column tests with fall armyworm larvae exposed to three different pyrethroid insecticides (cypermethrin, spinosad, and lambda-cyhalothrin) were exposed to a spray of different rates of lambda-cyhalothrin and spinosad. The results indicated that cypermethrin and spinosad were more toxic than lambda-cyhalothrin. Lambda-cyhalothrin was found to be more toxic, both acute and chronic, to fall armyworm larvae than the other two insecticides. The results of these experiments suggest that the use of pyrethroids in the management of fall armyworm may be effective in reducing the resistance levels of this pest.

INTRODUCTION
There is an increasing concern about the development of resistance to insecticides. Resistance to insecticides has been reported in many major crop pests and can reduce the effectiveness of control measures. The development of resistance to insecticides can be due to various factors, including the use of insecticides at high doses, improper application, and inadequate field management practices. The development of resistance can lead to the failure of control measures and increase the cost of pest management.

OBJECTIVE:
The objective of this study was to evaluate the impact of using various deposition patterns (small droplet deposits, large droplet deposits, and laser deposition) on the development of resistance to cypermethrin and spinosad on fall armyworm (FAW) and Spodoptera frugiperda larvae using continuous drop size deposition patterns produced by different methods.

2 MATERIALS AND METHODS
2.1 Insects
Fall armyworm (FAW) Spodoptera frugiperda (J. E. Smith) larvae and an artificial fall armyworm diet were supplied by the L. M. Hall laboratory at the University of Georgia. The larvae were reared on artificial diet until they reached the 2nd instar stage. The artificial diet contained 16% crude protein and 5% lipids and was provided ad libitum.

2.2 Plants
Corn plants were grown in a greenhouse at 25°C under natural light conditions and temperatures, which range from 25-35°C (day) and 18-28°C (night). Plants were sprayed approximately 30-40 days after planting when they became 130-150 cm tall.

2.3 Chemicals
Cypermethrin 2.5 EC (Asulam 60% cypermethrin) provided by FMC Corporation, Chemical Research and Development Center, Princeton, NJ was sprayed at the standard recommended application rate (20 g a.i./ha), and spinosad 22.5% SC provided by Dow AgroSciences® (DowAgroSciences LLC), Indianapolis, IN was sprayed at 187.5 g a.i./ha. Both pesticides were applied two times at 7 day intervals.

2.4 Insecticide application
Two different nozzle (XN0090S and XN0090T) were used to produce a small droplet size pattern (NMD 1010, 1010 lift) and a large droplet size pattern (NMD 550, 550 lift). The plants were sprayed at the laboratory of Pest Control Application Technology (LPCT) test site at Ohio Agricultural Research and Development Center in front of a corn field. Each treatment was replicated three times, and the experiment was conducted in a randomized complete block design.

2.5 Biomass
Five fall armyworm colonies (Table 1) were reared in the laboratory chamber for 10 generations before starting topical application treatments. For each 0.01 colony, 200-250 1st instar larvae were used. Tab 1 shows the number of larvae used for each colony. The control treatments were applied to corn plants using the laboratory of Pest Control Application Technology (LPCT) test site at Ohio Agricultural Research and Development Center in front of a corn field. Each treatment was replicated three times, and the experiment was conducted in a randomized complete block design.

3 RESULTS
The results of the standard topical application assay for cypermethrin and spinosad were significant in both assays. In general, the results indicated that the use of spinosad was more toxic than cypermethrin. However, the results also showed that there was a significant difference in the toxicity of spinosad and cypermethrin between the two test sites. The results of these experiments suggest that the use of spinosad in the management of fall armyworm may be effective in reducing the resistance levels of this pest.

4 DISCUSSION
The results of these experiments suggest that the use of spinosad in the management of fall armyworm may be effective in reducing the resistance levels of this pest. The results also showed that there was a significant difference in the toxicity of spinosad and cypermethrin between the two test sites. These results suggest that the use of spinosad in the management of fall armyworm may be effective in reducing the resistance levels of this pest

Table 1:  Five fall armyworm colonies fed on corn plant leaves, which were treated with cypermethrin and Spinosad using XN0090S and XN0090T, under different application conditions

<table>
<thead>
<tr>
<th>Colony</th>
<th>Insecticide</th>
<th>Nozzle</th>
<th>Pressure (kPa)</th>
<th>Volume (L/ha)</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cypermethrin</td>
<td>XN0090S</td>
<td>270</td>
<td>1.17</td>
<td>4-5</td>
</tr>
<tr>
<td>2</td>
<td>Spinosad</td>
<td>XN0090S</td>
<td>270</td>
<td>1.17</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>Cypermethrin</td>
<td>XN0090S</td>
<td>150</td>
<td>1.17</td>
<td>13.7</td>
</tr>
<tr>
<td>4</td>
<td>Spinosad</td>
<td>XN0090S</td>
<td>150</td>
<td>1.17</td>
<td>13.7</td>
</tr>
<tr>
<td>5</td>
<td>Control</td>
<td>Untreated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>