Cyt1A from *Bacillus thuringiensis* Lacks Toxicity to Susceptible and Resistant Larvae of Diamondback Moth (*Plutella xylostella*) and Pink Bollworm (*Pectinophora gossypiella*)

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We tested Cyt1Aa, a cytolytic endotoxin of *Bacillus thuringiensis*, against susceptible and Cry1A-resistant larvae of two lepidopteran pests, diamondback moth (*Plutella xylostella*) and pink bollworm (*Pectinophora gossypiella*). Unlike previous results obtained with mosquito and beetle larvae, Cyt1Aa alone or in combination with Cry toxins was not highly toxic to the lepidopteran larvae that we examined.

The soil bacterium *Bacillus thuringiensis* produces insecticidal cytolytic (Cyt) and crystal (Cry) proteins that are useful for pest control (7). Cyt1Aa interacts synergistically with Cry4A, Cry4B, and Cry11A to reduce the resistance of mosquito larvae (*Culex quinquefasciatus*) to these proteins (13) and with Cry3A proteins to reduce the resistance of cottonwood leaf beetle larvae (*Chrysomela scripta*) to Cry3A (2). These results led to the hypothesis that Cyt proteins may be useful for managing the resistance of other pests to Cry toxins used in microbial insecticides and transgenic plants (2). To test this hypothesis, we determined the effects of Cyt1Aa on susceptible and Cry1A-resistant larvae of two major lepidopteran pests, diamondback moth (*Plutella xylostella*) and pink bollworm (*Pectinophora gossypiella*).

For diamondback moth, we tested the susceptible LAB-PS strain and the resistant NO-QA strain (4, 10). For pink bollworm, we tested the susceptible APHIS-S strain and the resistant APHIS-98R strain (5). Both susceptible strains had been reared in the laboratory for many years without exposure to toxins. The NO-QA strain was derived from a resistant field population in Hawaii and had been selected repeatedly in the laboratory with Dipel. Dipel is a formulated version of the HD-1 strain of *B. thuringiensis* subsp. *kurstaki*, which contains Cry1Aa, Cry1Ab, Cry1Ac, Cry2A, spores, and other materials (Valent Biosciences, Libertyville, Ill.). The APHIS-98R strain was derived from the APHIS-S strain and had been selected repeatedly in the laboratory with leaf powder from transgenic cotton containing Cry1Ac and with MVPII (Dow Agrosciences, San Diego, Calif.), a liquid formulation containing Cry1Ac (3). Diamondback moth larvae were reared and tested on cabbage foliage (9). Pink bollworm larvae were reared and tested on an artificial diet (8).

We tested Cyt1Aa alone and in combination with Dipel against susceptible and resistant diamondback moth larvae.

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development were recorded. Pupae and live fourth-instar larvae were counted as survivors.

For all bioassays, mortality was adjusted for the mortality in controls (no Cry or Cyt1Aa protein) by using Abbott’s correction. The effect of Cyt1Aa was calculated as follows: percent mortality with Cyt1Aa − percent mortality without Cyt1Aa. Overall, adding Cyt1Aa did not significantly increase mortality for diamondback moth or pink bollworm (sign test, *P* > 0.05).

<table>
<thead>
<tr>
<th>Insect and resistance level</th>
<th>Cry prepn Type</th>
<th>Conc*</th>
<th>% Mortality without Cyt1Aa</th>
<th>Effect of Cyt1Aa on mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamondback moth</td>
<td>Susceptible</td>
<td>Dipel</td>
<td>0 NA d</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Resistant</td>
<td>Dipel</td>
<td>0.256 0.05 1.28 25.6 128 256 1,280</td>
<td>72.2 36.0 4.9 5.0 2.7 83.8</td>
</tr>
<tr>
<td>Pink bollworm</td>
<td>Susceptible</td>
<td>HD-1</td>
<td>0.5 2.0 5.0 20.0 50.0 20.0 50.0</td>
<td>18.4 43.5 65.8 81.6 15.3 15.3</td>
</tr>
<tr>
<td></td>
<td>Resistant</td>
<td>HD-1</td>
<td>0.0 0.03 0.1 1.0 10.0</td>
<td>NA 7.4 6.8 0 20.7</td>
</tr>
</tbody>
</table>

* Dipel and HD-1 concentrations are given in milligrams per liter. Cyt1Ac concentrations are given in micrograms per gram of diet. The concentrations of Cyt1Aa were 40 mg per liter with Dipel and 1.6 μg per g of diet. For tests with HD-1, the concentration of Cyt1Aa varied as the concentration of HD-1 varied (see text).

* Mortality values were adjusted for control mortality values by using Abbott’s correction.

* The effect of Cyt1Aa on mortality was calculated as follows: percent mortality with Cyt1Aa − percent mortality without Cyt1Aa. Overall, adding Cyt1Aa did not significantly increase mortality for diamondback moth or pink bollworm (sign test, *P* > 0.05).

* NA, not applicable.

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REFERENCES


