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Impact Of Three Commercial Insecticides On Some Biological Aspects Of The Cotton Leafworm, *Spodoptera littoralis* (Lepidoptera: Noctuidae)

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ABSTRACT

The sensitivity of *Spodoptera littoralis* 6th larval instar towards the three commercial insecticides: Tracer, Pendelta and Pyriban were investigated under laboratory conditions. All tested insecticides showed highly adverse bioactive effects. The highest tested concentration induced 20, 100 and 40% mortality 24 hours post treatment, while the lowest tested concentrations induced 40, 70 and 60% mortality, respectively. The middle concentration causes 80% mortality for the three tested insecticides. The calculated LC$_{50}$ was: 0.034, 0.135 and 0.170% for Pendelta, Tracer and Pyriban, respectively. The highest concentration of Pendelta achieved 100% mortality 24 hours post treatment, and suppressed the larval activity even at the low concentration. Results also showed a reduction in food consumption and larval growth rate in case of Teacer and Pendelta treatments. The efficiency of converting ingested and digested food into body substance was obviously reduced in Pendelta treatment. On the other hand, the approximate digestibility was considerably not affected in all treatments, except in Tracer higher concentration treatment.

Key words: *Spodoptera littoralis*, Tracer, Pendelta, Pyriban, food consumption (CI), relative growth rate (RGR), converting ingested food (ECI), digested food (ECD), approximate digestibility (AD)

Introduction

The increasing number of studies on plant/insect chemical interactions in the last few decades unveiled the potential of utilizing secondary plant metabolites or allelochemicals as pest control agents (Howe and Jander 2008). This interest in botanical insecticides resulted from the need to provide an alternative to the conventional synthetic insecticides, which that adverse effect on agroecological system is well known (Ferry *et al.*, 2004; Atwa *et al.*, 2010).

The effect of some plant chemical extracts and insecticides on consumption and assimilation of food, as well as on growth and development of different insect species were investigated by several authors (Amr, 2001; Senthil-Nathan, 2006 and Senthil-Nathan *et al.*, 2007).

Some plant extracts or isolated active compounds has been shown to act as potent acute or chronic insecticides (Emara *et al.*, 2002), antifeeedent (Swidan, 1994) and insect growth regulator (Abo EL-Ghar, *et al.*, 1996) against some insect species including *S. littoralis*.

The present study aims to evaluate the impact of the three commercial insecticides, *i.e.*. Tracer, Pendelta and Pyriban against the 6th larval instar of the cotton leafworm and their role on some physiological aspects under laboratory conditions. Also, to nominate the optimum concentration of these insecticides to apply as a suitable mean for use in the Integrated Pest Management (IPM) programs.

Materials and Methods

**Experimental insect:**

*Spodoptera littoralis* six larval instar was obtained from the National Research Centre Laboratory culture maintained on castor bean leaves for successive generations under constant conditions (25±2°C and 70±5% RH).

**Tested insecticides:**

- Tracer 24% SC: The trade name of Spinosad.
- Pendelta 27% EC: The trade name of Deltamethrin.

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Both Tracer and Pendelta were obtained from Wadi El-Nil Co. For Agricultural Development, Giza, Egypt.

- Pyriban 48% EC: The trade name of Chloropyrifos, the active ingredient is (organophosphorous group), locally formulated in Egypt and obtained from El-Help Co.

Preliminary experiment using the recommended concentrations induced 100% mortality for the treated insect. So, dilution was carried out to the recommended concentrations to ensure the survival of the treated larvae for some physiological studies. The experiment was carried out using three concentrations of each insecticide. Tracer (0.50, 0.125 and 0.075%), Pendelta (0.20, 0.10 and 0.05%) and Pyriban (0.20, 0.075 and 0.0375%) and the check (control) was water only. These concentrations were prepared using tap water according to the producing company’s recommendation for each of the aforementioned insecticides.

**Bioassay and treatment technique:**

Four groups of plastic cups (120ml volume) covered with muslin cloth were used. Each group contains 3 subgroups which comprise one of the 6th larval instar per each, supplied with castor bean leaves as food supply. Each subgroup was sprayed with one of the tested concentration of the three tested insecticides. The fourth subgroup was sprayed with water only as a check (control). All cups were kept under the same laboratory constant conditions for four days under daily examination. The percentage of mortality and the LC50 value were calculated. Five replicates were carried out for the whole experiment.

**Physiological studies:**

**Quantitative, food utilization and efficiency measurement:**

The newly moulted 6th larval instar was reared under the laboratory constant conditions (at 25±2°C and 70% RH). The initial weight of the larvae was recorded, and then they were individually introduced into separate plastic cups. Castor bean leaves (*Ricinus communis* L.) discs of 2.5cm diameter were treated with each previously mentioned concentration of the three tested insecticides for two minutes using dipping technique, and then dried at room temperature. These treated discs were weighed and offered to the experimental larvae as food supply for 24 hours, and then they fed on untreated discs for the next three days. The experimental larvae (five replicates each contain 20 larva/concentration) were allowed to feed on weighted quantities of insecticidal treated and untreated Castor bean leaves for four days. The differences in weight of the larvae give the fresh weight gained during the period of the study. Alive experimental larvae for 4 days post treatment and its remaining food leaves were weighted, then oven dried (48 hours at 50°C) and reweighed to reach its established dry weight. The quantity of ingested food was estimated by subtracting dry weight of the larvae remaining at the end of each experiment from the total weight of the diet provided. Faeces and exuviae were collected daily, weighed, oven dried and reweighed to estimate their constant dry weight.

To attain a considerable understand of how the three insecticides affect weight gain, the measurement of nutritional indices described by the traditional manner, the following equations were applied according to Waldbauer (1964 & 1968) and Senthil-Nathan and Kalaivani (2005).

- **Consumption index (CI)** = E/TA.
- **Relative growth rates (RGR)** = P/TA.
- **Approximate digestibility (AD)** = 100*(E-F)/E
- **Efficiency of conversion of ingested food (ECI)** = 100*P/E.
- **Efficiency of conversion of digested food (ECD)** = 100*P/(E-F),

Where:

A= means dry weight of larvae during the experimental period,
E= dry weight of food eaten,
F= dry weight of faeces produced,
P= dry weight gain of larvae
T= duration of experimental period.

**Statistical analysis:**

Corrected mortality was carried out using Abbott’s formula (Abbott, 1925). All data were subject to analysis of variances (ANOVA) through SPSS computer programme; the mean values were compared using Duncan’s Multiple Range test. The LC50 value was calculated using Finney’s equation (Finney, 1952).
Results and Discussion

A- Toxicity of the three insecticides against 6th larval instar of S. littoralis:

The toxicity of the three tested insecticides at the recommended concentrations was carried out against the 6th larval instar of the cotton leafworm. All used concentrations induced 100% mortality. So that 1-2 fold dilutions were carried out for all other concentrations.

Data in table (1) indicated that Pendelta at higher concentration (0.2%) possessed the highest mortality (100%), while the two other tested insecticides (Pyriban and Tracer) induced 40 and 20% mortality, respectively. At the middle concentration, the three insecticides scored the same mortality percentage (80%) (Table 1)

The percent mortality didn’t exceed 70% for all the tested insecticides at the lowest concentration of Tracer, Pendelta and Pyriban. Also, Pendelta showed significant higher mortality at the low concentration than the other two insecticides.

Mortality of larvae among the three insecticides at highest, middle and lowest concentrations were significantly increased, as compared with check larvae. The prevalence of mortality was similar with each insecticide.

Data illustrated in table (2) show that the LC50 value of the tested insecticides (24 hours post treatment) could be arranged in an ascending order as follow: Pendelta (0.034%), Tracer (0.135%) then Pyriban (0.170%).

The results of the present study showed that the Pendelta is more toxic to S. littoralis than both Tracer and Pyriban. The same results were observed by Rani et al. (2005), where they found that indoxacarb was more toxic to H. armigera than Tracer. On the other hand Ali et al. (2002) and Karabhantanal & Awaknavar (2004) do not agree with the results of the present study. They reported that Tracer was more toxic than indoxacarb as Tracer caused a higher mortality rate than indoxacarb for a specific time against the 2nd larval instar of H. armigera.

The obtained results clarify that the tested insecticides were relatively harmful to S. littoralis when used at relatively middle concentration, especially Pendelta at high and low concentration. These results were in accordance with those obtained by Sterk et al. (2001) who evaluated the harmful effect of some pesticides against non-target beneficial arthropods. Based on these results, field applications of Deltamethrin (Pendelta) would be the most disruptive insecticides of the tested insecticides to S. littoralis populations. Similar results were obtained by Raposo et al. (2011), where they found that Pendelta was highly toxic to adults of Glyptapanteles militaris but relatively safe when applied on parasitoid cocoons.

Our results were matched with those reported by Ezz El-Din et al. (2009), who mentioned that the most effective tested insecticide was Emamectin benzoate followed by Chlorpyrifos and Spinosad against 4th instar larvae of S. littoralis using topical application. Also they found that the Chlorpyrifos was more potent and toxic than Spinosad.

Also, our results were in accordance with those reported by Darriet et al. (2010) who reported that, the mixture of Pyriproxyfen and Spinosad (Tracer) kills larvae and pupae of S. littoralis giving it a broader range of action than either insecticide. This mixture could preserve the utility of both insecticides in public health programs.

Effect of three insecticides on the food utilization and nutritional indices of S. littoralis:

The nutritional indices and related parameters of the three chemical insecticides (Tracer, Pendelta and Pyriban) against S. littoralis 6th larval instar were presented in (Table 3). The obtained data show a significant decrease in food consumption index (CI) for larvae feed on leaves treated with Tracer and Pendelta insecticides at the lower and the middle concentrations for both insecticides compared with that consumed by check larvae; while it was insignificant in case of Pyriban treatment at the three tested concentrations.

Regarding to the body weight, the relative growth rate (RGR) which measures the relation between the duration of feeding period and the weight of body gain was significantly reduced for both Tracer and Pendelta, on the other hand, the opposite effect was observed by almost all Pyriban treatments; where it was increased significantly than control in case of middle and low concentrations (Table 3).

The ability of larvae to utilize food for growth was measured by approximate digestibility (AD) which measures the digestion of food ingested by larvae. This value was not affected by the lower concentration of Tracer, Pendelta and/or Pyriban, except the higher concentration of Tracer that was significantly decreased as compared to check larvae, i.e., the larvae adapted itself against this concentration of the three insecticides. At the same time, the highest concentration of Tracer insecticide induced a significant reduction in the approximate digestability for S. littoralis larvae compared to the check (Table 3).

The ability of treated larvae to convert the ingested food (ECI) was significantly increased when larvae treated with Tracer at all concentrations, the highest concentration of Pendelta and both middle and low
concentrations of Pyriban compared to check larvae, but it was markedly reduced after the treatment with Pendelta insecticide at middle and low concentrations (Table 3).

**Table 1:** Percent mortality of *Spodoptera littoralis* 6th larval instar treated with three commercial insecticides under laboratory conditions

<table>
<thead>
<tr>
<th>Concentration (%)</th>
<th>Insecticide</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td>Tracer</td>
<td>20.00±0.71c</td>
</tr>
<tr>
<td></td>
<td>Pendelta</td>
<td>100±0.00a</td>
</tr>
<tr>
<td></td>
<td>Pyriban</td>
<td>40.00±1.41b</td>
</tr>
<tr>
<td></td>
<td>Check</td>
<td>00.00±0.00d</td>
</tr>
<tr>
<td>F-value</td>
<td></td>
<td>298.667**</td>
</tr>
<tr>
<td>Middle</td>
<td>Tracer</td>
<td>80.00±1.92a</td>
</tr>
<tr>
<td></td>
<td>Pendelta</td>
<td>80.00±3.40a</td>
</tr>
<tr>
<td></td>
<td>Pyriban</td>
<td>80.00±1.79a</td>
</tr>
<tr>
<td></td>
<td>Check</td>
<td>00.00±0.00b</td>
</tr>
<tr>
<td>F-value</td>
<td></td>
<td>345.946**</td>
</tr>
<tr>
<td>Lowest</td>
<td>Tracer</td>
<td>40.00±1.52c</td>
</tr>
<tr>
<td></td>
<td>Pendelta</td>
<td>70.00±1.70a</td>
</tr>
<tr>
<td></td>
<td>Pyriban</td>
<td>60.00±2.35b</td>
</tr>
<tr>
<td></td>
<td>Check</td>
<td>00.00±0.00b</td>
</tr>
<tr>
<td>F-value</td>
<td></td>
<td>249.22</td>
</tr>
</tbody>
</table>

**Table 2:** The LC50 value and slope of tested insecticides for *Spodoptera littoralis* 6th instar larvae treated under laboratory conditions 4 days post treatment

<table>
<thead>
<tr>
<th>Insecticides</th>
<th>LC50</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracer</td>
<td>0.135</td>
<td>-1.060</td>
</tr>
<tr>
<td>Pendelta</td>
<td>0.034</td>
<td>2.437</td>
</tr>
<tr>
<td>Pyriban</td>
<td>0.170</td>
<td>-0.820</td>
</tr>
</tbody>
</table>

**Table 3:** Effect of three insecticides on the food utilization and nutritional indices of *S. littoralis* 6th larval instar

<table>
<thead>
<tr>
<th>Treatment (%)</th>
<th>Consumption index (CI)</th>
<th>Relative growth rate (RGR)</th>
<th>Approximate digestibility (AD)</th>
<th>Converting ingested food (ECI %)</th>
<th>Converting digested food (ECD %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracer</td>
<td>0.50</td>
<td>0.070±0.069</td>
<td>0.004±0.080</td>
<td>59.54±16.13b</td>
<td>35.40±2.92b</td>
</tr>
<tr>
<td></td>
<td>0.125</td>
<td>0.114±0.022</td>
<td>0.135±0.008</td>
<td>85.78±5.97b</td>
<td>35.31±2.67b</td>
</tr>
<tr>
<td></td>
<td>0.075</td>
<td>0.134±0.055</td>
<td>0.143±0.008</td>
<td>86.63±1.08b</td>
<td>39.63±4.29b</td>
</tr>
<tr>
<td>Control</td>
<td>16.2±3.34</td>
<td>8.09±1.350</td>
<td>85.55±2.99</td>
<td>18.88±2.28</td>
<td>25.80±3.40</td>
</tr>
<tr>
<td>F-test</td>
<td></td>
<td>28.81</td>
<td>23.55</td>
<td>4.286</td>
<td>3.851</td>
</tr>
<tr>
<td>Pendelta</td>
<td>0.20</td>
<td>0.35±0.019a</td>
<td>0.07±0.009</td>
<td>95.15±0.15d</td>
<td>47.09±7.09</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>0.176±0.080a</td>
<td>-0.078±0.02a</td>
<td>82.63±5.61a</td>
<td>-33.36±8.29</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.22±0.081a</td>
<td>-0.38±0.35</td>
<td>80.64±11.64</td>
<td>14.54±7.5</td>
</tr>
<tr>
<td>Control</td>
<td>16.2±3.34</td>
<td>8.09±1.333</td>
<td>85.55±2.99</td>
<td>18.88±2.28</td>
<td>25.80±3.40</td>
</tr>
<tr>
<td>F-test</td>
<td></td>
<td>28.81</td>
<td>23.55</td>
<td>4.286</td>
<td>3.851</td>
</tr>
<tr>
<td>Pyriban</td>
<td>0.20</td>
<td>10.29±0.178a</td>
<td>7.92±2.02</td>
<td>73.56±1.85</td>
<td>18.42±6.6</td>
</tr>
<tr>
<td></td>
<td>0.075</td>
<td>12.74±3.95a</td>
<td>19.69±3.32</td>
<td>79.05±5.89</td>
<td>57.42±11.9</td>
</tr>
<tr>
<td></td>
<td>0.0375</td>
<td>15.27±0.12a</td>
<td>17.89±6.35</td>
<td>86.39±5.54</td>
<td>32.12±0.26</td>
</tr>
<tr>
<td>Control</td>
<td>16.2±3.34</td>
<td>8.09±1.355</td>
<td>85.55±2.99</td>
<td>33.94±1.9</td>
<td>25.80±3.40</td>
</tr>
<tr>
<td>F-value</td>
<td></td>
<td>28.81</td>
<td>23.55</td>
<td>4.286</td>
<td>3.851</td>
</tr>
</tbody>
</table>

Means in a single column followed with the same letter are not significantly different at 5% level of probability

**The corresponding figure for the conversion of digested food (ECD) into body tissue was insignificantly affected in case of Tracer treatments although there was an increment at the middle and the lower concentrations. The highest concentration of Pendelta and the middle concentration of Pyriban treatments induced a significant increase in the conversion of digested food (ECD), compared to the check larvae. Significant reduction was observed in case of larvae treated with the middle and the low concentrations of Pendelta, respectively comparing with the check larvae.**

This reduction in (ECI and ECD) may resulted in diversion of energy from production of biomass to overcome the effect treatment with insecticides (Senthil-Nathan et al., 2005 a&b).

Our results suggest that Tracer, Pendelta and Pyriban are potentially potent compounds for control of *S. littoralis* larvae.
The present findings showing reduced growth rate during the 6th larval instar confirms the earlier findings of Nakatani et al. (1994); Juan, et al. (2000) on Sesamia nonagrioides and Banchio et al. (2003) on Liriomyza huidobrensis.

It may be concluded that the decreased larval growth coupled with lower RGR, which is more likely due to longer retention of food in the gut for maximization of AD to meet the increased demand of nutrients, as described by Sentih-Nathan, et al. (2005 a&b). The results revealed that although the treated larvae were capable of maintaining the AD, they failed to maintain the RGR during larval development (Table 3). Approximate digestibility (AD) could not be maintained due to a continuous decline in RGR in both Tracer and Pendelta treatments. The RGR reached its lowest level in all treatments of either Tracer or Pendelta (Table 3). A significant correlation between deterrence and toxicity of ingested secondary plant compounds in locusts has been reported earlier by Klocke et al. (1989), who found that the consumption of plant extracts resulted in retarded growth and affected the nutritional physiology of the larvae.

It was observed that Pendelta and Tracer cause a decline in the weight and development of the S. littoralis 6th larval instar. Dong Wang et al. (2009) suggest that the combination of lethal and sublethal effects of Tracer might affect pest population dynamics significantly by decreasing its survival and reproduction, and by delaying its development.

Based on these results, field applications of Pendelta (Deltamethrin) would be most disruptive of tested insecticides to populations of S. littoralis. Similar results were obtained by Raposo et al. (2011) on adults of Glyaptapanteles militaris parasitoid cocoons (Darriet et al., 2010; Ezz El-Din et al., 2009) on S. littoralis

Several pyrethroid compounds were sufficiently active to suggest that they may prove useful for the control the S. littoralis larvae in the field (Martyn et al., 1977). He mentioned that the speed of action is related to both chemical structure and applied dose Toxicity of pyrethroids towards the S. littoralis larvae.

Conventional insecticides are harmful to the beneficial insects and due to resistance in H. armigera it has become necessary to use such insecticides which are ecologically safe for natural enemies (Rashad et al., 2010). Spinosad and Indoxacarb belongs to a new chemical group of insecticides and are safe to the natural enemies of both predators (Nasreen et al., 2003) and parasitoids (Williams et al., 2003). These insecticides can be used in any Integrated Plant Management (IPM) programmes.

Previous studies carried out by Grafton-Cardwell et al. (2005) and Rashad et al. (2010) showed that, Indoxacarb and Spinosad are relatively safe and selective insecticides. Results showed that these insecticides are very effective as maximum mortality was noted when using these insecticides and thus, they can be used in the Integrated Pest Management programme of any crop.

References


