Performance of helicoverpa armigera larvae on leaves of plant species

Desempenho de larvas de helicoverpa armigera em folhas de espécies vegetais

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ABSTRACT
Helicoverpa armigera (Hübner) (Lep.: Noctuidae) has established itself as a soybean pest in southern Brazil; however, as a polyphagous species, the caterpillar has been found in other economically important crops and even uncultivated plants. The nutritional value
of host plants as food sources influences biological performance, which can interfere with population dynamics and pest management. In this sense, an experiment was carried out to assess the effect of different foods on biological aspects and larval consumption. Eight plant species were evaluated, including cultivated plants, ground cover plants, and weeds. Soybean, where caterpillars acquired greater importance as a pest, was considered the standard food. The plants were grown in pots in a greenhouse, and the leaves were harvested to feed the larvae as they hatched. The findings show that H. armigera larvae fed on canola or radish leaves exhibit biological performance comparable to that fed on soybean. The larvae did not survive when fed ryegrass, horseweed, corn, or wheat.

**Keywords:** biology, consumption, host plants.

**RESUMO**
No sul do Brasil, Helicoverpa armigera (Hübner) (Lep.: Noctuidae) se estabeleceu como praga de soja porém, como espécie polífaga, a lagarta tem sido encontrada em outras culturas de importância econômica e mesmo em plantas não cultivadas. O valor nutricional das plantas hospedeiras como alimento influencia o desempenho biológico o qual, junto com o consumo, podem interferir na dinâmica populacional e no manejo da praga. Foi conduzido um experimento objetivando avaliar a influência do alimento em aspectos biológicos e no consumo da larva. Foram avaliadas oito espécies vegetais, incluindo plantas cultivadas, plantas usadas como cobertura de solo e plantas daninhas. A soja, onde as lagartas adquiriram maior importância como praga, foi considerada o alimento padrão. As plantas foram cultivadas em vasos em casa-de-vegetação, de onde foram coletadas as folhas para alimentar as larvas desde a eclosão. Os resultados mostram que larvas de H. armigera alimentadas com folhas de canola ou nabo-forrageiro apresentam desempenho biológico comparável ao observado em soja. Quando alimentadas com folhas de azevém, buva, milho ou trigo as larvas não sobrevivem.

**Palavras-chave:** biologia, consumo, plantas hospedeiras.

**1 INTRODUCTION**
Helicoverpa armigera (Hübner) (Lepidoptera: Noctuidae: Heliothinae) was discovered in the Americas in 2013, first in agricultural areas of Brazil (CZEPAK et al., 2013; VILA et al., 2013), then in Paraguay (SENAVE, 2013), Argentina (MURA et al., 2014), and the United States (NORTH AMERICAN PLANT PROTECTION ORGANIZATION, 2015). The caterpillars have already been identified as polyphagous species in over 300 species of cultivated and wild plants (SHARMA et al., 2005), attacking both leaves and reproductive organs of some of these plants (CZEPAK et al., 2013; SALVADORI et al., 2013).

In Brazil, H. armigera caterpillars became pests in soybean and were found in several plant species, cultivated or not, involved in the soybean production system, raising questions about the significance of this impact in the context of integrated pest management.
Changes in *H. armigera* biology concerning their food source may be related to differences in the amount ingested and the nutritional quality of the plants in relation to the pest's needs, as well as the efficiency with which this food is used (BARTON & RAUBENHEIMER, 2003). *H. armigera* larvae fed on reproductive organs of soybean, corn, canola, black oat, white oat, turnip or ryegrass show variations in consumption, duration and survival (SUZANA et al., 2015). These and other food-related effects on species biology can have an impact on population dynamics and pest damage potential. The greater or lesser consumption of leaves, which is related to each crop's tolerance to defoliation, has a direct impact on control decision-making.

In light of the foregoing, the objective of this study is to compare the influence of leaves of plant species provided as food, compared to soybean, on the duration, survival and consumption of larvae and pupal weight of *H. armigera*.

**2 MATERIAL AND METHODS**

The experiment was conducted in the Entomology laboratory of the University of Passo Fundo, in an acclimatized chamber (25 ± 2 ºC, relative humidity of de 60 ± 10%, and photophase of 12 hours), in a completely randomized design, with eight treatments (plant species), and fifty repetitions (larvae). To avoid pre-adaptation to the natural foods tested, third-generation laboratory larvae reared on an artificial diet (GREENE et al., 1976) were used. These foods were black oat leaves (Avena strigosa), ryegrass (Lolium multiflorum), horseweed (Conyza sp.), canola (Brassica napus), corn (Zea mays), radish (Raphanus sativus), wheat (Triticum aestivum) and soybean (Glycine max).

In selecting the vegetables to be tested in comparison to soybean, both real host species (horseweed, canola, corn, and wheat) and potential hosts (black oat, ryegrass, and radish) present in the field during the soybean crop season were considered (SALVADORI et al., 2013, SALVADORI & SUZANA, 2014). Plants were grown in pots in a greenhouse, and leaves were collected to feed the larvae.

From the first instar onwards, the larvae were fed in the form of leaf discs with a known area (1, 4 or 7 cm²) that were changed daily in Petri dishes. The duration, consumption, and survival of larvae, number of instars, and pupal weight were all evaluated biologically. The consumption was measured in area and then corrected for mass using leaf discs that were not offered to the larvae. Images of the wear of the mandibles were recorded in a scanning electron microscope (Tescan, Vega LM 3),
following the methodology described by Azevedo Filho et al., in order to relate the lower consumption with eventual feeding difficulties of the larvae (2008).

Biological and consumption data were subjected to analysis of variance, and when significant differences were discovered, the means were compared using the Tukey test (p≤ 0.05).

3 RESULTS AND DISCUSSION

Larvae fed on ryegrass, horseweed, corn, or wheat did not survive. Only the larvae fed black oat, canola, radish, or soybean survived the larval stage, with no difference in survival rate between these plant species (Table 1). However, the average pupal weight derived from larvae fed on canola, radish, or soybean was greater than the weight of pupae derived from black oat, indicating that the latter had a lower accumulation of reserves, which may be harmful to the adult stage (LIU et al., 2004; LIU et al., 2006).

Table 1 – Larvae survival and pupae weight of H. armigera fed on leaves of plant species (25 ± 2°C; 60 ± 10% RH; 12 h of photophase)

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Larval survival (%)</th>
<th>Pupal weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black oat</td>
<td>42.0 ± 8.00</td>
<td>0.132 ± 0.005</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>Horsetail</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>Canola</td>
<td>64.0 ± 6.78</td>
<td>0.154 ± 0.004</td>
</tr>
<tr>
<td>Corn</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>Radish</td>
<td>64.0 ± 6.78</td>
<td>0.169 ± 0.006</td>
</tr>
<tr>
<td>Soy</td>
<td>56.0 ± 2.45</td>
<td>0.162 ± 0.007</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>C.V. (%)</td>
<td>13.5</td>
<td>20.1</td>
</tr>
</tbody>
</table>

Means ± SE followed by the same letter did not differ statistically from each other by the Tukey test (p<0.05); Initial number of specimens/plant species = 50.

Larvae fed black oat had a longer larval phase (33.1 days) and an additional instar, compared to the other foods tested (Table 2), indicating that this plant has a lower nutritional adequacy for the development of H. armigera than soybean (SLANSKY JR. & RODRIGUEZ, 1987). The larval period in radish was slightly longer than in soybean, but the larvae presented one less instar as compensation. Larvae fed on canola (24.3 days) developed faster than those fed on soybean (23.6 days). The faster or slower development of the larval stage is a determining factor in establishing whether a plant species is more or less suitable for feeding insects (PARRA & HADDAD, 1989; KOUHI et al., 2014).
Consumption of soybean and radish was lower among plants in which the larvae reached the pupa stage (Table 2). Leaf consumption was higher for black oat and canola than for soybean, by 61.9% and 40.1%, respectively. Lower consumption of soybean and radish can be explained by the species meeting its nutritional needs with a smaller amount of food ingested. However, the possibility that slower food passage in the digestive system has allowed for better food conversion and utilization cannot be ruled out (KOUHI et al. 2014). Insect growth is directly related to nutrient input, and lepidopteran larvae grow faster in foods of high nutritional quality than in foods of low nutritional quality (HWANG et al., 2008).

Table 2 – Duration, number of instars and consumption of H. armigera larvae fed on leaves of plant species (25 ± 2°C; 60 ± 10% RH; 12 h of photophase)

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Duration (days)</th>
<th>No. of instars</th>
<th>Consumption (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black oat</td>
<td>33.3 ± 0.84</td>
<td>8.2 ± 0.20</td>
<td>4.08 ± 0.24</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Horsetail</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canola</td>
<td>25.6 ± 0.62</td>
<td>6.8 ± 0.12</td>
<td>3.53 ± 0.15</td>
</tr>
<tr>
<td>Corn</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Radish</td>
<td>27.9 ± 0.77</td>
<td>6.1 ± 0.15</td>
<td>2.92 ± 0.11</td>
</tr>
<tr>
<td>Soy</td>
<td>23.6 ± 1.65</td>
<td>7.0 ± 0.12</td>
<td>2.52 ± 0.13</td>
</tr>
<tr>
<td>Wheat</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

C.V. (%) 10.1 7.8 9.2

Means ± SE followed by the same letter did not differ statistically from each other by the Tukey test (p≤0.05); Initial number of specimens/plant species = 50.

Insects can compensate for poor nutritional quality by consuming higher amounts of food or altering the efficiency with which it is consumed. The diversity of protease activity already observed in the intestine of H. armigera, as well as the flexibility in its expression during the stages of development (PATANKAR et al., 2001), may explain variations in survival, consumption, and duration of larvae found in the current study.

H. armigera larvae have been reported to survive on corn leaves, but only among specimens in their third instar or later, when their mandibles are more developed for chewing (JALLOW & ZALUCKI, 1996; AMER & EL-SAYED, 2014; LIU et al., 2004). The non-survival of newly hatched larvae in the current study could be attributed to the hardness of the corn leaves, which are high in hemicellulose, as it happens with S. frugiperda (HEDIN et al., 1990). In fact, when compared to larvae fed on soybean, the
analysis of larval mandibles revealed wear in the 4th and 6th instars (Figure 1). The negative impact of leaf hardness on feeding is more pronounced in newly hatched larvae, which have relatively delicate jaws (GASTON et al., 1991).

Figure 1 – Mandibles of 2nd, 4th and 6th larvae of H. armigera fed on soybean or corn leaves, showing wear in the latter (25 ± 2 °C; 60 ± 10% 12 h of photophase).

In terms of pest management, the findings of this study indicate that H. Armigera caterpillars cannot survive on ryegrass, horseweed, corn, or wheat leaves, and, as a result, these vegetables do not positively influence the population dynamics of the species in the production system where soybean is inserted. When they feed on the reproductive organs of white oat, black oat, canola, corn, radish, soybean, and wheat, the opposite occurs (SUZANA et al., 2015). The findings also suggest that H. armigera has the potential to harm black oat, canola, and radish crops.

4 CONCLUSIONS

H. armigera larvae fed on canola or radish leaves exhibit biological performance comparable to that of H. armigera larvae fed on soybean leaves. The larvae do not survive when fed ryegrass, horseweed, corn, or wheat.
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