Performance of *Spodoptera litura* Fabricius on different host plants: Influence of nitrogen and total phenolics of plants and mid-gut esterase activity of the insect

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Five host plants [castor, *Ricinus communis* (Carolus Linnaeus); cotton, *Gossypium hirsutum* (Carolus Linnaeus); tomato, *Lycopersicum esculentum* (Philip Miller); mint, *Mentha arvensis* (Carolus Linnaeus) and cabbage, *Brassica oleracea* (Carolus Linnaeus)] belonging to different families were used to study the performance of the Asian armyworm, *Spodoptera litura* larvae. Highest consumption of food and dry weight gain was observed in larvae fed on castor. Mint did not support optimum larval growth because of low digestibility and low efficiency of conversion of digested food to body matter. Dry weight gain ranged from 26.64 mg on mint to 86.80 mg in castor. These differences tend to be related to nitrogen and total phenolics content of the leaf tissues; however, the most clear-cut correlation is an inverse one between the host plant preference and the ratio of total phenolics to nitrogen in the leaf tissues. Mid-gut esterase activity in larvae showed an increasing trend with the increase in total phenolics : nitrogen ratio in the test plants and the order of mid-gut esterase activity in larvae was mint > cabbage > cotton > tomato > castor.

**Keywords**: Host plants, Mid-gut esterase activity, Nitrogen; *Spodoptera litura*, Total phenolics

The importance of induction of detoxifying enzymes in insects, in natural insect-plant interaction is yet to be conclusively demonstrated. Lindroth was the first to document a significant role of insect esterases vis-à-vis ecologically relevant plant allelochemicals. Esterases have also been reported to be involved in detoxification of phenolic glycosides by several insect species.

Since the Asian armyworm, *Spodoptera litura* is highly polyphagous, reported to feed on 112 species of plants belonging to 44 different families, it was felt that this insect would be an ideal model to assess the hypothesis that performance on different host plants is influenced by the different proportions of nitrogen and total phenolics in host plants vis-à-vis host plant stimulated induction of mid-gut esterase activity in the insect. We present evidence that performance of *S. litura* larvae is not only influenced by the proportion of host plant total phenolics to nitrogen alone but the insects' larval mid-gut esterase activity also possibly plays an important role in tandem.

**Materials and Methods**

*S. litura* larvae were obtained from a laboratory culture maintained at 28°C ± 2°C, 60% RH and 12:12 hr L:D photoperiod on an artificial diet.

Host plants used in the present study were castor (*Ricinus communis*, family: Euphorbiaceae), cotton
Chemical composition of host plant according to gravimetric techniques were conducted on a weight basis. Color intensity was recorded using a Shimadzu UV-240 spectrophotometer at 710 nm. A standard curve of p-hydroxybenzaldehyde was prepared fresh each time for quantitative estimation of total phenolics.

Dietary utilization studies in S. litura larvae were done by working out the nutritional indices of larvae fed on different host plants for a full instar duration according to the gravimetric techniques on a dry weight basis.

Mid-gut esterase activity in S. litura larvae was carried out as follows. Larvae fed on different host plants were pooled separately in groups of ten and their mid-guts were dissected out in 1.15% KCl solution and rinsed with 0.04M sodium phosphate buffer (pH 7). Rinsed tissue were then homogenized in 1 ml ice-cold buffer per 3 mid-guts in a motor driven tissue homogenizer. Homogenate thus obtained was centrifuged at 10,000 g for 10 min at 4°C. The supernatant was used directly as enzyme source after appropriate dilution. Mid-gut esterase activity was determined by using 1-naphthyl acetate as the substrate. Protein estimation was done using folin-phenol reagent.

Freshly moulted (0-2 hr old) fifth instar larvae were removed from the stock culture, weighed and kept individually in plastic containers (4.5 cm dia X 5 cm ht) along with pre-weighed amounts of the different host plant leaves. Larvae were allowed to feed at 28° ± 2°C so as to allow the insects to complete a full instar period, after which they were removed and the larvae, frass and remaining food were kept in an oven maintained at 60°C for 48 hr for obtaining constant dry weights. Nutritional indices were calculated on the basis of dry weights. Ten to fifteen larvae were used per host plant with five replications for each host plant on separate occasions.

Student's t-test, linear regression and ANOVA followed by least significant difference (LSD) were used to analyze data.

Results and Discussion

The results are presented in Tables 1-4.

While no attempt has been made to test the effectiveness of individual compounds that may be the main active principle(s) and that may be partially masked in simultaneous estimation of all their inactive companions, the inverse correlation obtained

<table>
<thead>
<tr>
<th>Host plants</th>
<th>Nitrogen (%)</th>
<th>Phenolics (%)</th>
<th>Phenolics:Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>2.29 ± 0.05</td>
<td>6.62 ± 0.78</td>
<td>2.89 ± 0.34</td>
</tr>
<tr>
<td>Cabbage</td>
<td>2.40 ± 0.23</td>
<td>5.17 ± 0.15</td>
<td>1.11 ± 0.11</td>
</tr>
<tr>
<td>Tomato</td>
<td>2.39 ± 0.06</td>
<td>5.52 ± 0.23</td>
<td>2.23 ± 0.12</td>
</tr>
<tr>
<td>Mint</td>
<td>2.65 ± 0.12</td>
<td>14.88 ± 0.95</td>
<td>5.65 ± 0.39</td>
</tr>
<tr>
<td>Castor</td>
<td>3.58 ± 0.23</td>
<td>6.6 ± 0.7</td>
<td>1.88 ± 0.27</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>0.485</td>
<td>1.92</td>
<td>0.818</td>
</tr>
<tr>
<td>1%</td>
<td>0.672</td>
<td>2.65</td>
<td>1.13</td>
</tr>
<tr>
<td>0.1%</td>
<td>0.928</td>
<td>3.67</td>
<td>1.56</td>
</tr>
</tbody>
</table>
between performance and the ratio of total phenolics to nitrogen are encouraging (Table 3).

Among the different host plants, variation in nitrogen content (Table 1) was not significant except castor, which had significantly higher nitrogen content and was also the most preferred host plant as reflected by significantly higher dry weight gain and ECI (Table 2). In contrast, variation of total phenolic content between the host plants tested had no obvious association with performance. However, the ratio of total phenolics to nitrogen was far more consistent in its inverse relationship with preference than either factors alone, i.e., lower the amount of total phenolics that accompanied a given titre of nitrogen, the better the performance by S. littura larvae. Similar findings have been reported in case of woolly aphid30, wherein the susceptibility of various strains of apple to feeding by aphids was inversely correlated with the ratio of phenolics to α-amino nitrogen in the tissue. Deviation from this relationship occurs only in cabbage and it is possibly not due to the proportion of total phenolics to nitrogen alone, since insect performance and feeding preference on a host plant may correspond with different properties of leaves, such as texture, nutritional quality and secondary metabolite content31-33.

Although it has long been suggested that host-plant preference and performance should be positively correlated, the theory and evidence have not been well matched34. Interestingly, increase in mid-gut esterase activity in S. littura larvae fed on different host plants was usually associated with decreasing preference. It has been already demonstrated that esterase activity was influenced by both dietary protein and phenolic glycosides in the western tent caterpillar, Malacosoma disstria, by constraining the insects' ability to perform successfully on foliage containing moderately high levels of phenolic glycosides and low to moderate levels of protein35. It was also suggested that dietary quality could affect the activity of insect esterases and thus could alter the capacity of insects to detoxify phenolic glycosides and ultimately influence host plant preference. Depressed food conversion efficiency could reflect metabolic costs associated with the detoxication of the allelochemicals36 which is possibly reflected in larvae fed on mint leaves, where both ECI and ECD were the lowest (Table 2) vis-à-vis mid-gut esterase activity which was highest (Table 4). The significantly lower ECI and ECD values in larvae fed on cotton and mint leaves (Table 2) were due to higher levels of total phenolics (more precisely higher total phenolics to nitrogen ratio) (Table 1) compared to the other host plants tested. However, the

### Table 2 — Effect of host plants on nutritional parameters in fifth instar larvae of S. littura

<table>
<thead>
<tr>
<th>Host plants</th>
<th>Dry weight gain (mg)</th>
<th>AD (%)</th>
<th>ECI (%)</th>
<th>ECD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>40.93±2.12</td>
<td>54.61±1.40</td>
<td>14.42±0.93</td>
<td>26.22±2.18</td>
</tr>
<tr>
<td>Cabbage</td>
<td>49.92±1.77</td>
<td>54.45±0.91</td>
<td>20.81±0.75</td>
<td>37.47±1.28</td>
</tr>
<tr>
<td>Tomato</td>
<td>46.30±2.03</td>
<td>46.85±2.31</td>
<td>20.98±0.92</td>
<td>45.93±3.10</td>
</tr>
<tr>
<td>Mint</td>
<td>26.64±1.74</td>
<td>35.37±2.26</td>
<td>10.62±0.60</td>
<td>31.85±3.01</td>
</tr>
<tr>
<td>Castor</td>
<td>86.80±2.31</td>
<td>55.11±1.01</td>
<td>25.71±1.29</td>
<td>46.96±2.84</td>
</tr>
</tbody>
</table>

LSD 5%  
| AD (%) | 4.53 | 5.7  |
| 1%     | 5.96 | 7.50 |
| 0.1%   | 7.6  | 9.58 |

AD = Approximate digestibility; ECI = Efficiency of conversion of ingested food; ECD = Efficiency of conversion of digested food

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dry weight gain</th>
<th>ECI</th>
<th>ECD</th>
<th>AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>0.8*</td>
<td>0.451</td>
<td>0.537</td>
<td>0.197</td>
</tr>
<tr>
<td>Total Phenolics</td>
<td>-0.51</td>
<td>-0.784*</td>
<td>-0.358</td>
<td>-0.886*</td>
</tr>
<tr>
<td>Phenolics:Nitrogen</td>
<td>-0.678</td>
<td>-0.891*</td>
<td>-0.5</td>
<td>-0.924*</td>
</tr>
</tbody>
</table>

*P values: * < 0.1; ** < 0.05
suitability/preference of leaves for insects in different host plants and at different developmental phases of leaves may be determined by different compounds. It is also true that the content of phenolics or of any plant secondary metabolites, do not alone determine leaf quality for herbivores; after all, herbivores require nutritive compounds from their diet, as was possibly reflected in larvae fed on cabbage in the present study.

References
3 Olson D M, Platak S C & Lewis W J. Influence of nitrogen levels on cotton plant/insect interactions in a conservative tillage system, in Proceedings of the 22nd annual southern conservation tillage conference for sustainable agriculture edited by J E Hook (Georgia Agriculture Experiment Station Special Publication 95, Athens, GA) 1999, 3.


