Nutritional indices of *Helicoverpa armigera* (Hübner) (Lepidoptera:Noctuidae) on three different host plants

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**ABSTRACT**

Nutritional indices of *Helicoverpa armigera* Hübner (Lepidoptera:Noctuidae) in response to feeding on three different host plants were evaluated under laboratory conditions. Food consumption, assimilation and tissue growth were maximum for the larvae fed on *Lycopersicum esculentum* (tomato) than those of *Pisum sativum* (pea) and *Zea mays* (maize). Mean values of approximate digestibility (AD), efficiency of conversion of digested food into body tissue (ECD) and efficiency of conversion of ingested food into body tissue (ECI) fall in the range of reported values for lepidopterans.

**Key words:** Food plants, *Helicoverpa armigera*, Lepidoptera, Nutritional indices.

**INTRODUCTION**

The cotton bollworm, *Helicoverpa armigera* Hübner (Lepidoptera:Noctuidae), a polyphagous insect pest that attacks most plant structures (including stems, leaves, flower heads and fruits) of important crops in India and worldwide (Tripathy and Singh, 2000., Reddy et al., 2004., Singh, 2005; Srivastava et al., 2005; Moral, Garcia, 2006., Varshney, 2018).

H. armigera larvae are extremely damaging because they prefer to feed and develop on the reproductive structures of crops which are rich in nitrogen and are often harvested (Fitt, 1989; King, 1994).

The quality and quantity of host plants significantly affects the life-history of lepidopteran larvae by affecting the survival rate of different development stages, sex ratio and reproduction (Scriber and Slansky, 1981; Hasan and Ansari, 2010). Energy flow studies through different larval stages of lepidopterans have been reported (Kaushal and Vats, 1983; Cohen and Patana, 1984; Lazraevic and Mataruga, 2003; Bagheri et al., 2011; Namin et al., 2014).

In the present study, nutritional indices of *H. armigera* through the larval stages of *H. armigera* fed on *Lycopersicum esculentum* (tomato), *Pisum sativum* (pea) and *Zea mays* (maize) were investigated under laboratory conditions. The results of this study will provide useful information for designing pest management strategies against *H. armigera*.

**MATERIALS AND METHODS**

**Plant sources:** Leaves of three plant materials *Lycopersicum esculentum* (tomato), *Pisum sativum* (pea), *Zea mays* (maize) were given for feeding larvae till completion of their life-cycle.

**Laboratory Colony:** Eggs of *Helicoverpa armigera* were collected from three different plant leaves and kept in moist petri-dishes until their hatching. On emergence, the larvae were transferred to three food plants in glass beakers (11.0 cm x 9.0 cm) covered with muslin cloth and were maintained in laboratory conditions at 23±1ºC, 75±5% RH and fed with natural diet of above mentioned plant leaves.

Newly hatched larvae were collected from the stock culture and divided into 5 replicates for each of the three plants having 10 larvae up to 2nd instar and 5 larvae in the next consecutive instars and transferred into glass beakers by fine mesh net for ventilation. Fresh leaves were fed daily to the larvae. Some dry tissue papers were also placed on top of wet cotton to maintain the freshness of the leaves provided to the larvae. The beakers were cleaned every day to avoid the risk of humidity and diseases.

Before the start of the experiment, each larva was weighed and provided with fresh food. After 24 h of feeding, the larvae, the unconsumed leaves and the egesta were collected. The larvae were weighed. The unconsumed leaves and the egesta were oven dried at 60°C for 24 h till a constant weight was reached. Dry weight values of food plants and larvae were converted into calorific values, (Kaushal and Vats, 1983). Larvae which died during the course of the experiment were replaced by the larvae of approximately the same age from the stock culture maintained for each host plant. Food consumption was calculated as the difference between the initial weight of the leaves provided and the weight of unconsumed plant material at the end of the experiment, after correcting for weight loss in the food material due to respiration and transpiration within this

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period. Dry weight equivalents of the food consumed were estimated from the percentage of the dry matter in all the three plant species separately. Percentage dry matter was obtained by oven drying of fifteen samples of the leaves of each species at 60°C. The dry weight was expressed as a percentage of the weight of the fresh foliage. Nutritional indices (weight gain, food consumed, faeces produced and various efficiencies of food utilization) were calculated as described by Waldbauer (1968). Assimilation was calculated by subtracting the weight of faecal matter from the weight of the food consumed, while increase in body weight was taken as a measure of tissue growth.

**Ecological efficiencies were calculated as follows:**

Approximate digestibility = Assimilation/Consumption x 100

Tissue growth efficiency = Tissue growth/Assimilation x 100

Ecological growth efficiency (ECI) =

Tissue growth/Consumption x 100

**RESULTS AND DISCUSSION**

The data on duration of instars, consumption, egesta, assimilation and tissue growth are presented in Table 1.

No significant difference was observed in the duration of instars fed on three different food plants.

**Consumption:** The larvae consumed a total of 3086.72 cal, 5639.4 cal and 711.18 cal, of pea, tomato and maize leaves, respectively.

The percentage requirements of food for the consecutive stages calculated from total consumption for the whole development were: 4.56, 5.09, 5.92, 7.07, 37.24 and 40.14% on pea; 3.95, 4.64, 12.15, 16.69, 30.82 and 31.75% on tomato and 14.2, 15.49, 16.49, 17.26, 17.88 and 18.68% on maize, respectively.

Feeding behaviour of *H. armigera* larvae showed strong preference for *Pisum sativum* and *L. esculentum* than *Z. mays*.

The steep increase in the amount of food consumed during, third, fourth, fifth and sixth instar was due to the change in the way the larvae feed and the duration of these instars. The larvae of first and second instars feed on the lower surface of the leaves, eating chiefly the soft plant tissue. In the later stages, the larvae disperse and feed upon small veins containing more cellulose which is poorly digested (Strawinski, 1929). The nutritional requirements of an insect are associated with the biomass of immature stages. Similar observations have also been reported for other lepidopteran larvae (Schroder, 1976; Kaushal and Vats, 1983). Total consumption value for *H. armigera* was higher on *P. sativum* and *L. esculentum* than *Z. mays* in the present study. More than 80% of the total food was consumed by the last three larval instars because of their higher biomass; this is the case for all three food plants.

Naseri *et al.* (2010), Bisht *et al.* (2012), Hemati *et al.* (2012) and Namin *et al.* (2014) also observed maximum consumption values in the last two/three instars of lepidopteran larvae. Bailey and Singh (1977) reported that sixth instar larva of *Mamestra configurata* alone consumed 80% of the total ingestion.

**Egesta:** Higher consumption in the fourth, fifth and sixth instars resulted in higher amount of egesta produced by the larvae and accounted for 89 to 93% of total egestion. A curvilinear and positive correlation was observed for the food consumed and egesta produced by the larvae and accounted for 89 to 93% of total egestion. A curvilinear and positive correlation was observed for the food consumed and egesta produced by the larvae and accounted for 89 to 93% of total egestion. A curvilinear and positive correlation was observed for the food consumed and egesta produced by the larvae and accounted for 89 to 93% of total egestion.

**Tissue growth:** The larvae of first and second instars feed on the lower surface of the leaves, eating chiefly the soft plant tissue. In the later stages, the larvae disperse and feed upon small veins containing more cellulose which is poorly digested (Strawinski, 1929). The nutritional requirements of an insect are associated with the biomass of immature stages. Similar observations have also been reported for other lepidopteran larvae (Schroder, 1976; Kaushal and Vats, 1983). Total consumption value for *H. armigera* was higher on *P. sativum* and *L. esculentum* than *Z. mays* in the present study. More than 80% of the total food was consumed by the last three larval instars because of their higher biomass; this is the case for all three food plants.

**Table 1: Duration of instar, consumption, egesta, assimilation and tissue growth in *Pieris brassicae* larvae fed on three host plants.**

| Stage   | Duration of instar (days) | Consumption (cal insect^{-1} day^{-1}) | Egesta (cal insect^{-1} day^{-1}) | Assimilation (cal insect^{-1} day^{-1}) | Tissue growth (cal insect^{-1} day^{-1}) |
|---------|---------------------------|----------------------------------------|-----------------------------------|-----------------------------------------|------------------------------------------|
| 1st instar | 4.9 ± 0.87                | 202.76 ± 4.43                          | 2.05 ± 0.02                       | 200.71 ± 4.41                          | 1.02 ± 0.01                              |
| 2nd instar | 4.6 ± 0.54                | 232.07 ± 2.88                          | 2.06 ± 0.02                       | 230.01 ± 2.89                          | 2.73 ± 0.07                              |
| 3rd instar | 4.6 ± 0.54                | 661.19 ± 4.80                          | 6.81 ± 0.03                       | 654.38 ± 4.79                          | 30.54 ± 6.77                             |
| 4th instar | 4.8 ± 0.44                | 950.50 ± 7.03                          | 16.10 ± 0.15                      | 934.4 ± 6.92                           | 28.60 ± 1.08                             |
| 5th instar | 6.4 ± 0.54                | 1717.13 ± 18.49                        | 40.75 ± 1.12                      | 1676.38 ± 17.92                        | 80.93 ± 3.03                             |
| 1st instar | 4.0 ± 0.94                | 118.43 ± 5.20                          | 1.64 ± 0.15                       | 116.79 ± 5.17                          | 0.54 ± 0.18                              |
| 2nd instar | 3.6 ± 0.54                | 131.75 ± 7.92                          | 2.24 ± 0.04                       | 129.51 ± 7.88                          | 4.50 ± 2.30                              |
| 3rd instar | 4.6 ± 0.54                | 184.04 ± 9.10                          | 12.28 ± 1.92                      | 171.76 ± 7.65                          | 63.05 ± 9.91                             |
| 4th instar | 5.4 ± 0.54                | 1132.36 ± 7.64                         | 36.62 ± 12.24                     | 1095.74 ± 8.30                         | 61.94 ± 6.82                             |
| 5th instar | 6.6 ± 0.54                | 1216.82 ± 10.92                        | 105.82 ± 5.09                     | 1110.99 ± 11.69                        | 66.84 ± 5.53                             |
| 1st instar | 4.0 ± 0.81                | 155.01 ± 3.71                          | 0.70 ± 0.13                       | 154.31 ± 3.58                          | 1.74 ± 0.07                              |
| 2nd instar | 4.4 ± 0.54                | 171.17 ± 5.27                          | 0.24 ± 0.42                       | 170.93 ± 6.22                          | 3.22 ± 0.21                              |
| 3rd instar | 4.6 ± 0.54                | 520.96 ± 8.21                          | 14.51 ± 3.77                      | 506.45 ± 6.75                          | 86.17 ± 9.83                             |
| 4th instar | 4.6 ± 0.54                | 931.17 ± 7.54                          | 37.81 ± 5.72                      | 893.36 ± 2.91                          | 123.70 ± 8.77                            |
| 5th instar | 6.6 ± 0.54                | 2033.66 ± 7.89                         | 142.94 ± 5.53                     | 1890.72 ± 2.62                         | 132.79 ± 6.12                            |
Table 2: Efficiencies of food utilization in *Pieris brassicae* larvae fed on three host plant species (mean ± SD).

| Stage  | Approximate digestibility (AD) (%) | Tissue growth efficiency (ECD) (%) | Ecological growth efficiency (ECI) (%) |
|--------|-----------------------------------|-----------------------------------|---------------------------------------|
|        |                                   |                                   |                                        |
| *Pisum sativum* (pea) |                                   |                                   |                                        |
| 1\textsuperscript{st} instar | 98.63 ± 0.00 | 1.24 ± 0.00 | 1.22 ± 0.00 |
| 2\textsuperscript{nd} instar | 98.37 ± 0.02 | 2.67 ± 0.03 | 2.63 ± 0.03 |
| 3\textsuperscript{rd} instar | 91.46 ± 0.25 | 59.1 ± 1.17 | 54.05 ± 1.41 |
| 4\textsuperscript{th} instar | 69.75 ± 0.95 | 88.00 ± 0.19 | 61.39 ± 1.39 |
| 5\textsuperscript{th} instar | 91.84 ± 0.26 | 13.93 ± 0.28 | 12.79 ± 0.23 |
| 6\textsuperscript{th} instar | 90.27 ± 0.27 | 13.55 ± 0.01 | 12.24 ± 0.02 |
| *Lycopersicum esculentum* (tomato) |                                   |                                   |                                        |
| 1\textsuperscript{st} instar | 98.82 ± 0.15 | 0.48 ± 0.02 | 0.48 ± 0.02 |
| 2\textsuperscript{nd} instar | 98.80 ± 0.01 | 1.09 ± 0.05 | 1.09 ± 0.02 |
| 3\textsuperscript{rd} instar | 98.24 ± 0.02 | 3.98 ± 0.33 | 3.91 ± 0.33 |
| 5\textsuperscript{th} instar | 97.63 ± 0.03 | 3.70 ± 0.26 | 3.61 ± 0.26 |
| 6\textsuperscript{th} instar | 98.06 ± 0.89 | 4.42 ± 0.17 | 4.32 ± 0.16 |
| *Zea mays* (Maize) |                                   |                                   |                                        |
| 1\textsuperscript{st} instar | 99.57 ± 0.44 | 1.00 ± 0.00 | 0.99 ± 0.00 |
| 2\textsuperscript{nd} instar | 99.57 ± 1.02 | 2.43 ± 0.06 | 3.03 ± 0.06 |
| 3\textsuperscript{rd} instar | 99.15 ± 0.04 | 12.56 ± 2.04 | 16.23 ± 2.02 |
| 4\textsuperscript{th} instar | 98.99 ± 0.03 | 35.76 ± 4.52 | 35.40 ± 4.46 |
| 5\textsuperscript{th} instar | 95.2 ± 0.15 | 52.97 ± 1.92 | 50.50 ± 1.69 |
| 6\textsuperscript{th} instar | 91.12 ± 0.67 | 67.65 ± 0.64 | 61.65 ± 0.27 |

Fig 1(a-c): Relationship between consumption and egesta. (a) *Pisum sativum* (pea) (b) *Lycopersicum esculentum* (tomato), (c) *Zea mays* (maize).
Fig 2(a-c): Relationship between consumption and assimilation. (a) Pisum sativum (pea) (b) Lycopersicum esculentum (tomato), (c) Zea mays (maize).

Data on consumption and tissue growth in the present study showed that the larvae of *H. armigera* grew on all three food plant almost equally although amount of food consumed was less when larvae were fed on maize leaves than pea and tomato.

90 to 95% of the total tissue growth occurred in the last two instars of *Platysomia cercopia* (Schroeder, 1973), *Mamestra configurata* (Bailey and Singh, 1977) and *H. armigera* (Namin et al., 2014). Almost similar results have been obtained in the present study.

**Efficiencies of food utilization:** Percentage values of approximate digestibility (AD), efficiency of conversion of ingested food into body tissue (ECI) and the efficiency of conversion of digested food into body tissue (ECD) are given in Table 2.
ECI is a measure of an insect's ability to incorporate ingested food into tissue growth and ECD as a parallel parameter, indicates the proportion of digested food converted into net insect biomass (Nathan et al., 2005).

No set pattern in values of ECD and ECI were recorded in *H. armigera*. Mean ECD values obtained for pea, tomato and maize were: 29.7%, 3.5% and 28.7% respectively. Mean ECI was 28.9% for the larvae fed on pea, 3.5%, on tomato and 33.6% for those fed on maize.

The lowest ECI and ECD values were observed when larvae were fed on tomato leaves, suggesting that the larvae were less efficient at converting ingested and digested food to body biomass or due to lack of nutritional components.

The significant differences obtained for these nutritional indices of fourth to sixth instar larva of *H. armigera* in the present study indicated that the host plants fed had different nutritional values.

It was observed in the present study that nutritional responses for fourth to sixth instar larvae of *H. armigera* were different from each other and are similar to other reported studies (Naseri et al., 2010; Arghand et al., 2011; Maha Lakshmi and Prasad, 2014., Namin et al., 2014). Insect growth is directly correlated with nutrient input; larvae fed with high nutrient food show faster growth rates than those fed nutrient-poor food (Hwang et al., 2008). The decreased growth of larvae fed on tomato despite high values of AD in the present study could be due to decreased consumption, utilization or both. It appeared that high AD could not compensate for low ECD, which consequently resulted in lower growth rate, in the present study and is in accordance with the findings of Lazarevic and Peric-Mataruga (2003).
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