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Research Article

Effect of host plants on nutritional performance of cotton bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae)

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Abstract: In this study, the nutritional indices of the larval stages of *Helicoverpa armigera* were determined on four vegetable crops under laboratory conditions (25 ± 1 °C, 65 ± 5% RH, with a 16:8 (L: D) h photoperiod). The third instar larvae reared on potato showed the highest value of efficiency on the conversion of ingested food (ECI) and efficiency of conversion of digested food (ECD) (8.281 ± 0.767% and 11.016 ± 1.142%, respectively). The highest (0.129 ± 0.014 mg/mg/day) and lowest (0.069 ±0.012 mg/mg/day) relative growth rate (RGR) of the fourth instar larvae were obtained on potato and tomato, respectively. Data indicated that the highest value of (ECI) and (ECD) for fourth instar larvae were on tomato (12.361 ± 2.258% and 18.588 ± 3.834%, respectively). The lowest value of the relative consumption rate (RCR) and approximate digestibility (AD) of the fifth instar was recorded on tomato (0.592 ± 0.063 mg/mg/day) and potato (51.85 ± 4.607%), respectively. The ECI and ECD values of the fifth larval instar were the highest on tomato (12.477 ± 1.333% and 17.624 ± 1.609%, respectively). Overall, among different host plants tested, the highest ECI and ECD of all the larval instars were observed on tomato (9.813 ± 0.692% and 12.506 ± 0.882%, respectively), and the lowest values (3.735 ± 0.201% and 5.463 ± 0.426%) were on artichoke. Tomato and artichoke were the most nutritionally suitable and unsuitable host plants, respectively, for *H. armigera*.

Keywords: host plants, RCR, RGR, nutritional indices, *Helicoverpa armigera*

Introduction

The cotton bollworm *Helicoverpa armigera* (Hübner, 1808) (Lepidoptera: Noctuidae) is a polyphagous defoliator that attacks a wide range of cultivated plants (Brown and Dewhurst, 1975; Holloway, 1989). It has a diverse host range of at least 87 plant species from 40 plant families, including several vegetables, fruits, and ornamental crops (Salama *et al*., 1970). Many vegetable crops are affected by *Helicoverpa armigera*, including tomato, pepper, eggplant, lettuce, artichoke, strawberry, and asparagus, but it also harms ornamentals and herbs (Lanzoni *et al*., 2012).

Helicoverpa armigera is reported in Algeria as well as many other African and

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Mediterranean regions, including Cyprus, Malta, Morocco, Italy, Greece, and Spain (Salama *et al*., 1970; Ahmad, 1988; Blackford *et al*., 1997; Champion *et al*., 1997; Azab *et al*., 2001; Hatem *et al*., 2009).

Different host plants may have a crucial influence on polyphagous insect pest population expansion and outbreaks (Singh and Parihar, 1988; Lu and Xu, 1998). Nutritionally, consumption efficiency represents the quality and amount of food ingested (Naseri *et al*., 2010; Baghery *et al*., 2013), which may greatly affect insect development, survival, reproduction, and life table parameters (Scriber and Slansky, 1981; Tsai and Wang, 2001; Kim and Lee, 2002). Low-quality plants may decrease insect survival, size or weight, lifespan, and reproductive potential or indirectly increase their susceptibility to natural predators due to extended development time (Ali and Gaylor, 1992; Awmack and Leather, 2002; Chen *et al*., 2008). As a result, the current study focuses on the quantitative consumption rate of several vegetable crops grown in Algeria and the food utilization of *H. armigera* in the four host plants, artichoke, cabbage, potato, and tomato. The findings may help enhance pest management strategies for vegetable crops.

Materials and Methods

The current research was conducted at Algeria's National Institute of Agronomic Research, Hmadna Experimental Station, Algeria (35° 54' N. and 0° 47' E. with an altitude of 48 m) to study the effect of different host plants on the nutritional indices of *H. armigera* larvae. The experiment was performed at a constant temperature 25 ± 1 °C, 65 ± 5% RH, with a 16:8 (L: D) h photoperiod.

Host plants

Four host plants used in this experiment were cabbage *Brassica oleracea* L., globe artichoke *Cynara scolymus* L., potato *Solanum tuberosum* L., and tomato *Solanum lycopersicum* L. These plants were selected due to their importance as vegetable crops in Algeria. All plant materials tested in this experiment were obtained from insecticide-free plants cultivated in the field.

Insect

The cotton bollworm *Helicoverpa armigera* larvae were collected initially from artichoke fields in October 2017 and reared on artichoke until pupation. Newly emerged adults of *H. armigera* were transferred into plastic jars for mating and egg laying. Adults were fed with 10% honey solution impregnated onto cotton wool.

Experiments

Newly hatched larvae collected from stock culture were reared on mentioned host plants. Fifty larvae were used in each of the four host plant treatments. Nutritional indices were determined using third to sixth instar larvae of *H. armigera* on each host plant, as they were easier to measure than the primary instars. For this purpose, leaves and larvae were weighed and placed inside plastic containers (Diameter 8 cm, Depth, 7 cm), with a hole covered by a mesh net for ventilation. After 24 h, the weights of the larvae were recorded daily before and after feeding until they finished feeding and reached the prepupal stage. The initial fresh leaves and the leaves and feces remaining at the end of each experiment were weighed daily. Plastic containers were cleaned, and newly weighed leaves were supplied. Sixth instars were kept in plastic tubes (4 cm diameter, 5 cm deep) for prepupation and pupation.

Extra specimens (20 for each) were weighed, oven-dried (48 hours at 60 °C), and re-weighed to establish a percentage of their dry weight to determine the dry weights of leaves, excrement, and larval through adult stages. The pre-pupa, pupa, and adults of the larvae grown on each host plant were also weighed. The amount of food consumed was calculated by subtracting the residual diet at the end of each trial from the total weight of food supplied. Food utilization rates were then

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calculated based on the formulas of Waldbauer (1968): CI (Consumption index), AD (Approximate digestibility), ECI (Efficiency of conversion of Ingested food), ECD (Efficiency of conversion of digested food), RCR (Relative consumption rate), and RGR (Relative growth rate):

$$CI = \frac{E}{A}$$

$$RCR = \frac{E}{A \times T}$$

$$RGR = \frac{P}{A \times T}$$

$$AD = \frac{E - F}{E} \times 100$$

$$ECI = \frac{P}{E} \times 100$$

$$ECD = \frac{P}{E - F} \times 100$$

P–dry weight gain (g), A–initial and final mean dry weights of the larvae during feeding period (g), E–dry weight of food ingested (g), T–duration of feeding period (days), F–the dry weight of feces produced (g).

Statistical analysis

Nutritional indices of *H. armigera* reared on different host plants were analyzed with one-way ANOVA using the statistical software XLSTAT to find significant differences. Statistical differences among the means were assessed using the LSD test (α = 0.05). A dendrogram of different host plants based on nutritional indices of whole larval instars of *H. armigera* was created after cluster analysis by Ward's method using XLSTAT statistical software.

Results

The results of the nutritional indices of the third, fourth, and fifth and whole larval instars of *H. armigera* are presented in Tables 1, 2, 3, and 4. Different host plants had significant effects on nutritional indices of *H. armigera* ($p < 0.05$).

Nutritional indices of third instar larvae of *H. armigera* were significantly different on various host plants except for RCR, ECD, and ECI. The highest and lowest values of CI (F = 3.35; df = 3, 39; P = 0.02) resulted from feeding *H. armigera* tomato and cabbage, respectively. The highest and lowest AD values (F = 20.53; df = 3, 39; P < 0.0001) resulted from feeding the third instar larvae tomato and potato, respectively. The larvae fed on potato showed the highest value of RGR (F = 5.68; df = 3, 39; P = 0.002), and the lowest value of RGR was from feeding on tomato. The nutritional indices of fourth instar larvae are shown in table 2; the data showed significant differences among nutritional indices of fourth instar larvae of *H. armigera* on the four host plants. The highest and lowest CI values (F = 14.492 df = 3, 39; P < 0.0001) were observed on cabbage and tomato, respectively. The larvae fed on tomato had the highest ECD (F = 5.82; df = 3, 39; P < 0.01) and ECI (F = 10.43; df = 3, 39; P < 0.0001), while the lowest values of ECD and ECI were recorded on cabbage (5.84 and 3.72%, respectively). The highest AD (F = 9.49; df = 3, 39; P < 0.0001) was on tomato (70.62%), and the lowest value was on potato. The RGR index ((F = 3.49; df = 3, 39; P = 0.02) and RCR (F = 11.87; df = 3, 39; P < 0.0001) had the highest values when larvae fed on potato and cabbage, respectively. The lowest values of RGR and RCR were those of larvae fed on tomato (Table 2). The indices of fifth instar larvae are shown in table 3. The results indicated that host plants had a highly significant effect on nutritional indices except for RGR. The highest and lowest CI values (F = 27.03; df = 3, 39; P < 0.0001) were those of artichoke and tomato, respectively. The larvae fed on artichoke and potato had the highest and lowest values of AD, respectively (F = 6.92; df = 3, 39; P < 0.0001). The highest and lowest ECI values (F = 30.41; df = 3, 39; P < 0.0001) were when larvae fed on tomato and artichoke, respectively. The ECD values (F = 20.98; df = 3, 39; P < 0.0001) of *H. armigera* fifth instars were highest when reared on tomato and lowest when fed on the artichoke. The highest value of RCR (F = 17.72; df = 3, 39; P < 0.0001) was observed on the artichoke.

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Table 1 Nutritional indices (Mean ± SE) of third instar larvae of *Helicoverpa armigera* on different host plants.

Host plants	RGR (mg/mg/day)	RCR (mg/mg/day)	ECD (%)	ECI (%)	CI	AD (%)	E (g)	F (g)	P (g)
Artichoke	0.179 ± 0.019a	2.349 ± 0.244ab	10.28 ± 1.029ab	7.973 ± 0.725a	7.863 ± 0.848b	78.072 ± 1.393c	1.827 ±0.146ab	0.400 ± 0.040a	0.142 ± 0.014a
Cabbage	0.184 ± 0.012a	2.423 ± 0.223a	9.937 ± 0.965ab	7.813 ± 0.476a	6.789 ± 0.411b	83.06 ± 1.935b	1.789 ± 0.082ab	0.337 ± 0.057a	0.138 ± 0.008a
Potato	0.196 ± 0.031a	2.635 ± 0.551a	11.016 ± 1.142 a	8.281 ± 0.767a	8.814 ± 0.977ab	75.995 ± 1.825c	1.888 ± 0.126a	0.454 ± 0.046a	0.151 ± 0.010a
Tomato	0.094 ± 0.006b	1.418 ± 0.130b	7.590 ± 0.588b	6.939 ± 0.503a	10.295 ± 0.890a	91.678 ± 0.668a	1.520 ± 0.068b	0.126 ± 0.011b	0.104 ± 0.007b
F (df = 3)	5.6823	2.7054	2.4117	0.8309	3.3581	20.5976	2.1800	11.6036	4.1638
P	0.0027	0.0597	0.0828	0.4856	0.0293	< 0.0001	0.1073	< 0.0001	0.0125

The means followed by the same letters in each column are not significantly different (P < 0.05, LSD) RCR= relative consumption rate, RGR = relative growth rate, ECI = efficiency of conversion of ingested food, ECD = efficiency of conversion of digested food, CI = consumption index, AD = approximate digestibility, P = dry weight gain, E = dry weight of food ingested, F= the dry weight of feces produced.

Table 2 Nutritional indices (Mean ± SE) of fourth instar larvae of *Helicoverpa armigera* on different host plants.

Host plants	RGR (mg/mg/day)	RCR (mg/mg/day)	ECD (%)	ECI (%)	CI	AD (%)	E (g)	F (g)	P (g)
Artichoke	0.095 ± 0.012ab	1.780 ± 0.190b	11.143 ± 1.666b	5.515 ± 0.554b	5.814 ± 0.842b	52.991 ± 3.130b	3.424 ± 0.343b	1.556 ± 0.124a	0.175 ± 0.009a
Cabbage	0.112 ± 0.016a	3.585 ± 0.640a	5.849 ± 0.896b	3.724 ± 0.497b	9.147 ± 1.071a	65.598 ± 2.062a	4.792 ± 0.418a	1.617 ± 0.131a	0.161 ± 0.014a
Potato	0.129 ± 0.014a	2.575 ± 0.322ab	10.416 ± 0.914b	5.105 ± 0.296b	5.709 ± 0.656b	50.720 ± 2.882b	3.916 ± 0.362ab	1.901 ± 0.167a	0.193 ± 0.011a
Tomato	0.069 ± 0.012b	0.559 ± 0.042c	18.588 ± 3.834a	12.361 ± 2.256a	2.084 ± 0.145c	70.622 ± 4.110a	0.843 ± 0.055c	0.252 ± 0.042b	0.100 ± 0.016b
F (df = 3)	3.493	11.867	5.822	10.436	14.425	9.493	26.999	34.765	9.920
P	0.025	< 0.0001	0.002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

The means followed by the same letters in each column are not significantly different (P < 0.05, LSD) RCR = relative consumption rate, RGR = relative growth rate, ECI = efficiency of conversion of ingested food, ECD = efficiency of conversion of digested food, CI = consumption index, AD = approximate digestibility, P = dry weight gain, E = dry weight of food ingested, F = the dry weight of feces produced.

Table 3 Nutritional indices (Mean ± SE) of fifth instar larvae of *Helicoverpa armigera* on different host plants.

Host plants	RGR (mg/mg/day)	RCR (mg/mg/day)	ECD (%)	ECI (%)	CI	AD (%)	E (g)	F (g)	P (g)
Artichoke	0.048 ± 0.009ab	1.841 ± 0.165a	3.746 ± 0.690c	2.609 ± 0.388b	7.144 ± 0.648a	74.124 ± 3.221a	7.209 ± 0.905a	1.654 ± 0.129a	0.161 ± 0.010ab
Cabbage	0.058 ± 0.011ab	1.528 ± 0.175a	7.174 ± 1.500bc	3.937 ± 0.728b	4.055 ± 0.333b	58.306 ± 4.189b	3.757 ± 0.390b	1.517 ± 0.189a	0.127 ± 0.013b
Potato	0.044 ± 0.005b	0.981 ± 0.091b	9.468 ± 1.153b	4.513 ± 0.407b	4.262 ± 0.197b	51.580 ± 4.607b	4.002 ± 0.185b	1.914 ± 0.180a	0.176 ± 0.011a
Tomato	0.074 ± 0.011a	0.592 ± 0.063c	17.624 ± 1.609a	12.477 ± 1.333a	2.210 ± 0.211c	71.095 ± 4.025a	1.483 ± 0.130c	0.449 ± 0.090b	0.182 ± 0.020a
F (df = 3)	1.9571	17.7231	20.9844	30.4172	27.0364	6.9230	21.6947	17.9174	3.0977
P	0.1379	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0008	< 0.0001	< 0.0001	0.0388

Means in a column followed by the same lettersare not significantly different (P < 0.05, LSD) RCR = relative consumption rate, RGR = relative growth rate, CI = consumption index, ECI = efficiency of conversion of ingested food, ECD = efficiency of conversion of digested food, AD = approximate digestibility, P = dry weight gain, E = dry weight of food ingested, F = the dry weight of feces produced.

Table 4 Nutritional indices (Mean ± SE) of three larval instars of *Helicoverpa armigera* on different host plants as a whole.

Host plants	RGR (mg/mg/day)	RCR (mg/mg/day)	ECD (%)	ECI (%)	CI	AD (%)	E (g)	F (g)	P (g)
Artichoke	0.086 ± 0.005b	2.312 ± 0.113b	5.463 ± 0.426c	3.735 ± 0.201b	25.893 ± 2.107ab	69.762 ± 2.495b	12.460 ± 0.869a	3.610 ± 0.176b	0.455 ± 0.022a
Cabbage	0.131 ± 0.011a	3.243 ± 0.400a	6.462 ± 0.372c	4.215 ± 0.213b	26.948 ± 2.625a	65.827 ± 2.218b	10.338 ± 0.722b	3.471 ± 0.247b	0.425 ± 0.017ab
Potato	0.091 ± 0.006b	2.006 ± 0.106b	8.254 ± 0.631b	4.618 ± 0.321b	21.479 ± 1.263b	56.428 ± 1.913c	9.806 ± 0.354b	4.269 ± 0.243a	0.445 ± 0.022a
Tomato	0.078 ± 0.005b	0.805 ± 0.047c	12.506 ± 0.882a	9.813 ± 0.692a	12.060 ± 0.744c	78.835 ± 2.116a	3.846 ± 0.165c	0.827 ± 0.101c	0.372 ± 0.022b
F (df = 3)	11.321	21.750	25.905	48.183	13.657	17.893	38.160	57.181	3.193
P	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0350

Means in a column followed by the same letters are not significantly different (P < 0.05. LSD) RCR = relative consumption rate. RGR = relative growth rate. CI = consumption index. ECI = efficiency of conversion of ingested food. ECD = efficiency of conversion of digested food. AD = approximate digestibility. P = dry weight gain. E = dry weight of food ingested. F = the dry weight of feces produced.

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The nutritional indices of the third, fourth, and fifth instars combined are shown in table 4, indicating that host plants significantly affected all nutritional indices. The highest and lowest values of CI ($F = 13.65$; df = 3, 39; $P < 0.0001$) resulted from larvae fed on cabbage and tomato, respectively. The highest and lowest AD ($F = 17.89$; df = 3, 39; $P < 0.0001$) belonged to larvae reared on tomato and potato, respectively. The highest ECI ($F = 48.18$; df = 3, 39; $P < 0.0001$) and ECD ($F = 25.90$; df = 3, 39; $P < 0.0001$) values were resulted from larvae fed on tomato, and the lowest was recorded on the artichoke. RGR ($F = 11.32$; df = 3, 39; $P < 0.0001$) and RCR ($F = 21.74$; df = 3, 39; $P < 0.0001$) had the highest values when larvae reared on cabbage, the lowest values were from larvae fed on tomato. The larval weight, food consumed, and feces produced for the combined larval instars are shown in table 4. Larval weight ($F = 3.19$; df = 3, 39; $P < 0.0001$) and food consumed ($F = 38.16$; df = 3, 39; $P < 0.05$) were highest on artichoke (0.45 and 12.46 g, respectively) and lowest on tomato (0.37 and 3.84 g, respectively). The highest and lowest values of feces produced ($F = 57.1$; df = 3, 39; $P < 0.0001$) were on potato (4.26 g) and tomato (0.827 g).

Different host plants significantly affected prepupal, pupal, and adult weights. The highest prepupal ($F = 11.33$; df = 3, 39; $P < 0.0001$) and pupal weights ($F = 17.19$; df = 3, 39; $P < 0.0001$) were obtained from larvae reared on artichoke. However, larvae fed on tomato showed the lowest values. The highest adult weight ($F = 8.01$; df = 3, 39; $P < 0.0001$) was on potato (0.17 g), and the lowest was on tomato (Fig. 1).

Cluster analysis

Figure 2 shows a dendrogram based on nutritional parameters of the combined larval instars of *H. armigera* grown on four host plants. The dendrogram reveals two distinct clusters: A (A1 and A2) and B. The cluster A consisted of subclusters A1 (artichoke and cabbage) and A2 (Potato). Cluster B included tomato.

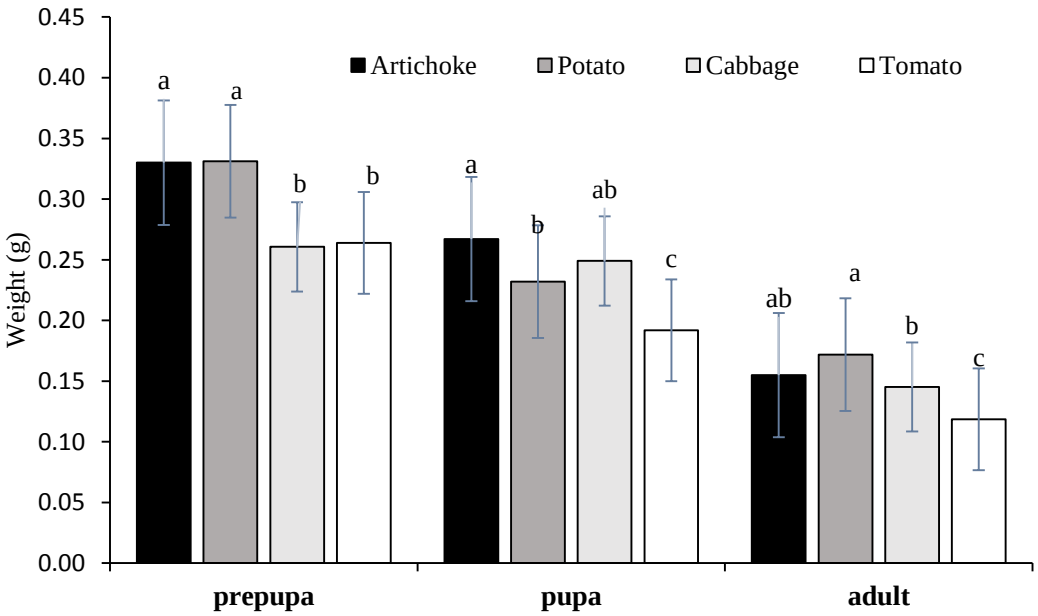

Figure 1 Prepupae, pupae and adults weights of *Helicoverpa armigera* on different host plants.

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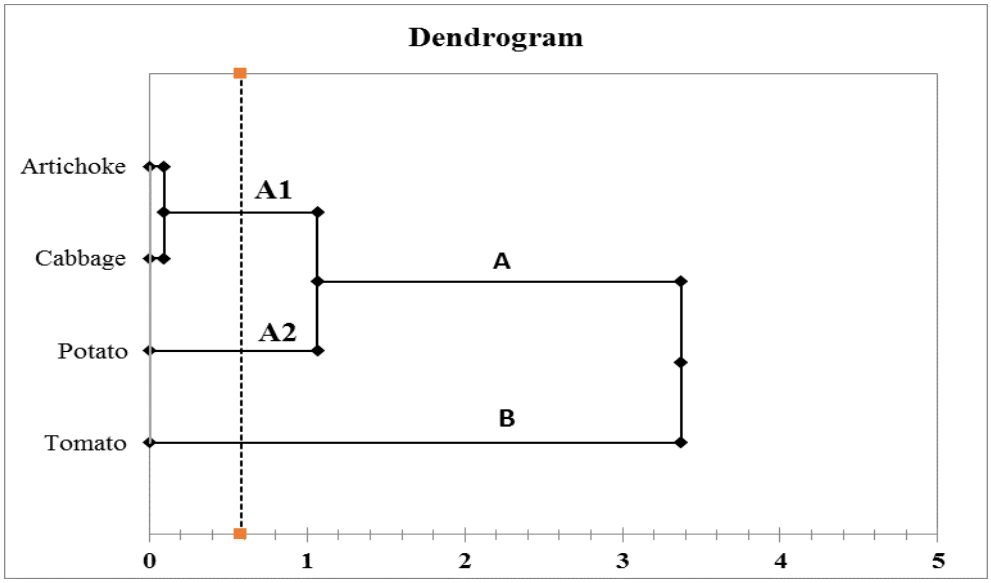

Figure 2 Dendrogram of four host plants based on nutritional indices of *Helicoverpa armigera.*

Discussion

In this study, the nutritional indices, particularly ECI and ECD values of *H. armigera* reared on different host plants, were significantly different, which suggests that host plants had different nutritional values. Among nutritional indices, ECI is an indicative index of an insect's ability to utilize the ingested food for growth and development, and ECD is an index of the efficiency of conversion of digested food into growth (Nathan *et al*., 2005). The data generated for the *H. armigera* third to fifth instars larvae are discordant with one another because the nutritional requirements of the insect vary during development, and such differences often result in changes in food consumption and utilization (Barton Browne, 1995). When the amount of food consumed is reduced, the period of growth is usually prolonged, and the insect remains smaller and lighter. Another explanation might be the extended instar period when a larger amount of food must be consumed to sustain metabolism (Phillipson, 1981; Schroeder, 1981).

The fourth instar data revealed that the larvae that fed on potato had the highest ECI and ECD values. High ECI and ECD values indicate that the larval feeding and weight have improved. Consequently, larger pupae are produced, which has a direct correlation to adult fertility, which is ecologically very important for the survival of this insect (Daryaei *et al*., 2007; Kouhi *et al*., 2014). RGR is the rate of weight gain per unit of time. RCR, on the other hand, is the amount of food consumed per unit of insect body per unit of time (Talaee *et al*., 2017). The period of the developmental stages can be influenced by the suitability of the host plant (Hwang *et al*., 2008). Results showed that tomato-fed larvae had the greatest AD and nearly the lowest ECD as third instars. The rise in AD value was insufficient to compensate for the decrease in ECD value, resulting in a low growth rate. Third instar larvae fed on tomato had the highest AD and almost the lowest ECI and ECD values. In line with our result, Fite *et al*. (2018) reported that when third instar *H. armigera* larvae were raised on tomato Hashem, they had the greatest AD and lowest ECD. A higher CI value for the whole *H. armigera* larval instar on cabbage suggested that the intake rate compared to the mean larval weight throughout the feeding period was the highest on this host plant. The AD value of the combined larval instars fed on tomato was similar to those reported by Fite *et al*. (2018) on tomato var. Koshary (77.9 ± 1.92%), but different from those reported by Hemati *et al*. (2012) on tomato var. Meshkin (67.470 ±

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0.016%) and nearly similar to those of Kouhi *et al*. (2014) (80.97 ± 1.17%) on tomato var. Korral. This variation is likely due to differences in tomato cultivars, which differ in acidity and secondary chemical compounds. The lowest value of AD in combined larval instars belonged tolarvae fed on potato; this finding is in line with those of Hemati *et al*. (2012) on potato var. Agria (57.26 ± 0.003%). Among different host plants, the highest ECI and ECD values of the combined larval instars were observed on tomato, indicating that they were more efficient at the conversion of ingested and digested food to biomass in the larval body. The results for ECI and ECD values of the larvae that fed on tomato was nearly similar to those reported by Kouhi *et al*. (2014) on tomato and Fathipour *et al*. (2018) on canola var. Hayula. The mean ECD value of entire larval instarsreared on various tomato cultivars was lower than those obtained by Naseri *et al*. (2010) on soybean cultivars (60.592 ± 2.012%).

Data of fourth instar nutritional indices show that the larvae fed on tomato had the highest ECD and ECI values, whereas those raereded on cabbage had the lowest. On the other hand, the lowest AD at the fourth stage was recorded in potato. This finding suggests that increased intake does not always imply improved digestion. Different variables, such as secondary biochemicals, might induce decreased digestibility, resulting in delayed development despite consuming a significant amount of food (Price *et al*., 2011; Panizzi and Parra. 2012). The fifth instar larvae reared on artichoke had the highest value of RCR and lowest ECI and ECD values. Besides. The highest AD value was recorded on artichoke, which can be explained by the highest quantity of food consumed by larvae fed on artichoke. Our results are similar to those of Baghery *et al*. (2013) on corn with the highest RCR and AD values and the lowest ECI and ECD.

The decrease in ECI of *H. armigera* larvae may result from the reduced efficiency in converting ingested food into growth. According to Batista Pereira *et al*. (2002), the larvae fed on corn had the lowest value of ECD compared with other host plants, indicating that these larvae have less efficiency in converting digested food to their biomass. It is well known that the degree of food utilization depends upon the digestibility of food and the efficiency with which digested food is converted into biomass (Batista Pereira *et al*., 2002).

In the present study, the lowest RGR was on tomato, possibly due to decreased consumption. The larvae fed on cabbage showed the highest RCR, probably due to unsuitable nutrient content and secondary substances. The high AD in larvae reared on tomato might be due to compensation of nutrient deficiency. Maximum RCR, RGR, and food consumption were observed at the fourth and fifth instars. It is due to a greater ingestion rate and maximum food intake during the fourth and fifth instars. During the development of an insect, its nutritional requirements change, reflecting changes in food consumption and feeding behavior (Barton Browne and Raubenheimer, 2003). Nutritional requirements are positively correlated with biomass and the duration of development (Kumar *et al*., 2008).

For the RGR and RCR values, the duration of the feeding period is an effective factor. Among different host plants, the highest RCR and RGR values of the whole larval instars *H. armigera* were on cabbage, and the lowest were on tomato. Our results indicate that tomato has low nutritional value for larvae of *H. armigera*.

Body weight is an essential fitness measure of insect population dynamics (Liu *et al*., 2004). Pupal weight can be an indirect but simple predictor of lepidopteran fitness (Leuck and Perkins 1972). The pupae produced by larvae reared on tomato were lighter than those produced by larvae reared on other host plants. This supports the idea that tomato is a less favorable host plant for *H. armigera* larvae than the others. Liu *et al*. (2004) demonstrated that different host plants influenced the pupal weight of *H. armigera*, which ranged from 0.167 ± 3.9 gr on tomato to 0.285 ± 4.2 gr on corn. The present findings on the pupal weight of *H. armigera* reared on artichoke (0.267 ± 0.008 gr) were close to those reported by Liu *et al*. (2004) on corn.

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According to Fite *et al*. (2018) highest AD (%) value of the all the larval instars of *H. armigera* was on tomato var. Koshari. Demonstrating that the intake rate was lower than other host varieties in terms of the mean larval dry weight acquired throughout the feeding time, also evidence that larvae fed on this host were less efficient in converting ingested and digested food to biomass. Possibly, due to the lack of nutritional components and the presence of several secondary compounds, tomato Koshari was not a suitable host for *H. armigera* larval growth. According to Batista Pereira *et al*. (2002), the degree of food utilization is determined by the digestibility and the efficiency with which digested food is transformed into biomass. Tomato unsuitability, when fed to *H. armigera*, was also reported by Hemati *et al*. (2012). However, according to our findings in ECI and ECD tomato is the most suitable host plant for *H. armigera* larvae.

The cluster analysis shown here suggests that grouping within each cluster might be attributable to a high level of physiological similarity between various varieties of the same host plant or to diversity in the group's physiological characteristics. The comparative nutritional indicators of *H. armigera* on several host plants demonstrated that cluster B was the most suitable, and subcluster A1 was the least suitable for *H. armigera*. However, the status of the host in subcluster A2 was intermediate. These findings were linked to ECI and ECD values of whole larval instars on various host plants. Table 4 shows tomato had the greatest ECI and ECD values of the all larval instars, whereas artichoke had the lowest compared to the other hosts.

Conclusion

The present research demonstrated that selected host plants are suitable for the development and survival of *H. armigera*. These findings will help understand this pest's preference for host plants and to manage its control in vegetable crops. This is especially useful when insects can adapt to different host plants despite their different nutritional values.

To further explore about *H. armigera,* future studies should focus on testing a wider range of host plants and cultivars for nutritional indices and assessing the host plants' chemical components to understand the host suitability mechanisms.

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تأثیر گیاهان میزبان بر عملکرد تغذیه‌ای کرم غوزه پنبه، *Helicoverpa armigera* (Lepidoptera: Noctuidae)

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چکیده: در این مطالعه، شاخص‌های تغذیه‌ای مراحل لاروی کرم غوزه پنبه *Helicoverpa armigera* روی چهار محصول باغبانی در شرایط آزمایشگاهی (۱ ± ۲۵ درجه سلسیوس، رطوبت نسبی ٥ ± ٦٥ درصد، با دوره نوری ۱٦:۸ (L: D) ساعت تعیین شد. لاروهای سن سوم پرورش یافته روی سیب‌زمینی بیش‌ترین میزان کارایی را در بازدهی تبدیل غذای خورده شده (ECI) و بازدهی تبدیل غذای هضم شده (ECD) به‌ترتیب (۰/۷٦۷ ± ۸/۲۸۱ درصد و ۱/۱٤۲ ± ۱۱/۰۱٦ درصد) نشان دادند. بیش‌ترین (۰/۰۱٤ ± ۰/۱۲۹ میلی‌گرم بر میلی‌گرم در روز) و کم‌ترین (۰/۰۱۲ ± ۰/۰٦۹ میلی‌گرم بر میلی‌گرم در روز) نرخ رشد نسبی (RGR) لاروهای سن چهارم به‌ترتیب روی سیب‌زمینی و گوجه‌فرنگی به‌دست آمد. داده‌ها نشان داد که بیش‌ترین مقدار (ECI) و (ECD) برای لاروهای سن چهارم روی گوجه‌فرنگی (۳٦۱/۲٥۸ ± ۱۲/۳٦۱ و ۳/۸۳٤ ± ۱۸/٥۸۸ درصد) بود. کم‌ترین میزان مصرف نسبی (RCR) و قابلیت هضم تقریبی (AD) سن پنجم به‌ترتیب روی گوجه‌فرنگی (۰/۰٦۳ ± ۰/٥۹۲ میلی‌گرم بر میلی‌گرم در روز) و سیب‌زمینی (٤/٦۰۷ ± ٥۱/۸٥ درصد) ثبت شد. مقادیر ECI و ECD سن پنجم لارو بالاترین میزان را در گوجه‌فرنگی داشت (به‌ترتیب ۱/۳۳۳ ± ۱۲/٤۷ و ۱/٦۰۹ ± ۱۷/٦۲٤درصد). به‌طور کلی، در بین گیاهان میزبان مختلف آزمایش شده، بالاترین ECI و ECD از تمام سنین لاروی روی گوجه‌فرنگی (به‌ترتیب ۰/٦۹۲ ± ۹/۸۱۳ و ۰/۸۸۲ ± ۱۲/٥۰٦و کم‌ترین مقدار (۰/۲۰۱ ± ۳/۷۳٥ و ۰/٤۲٦ ± ٥/٤٦۳ درصد) روی کنگرفرنگی مشاهده شد. گوجه‌فرنگی و کنگرفرنگی به‌ترتیب مناسب‌ترین و نامناسب‌ترین گیاهان میزبان برای کرم غوزه پنبه بودند.

واژگان کلیدی: گیاهان میزبان، RGR، RCR ، شاخص‌های تغذیه‌ای، کرم غوزه پنبه

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