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Effect of Different Host Plants and Artificial Diet on *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) Development and Growth Index

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ABSTRACT

The developmental periods, mortality, reproduction, growth index and fitness index of the cotton bollworm (*Helicoverpa armigera*) were studied in the laboratory at 26°C and photoperiod 14 L:10 D on cotton seed, okra fruit, maize (ears of corn), castor bean, pea, bean and artificial diet. The developmental periods of larvae were found shortest on pea and artificial diet and longest on cotton seed and maize. Larval mortality percentage was high on maize followed by cotton seed. No significant differences were found between pupal periods. The pupal mortality was high on maize followed by cotton seed. The mean number of deposited eggs were high on pea (560 eggs/female) and low on cotton seed (350 eggs/female). No significant differences were found between hatchability percentages. The growth index and fitness index was highest on pea while the lowest on maize.

Key words: Host plants, artificial diet, cotton bollworm, *Helicoverpa armigera*

INTRODUCTION

The cotton bollworm (*H. armigera* (Hübner)) (Lepidoptera: Noctuidae) (ABW) is one of the most serious insect pests in China, Australia, India and Africa. *Helicoverpa armigera* a polyphagous insect can feed on more than 181 cultivated and wild species belonging to 45 botanical families (Manjunath *et al.*, 1989). The fecundity and longevity of *H. armigera* was affected by fed during larval stage on different host plants (Doss, 1979; Shanower *et al.*, 1997; Kulkarni and Gawande, 1999). The reproductive organs of cotton, corn, tomato and legumes are the most suitable foods for cotton bollworm larvae (Fitt, 1989; Zalucki *et al.*, 1986; Qin *et al.*, 1962). Liu *et al.* (2004) reared *H. armigera* on cotton, corn, tomato, hot pepper, tobacco and common bean. They found that the larvae successfully survived on all six host plants, although mortality was very high on hot pepper and tomato. The developmental time of immature stages reared on six host plants were 29.69, 26.60, 35.07, 33.81, 32.91 and 27.96 days, respectively. Singh *et al.* (2009) studied the effect of natural host plants (pea pod, French bean, okra fruit, brinjal fruit and cauliflower curd) on ABW. Larval period was found shortest on cauliflower curd and longer on brinjal fruits. The average life cycle was completed in 23.32, 25.15, 26.82, 27.33 and 27.93 days on cauliflower curd, okra fruit, French bean, brinjal fruit and pea pod, respectively. The developmental periods of *H. armigera* different stages when fed as larvae on artificial diet at 27°C were 16.30, 10.60, 9.50 and 9.90 days for larval, pupal, female and male longevity, respectively (Amer *et al.*, 2009).

The aim of this study is to evaluate the effect of different host plants and artificial diet on some biological aspects and growth index of the cotton bollworm (*H. armigera*).

MATERIALS AND METHODS

The present study was carried out in Bollworms Research Department, Plant Protection Research Institute, Sharkia Branch to study the effect of different host plants and artificial diet on the development of different stages of ABW. The experiment was performed at constant temperatures $26\pm 1^{\circ}\text{C}$ and 70-75% R.H and 14 L:10 D h.

Insect rearing: The ABW larvae were collected from cotton fields in Daquahlia Governorate during June and July of 2011 cotton growing season and brought to the laboratory. It was fed separately on cotton seed until pupation in glass tubes (3×7.5 cm) covered with cotton wool. The food was daily renewed. Pupae were transferred to clean glass tubes and incubated until moth emergence. When moths emerged were sexed and caged to eggs laying. Moths were provided with 10% honey solution on a cotton swab. The eggs were separated daily and placed in glass jars. The ABW was reared for 12 generations on the artificial diet according to Abd El-Hafez *et al.* (1982). The diet consisted of 250 g dried kidney beans boiled in water, 2.25 g ascorbic acid, 2.25 g methyl-p-hydroxy benzoate, 1 g sorbic acid, 25 g dried brewar's yeast, 10 g agar to which 500 mL distilled water and 2.50 mL formaldehyde 40% were added.

Host plants: The larvae were fed on six host plants and artificial diet. The host plants used were cotton seed (*Gossypium barbadense*, giza 86), okra fruit (*Hibiscus esculentus*), maize (ears of corn) (*Zea mize*), castor bean (*Recinus communis*), pea (*Pisum sativum*) and bean (*Phaseolus vulgaris*).

Larvae of *H. armigera* were obtained from a laboratory strain which reared on artificial diet. The larvae were reared on each host plant for one generation. Three hundred larvae were taken and divided to three replicates, each 100 newly hatched larvae. The larvae was fed on the same host plant, each newly hatched larvae was transferred to glasses tubes 3×7.5 cm and plugged with apiece cotton. The food was renewed with fresh one daily until pupation.

The pupae were separated in clean jars. The newly emerged moths were sexed and put in glass jars 1 kg each jar three pairs and repeated three times for each host plants and artificial diet. The adults fed on 10% sugar solution. The muslin with attached eggs was separated and counted daily. The eggs were incubated under the previous conditions. The larval, pupal, pre-oviposition, oviposition, post oviposition periods, female and male longevity, mean number of deposited eggs and hatchability percentage were recorded for each host plants and artificial diet.

Growth and fitness index: The larval and pupal growth index, immature growth index, standardize growth index and fitness index of *H. armigera* were calculated using the following equations (Pretorius, 1976; Itoyama *et al.*, 1999):

$$\text{Larval growth index} = \frac{\text{Pupation (\%)}}{\text{Larval period (days)}}$$

$$\text{Pupal growth index} = \frac{\text{Emergence (\%)}}{\text{Pupal period (days)}}$$

$$\text{Immature growth index} = \frac{\text{Emergence (\%)}}{\text{Immature stages (larval period+pupal period (days))}}$$

$$\text{Standardize growth index} = \frac{\text{Pupal weight}}{\text{Larval period (days)}}$$

$$\text{Fitness index} = \frac{\text{Pupation(\%)} \times \text{pupal weight}}{\text{Larval period+pupal period}}$$

Statistical analysis: The obtained data was subjected to statistical analysis according to Little and Hills (1975).

RESULTS AND DISCUSSION

Larval stage: The effects of different host plants and artificial diet on developmental time of different stages of *H. armigera* are given in Table 1. Larval food had effect on different developmental stages. The mean larval durations were affected significantly by food. The larval durations were found longest when fed on cotton seed and okra fruit (23.00 and 22.00 days, respectively). But, larvae fed on pea, bean and artificial diet were shortened. The average larval durations were 18.50, 16.00, 16.00, 17.00 and 16.50 days for maize, castor bean, pea, bean and artificial diet, respectively.

When the larvae were fed on the different host plants and artificial diet, mortality percentages were 35.00, 48.33, 20.00, 30.00, 8.33, 11.67 and 6.00% for cotton seed, okra fruit, maize, castor bean, pea, bean and artificial diet, respectively. Highly significant differences were found between different host plants and artificial diet. The pea and artificial diet were recorded the lowest mortality percentages while, maize recorded the highest larval mortality. The pea and artificial diet were favorable for *H. armigera* larval development (Table 1).

Pupal stage: Data in Table 1 clear that the duration of the *H. armigera* pupae lasted 11.00, 9.50, 12.00, 11.50, 11.00, 11.50 and 11.50 days for cotton seed, okra fruit, maize, castor bean, pea, bean and artificial diet, respectively. The pupal duration was shorter on maize and longer on castor bean. No significant differences were found between pupal duration resulted from larval fed on different host plants and artificial diet.

Different host plants and artificial diet have highly significant effect on the pupation percentage. The average pupation percentages were 65.00, 51.67, 80.00, 70.00, 91.67, 88.33 and

Table 1: Effect of different host plants and artificial diet on the immature stages of *Helicoverpa armigera*

Host plant	No. of insects	Larval duration (days)	Larval mortality (%)	Pupation (%)	Pupal duration (days)	Pupal weight (g)	Pupal mortality (%)
Cotton seed	300	23.00 ^a	35.00 ^b	65.00 ^e	11.00	0.280 ^e	25.64 ^b
Maize	300	18.50 ^b	48.33 ^a	51.67 ^f	9.50	0.285 ^{de}	45.16 ^a
Castor bean	300	16.00 ^c	20.00 ^d	80.00 ^c	12.00	0.315 ^{cd}	12.50 ^d
Okra fruit	300	22.00 ^a	30.00 ^c	70.00 ^d	11.50	0.295 ^{cde}	16.67 ^c
Pea	300	16.00 ^c	8.33 ^e	91.67 ^{ab}	11.00	0.330 ^a	9.43 ^{ef}
Bean	300	17.00 ^{bc}	11.67 ^e	88.33 ^d	11.50	0.319 ^{ab}	11.54 ^{de}
Artificial diet	300	16.50 ^{bc}	6.00 ^f	94.00 ^a	11.50	0.325 ^{bc}	7.27 ^f
p		0.000***	0.000***	0.000***	NS	0.000***	0.000***
LSD _{0.05}		2.38	2.64	4.58	-	0.334	2.38

94.00% for cotton seed, maize, castor bean, okra fruit, pea, bean and artificial diet, respectively (Table 1).

Highly significant differences were found between pupal weights. The average pupal weights were 0.280, 0.285, 0.315, 0.295, 0.330, 0.319 and 0.325 g for different host plants and artificial diet, respectively. The larval fed on the pea gave the highest pupal weight while those fed on cotton seed gave lowest pupal weight.

Data in Table 1 showed highly significant differences between pupal mortality when larval stage fed on different host plants and artificial diet. The average pupal mortality percentages were 25.14, 45.16, 12.25, 16.67, 9.45, 11.50 and 7.27% for different host plants and artificial diet, respectively. The larvae of *H. armigera* fed on maize caused the highest pupal mortality (45.16%) while, the artificial diet caused the lowest mortality percentage (7.27%).

Adult emergence: Data given in Table 2 showed highly significant differences in the moth emergence percentage as larval stage fed on different host plants and artificial diet. The averages moths emergence were 74.36, 54.84, 87.50, 83.33, 90.57, 88.46 and 92.73% for cotton seed, maize, castor bean, okra fruit, pea, bean and artificial diet, respectively. The larval fed on maize caused highly significant reduction on moths emergence. Sex ratio of moths emergence was nearly 50% as female from total emergence and no significant differences were found.

Adult longevity: Data in Table 2 show the pre-oviposition period for the female of *H. armigera* resulted from larvae fed on different host plants and artificial diet. The mean time required for maturation of the ovaries and starting eggs laying, was insignificantly between food sources. The pre-oviposition periods were 2.50, 3.00, 2.50, 2.00, 2.00, 2.50 and 2.00 days for different host plants and artificial diet, respectively. The oviposition periods averaged 5.00, 4.00, 6.00, 6.00, 7.00, 5.50 and 6.00 days for host plants and artificial diet, respectively. No significant differences were found between female post oviposition period of *H. armigera* when larvae fed on different host plants and artificial diet (Table 2).

Data in Table 2 indicated that the *H. armigera* male longevity were 7.00, 6.00, 7.50, 8.00, 9.50, 8.00 and 9.50 days, respectively. The male longevity was shortened on maize (6.00 days) while elongated to 9.50 days on pea and artificial diet. Highly significant differences were recorded between male longevity fed as larvae on different host plants and artificial diet.

Table 2: Effect of different host plants and artificial diet on the adult longevity and reproductive potential of *Helicoverpa armigera*

Host plant	Adult emergence (%)	Sex ratio as female	Female longevity (days)			Male longevity (days)	Mean no. of eggs/female	Hatchability (%)
			Pre oviposition	Oviposition	Post oviposition			
Cotton seed	74.36 ^d	49	2.50	5.00	2.00	7.00 ^{bc}	380.00 ^{de}	65.00
Maize	54.84 ^e	52	3.00	4.00	1.00	6.00 ^e	350.00 ^e	66.00
Castor bean	87.50 ^{bc}	51	2.50	6.00	2.00	7.50 ^{bc}	420.00 ^d	69.00
Okra fruit	83.33 ^c	52	2.00	6.00	1.50	8.00 ^{ab}	520.00 ^{ab}	68.50
Pea	90.57 ^{ab}	53	2.00	7.00	1.50	9.50 ^a	560.00 ^a	70.00
Bean	88.46 ^{ab}	49	2.50	5.50	1.00	8.00 ^{ab}	470.00 ^e	67.00
Artificial diet	92.73 ^a	51	2.00	6.00	2.00	9.50 ^a	500.00 ^{bc}	70.00
p	0.00 ^{**}	NS	NS	NS	NS	0.007 ^{**}	0.000 ^{***}	NS
LSD _{0.05}	4.68					1.75	43.40	

Eggs laying and hatchability percentage: The effects of larvae reared on different host plants and artificial diet on the number of the laid eggs per female of the American bollworm are shown in Table 2. It is clear that the average number of laid eggs per female were 380, 350, 420, 520, 560, 470 and 500 eggs/female, respectively. Reared the larvae of *H. armigera* on maize and cotton seed caused significant decreased in the number of deposited eggs/female while, pea and artificial diet caused significant increase.

Hatchability percentages were differed insignificantly as affected by larvae, fed on different host plants and artificial diet. Hatchability percentages were 65, 66, 69, 68.50, 70, 67 and 70%, respectively. Lepidopteran larvae feed on high nutritious food increase growth rates and complete development time faster than those larvae feed on low nutrient food (Hwang *et al.*, 2008). Hemati *et al.* (2013) reported that various host plants including chickpea, common bean, white kidney bean and tomato affected the reproductive performance of *H. armigera* and the highest pupal mortality of *H. armigera* fed on common bean (15.78%). Arghand (2011) found that the larval mortality of *H. armigera*, among various maize hybrids varied from 58-62%. Doss (1979) found that the *H. armigera* larvae fed on soybean, cotton boll and tomato fruit caused significant differences in the females longevity. Razmjou *et al.* (2014) reported that larval period, pupal period and development time of *H. armigera* was longest on tomato (24.9, 15.1 and 45.4 days, respectively) and shortest on chickpea Arman (17.5, 9.1 and 31.7 days, respectively). Among various host plants fecundity was highest (2665 eggs) on chickpea and the lowest (700 eggs) on tomato.

Growth and fitness index: The growth index emphasizes the importance of both survival rate and developmental time in measuring food quality (Setamou *et al.*, 1999). The highest growth index of *H. armigera* larvae was 5.73 on pea while the lowest one on maize (2.79) (Table 3). The growth index of pupal stage was 6.76, 5.77, 7.29, 7.25, 8.23, 7.69 and 8.06 on cotton seed, maize, castor bean, okra fruit, pea, bean and artificial diet, respectively. The highest growth index for immature stages was 3.35 on pea while, the lowest was 1.96 on maize. The highest fitness index was 1.12 on pea and the lowest 0.53 on maize (Table 3). The highest growth index and fitness index was on pea while the lowest on maize. Lepidoptera larvae feed on high nutritious food increase growth rates and complete developmental time faster than those larvae that fed on low nutrient food (Hwang *et al.*, 2008). The *H. armigera* larval growth index and standardized growth index and fitness index were differed significantly on different tomato cultivars (Kalkhoran *et al.*, 2013). Arghand (2011) reported that the lowest larval growth index of *H. armigera* was 1.54 on corn. Surana *et al.* (2004) reported that the highest growth index of *H. armigera* on chickpea and lowest on linseed.

Table 3: Growth index and fitness index of *Helicoverpa armigera* on different host plants and artificial diet

Host plant	Growth index				Fitness index
	Larval	Pupal	Immature	Standardized	
Cotton seed	2.83	6.76	2.19	0.012	0.54
Maize	2.79	5.77	1.96	0.025	0.53
Castor bean	5.00	7.29	3.13	0.020	0.90
Okra fruit	3.18	7.25	2.49	0.013	0.62
Pea	5.73	8.23	3.35	0.021	1.12
Bean	5.20	7.69	3.10	0.029	0.99
Artificial diet	5.70	8.06	3.31	0.020	1.09

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