



Research Paper

**LABORATORY EVALUATION OF HOST PLANT SUITABILITY FOR
Helicoverpa armigera (HÜBNER) ON GROWTH AND DEVELOPMENT**

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Abstract

Effect of different host plants viz. carnation, pigeonpea, bathua, chickpea, sorghum, mothbean, tomato, capsule of castor, cotton, sonchus and cowpea were studied by calculating the food utilization indices of fifth instar larvae of *H. armigera*. On dry weight basis the values of ECI (17.65%), AD (87.56%), ECD (20.15%) and GR (0.388) were recorded maximum in case of chickpea, hence was adjudged as the most preferred host of *H. armigera* followed by tomato and cotton. Capsule of castor, cowpea and mothbean were proved to be the least preferred hosts. Growth indices of *H. armigera* against all these host plants were also recorded. On the basis of all larval, pupal and adult parameters chickpea confirmed to be the most preferred host. Moderate larval and pupal period, adult emergence, GI, LPI and SI values were obtained in pigeonpea, carnation sorghum, bathua and mothbean. The capsule of castor was found to be the least preferred, host plant. The order of preference was : chickpea > tomato > cotton > pigeonpea > sorghum > carnation > bathua > mothbean > sonchus > cowpea > capsule of castor.

Key words: *H. Armigera*, Host preference, Food utilization.

INTRODUCTION

Heliothis armigera (Hubner) (Lepidoptera; Noctuidae), commonly called as gram pod borer, is a polyphagous pest attacking a number of crops of economic importance including pulses, tomato, cotton and other crops. It is widely distributed throughout India and has been recorded feeding on 181 cultivated and uncultivated plant species belonging to 45 families [Manjunath *et al.*, 1989].

Quantitative yearly losses varying from 5 to 70 per cent to gram crop have been estimated by Bhatnagar *et al.*, 1981. As high as 50-100 per cent damage to tomato fruits [Mathur *et al.* 1974; Singh and Singh, 1975; Kakar *et al.*, 1980; Sithanathan *et al.*, 1983 and Tewari and Krishnamoorthy, 1984], about 40 per cent to cotton [Sundramurthy, 1990], 10 to 80 per cent to safflower [Panchabhavi and Krishnamurthy, 1978 and Margal, 1990] has been reported by *H. armigera* in the different parts of the country.

MATERIALS AND METHODS:

Maintenance of culture of *Heliothis armigera* (Hub.): The initial culture of *H. armigera* was raised from the moths captured from light trap during the month of Feb., 1999. Two to three pairs of the moths were engaged for egg laying in egg laying cage (Kumar and Ballal, 1990). The cage consisted of cylindrical frame (50 cm height and 80 cm dia.) made up of a 5 mm thick

galvanized iron wire. A circular stout plastic mesh disc rested on a support 5 cm above the base of the frame. At the top of the frame, a rubber band supported the feeding vial. A white cotton cloth (90 cm x 50 cm) enclosed the frame of the cage. To keep the cage cool and to maintain a relative humidity (RH) of 60-80 per cent, it was placed in an enamelled tray provided with a 3 cm thick sponge sheet soaked in water.

Hundred pupae, ready to emerge were kept in a Petridish over the disc. A 20 ml plastic cup containing 5 per cent honey solution was kept on top of the frame and on the disc for feeding of the emerging moths. The eggs were laid all over the inner surface of the cloth cover and on both the sides of the cloth strip. For the collection of the eggs, the moths were transferred to another cage. The cover and strip bearing eggs were soaked in 0.05% sodium hypochlorite (NaOCl) for five minutes and run the washing machine for five minutes and collect the eggs threw sieve and wash with water. After collection of the eggs, they were kept at $24 \pm 1^\circ$ Cand RH 60 per cent in an incubator. After hatching, the newly emerged larvae were transferred to artificial diet (Singh and Rembold, 1992). Because of the problem of cannibalism after second instar, the larvae were raised individually into the glass tube (25 mm x 90 mm). The larvae were provided fresh diet daily. The battery jars (37.5 cm x 25 cm) were prepared for pupation by placing four inch thick layer of fine sandy soil at the bottom. The sand layer was covered with blotting paper to absorb excess moisture. The full grown final instar larvae were placed for pupation (10 larvae per jar). Two days later, the pupae were recovered from the sand and were placed in new glass jars lined with blotting paper at the bottom. The jars were placed under controlled condition after covering them with muslin cloth, to avail the emergence of adults. According to duration the pupae then transferred to the egg laying chamber.

Food utilization: The study was conducted under ambient laboratory conditions. During the period of experiments the average maximum and minimum temperature were 33.2 and 16.5 °C, respectively; while the relative humidity was 72.5 per cent. The food utilization studies were carried out on eleven hosts viz., Bathua, Chickpea, Carnation, Pigeonpea, Sonchus, Sorghum, Cotton, Castor, Tomato, Mothbean and Cowpea replicated four times, each replication consisting of 25 larvae. The larvae were starved for 12 h, weighed and then were allowed to feed on the host for a period of 48 h. For dry weight calculation some equal number of test insect larvae were taken as aliquot for 12 h, weighed and then dried in oven till constant weight, like wise an aliquot, starved of host food was also taken, weighed and dried till constant weight. The ratio of dry and wet weights of these aliquots, test insect, as well as, host food was used for computing food utilization indices on dry weight basis.

After feeding for 48 h, the larvae were separated, weighed and dried till constant weight. The faeces were collected, weighed and dried to constant weight. The left over food was collected in separate petri dish. The dry weight of left over food, faeces and larvae were determined by drying them to a constant weight in an oven at 100°C. Food utilization indices of *H. armigera* viz. consumption index (CI), efficiency of conversion of ingested food to body substances (ECI), approximate digestibility (AD), efficiency of conversion of digested food to body substances (ECD) and growth rate (GR) on different host plants like Bathua (*Chenopodium album* (L.)), Chickpea (*Cicer arietinum* (L.)), Carnation(*Dianthus caryophyllus* (L.)) Pigeonpea *Cajanus cajan* (L.) Millsp., Sonchus(*Sonchus harvensis*) (L.), Sorghum (*Sorghum bicolor* (L.) Moench, Cotton(*Gossypium hirsutum* (L.)), Castor(*Ricinus communis* (L.)), Tomato (*Lycopersicon esculentum* (L.)), Mothbean (*Vigna aconitifolia* (Jacq.) Marechal and Cowpea (*Vigna unguiculata* (L.) Walp.

Formula:

were calculated on dry weight basis as per the method of Waldbaur (1968).

1. Consumption Index (CI) = F / TA

Where,

F = Fresh or dry weight of food eaten

T = Duration of feeding period (days)

A = Mean fresh or dry weight of larvae during feeding period.

2. Growth Rate (GR) = $\frac{G}{T}$

Where,

G = Fresh or dry weight gain of larvae during feeding period

T = Duration of feeding period (days)

A = Mean fresh or dry weight of larvae during feeding period.

3. The efficiency of conversion of ingested food to body substances (ECI) was calculated as :

$$ECI = \frac{\text{Weight gained}}{\text{Weight of food ingested}} \times 100$$

Weight of food ingested

4. The approximate digestibility (AD) was calculated as :

$$AD = \frac{\text{Weight of food ingested} - \text{Weight of faeces}}{\text{Weight of food ingested}} \times 100$$

5. The efficiency of conversion of digested food to body substances (ECD) was calculated as :

$$ECD = \frac{\text{Weight gained}}{\text{Weight of food ingested} - \text{Weight of faeces}} \times 100$$

Growth indices: In order to study the host preference, 25 newly hatched first instar larvae were carefully transferred with the help of a camel's hair brush to individual jar containing leaves of different host plants. The jars were kept in an incubator maintained at a temperature of $25 \pm 2^\circ\text{C}$ and 80 per cent relative humidity. The food was changed after every 24 hrs for the complete larval period. The experiment was replicated four times.

Observation on larval period, weight of mature larva, length of mature larva, per cent larval survival were recorded on each host. The mature larvae were transferred to another jars provided with 2" thick sand layer for pupation and observation on pupal period, and weight of mature pupae and length of mature pupae were recorded on each host.

Two days old pupae were taken for weighing so that they may become sufficiently hard and may not be damaged during handling. Properly labelled and marked individual pupa was placed in small jars for further observations. The time required for emergence of adult and per cent survival to pupal adult ecdysis was recorded. Per cent survival to larval pupal ecdysis and pupal adult ecdysis were calculated on the basis of the number of larvae pupated and adult emerged. The moths obtained from the larvae reared on different host plants were kept under constant observations for longevity. Moths obtained were paired and kept in egg laying chamber to find out the fecundity of individual female. The growth index was calculated and the developmental potential was assessed by taking into account the growth index, percentage adult emergence and sex ratio. Growth indices were worked out as per Dubey *et al.* (1981).

RESULTS AND DISCUSSION

Food Utilization Indices: Investigation on food utilization by the fifth instar larvae of *Heliothis armigera* on eleven host plants viz., carnation, pigeonpea, bathua, chickpea, sorghum, mothbean, tomato, capsule of castor, cotton, sonchus and cowpea were carried out. Dry weight of food ingested, food digested, faeces and weight gained by the larvae and the utilization indices (ECI, AD and ECD) were calculated as described by Waldbauer (1968).

Food Utilization: Data presented in Table 1 revealed that the larvae gained maximum weight (1.0218 g) and the values of ECI (17.6502 %), AD (87.56 %), ECD (20.15 %) and GR (0.388) were maximum when fed on chickpea which is confirmed to be the most suitable host as compared to other hosts. Chickpea was followed by tomato in which weight gained by the larvae was 0.9269 g and the values of ECI, AD, ECD were 16.893, 83.239, 20.29 per cent respectively, growth rate was 0.383. Although the ECD was higher in case of tomato as compared to chickpea. Next preferred hosts were cotton and pigeonpea. Waldbauer (1968) also reported that in leaf feeding species digestibility and efficiency of conversion vary widely with the species of food plants. Soo Hoo and Fraenkel (1966) studied the consumption digestion and utilization of eighteen different host plants by the larvae of *Prodenia eridania* (Cramer) and reported lower

values of digestibility among poor hosts and higher values of digestibility among preferred hosts, corroborate the present findings. Similarly Dhandapani and Balasubramanian (1980) observed that among all the eleven hosts, the maximum food consumed was in cotton (6.0183 g), followed by chickpea (5.7891 g), tomato (5.4862 g), pigeonpea (5.1877 g), bathua (4.8423 g), cowpea (4.7726 g). In other hosts like carnation, sorghum and mothbean the average consumption was almost equal (4.3255, 4.4484 and 4.4459 g) and the lowest was in case of capsule of castor i.e. 3.1547 g.

Moderately preferred hosts were carnation, bathua, sorghum and mothbean. The weight gained by the larvae on these hosts ranged from 0.4435 g to 0.6238 g and the values of ECI, AD, ECD and growth rate ranged from 9.973 to 14.422, 63.654 to 73.685, 15.668 to 20.021 and 0.306 to 0.344, respectively. The capsule of castor proved poor on the dry weight basis with all lowest values. Shahid *et al.* (1990) also reported chickpea as most preferred host by *H. armigera* larvae followed by tomato and other hosts are in agreement with the present results. Hussain (2001) studied the food utilization indices on *H. armigera* against ten different host plants and reported that chickpea is most preferred host with higher values of AD, ECI and ECD and growth rate of 0.399 followed by tomato. These studied are in agreement with present study. The rate of food intake (CI) was lower on preferred host chickpea (2.20) followed by tomato (2.27) and pigeonpea (2.38). Similar results were reported by Chhibber *et al.* (1985) who observed low rate of food intake (C.I.) and higher values of AD, ECI, ECD and GR on preferred host plants by *Spodoptera litura* are in corroboration with present findings.

Growth Indices: Minimum larval period (16.12 days) was recorded in case of chickpea followed by cotton (16.97 days) and tomato (17.06 days). Moderate larval period was recorded in carnation, pigeonpea, sorghum and bathua. Maximum larval period was in capsule of castor (20.69 days), followed by cowpea (20.12 days) (Table 2). Maximum larval weight was gained in chickpea reared larvae (0.526 g) and lowest was recorded on capsule of castor (0.368 g). Lowest larval length was attained in case of capsule of castor (29.60 mm) and highest was attained in chickpea (35.60 mm). Larval mortality for all host plant varies between 6.88 to 11.85 per cent. Among pupal characters different developmental parameters were recorded, the lowest pupal period was in chickpea reared larvae (14.25 days) and highest was in capsule of castor 15.81 days. The lighter (0.271 g) and shorter (15.78 mm) pupa was in capsule of castor. Per cent pupation on different host plants varied from 88.14 to 93.12. 90.09 per cent pupation was recorded in bathua, carnation and mothbean (Table 6). Capsule of castor was significantly differed from chickpea, tomato and pigeonpea. Dubey *et al.* (1981) studied the effect of host plants on different stages of gram pod borer, *H. armigera* and reported significant difference in pupal period and weight from host to host, supports the present findings.

On the basis of adult emergence it is confirmed that chickpea (85.04 per cent) was most efficient host, closely followed by cotton (84.10 per cent), tomato (83.03 per cent) and pigeonpea (82.04 per cent). Carnation, sonchus sorghum and bathua were moderate host plants in terms of adult emergence.

Under the present study, the longevity of male and female moths, emerging from larvae reared on different host plants were recorded on 5 per cent sucrose. Moths emerged from chickpea reared larvae were survived more (male 7.20 days, female 10.64 days) as compared to other host plants. The moths emerged from capsule of castor could not survived so long (female 7.10 days, male 5.62 days). The longevity varied from 5.62 to 7.33 days for male and 7.10 to 10.64 days for female. The male emerged from tomato reared larvae survived maximum. Significant differences of the host plants were recorded on the fecundity of the female of *H. armigera*, varying from 168.25 to 200 eggs per female per day. After chickpea, bathua was the host, preferred for egg laying with 194.25 eggs. Present findings are in agreement with Bajpai and Sehgal (1993). The host plants had no major effects on the incubation period of *H. armigera* eggs. The highest male : female ratio was on chickpea (1:0.92).

Highest growth index (5.77), Larval pupal index (1.00) and Survival Index (1.00) values were recorded on chickpea. Tomato was second on the basis of LPI (0.978), GI (5.39) and followed by cotton. The survival index varied from 0.848 to 1.00 and larval pupal index from

0.832 to 1.00. On the basis of GI, the sorghum, pigeonpea, carnation, sonchus were the moderate host plants. These finding are in agreement with Hussain (2001).

Least preferred host capsule of castor had lowest GI (4.26) and LPI (0.832) followed by cowpea 4.42 and 0.872, respectively. On the basis of growth indices the descending order of host superiority was found to be chickpea > tomato > cotton > pigeonpea > sorghum > carnation > bathua > mothbean > sonchus > cowpea > capsule of castor. Bilapate (1988) reported that the mean pupation of *H. armigera* ranged from 77.77 per cent on safflower and maize, to 100 per cent on chickpea and the growth index was highest on chickpea supports the present findings. Similarly Goyal and Rathore (1988) reported that larval period of *H. armigera* occupying 10.10 to 17.84 days leading to 85.71 to 100 per cent adult emergence on different host plants. The growth index ranged from 4.8 to 9.9. Host gram was most preferred by *H. armigera* confirms the present investigation. Similarly on the basis of growth index (GI) Tripathi and Singh (1989), Bilapate *et al.* (1991), Ramanath *et al.* (1992). Bhagat and Balani (1994) and Venkataish *et al.* (1994) reported chickpea as the most preferred host of *H. armigera* corroborate the present findings.

Table 1. Comparison of rate of intake, digestibility and efficiency of conversion of food to body substances by fifth instar larvae of *H. armigera* on different host plants

Host plants	Weight gained (g)	Weight of ingested food (g)	Weight of digested food (g)	Weight of faeces (g)	CI	ECI (%)	AD (%)	ECD (%)	GR
Carnation	0.6238	4.3255	3.1167	1.2088	2.3882	14.4228	72.044	20.0213	0.344
Pigeonpea	0.7982	5.1877	3.9837	1.2040	2.3888	15.3787	76.785	20.0228	0.366
Bathua	0.6216	4.8423	3.5689	0.2734	2.6691	12.8357	73.685	17.4211	0.342
Chickpea	1.0218	5.7891	5.0692	1.7199	2.2033	17.6502	87.562	20.1576	0.388
Sorghum	0.5249	4.4484	3.3163	1.4321	2.7661	11.7952	74.543	15.8225	0.326
Mothbean	0.4435	4.4459	2.8302	1.6157	3.0774	9.9734	63.654	15.6689	0.306
Tomato	0.9269	5.4862	4.5678	0.9184	2.2702	16.8937	83.239	20.2989	0.383
Capsule of castor	0.2049	3.1547	1.4530	1.7017	3.2052	6.4888	46.027	14.0952	0.207
Cotton	0.8134	6.0183	4.9511	1.0672	2.7358	13.5119	82.257	16.4253	0.369
Sonchus	0.3027	4.1831	2.5752	1.6079	3.5221	7.2300	61.5425	11.7648	0.254
Cowpea	0.3604	4.7726	3.1684	1.6642	3.7243	7.5493	66.366	11.3778	0.281
SEm+ CD at 5%					0.0281 0.0825	0.2387 0.7003	0.5975 1.7527	0.2962 0.8689	

Table 2. Effect of different host plants on larval development of *H. armigera*

Host plants	Larval period (days)	Larval wt. (mg)	Larval length (mm)	Larval mortality (%)
Carnation	18.94	0.407	31.59	18.34* (9.91)
Pigeonpea	18.17	0.483	32.19	16.16 (7.75)
Bathua	19.62	0.462	32.39	18.34 (9.91)
Chickpea	16.12	0.526	35.60	15.20 (6.88)
Sorghum	18.94	0.425	31.50	18.34 (9.91)
Mothbean	19.86	0.404	30.69	18.34 (9.91)
Tomato	17.06	0.512	34.80	16.42 (8.00)
Capsule of castor	20.69	0.368	29.60	20.13 (11.85)
Cotton	16.97	0.493	32.40	17.38 (8.93)
Sonchus	19.69	0.354	30.90	19.17 (10.79)
Cowpea	20.12	0.398	29.80	19.30 (10.93)
SEm±	0.530	0.0074	0.69	1.2
CD at 5%	1.525	0.0212	2.01	3.52

* Figures are angular values and in parenthesis are retransformed values.

Table 3. Effect of different host plants on pupal development and adult emergence of *H. armigera*

Host plants	Pupal period (days)	Pupal weight (g)	Pupal length (mm)	Pupation (%)	Pupal mortality (%)	Adult emergence
Carnation	14.06	0.341	16.19	71.65* (90.09)	21.92* (13.94)	60.70* (76.05)
Pigeonpea	14.53	0.372	16.37	73.83 (92.24)	18.34 (9.91)	64.92 (82.04)
Bathua	14.97	0.317	16.09	71.65 (90.09)	19.30 (10.93)	62.74 (79.02)
Chickpea	14.25	0.398	17.32	74.79 (93.12)	16.42 (8.00)	67.24 (85.04)
Sorghum	14.74	0.325	16.20	71.65 (90.09)	21.92 (13.94)	60.70 (76.05)
Mothbean	14.71	0.324	15.99	71.65 (90.09)	23.49 (15.89)	59.42 (74.12)
Tomato	13.99	0.387	16.96	73.57 (92.00)	17.38 (8.93)	65.67 (83.03)
Capsule of castor	15.81	0.271	15.78	69.86 (88.14)	23.49 (15.89)	58.12 (72.12)
Cotton	14.50	0.392	16.52	72.61 (91.06)	15.20 (6.88)	66.50 (84.10)
Sonchus	14.98	0.283	15.91	70.82 (89.21)	22.66 (14.85)	59.39 (74.08)
Cowpea	14.68	0.296	15.89	70.69 (89.06)	23.49 (15.84)	58.73 (73.06)
SEm±	0.277	0.0051	0.311	1.22	1.11	1.20
CD at 5%	0.798	0.0147	0.895	3.52	3.20	3.45

* Figures are angular values and in parenthesis are retransformed values.

Table 4. Effect of host plants on incubation period, adult longevity, fecundity and sex ratio of *H. armigera*

Host plants	Adult longevity		Fecundity	Incubation period	Sex
	Male	Female			
Carnation	6.20	7.53	182.50	3.97	1:0.85
Pigeonpea	6.42	9.81	180.00	3.92	1:0.81
Bathua	6.28	8.61	194.25	4.05	1:0.88
Chickpea	7.20	10.64	200.00	3.80	1:0.92
Sorghum	6.41	7.38	170.50	4.07	1:0.85
Mothbean	6.21	7.38	160.50	4.10	1:0.76
Tomato	7.33	9.99	180.00	3.92	1:0.92
Capsule of castor	5.62	7.10	168.25	4.12	1:0.76
Cotton	6.89	9.95	190.25	3.97	1:0.82
Sonchus	5.60	7.22	171.50	4.07	1:0.85
Cowpea	5.80	7.20	174.00	4.15	1:0.82
SEm±	0.076	0.2113	4.563	0.076	
CD. at 5%	0.219	0.607	13.131		

Table 5. Effect of host plants on larval pupal, survival and growth index

Host plants	Larval pupal index	Survival index	Growth index
Carnation	0.920	0.894	0.475
Pigeonpea	0.928	0.964	5.07
Bathua	0.877	0.929	4.59
chickpea	1.00	1.00	5.77
Sorghum	0.901	0.894	4.75
Mothbean	0.878	0.871	4.53
Tomato	0.978	0.976	5.39
Capsule of castor	0.832	0.848	4.26
Cotton	0.965	0.989	5.36
Sonchus	0.875	0.871	4.53
Cowpea	0.872	0.859	4.42

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