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Impact of differential feeding on the growth and development of *Helicoverpa armigera* (Hubner)

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Abstract: *The growth and development of Helicoverpa armigera was observed in the laboratory by feeding them on different foods viz; leaf, flower and fruit of lady finger, cotton, pigeon pea and chick pea. Based on the food ingested, food digested and food excreted as well as on weight and size of the larvae and the duration of larval period, the fruit of chick pea was found to be the most suitable food for H.armigera development, as the food ingesta and food digesta of the larvae on pigeon pea were more than on the other plants. On the pigeon pea pod the larval growth and development was fast and larval duration was short. Next to the fruit, the larvae preferred the leaf of lady finger and cotton and flower of pigeon pea. The results suggested that the larval growth and development was dependent on the feed i.e. both on the part and the type of the plant.*

Key words: *Differential feeding, Growth, Development, Helicoverpa armigera*
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Introduction

Helicoverpa armigera is a polyphagous insect pest with attacks about 181 species of plants belonging to 45 families in India (Armes *et al.,* 1992; Zhao *et al*., 2000). However it prefers to feed more on cotton, pulses, vegetables and oilseeds (Srinivas *et al.,* 2004 ; Sharma *et al.,* 2004). Growth and development of a pest are dependent on the type of feed and feeding efficiency. Hence in the present study efforts are made to generate information on growth and development of *Helicoverpa armigera,* on consumption of different parts of some important host plants like lady finger (*Abelmosches esculentus*), cotton (*Gossypium herbaceum*), pigeon pea(*Cajanus cajan*) and chick pea(*Cicer aretinum*). The study includes measurement of food ingested, food excreted and food digested by the larvae, and comparison of feeding efficiency with the larval period and growth rate. This study was planned to understand the suitability of various parts of host plants for rapid multiplication of the pest.

Materials and Methods

The eggs of *H.armigera* were collected from fields. After hatching, larvae were reared in groups by feeding on natural diet (tender leaves) up to second instar. Later they were transferred to individual glass vials. The experimental larvae at the first day of the third instar were having on an average weight of 40 ± 5 mg and a length of 1.0 ± 0.2 mm. Different parts of plants such as tender leaf, flower, pod or mature fruit of crops such as lady finger, cotton, pigeon pea and chick pea were selected to fed the larvae. As the flower of chick pea is very small and the larvae are not feeding on it, this has not been included in the present study. The larvae were maintained at temperature 26 ± 1°C, humidity 65 ± 2% and photo period 12 hr light and 12 hr dark.

Method of feeding: One gram of selected food was given at a regular time everyday. The gravimetric method given by Waldbauer (1968), was followed to calculate the dry matter food ingested, digested and excreted. According to this, a known quantity of the selected feed was supplied to larvae and simultaneously the same quantity of feed was kept in the oven at 80°C for 24 hr and then the dry weight was measured. Next day the left over food was collected from rearing vial, kept in the oven at 80°C for 24 hr and the dry weight of it was measured. The value was subtracted from the dry food weight given to the insect, which gave the dry matter of food ingested. The excreta of the larva was collected separately and kept in oven at 80°C for 24 hr and weight was measured, which gave the dry weight of excreta. For measuring food digested, the dry weight of excreta was subtracted from dry weight of food ingested. The cumulative weights of the dry matter ingested, digested and excreted at each instar of the larvae are expressed in mg per larvae per instar. Just after each moult, length of larvae in mm. and weight in mg were recorded. The duration of larval period from 3rd to 6th instar was also recorded.

The data on the weight and size of the larvae, food ingested, food digested and food excreted and the larval period was recorded from six individuals fed on the specific feed, and the mean was taken into account for presentation. The rate of mortality of the larvae during experimentation was insignificant. For each mean, standard deviation was derived, and the significance was tested using the 't' test at 5% level (Choudhary, 2006).

Results and Discussion

The data on the growth and development of the larvae of H. *armigera* based on the dry matter ingested (mg day^{-1}), dry matter excreted (mg day^{-1}), larval weight gained day^{-1}, larval size gained day^{-1} and larval period on feeding with different parts of the plant like leaf, flower and fruit of lady finger, cotton, pigeon pea is presented in Tables

Table - 1: Growth and development of the larvae of *H.armigera* on leaf, flower and fruit of lady finger. Each value is a mean ± = standard deviation of six individuals

Part of the plant	Instar	Dry matter ingested (mg day^{-1})	Dry matter excreted (mg day^{-1})	Dry matter digested (mg day^{-1})	Larval weight gained day^{-1} (mg)	Larval size gained day^{-1} (mm)	Larval period (days)
Leaf	3rd	180.59 ± 2.22	52.76 ± 6.22	127.33 ± 5.12	10.25 ± 0.52	1.61 ± 0.03	2.66 ± 0.12
	4th	239.56 ± 11.33	75.04 ± 3.81	164.52 ± 9.56	19.80 ± 0.66	1.87 ± 0.05	3.03 ± 0.17
	5th	264.75 ± 12.99	70.02 ± 3.15	194.73 ± 8.69	25.21 ± 0.76	2.42 ± 0.04	3.05 ± 0.21
	6th	255.06 ± 12.66	48.42 ± 3.51	186.64 ± 9.33	23.41 ± 1.28	1.95 ± 0.05	2.02 ± 0.15
	Total	939.96 ± 37.24	246.24 ± 18.24	673.72 ± 32.74	78.67 ± 3.22	7.85 ± 0.17	10.77 ± 0.85
Flower	3rd	133.34 ± 9.23	49.62 ± 2.76	33.72 ± 6.99	11.02 ± 0.94	1.02 ± 0.05	3.33 ± 0.25
	4th	170.98 ± 8.99	51.34 ± 2.22	119.64 ± 8.02	12.61 ± 0.99	1.54 ± 0.42	2.30 ± 0.21
	5th	198.39 ± 1.99	50.85 ± 2.68	147.54 ± 7.96	18.61 ± 0.67	1.80 ± 0.46	3.30 ± 0.24
	6th	191.06 ± 10.22	53.53 ± 2.77	137.53 ± 8.99	12.02 ± 0.77	1.16 ± 0.45	3.33 ± 0.25
	Total	693.77 ± 40.33	205.3 ± 10.43	488.43 ± 34.88	54.26 ± 3.77	5.52 ± 1.33	12.66 ± 0.95
Fruit	3rd	384.76 ± 19.22	107.32 ± 5.68	277.44 ± 14.77	14.56 ± 0.96	1.82 ± 0.14	2.16 ± 0.21
	4th	414.29 ± 21.25	105.65 ± 5.42	308.64 ± 15.48	23.96 ± 1.44	2.57 ± 0.15	2.66 ± 0.18
	5th	421.86 ± 22.28	125.03 ± 6.66	296.83 ± 16.24	37.89 ± 1.92	2.17 ± 0.12	2.33 ± 0.21
	6th	422.64 ± 24.52	127.52 ± 6.67	295.14 ± 16.68	36.35 ± 1.78	3.35 ± 0.15	2.66 ± 0.18
	Total	1643.65 ± 87.27	465.52 ± 26.66	1178.93 ± 63.27	112.76 ± 5.21	9.94 ± 0.56	9.81* ± 0.38

The values between the parts of plant in each parameter are statically significant ($p<0.05$), * = Not significant with leaf ($p>0.05$)

Table - 2: Growth and development of the larvae of *H. armigera* on leaf, flower and fruit of cotton. Each value is a mean ± = standard deviation of six individuals

Part of the plant	Instar	Dry matter ingested (mg day^{-1})	Dry matter excreted (mg day^{-1})	Dry matter digested (mg day^{-1})	Larval weight gained day^{-1} (mg)	Larval size gained day^{-1} (mm)	Larval period (days)
Leaf	3rd	252.05 ± 12.48	99.24 ± 4.48	151.71 ± 7.22	18.33 ± 0.92	1.41 ± 0.48	2.02 ± 0.21
	4th	327.86 ± 16.44	84.43 ± 4.58	243.43 ± 12.44	31.42 ± 1.72	2.31 ± 0.08	2.66 ± 0.18
	5th	378.84 ± 18.65	96.04 ± 4.99	282.80 ± 14.22	33.69 ± 1.66	2.91 ± 0.18	2.33 ± 0.27
	6th	335.18 ± 16.52	94.92 ± 4.77	204.26 ± 11.66	22.76 ± 1.22	2.61 ± 0.16	2.33 ± 0.27
	Total	1293.93 ± 63.99	374.63 ± 22.82	918.30 ± 45.54	106.20 ± 5.52	9.24 ± 0.16	2.66 ± 0.18
Flower	3rd	186.16 ± 13.33	89.43 ± 4.76	96.63 ± 8.85	12.45 ± 0.94	1.24 ± 0.12	2.01 ± 0.13
	4th	302.54 ± 14.56	125.82 ± 6.78	176.72 ± 9.99	30.32 ± 1.99	2.08 ± 0.11	2.50 ± 0.15
	5th	309.56 ± 14.96	111.42 ± 6.99	198.14 ± 9.72	31.63 ± 1.78	2.33 ± 0.12	3.33 ± 0.13
	6th	301.48 ± 17.48	119.34 ± 7.22	182.14 ± 12.44	23.87 ± 1.99	2.30 ± 0.19	2.66 ± 0.12
	Total	1099.74 ± 60.33	448.01 ± 23.75	653.73 ± 40.70	98.27 ± 6.70	7.95 ± 0.44	10.50 ± 0.48
Fruit	3rd	355.54 ± 20.66	99.62 ± 3.33	256.04 ± 19.22	21.21 ± 1.21	1.63 ± 0.09	2.06 ± 0.02
	4th	464.86 ± 23.33	110.82 ± 6.66	354.02 ± 17.22	33.78 ± 1.88	2.06 ± 0.18	2.33 ± 0.16
	5th	493.57 ± 28.88	126.24 ± 6.68	367.33 ± 19.68	45.29 ± 2.22	3.68 ± 0.18	2.33 ± 0.19
	6th	457.65 ± 33.33	111.54 ± 5.22	346.01 ± 17.68	39.82 ± 1.88	3.12 ± 0.21	2.06 ± 0.25
	Total	1771.52 ± 106.20	448.22* ± 21.84	1323.30 ± 73.80	140.10 ± 7.19	10.49 ± 0.66	8.78 ± 0.62

The values between the parts of plant in each parameter are statistically significant ($p<0.05$)
* = Not significant with flower ($p>0.05$)

1 to 4. A comparison is also drawn on the total dry matter ingested, dry matter digested and dry matter excreted, larval weight, larval size and larval period from 3rd to 6th instar is also presented in Table 5.

The feeding preference of *H.armigera* among different host plants provided significant information on the growth and development of the larvae on those plants. Further, the selection of different parts of the plant by the larvae also gave an indication about the amount of damage caused by them to that specific part of the plant. In the present study the larvae were fed with leaf, flower and fruit of lady finger, cotton and pigeon pea and with leaf and fruit of chick pea, as the occurrence of infestation was not observed on the flower of the chick pea and the amount food ingested, food digested and food excreted in relation to the larval weight and size and total larval period was analysed. The results revealed that among different parts of the plant provided, the larvae consumed the fruit of the plant to a greater extent than the leaf and flower. The fruit generally consists of more nutrients like required for the growth and development of the larvae. Morton (1976) reported that the mature seeds of pigeon pea contain 7.2 g proteins, 21.3 g total carbohydrates, 0.6 g fats, 69.5% moisture and 3.3 g fiber. In the

Table - 3: Growth and development of the larvae of *H. armigera* on leaf, flower and fruit of pigeon pea. Each value is a mean ± = standard deviation of six individuals

Part of the plant	Instar	Dry matter ingested (mg day^{-1})	Dry matter excreted (mg day^{-1})	Dry matter digested (mg day^{-1})	Larval weight gained day^{-1} (mg)	Larval size gained day^{-1} (mm)	Larval period (days)
Leaf	3rd	158.35 ± 9.28	54.67 ± 2.22	103.68 ± 5.77	9.33 ± 0.62	1.02 ± 0.01	3.01 ± 0.21
	4th	215.91 ± 12.88	61.36 ± 3.48	154.65 ± 7.68	13.33 ± 0.95	1.66 ± 0.09	3.03 ± 0.21
	5th	236.01 ± 12.99	63.52 ± 3.15	172.51 ± 8.69	15.63 ± 0.76	1.72 ± 0.04	3.32 ± 0.21
	6th	208.33 ± 20.66	60.82 ± 3.31	147.51 ± 7.78	11.66 ± 0.68	1.16 ± 0.09	3.02 ± 0.27
	Total	818.60 ± 55.81	240.35 ± 12.16	578.25 ± 24.92	49.95 ± 3.01	5.50 ± 0.23	12.36 ± 0.90
Flower	3rd	233.34 ± 12.44	108.30 ± 5.65	125.04 ± 8.88	2.41 ± 1.62	1.72 ± 0.09	2.01 ± 0.12
	4th	366.62 ± 17.34	132.51 ± 7.68	234.11 ± 11.22	40.42 ± 2.21	3.35 ± 0.2	2.01 ± 0.19
	5th	406.15 ± 22.12	134.60 ± 7.44	271.65 ± 11.44	45.51 ± 2.24	3.27 ± 0.17	1.83 ± 0.02
	6th	398.39 ± 24.44	141.63 ± 8.62	256.76 ± 14.98	37.5 ± 2.48	3.01 ± 0.26	2.01 ± 0.16
	Total	1404.50 ± 76.34	517.04 ± 29.29	887.46 ± 46.53	145.84 ± 8.65	11.35 ± 0.73	7.86 ± 0.49
Fruit	3rd	411.62 ± 26.66	122.41 ± 6.62	289.21 ± 19.22	25.66 ± 1.82	2.12 ± 0.21	1.16 ± 0.02
	4th	566.65 ± 24.88	177.74 ± 8.64	388.91 ± 19.88	49.55 ± 2.25	4.12 ± 0.22	2.02 ± 0.15
	5th	565.34 ± 8.84	146.62 ± 7.78	418.72 ± 22.24	53.33 ± 2.44	4.86 ± 0.25	1.52 ± 0.02
	6th	445.96 ± 24.24	131.93 ± 7.68	314.03 ± 25.22	45.21 ± 2.15	3.70 ± 0.22	1.51 ± 0.02
	Total	1989.50 ± 84.62	578.70 ± 30.72	1410.87 ± 86.50	173.75 ± 18.66	16.90 ± 0.90	6.21 ± 0.21

The values between the parts of plant in each parameter are statistically significant ($p<0.05$)

Table - 4: Growth and development of the larvae of *H.armigera* fed on leaf, flower and fruit of chick pea. Each value is mean ± = standard deviation of six individuals

Part of the plant	Instar	Dry matter ingested (mg day^{-1})	Dry matter excreted (mg day^{-1})	Dry matter digested (mg day^{-1})	Larval weight gained day^{-1} (mg)	Larval size gained day^{-1} (mm)	Larval period (days)
Leaf	3rd	204.68 ± 15.22	70.76 ± 3.38	133.82 ± 14.66	13.51 ± 0.82	1.17 ± 0.02	2.66 ± 0.21
	4th	287.87 ± 15.44	76.24 ± 3.74	211.68 ± 11.68	28.42 ± 1.88	2.25 ± 0.16	2.66 ± 0.19
	5th	297.95 ± 14.77	77.22 ± 3.42	215.73 ± 12.44	21.47 ± 1.82	2.69 ± 0.16	2.33 ± 0.18
	6th	253.6 ± 16.48	85.14 ± 4.66	168.45 ± 8.64	21.14 ± 1.22	2.06 ± 0.12	2.33 ± 0.13
	Total	1044.10 ± 61.41	309.36 ± 15.20	734.74 ± 47.42	84.54 ± 5.76	8.17 ± 0.46	9.98 ± 0.71
Fruit	3rd	395.84 ± 22.44	105.02 ± 5.42	290.82 ± 17.44	30.24 ± 1.82	2.12 ± 0.21	1.66 ± 0.09
	4th	616.64 ± 38.33	142.52 ± 7.82	474.12 ± 22.48	59.42 ± 3.34	4.80 ± 0.21	1.50 ± 0.02
	5th	680.56 ± 34.44	174.33 ± 8.84	506.23 ± 25.22	63.33 ± 2.48	5.33 ± 0.32	1.50 ± 0.02
	6th	541.68 ± 8.55	155.06 ± 7.24	386.62 ± 18.48	48.87 ± 3.44	4.51 ± 0.22	1.16 ± 0.02
	Total	2234.72 ± 103.76	576.93 ± 29.92	1657.79 ± 83.62	201.86 ± 11.08	16.76 ± 0.96	5.82 ± 0.15

The values between the parts of plant in each parameter are statistically significant ($p<0.05$)

larvae fed with fruit, the growth rate was high from 3rd to 6th instar in terms of its weight and size. Interestingly the larval period considerably decreased in those larvae fed with the fruit of the plant than with the leaf and flower, suggesting that the fruit of those plants have better nutritive value. Faster growth rate as evident by higher weight and size was observed from 3rd to 6th instar of larvae fed on fruits (Table 1-4).

From the Table 5 it is clear that the *H.armigera* larvae mostly preferred the fruit of chick pea, and showed less preference for the fruit of lady finger and intermediate preference for the fruits of pigeon pea and cotton respectively. The main reason for greater preference of the fruits of chick pea than pigeon pea and cotton by the larvae could due to be the presence of high protein content in them. Sequeira *et al*. (2001), reported that the chick pea seeds contain 8.86 g protein, 27.42 g carbohydrates 2.59 g fats, 16.21 g water and many minerals per 100 g seeds. Less preference of the fruits of lady finger and cotton by the larvae could probably due to less protein in them and more fiber content (King, 1994). Corresponding to the amount of consumption of the fruit the larval weight and larval size also increased greatly from 3rd to 6th instar on chick pea, relatively less increase on lady finger. Interestingly the larval period was significantly less in the larvae fed on the fruit of chick pea and more in those fed on the fruit of lady finger, with intermediate period in those fed on pigeon pea and cotton respectively. Thus the total larval period is not only dependent on the part of the plant but also on the type of the plant.

In between flower and leaf, more dependence of the larvae on the leaf of lady finger and cotton, than on flower indicates that more nutrients are present in them required for the growth and development (Dhandapani and Balasubramanian, 1980; Prabhakara Rao *et al*., 2001).Hence significant increase in larval size and larval weight was observed in those who fed on leaf of lady finger and

Table - 5: Growth and development of the larvae of *H.armigera*, fed on leaf, flower and fruit of lady finger, cotton, pigeon pea and chick pea. Each value is mean ± = standard deviation of six individuals

Part of the plant	Instar	Dry matter ingested (mg day^{-1})	Dry matter excreted (mg day^{-1})	Dry matter digested (mg day^{-1})	Larval weight gained day^{-1} (mg)	Larval size gained day^{-1} (mm)	Larval period (days)
Leaf	Lady finger	939.96 ± 37.24	246.24 ± 18.24	673.72 ± 32.74	78.67 ± 3.22	7.85 ± 0.17	10.77 ± 0.85
	Cotton	1293.93 ± 63.99	374.63 ± 22.82	918.30 ± 45.54	106.20 ± 5.52	9.24 ± 0.59	9.67 ± 0.84
	Pigeon pea	818.60 ± 65.81	240.35 ± 12.16	578.25 ± 24.92	49.95 ± 3.01	5.50 ± 0.23	12.36 ± 0.90
	Chick pea	1044.10 ± 61.41	309.36 ± 15.20	734.74 ± 47.42	84.54 ± 5.76	8.17 ± 0.46	9.98 ± 0.71
Flower	Lady finger	693.77 ± 40.33	205.34 ± 10.43	488.43 ± 34.88	54.26 ± 3.77	5.52 ± 1.33	12.66 ± 0.95
	Cotton	1099.74 ± 60.33	448.01 ± 23.75	653.73 ± 40.70	98.27 ± 6.70	7.95 ± 0.44	10.50 ± 0.48
	Pigeon pea	1404.50 ± 76.34	517.04 ± 29.29	887.46 ± 46.53	145.84 ± 8.65	11.35 ± 0.73	7.86 ± 0.49
Fruit	Lady finger	1643.65 ± 87.27	465.52 ± 26.66	1178.93 ± 63.27	112.76 ± 5.21	9.94 ± 0.56	9.81 ± 0.38
	Cotton	1771.52 ± 106.20	448.22 ± 21.84	1323.30 ± 73.80	140.10 ± 7.19	10.49 ± 0.66	8.78 ± 0.62
	Pigeon pea	1989.50 ± 84.62	578.70 ± 30.72	1410.87 ± 86.50	173.75 ± 18.66	16.90 ± 0.90	6.21 ± 0.21
	Chick pea	2234.72 ± 103.76	576.93 ± 29.92	1657.79 ± 83.62	201.86 ± 11.08	16.76 ± 0.96	5.82 ± 0.15

The values between the type of the plant and part of the plant are statistically significant ($p<0.05$)

cotton than on the flower. In addition to nutritive value, the glabrous character of the leaves of *esculantus* species of lady finger and *herbaceum* species of cotton might be responsible for more dependence of the larvae on their leaves than on flowers (Jayaraj,1990; Akbar Ali *et al.,* 2003). High quality of gossypol content in the pigment glands on the cotton leaves also could be one of the reasons for greater preference by the pest (Meisner *et al.,* 1991). On pigeon pea the consumption of flower by the larvae was more than consumption of leaves. Probably the smooth surface of leaves and their higher thickness might be responsible for less preference. Whereas the flower is soft and may also consist more nutrients. Due to more consumption, the growth rate increased and larval period decreased in the larvae fed on flower of pigeon pea than in those fed with leaves.

Even though in cotton and lady finger the flower is least preferred still significant quantity of the flower is consumed by the larvae. This indicates that the larvae will eat even the flower of the crops, if other parts of the plant are exhausted. In between the two plants the cotton flower was preferred more by the pest than lady finger, there by a corresponding increase in the growth of the larvae and decrease in the total larval period was observed.

The overall results indicated that the larval preference was mostly for chick pea, followed by pigeon pea, cotton and the least preferred was lady finger. Ramanath *et al.* (1992) also stated that the pest prefers the chick pea, pigeon pea, lady finger, cotton and tomato than other crops. Thus various host plants have significant effect on the larval growth and development of *H. armigera.* The larval period was less on chick pea and longer on lady finger when larvae were fed with their fruit, shorter on chick pea and longer on pigeon pea when larvae were fed with leaves, and shorter on pigeon pea and longer on lady finger when they were fed with the flowers of the plant.

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