Chhattisgarh is an emerging pulse growing tract. Among the various factors responsible for causing losses to the major pulses, pod borers are most harmful, and polyphagous Heliothis armigera (Hb) is pre-eminent one. Information on its biological behaviour and threshold level is not ample, particularly from this region.

On the basis of slight structural differences, biological races of polyphagous and oligophagous insects have been formed, and in some cases these differences may not be even clear. Studies on host-preference in succeeding generation have not been given due attention. However, from past few decades this problem has received critical and healthy attitude, but even at present in all cases larger scale and more prolonged investigations are still awaited. Such investigations are not only capable to decide the line of applied entomology, but also facilitate insect resistance programme.

Entomologists all over the world have started realising the danger in absolute reliance on insecticidal approaches. "Need based" application of chemicals is now desired and therefore, it is essential to decide the level of insect
population which create "need" of control. Similarly, it is better to avoid insect pest by adopting resistant lines.

Different aspects of biological studies under laboratory and field conditions were undertaken. The results obtained are compared with those recorded by earlier workers, and are briefly discussed under various headings in the succeeding sections.

5.1. **EGG STAGE**

5.1.1. **Egg period (Table 1 and Fig. 4.1):**

In the first generation, period between egg laying to hatching was the shortest of 3.13 ± 0.52 days on chick-pea and longest duration (4.13 ± 0.74 days) was lasted on linseed.

Egg period in the second generation varied from 2.93 ± 0.59 days (chick-pea) to 3.87 ± 0.64 days (linseed).

These results are inconfirrmity with those of Raich (1966) Singh and Singh (1975), Patel (1977), Gatoria et al. (1978) and Bhatnagar et al. (1982). Simultaneously present finding did not agree with the results reported by Goyal (1979) and Bhadoria (1987), former worker has reported shorter and later worker has found quite longer period than that of present results.
5.1.2. Egg size (Table-1):

In both the generations significant effect of different hosts on the egg size did not appear. However in the first generation egg size ranged from \(0.366 \pm 0.009\) mm \(x\) \(0.34 \pm 0.009\) mm to \(0.4 \pm 0.00 \times 0.37 \pm 0.00\) mm. These lowest and highest values were observed on chrysanthemum and artificial diet, respectively. In second generation both the hosts again gave shortest and longest egg size which was \(0.37 \pm 0.009 \times 0.34 \pm 0.009\) mm and \(0.4 \pm 0.00 \times 0.37 \pm 0.00\) mm. Almost similar finding also reported by Patel (1977), but results of Bhadoria, regarding egg size is quite different, than that recorded in present study.

5.1.3. Viability of eggs (Table-1):

In both the generation lowest and highest number of viable eggs were recorded on chrysanthemum and chick pea respectively. During the first generation number of viable eggs was \(129.2 \pm 87.80\) and \(320.6 \pm 48.69\) while corresponding values for second generation were \(141.6 \pm 96.98\) and \(346.0 \pm 49.91\) respectively. Variation in viability of eggs observed on different hosts can be explained on the basis of amount of yolk content in eggs number and fertile eggs laid.

The results of present findings are in conformity with those of Goyal (1979), who obtained viability per cent between 79.58 to 98.01 per cent on chick-pea.
5.2. Larval Stage

On the damaging stage of *Heliothis* following observations were recorded.

5.2.1. Larval period (Table-2 and Fig.-4.2).

5.2.1.1. First instar:

The duration of first instar caterpillar, ranged between 3.53 ± 0.52 (artificial diet) and 4.46 ± 0.52 days (Amaranthus) while in second generation on the same hosts, the minimum (2.60 ± 0.51 days) and maximum (3.46 ± 0.52 days) larval period of first instar was found. However, among the natural hosts, more preference was shown for cauliflower, berseem and chick-pea. Similar preference for chick-pea has been reported by Deshmukh (1989). The duration observed on chick-pea was 4.26 ± 0.46 and 3.07 ± 0.41 days in first and second generations, respectively which is in agreement with the findings of Singh (1972).

5.2.1.2. Second instar:

Larval duration of second instar varied from 2.53 ± 0.052 days (linseed) to 3.13± 0.52 days (cauliflower) in the first generation while in the second generation, the minimum (2.13±0.35 days) and maximum (2.73 ± 0.39 days) duration was obtained on artificial diet and rose. In the second generation next to artificial diet was chick-pea (2.20±
0.41 days). Similar results with chickpea have been reported by Singh (1972) and Deshmukh (1989).

5.2.1.3. Third instar:

The third instar duration was shortest (2.20 ± 0.41 days) on chick-pea in first generation and on artificial diet (2.13 ± 0.35 days) in the second generation. Chrysanthemum gave the longest duration in both the generations. On chick-pea, it was 2.27 ± 0.46 days in second generation. Similar period of third instar on chick-pea has been reported by Singh (1972) and Deshmukh (1989).

5.2.1.4. Fourth instar:

In both the generations, shortest larval period of forth instar caterpillar (2.13 ± 0.35 days) was obtained on chick-pea. The longest period in first and second generation, was 3.06 ± 0.26 days (Amaranthus) and 2.73 ± 0.46 days (chrysanthemum) respectively. This period was lesser than that reported by Singh (1972) and Deshmukh (1989).

5.2.1.5. Fifth instar:

The fifth instar duration in the two generations was shortest on chick-pea (2.06 ± 0.26 days) and artificial diet (2.13 ± 0.35 days), while it was the longest on cotton (3.0
... and chrysanthemum (2.80 \pm 0.41 \text{ days}). The results in respect of chick-pea are in conformity with those of Singh (1972) and Deshmukh (1989).

5.2.1.6. Sixth instar:

The sixth instar larval duration was shortest on chrysanthemum and longest on rose during both the generations. The values were 2.40 \pm 0.51 and 4.46 \pm 0.52 days in first generation, whereas, in the second generation, it was 2.40 \pm 0.51 and 3.33 \pm 0.49 days. For chick-pea, values of larval period was 3.93 \pm 0.46 and 2.80 \pm 0.56 days respectively. These results were comparatively closer with those, reported by Deshmukh (1989). However, Singh (1972) reported larval duration of sixth instar to be about two to three times higher than that recorded in the present study.

5.2.1.7. Seventh instar:

In the present investigation out of the nine hosts only three namely, linseed, Amaranthus and chrysanthemum were effective in giving the seventh instar. In first generation, shortest and longest larval duration were noticed on chrysanthemum (2.53 \pm 0.52 \text{ days}) and Amaranthus (4.20 \pm 0.56 \text{ days}), respectively. Linseed and chrysanthemum gave shortest (3.27 \pm 0.46 \text{ days}) and longest (3.46 \pm 0.52 \text{ days}) larval duration in the second generation. Raich (1966) and
Singh (1972) have also supported this finding with the statement, that 10 per cent of the total larvae get 7th instar.

5.2.1.8. Eighth instar:

In the present investigation chrysanthemum feeding resulted with eighth instar of *H. armigera* and larvae lasted for 4.13 ± 0.35 days. However the eighth instar has not been reported by any of the previous workers under references.

5.2.1.9. Total larval period:

Total larval period was found to be varying from 17.33 ± 0.82 to 24.06 ± 1.49 days, in the first generation and 13.86 ± 0.74 to 19.86 ± 1.36 days in the second generation on artificial diet and chrysanthemum respectively. On chickpea and cotton the total larval period in the first generation was 17.53 ± 1.25 and 19.33 ± 1.45 days respectively while in the second generation, these values were 14.66 ± 1.27 and 15.33 ± 1.29 days respectively.

These results are in confirmation with those of Raich (1966), Goddewar (1969), Gatoria *et al.* (1978) and Dhandapani and Balasubramanian (1980). However contradictory results have been reported by Singh (1972) and Singh and Singh (1975).
In the present study chick-pea was most preferred natural host as also stated by Bhatnagar and Davis (1978).

5.2.2. Larval length (Table-3 and Fig.-4.3):

5.2.2.1. First instar:

The larval length in the first instar, during the first generation was $1.77 \pm 0.11$ mm to $1.88 \pm 0.08$ mm on linseed and chick-pea respectively. In second generation the minimum and maximum values were ranging from $1.66 \pm 0.11$ to $2.16 \pm 0.12$ mm. On chrysanthemum and artificial diet, respectively. On chick-pea the larval length of the first instar larvae was quite high than those reported by Patel (1977) and Bhadoria (1987).

5.2.2.2. Second instar:

The minimum and maximum larval length in both the generations were observed on chrysanthemum and artificial diet, respectively. In the first generation it ranged between $3.06 \pm 0.13$ mm and $4.26 \pm 0.56$ mm. While in second generation these values were $3.62 \pm 0.41$ mm and $5.32 \pm 0.44$ mm, respectively. Almost similar larval length was measured by Patel (1977) and Bhadoria (1987).
5.2.2.3. Third instar:

In the first generation, minimum (5.05 ± 0.29 mm) and maximum length (14.33 ± 0.70 mm) of third instar larvae were observed on chrysanthemum and artificial diet. In the second generation larval length were ranging from 11.83 ± 0.53 mm (chrysanthemum) to 15.30 ± 0.42 mm (artificial diet).

On chick-pea the larval length ranged from 13 to 15 mm in both the generations. These observations are in agreement with those of Bhadoria (1987) while value stated by Patel (1977) were quite less.

5.2.2.4. Fourth instar:

In the fourth, fifth and sixth instar, chrysanthemum gave minimum larval length, while artificial diet produced the longest.

Length of fourth instar in first generation was ranging from 14.17 ± 0.71 to 16.10 ± 0.76 mm. While in second generation larval length measured between 14.17 ± 0.71 to 17.07 ± 1.04 mm. On chick-pea larval length in first and second generation was 15.80 ± 0.80 mm and 16.80 ± 0.94 mm, respectively. These were, comparatively higher than those of Patel (1977) while almost at par with those of Bhadoria (1987).
5.2.2.5. Fifth instar:

In the first and second generations the shortest larval length varied between 12.03 ± 0.97 and 17.32 ± 1.23 mm. While in both the generations, longest larval length was 25.0 ± 1.54 and 26.62 ± 1.44 mm respectively. Chick-pea reared larvae were measured between 24.96 ± 1.77 to 25.96 ± 1.31 mm, in two generations. These observations are almost similar as reported by Bhadoria (1987) while higher than observations reported by Patel (1977).

5.2.2.6. Sixth instar:

The larval length ranged between 16.20 ± 1.21 to 32.06 ± 1.80 mm in the first generation and 20.40 ± 1.71 to 32.70 ± 1.13 mm in the second generation. Chick-pea gave 31.84 ± 1.77 and 32.00 ± 0.83 mm larval length in both the generations. These results are in agreement with those of Patel (1977) and Bhadoria (1987).

5.2.2.7. Seventh instar:

Referring to different references, it is found that earlier workers have here to fore have not measured larval length in seventh and eighth instar. However in the present study seventh instar measured between 23.18 ± 1.56 mm (chrysanthemum) and 29.74 ± 0.87 mm (linseed) in the first generation. During the second generation Amaranthus fed
larvae had minimum length (28.22 ± 2.42 mm) and linseed gave maximum one i.e. 30.22 ± 1.31 mm).

5.2.2.8. Eight instar:

The eighth instar of Heliothis was obtained on chrysanthemum and in the first generation only. The length of larvae was 28.93 ± 1.44 mm.

The larval length was almost in conformity with those of Raich (1966), Patel (1977), Bhadoria (1987) and Deshmukh (1989). Chick-pea was found to be the best natural host.

5.2.3. Larval weight (Table-4 and Fig.4.4):

In the first generation, the minimum larval weight of first, third, fifth, sixth and seventh instars were recorded on chrysanthemum, while on Amaranthus in second and fourth instars. Similarly in the second generation, linseed gave minimum larval weight of first instar caterpillar. Lighter larvae of second, third and fourth instars were noticed on Amaranthus. Remaining three instars were found to be on chrysanthemum. The maximum larval weight up to sixth instars were recorded on artificial diet in both the generations. Larvae reared on linseed were heaviour during seventh instar larval stage in both the generations.

In the first generation, maximum instar wise, larval weight was 2.30 ± 0.14, 8.76 ± 0.21, 58.08 ± 0.46, 78.60
1.04, 159.59 ± 2.17 and 324.46 ± 3.49 mg. During the second generation these values were 2.53 ± 0.10, 11.36 ± 0.73, 60.28 ± 0.86, 80.85 ± 1.52, 161.75 ± 3.02 and 325.33 ± 1.73 mg. Final larval weight in both the generations, recorded on artificial diet which were followed by chick-pea (319.80 ± 0.91 and 321.48 ± 1.83 mg.) and cotton (318.92 ± 4.02 and 320.14 ± 2.43 mg.).

The larval weight was almost similar to those of Goddewar (1969) and Katole (1970), on chick-pea and cotton but the larval weight on these hosts were far below than reported by Dhandapani and Balasubramanian (1980).

Variation in the larval weight influenced by hosts was in agreement with those of Katole (1970), and Dhandapani and Balasubramanian (1980). Artificial diet gave maximum larval weight, because its nutritive value is much higher than that of any other test host.

5.2.4. APPLICABILITY OF DYAR'S LAW (Table-5 and Fig.-4.5):

Verification of Dyar's law was carried out only on artificial diet fed larvae.

The width of head capsule instar-wise varied from 0.288 to 2.613 mm. The growth ratio between the head capsule of first and second, second and third, third and fourth and
fourth to fifth moult was 1.76, 1.72, 1.88 and 1.58 mm respectively, with overall average of 1.74. This ratio is almost similar to the growth ratio reported by Bilapate and Pawar (1978) and Bilapate et al. (1985), who reported overall growth ratio being 1.745 and 1.750 respectively.

This study confirm the applicability of Dyar's law in this insect.

5.3. PREPUPAL AND PUPAL STAGE:

5.3.1. Prepupal period (Table-6 and Fig.-4.6):

In the first and second generation pre-pupal period was shortest on artificial diet (2.60 ± 0.74 and 2.40 ± 0.51 days) and the longest pre-pupal period was recorded on chrysanthemum (4.27 ± 0.46 and 4.07 ± 0.79 days), respectively. However, chick-pea fed larvae in both the generations were lasted 2.80 ± 0.56 and 2.53 ± 0.52 days respectively.

These findings are similar to those of Goyal (1979) and Bhadoria (1987) who reported almost similar results for chick-pea fed larvae simultaneously present findings did not agree with those of Singh and Singh (1975), who reported far short pre-pupal period on tomato.
5.3.2. **Pupal period** (Table-6 and Fig.-4.7):

The trend of pupal period was similar to that of pre-pupal period. In both the generations, artificial diet and chrysanthemum gave shortest and the longest pupal period. On artificial diet pupal period was $14.47 \pm 0.52$ and $13.93 \pm 0.80$ days. The corresponding figures on chrysanthemum was $19.13 \pm 0.49$ and $19.20 \pm 0.94$ days.

Similar chrysalis duration have been given by Bot (1966), Raich (1966), Bilapate (1978), Gatoria et al. (1978), Bhatnagar et al. (1982), Tripathi and Sharma (1984) and Bhadoria (1989). But the findings of Patel et al. (1968), Goddewar (1969), Singh and Singh (1975) and Goyal (1979) however, different. In respect to pupal period chick-pea gave shorter pupal period over another seven natural host, this result is confirmed by the finding of Goddewar (1969).

5.3.3. **Pupal size** (Table-6):

Pupal size was also maximum when larvae reared on artificial diet $19.7 \pm 0.28 \times 5.89 \pm 0.17$ and $19.91 \pm 0.11 \times 5.94 \pm 0.12$ mm in first and second generations respectively. Chrysanthemum fed larvae gave smallest pupae in both the generations. In the first generation, chick-pea had $19.60 \pm 0.33 \times 5.69 \pm 0.21$ mm size pupae but in second generation
corresponding figures were $19.73 \pm 0.27 \times 5.79 \pm 0.21$ mm. Slight variation in the mean size of pupae due to hosts may be justified on the basis of nutritive values of hosts. These findings are in conformity with the result reported by Bilapate (1978). Similar size also reported by Goddewar (1969) when larvae fed on chick-pea this result related with Amaranthus in present findings. But present results do not tally with those reported by Patel (1977).

5.3.4. Pupal weight (Table-6 and Fig.-4.8):

Pupal weight in the first generation ranged between 297.0 ± 3.86 mg (artificial diet) and 253.80 ± 14.13 mg (chrysanthemum) while in second generation these two hosts gave 300.03 ± 2.15 mg and 281.51 ± 3.50 mg pupal weight respectively. Chick-pea and cotton fed larvae were produced 296.18 ± 5.29 and 293.7 ± 3.75 mg pupal weight in the first generation. During the second generation, chick-pea and cotton gave 297.85 ± 295.15, 1.59 mg pupal weight.

Reduction in weight between larval and pupal stage may be explained on the basis of drastic histolytic and histogenetic changes during the metamorphosis. Secondly pupal weight depends upon the amount of assimilable nutritive material contained, in this way variation in pupal weight which influenced by different hosts can be unravel through a critical nutritional study.
These results are in agreement with those of Goddewar (1969) and Narayanan et al (1977). Katole (1970) reported pupal weight on gram and cotton were less, than that recorded in present investigation.

5.3.5 Total development period : (Table 7 and Fig. 4.9):

The period lasted from egg laying to adult emergence was ranged between 37.80 days (artificial diet) and 51.46 days (chrysanthemum), during the first generation. Total developmental period recorded on artificial diet was at par with that of chick pea (38.32 days) however it was significantly shorter than that recorded on cotton (41.00 days).

In the second generation, in respect to total developmental period, artificial diet pre-eminent and gave shortest period for development (33.45 days). On chrysanthemum insect lasted longest duration of 46.80 days.

On the basis of two generation, the preference of different hosts for total developmental period in sequence was artificial diet > Chick-pea > Cotton > Berseem > Cauliflower > Rose > Linseed > Amaranthus > Chrysanthemum.

These findings were confirmed with the results reported by Bhadoria (1987) on chick-pea. Simultaneously Singh (1972), Patel (1977), Bilapate (1978) and Gatoria et al.,
(1978), reported the duration of life-cycle. However shorter life-cycle than that of present developmental period were reported by Goyal (1979).

5.4.1 ADULT STAGE:

5.4.1.1. Longevity of male adult (Table 6 and Fig. 4.10):

The longevity of male alata during the first generation was varying from $4.2 \pm 0.25$ days to $6.4 \pm 0.55$ days on chrysanthemum and artificial diet. In the second generation the corresponding periods on these hosts were $4.4 \pm 0.55$ and $7.0 \pm 0.71$ days, respectively.

5.4.2. Longevity of female adult (Table 6 and Fig. 4.11):

The longevity of female alata in the first generation, shortest and longest was observed on chrysanthemum ($5.4 \pm 0.55$ days) and artificial diet ($7.6 \pm 0.55$ days) respectively. On chick-pea and Cotton longevity of female alata in the first generation was $7.2 \pm 0.45$ and $6.8 \pm 0.45$ days while in second generation chick pea and cotton gave $7.4 \pm 0.55$ and $7.0 \pm 0.71$ days, respectively.

These results in agreement with those reported by Boddewar (1969), Katole (1970) and Bhatnagar et al. (1982). But the longevity of adults reported by Tripathi and Sharma (1984) was different.
5.4.3  
**Size of the male adult (Table 8):**

During the first generation shortest male alata emerged from chrysanthemum $(27.60 \pm 0.24 \times 17.3 \pm 0.12 \text{ mm})$ and largest sized male alata come soon from artificial diet $(30.0 \pm 0.19 \times 19 \pm 56 \pm 0.17 \text{ mm})$. The trend of male size was the same, in the second generation. As found during the first generation. The shortest and largest sized of male alata found to be $28.64 \pm 0.42 \times 18.04 \pm 0.66 \text{ mm}$ and $31.4 \pm 0.55 \times 20.82 \pm 0.63 \text{ mm}$, respectively.

5.4.4.  **Size of the female adult (Table 8):**

In the first generation the wing span x body length of female alata varied from $28.98 \pm 0.85 \times 19.16 \pm 0.23 \text{ mm}$ (chrysanthemum) to $33.8 \pm 0.45 \times 21.96 \pm 0.27$ (chick-pea). The corresponding values in the second generation were deviated between $30.10 \pm 0.74 \times 18.74 \pm 0.88$ and $35.38 \pm 1.37 \times 23.9 \pm 0.53 \text{ mm}$. These results are not in confirmation with those of Singh and Singh (1975) who reported that moth was $19.4 \pm 0.18 \text{ mm}$ long and $16.5 \pm 0.31 \text{ mm}$ broad. But Edward and Heath (1964) reported that wing span varied from 35 to 40 mm.

5.4.5.  **Sex ratio:** (Table 8):

The sex ratio of male Vs. female varying from $1:0.25$ (Amaranthus) to $1:1.14$ (Cotton) in the first generation.
During the second generation it was ranging from 1:0.25 to 1:1.5 on chrysanthemum to artificial diet. From the results it was evident that in the first generation male dominance was observed except cotton on each test hosts but in the second generation male dominance was observed on cotton, rose, Amaranthus and Chrysanthemum.

The sex ratio reported by Mourikis (1973), Bhadoria (1987) and Deshmukh (1989) were in conformity, with the results of present finding. On chick-pea male dominance was reported by Bhadoria (1987) and female dominance by Deshmukh (1989). In the present finding dominance of male noticed in first generation and female dominance in the second generation.

5.4.6. Pre-oviposition period (Table 8):

During the first generation, pre-oviposition period was shortest of 1.2 ± 0.45 days recorded on cauliflower and chrysanthemum while females of artificial diet, rose and Amaranthus were lasted for 1.8 ± 0.45 days chick-pea reared females were taken 1.4 ± 0.55 days for oviposition. In the second generation pre-oviposition period minimum (1.2 ± 0.45 days) was recorded on amaranthus and linseed, whereas maximum period of 2.0 ± 0.0 days. Noticed on artificial diet. Chick-pea in both the generations gave 1.4 ± 0.55 and 1.8 ± 0.45 days. In respect to pre-oviposition period the
significant differences among the hosts were not observed.

Present results are in agreement with that of Mourikis
(1973), Goyal (1979), Jayaraj (1981) and Choudhary and
Sharma (1983).

5.4.7. Oviposition period (Table 8 and Fig. 4.12):

Period of egg laying in the first generation was the
shortest on chrysanthemum and amaranthus, (2.6 ± 0.55 days)
and the longest oviposition period of 4.2 ± 0.45 days
noticed on artificial diet followed by 3.8 ± 0.45 days on
chick-pea and 3.6 ± 0.55 days on cotton.

In the second generation, chrysanthemum gave the
shortest period of oviposition (2.6 ± 0.55 days) while
longest one observed on chick-pea (4.6 ± 0.55 days) which
was atpar with the oviposition period recorded on artificial
diet and cotton.

The present results are in confirmity with those of
Singh and Singh (1975) who reported oviposition period on
Tomato.

Slightly higher period of oviposition also reported by
Choudhary and Sharma (1983). Goyal (1979) found it of 6 to 8
days while Raich (1966) have record 9 to 12 days for egg-
laying.
5.4.8. **Post-oviposition period** (Table 8):

During the first generation period of female survival after the withdrawal of egg-laying was the shortest on rose and amaranthus (1.2 ± 0.45 days) while it expended up to 2.0 ± 0.71 days on chick-pea. In the second generation post oviposition period ranged between 1.0 ± 0.0 days (Chick-pea) and 2.0 ± 0.71 days (Amaranthus). It was observed that in both the generations, hosts did not (has) any significant effect on the post-oviposition period.

These results are almost similar to those of Singh and Singh (1975), Goyal (1979), Choudhary and Sharma (1983).

5.4.9. **Fecundity** (Table 8 and Fig. 4.13):

In the first generation capacity of egg laying was observed on chrysanthemum (183.8 ± 102.16 eggs) while maximum one was recorded on chick-pea (368.4 ± 47.29 eggs). In the second generation, on the same hosts minimum (188.4 ± 104.77 eggs) and maximum (389.0 ± 51.29 eggs) fecundity were recorded.

Fecundity reported by Patel et al. (1968) and Bhatnagar et al. (1982) was almost four times to that noticed in the present findings. Goyal (1979), has given the range of 250 to 526 eggs which is inagreement with the present study. Similar range was reported by Choudhary and Sharma (1983).
Deshmukh (1989) has found maximum oviposition on Chick-pea than that of soybean. Similar reproductive liking of Heliothis was noticed in present piece of study. Vargas et al. (1979) and Anderson (1980) also made same view that larval diet capable to effect fecundity of female.

5.5. Qualitative and Quantitative studies on H. armigera:

5.5.1. Survival of different life stages:

5.5.1.1. Larval survival (Table 2 and Fig. 4.14):

Larval survival of first instar caterpillar was the highest on chick-pea (28) followed by artificial diet (27). Rose gave minimum larval survival for first instar (23). The maximum larval survival for the first instar was again recorded on chick-pea (29) but minimum first instar survival shifted from rose to amaranthus (24).

Minimum first instar survival on rose may be due to the texture of leaves. Upto sixth instar, artificial diet performed as the best suitable meal for larval survival in both the generations. Rose upto fourth instar in the first generation gave minimum survival in both the generations. Rose upto fourth instar in the first generation gave minimum survival and from fifth to eight instar minimum larval survival was recorded on chrysanthemum. In the second generation upto seventh instar minimum larval survival was
noticed on amaranthus. Overall larval survival in the first generation ranged between 25 larvae (artificial diet) and 15 larvae out of 30 larvae (chrysanthemum) while corresponding figures in the second generation was 26 larvae (artificial diet) and 18 larvae (amaranthus). In both the generations chick-pea gave larval survival to 23 and 24 larvae.

Variation in larval survival may be understood on the basis of preference of the insect for introduced hosts. These results are slightly less than those reported by Goddewar (1969). According to Goddewar, Chick-pea was predominant over cotton and in present study also some to end was obtained. Singh; (1972) have also reported higher survival on preferred host.

5.5.1.2. Pre-pupal survival (Table 9):

Pre-pupal survival in both the generations was the highest on artificial diet. On chick-pea in both the generations, 22 and 23 pre pupae were formed. Cotton gave 21 and 25 pre pupal. Minimum pre-pupal survival in the first generation was recorded on chrysanthemum 14 pre pupal and in second generation 19 pre-pupal were recorded on amaranthus.

5.5.1.3. Pupal survival (Table 9 and fig 4.15):

Trend of pupal survival in both the generations was the same, as found in case of pre-pupal survival. In the first
and the second generations pupal survival on artificial diet was the highest.

On chick-pea and cotton in the first generation, pupal survival was the same, 20 pupal while during the second generation corresponding value on these hosts were found to be 23 and 22 pupal. The minimum pupal survival on chrysanthemum and Amaranthus were noticed in the first and second generations, respectively. (12 and 16 pupal).

Goddewar (1969) have reported that pupal survival on gram and cotton was 95.23 and 88.8 per cent. Thus, pupal survival reported by author, confirmed with present study.

5.5.1.4. Adult survival (Table 9 and Fig. 4.16):

Artificial diet in both the generations gave highest adult survival. It was 22 and 25 alata respectively. Minimum healthy adult emergence in first and second generations were observed on chrysanthemum 11 and amaranthus 16. In both the generation on chick-pea and cotton it varied from 19 and 23, 19 and 21 adults respectively.

These results are in conformity with those of Goddewar (1969). According to Goddewar per cent adult survival on gram and cotton was 100 and 93.33 per cent. But contradictory results reported by Patel (1977).
5.5.2. Cross ovipositional study (Table 10):

The female alata which emerged from artificial diet oviposited minimum (19.33 ± 3.79) and maximum (77.66 ± 6.66) eggs on linseed and chick-pea respectively. These moths laid 51.33 ± 9.02 eggs on artificial diet and 32.33 ± 17.16 on chrysanthemum.

Chick-pea female gave almost similar preference to cotton and chick-pea (82.00 ± 25.51 and 81.00 ± 15.39 eggs, respectively). On the basis of oviposition berseem categorised as least preferred host for chick-pea reared moths.

Moths emerged from cotton, oviposited the maximum number of eggs on cotton (79.66 ± 12.01) than any other tested hosts, including chick-pea (50.00 ± 29.89 eggs). For cotton female, least preferred host was linseed (12.66 ± 11.72 eggs).

Almost similar oviposition was recorded on chick-pea and berseem (62.33 ± 11.59 and 61.66 ± 9.60 eggs, respectively). Artificial diet received minimum number of eggs (23.00 ± 5.56) by berseem reared moths, diet was followed by linseed (23.33 ± 6.50 eggs).

Female moths emerged from cauliflower gave maximum eggs on cauliflower (63.33 ± 16.04) and cotton 44.00 ± 36.38
eggs). Least preferred host was linseed (26.33 ± 8.50 eggs).

Female moths which were emerged from rose gave 72.00 ± 8.88 eggs on rose while on chick pea and cotton they were laid 32.33 ± 14.18 and 31.33 ± 12.85 eggs, respectively. Similar least preference was noticed on berseem and cauliflower (16.09).

Females emerged from linseed feeding deposited maximum eggs on linseed (38.00 ± 11.78 eggs), which was followed by chick pea (34.00 ± 22.27) and cotton (30.33 ± 3.05 eggs), Chrysanthemum received 27.33 ± 6.80 eggs. Minimum choice for egg laying was noticed on artificial diet (13.00 ± 10.14).

Female alata which came out from linseed fed life stages gave first choice to linseed and deposited 32.00 ± 21.79 egg, which was at par with the eggs laid on chick pea (30.33 ± 12.85) and diet (26.33 ± 11.59 eggs) Minimum oviposition of 15.00 ± 8.88 eggs were noticed on berseem.

Eggs laid by chrysanthemum female alata was the maximum on chrysanthemum, (39.33 ± 24.00 eggs) significantly least preference than that of chrysanthemum was noticed on Amaranthus, artificial diet and rose. Remaining hosts were at par with chrysanthemum in respect to egg laying.

This study confirmed to theory of Hopkin's (1916) who stated that, a insect species is capable to breed in two or
more hosts, but individuals will normally continue to select the particular host but individuals will normally continue to select the particular host species, upon which their own life-cycle was passed. However, selection for a particular host is not concerned with one or two generations. Host selection not only depends upon the completion of life-cycle, host recognition is also one of them, and this recognition seen. When total number of eggs were counted for each host. Sequence of different hosts were, chick-pea, cotton, rose, cauliflower, chrysanthemum, berseem, artificial diet, Amaranthus, Linseed. These results revealed that, texture, of plant or leaves, which can create excitement for egg-laying, received higher number of eggs and so that rose occupied third rank, and artificial diet seventh in this study.

The present findings are at par with those of Bhatnagar and David (1978), who reported that chick-pea received maximum eggs in cross ovipositional study, and same result was evident in the present study.

5.5.3. Life indices for Heliothis Armigera:

The preference of the different hosts to an insect in demonstrated by the rate of development, fecundity of a female, longevity of adults, and viability of eggs. In the nutritional study several indices have been used by
different workers, using their own computational formulae. In the present context artificial diet was considered as standard host.

5.5.3.1. Growth index (Table 11):

_Hellothis armigera_ (Hb.) is mainly a pest of chick-pea and its growth index on chick-pea was the highest, among the natural hosts, which closely followed by berseem in the first generation, but in the second generation chick-pea followed by cotton. However, highest growth index value in both the generations was recorded on artificial diet and minimum value was obtained on chrysanthemum and amaranthus during the first and second generations, respectively. These results are in conformity, with Goddewar, (1969) who reported higher growth value on chick-pea than that of cotton.

5.5.3.2. Larval index (Table 11):

Larval index values were observed the highest on chick-pea, and lowest on chrysanthemum in both the generations. In the first generation. Similar larval index was observed on cotton and berseem (0.983). It indicate that in respect to larval weight cotton and berseem performed the similar efficiency in the second generation cotton gave better larval index value than that of berseem. At this point,
cotton performed as the second host of Heliothis and it is fact from various literature also.

5.5.3.3. Pupal index (Table 11):

Pupal index related with pupal body weight, in the first and second generations it ranged between 0.997 to 0.854 and 0.992 to 0.938 on chick-pea and chrysanthemum. Chick-pea followed by cotton, berseem and cauliflower in both the generations.

5.5.3.4. Larval-pupal index (Table 11):

In larval pupal index, developmental period, consumed in larval and pupal stages was considered. On chick-pea, and chrysanthemum larval pupal index in the two generations were found to be, 1.01, 1.36 and 1.04, 1.41 respectively.

5.5.3.5. Adult index (Table 11):

Adult index, indicates to longevity of adult and in the present study female alata were considered as adult.

Trend of adult index of the same as it was observed in previous three indices. Chick-pea was pre-dominant in both the generations over remaining hosts and shown 0.947 and 0.949 adult index value while corresponding value on chrysanthemum in both generations were 0.711 and 0.718.
5.5.3.6. **Ovipositional index** *(Table 11)*:

Ovipositional index value in both the generations was the highest on chick-pea (1.02 and 1.04) as compared to artificial diet (standard host) being 1.0. Chrysanthemum in both the generations gave 0.508 and 0.503 ovipositional index values. In the first generation chick-pea closely followed by cotton (1.00).

5.5.3.7. **Survival index** *(Table 11)*:

Survival index means comparison between number of adults emerged from test host and standard host. Similar survival index was obtained on chick-pea and cotton (0.864), while minimum value of this index was recorded on chrysanthemum (0.500). In the second generation, highest value was computed on chick-pea (0.920), followed by cotton (0.840). On amaranthus and chrysanthemum minimum survival index of 0.640 was observed.

Despite the fact that the *Heliothis armigera* (Hb.) is one of the most important insect of crops. If we see the present finding critically it would appear that in respect to ovipositional behaviour chick-pea is a superior host to artificial diet. Artificial diet only capable to provide suitability only during the developmental stage, but as insect reached in reproductive phase, chick-pea become
superior hence. Among the all test hosts, chick-pea is the only best suitable host, even better than cotton, closely follow to chick pea than that to artificial diet.

5.6. FIELD STUDIES :

5.6.1 Effect of defoliation on chick-pea yield (Table 12):

Artificial defoliation was created at vegetative stage of chick-pea, by releasing variable number of Heliothis larvae. Which ranged between no larva and ten larvae per plant. It was observed that maximum of 70 per cent defoliation had very little yield reduction as compared to no defoliation. In these treatments, grain field was 1954 and 1920 kg/ha. respectively.

These results are supported by the results of Sithanantham et al. (1983) on chick-pea but Bhattacharjee and Ghude (1985) created defoliation just before blooming of soybean and found that there was reduction in pod number, pod weight and grain yield.

5.6.2. Economic threshold level for Heliothis larvae :

5.6.2.1. Number of pods (Table 13):

The number of pods per ten plants in zero to ten larvae per ten plants did not differ significantly. The total number of pods varying from 359 to 414 per ten plants. It
shows that in different treatments the bearing of the pods was almost uniform.

5.6.2.2. Larval density Vs. pod damage (Table 13 and Fig. 4.17)

The per cent pod damage treatment wise deviated between 0 per cent (T1) and 26.93 per cent (T10). Remaining treatments gave 5.26, 9.57, 11.33, 12.33, 12.60, 16.50, 18.70 and 22.60 per cent pod damage in ascending order. Larval density of T4, T5 and T6 caused 11.33, 12.33 and 12.60 per cent pod damage which was at par with each other but significantly less than that recorded in T7 (16.50 per cent). Larval density and per cent pod damage had significant positive co-relation (Y = 2.15 ± 2.46).

These findings are not in conformity with those of Choudhary and Sharma (1981) and Sharma (1985) who reported larval density of one and two as economic threshold level on chick-pea. In the present study, single larva was capable to reduce yield only negligibly, while the four larvae per ten plants had shown significant reduction in yield. Results are in confirmation with Odak and Thakur (1975). Almost similar results on cotton have been reported by Kurdov (1974), Tanskii (1975), Mahalle et al. (1976) but the results reported by Tanskii (1969 and Chaing (1977) are different.
5.6.2.3. Larval density Vs. grain weight (Table 13 and Fig. 4.17)

Minimum grain weight per plot 40.10 gm and maximum 59.24 gms in T10 and T1 treatments respectively. However, grain weight in T4, T5 and T6 was atpar, yield in these treatments was 55.66, 53.03 and 50.40 gms, respectively. This indicates that the economic threshold level may lie between T4 to T6 as the grain weight of T1 and T5 had significant difference.

Larval density per plot and grain yield were negatively correlated \( Y = 60.41 - 2.09 x \).

These results are in agreement with those of Odak and Thakur (1975), who reported that four larvae per ten plants gave economic threshold level, over which grain yield reduced significantly. Contradictory results also have been reported by Singh (1980) and found 2 larvae per ten plants as economic threshold level. Agreement or disagreement depends upon, location, crop season, crop variety, prevailing market price and ecological variations during the experimentation.

5.6.2.4. Percent pod damage Vs. grain Yield (Table 13 and Fig. 4.18)

There was no significant difference in grain yield till T5 but from T6 it decreased significantly. Significant but negative correlation between per cent pod damage and grain
yield was noticed \( (Y = 61.78 - 0.81 x) \). This revealed that four larvae per ten plants was found to be economic threshold level for chick-pea.

Choudhary and Sharma (1981) observed 5.4 per cent yield loss with 6.4 per cent pod damage, with one larva per ten plants. Present findings is in confirmation with those of Odak and Thakur (1975). The reduction in grain yield due to *Heliothis* larvae was reported by Ram and Khare (1987), Vaishampayan and Veda (1980) and Anonymous (1980).

5.6.2.5. **Cost benefit ratio (Table 13):**

The ratio of cost of pest control taken and cost of grain yield was varying from 1:0.22 to 1:1.37 between T1 to T5. Therefore larval density of four larvae per ten plants was considered as economic threshold level. Though this level depends upon several factors, reported by, Judenko (1972), Tanskii (1975), Mahalle et al. (1976), Dakwale and Singh (1980) and Mehta et al. (1985).

5.6.1.3. **Varietal preference by *H. armigera* (Hb.):**

To test, sixteen chick-pea cultivars against *Heliothis* larvae the cultures were sown and observations were recorded at twenty days interval starting from 50 days after sowing (DAS).
5.6.1.3.1. Percent pod damage at 50 DAS (Table 14):

At the initiation of podding minimum per cent pod damage was recorded on the culture KPG-27 (0.67). Culture 959, PDG 83-84, BG 312 and GL 1200 were infested with pod damage between 1.67 to 1.00 per cent, which was at par with each other. Culture ICCC-37 gave maximum per cent pod damage which was 6.86 per cent.

The variation in per cent pod damage caused by Heliothis, due to varietal choice also been reported by Shrivastava et al. (1975). They screened out 20 chick-pea cultivars and observed F 378 and 850-3/27 with minimum (4.6 per cent and maximum (15.1 per cent) pod damage.

5.6.1.3.2. Percent pod damage at 70 DAS (Table 14):

At 70 DAS per cent pod damage ranged between 3.78 (GL 1002) and 15.10 (GL 1208). Culture RSG-2 had significantly less per cent pod damage than that of BGM. 426 and GL 1002. Culture GL-769 (13.99) had higher per cent pod damage than that recorded on BDNG-9-3, KPG - 27 and PDG 83-84.

These results are not in conformity with those of Sharma (1985) who reported that culture GL 1002 had 17.09 per cent pod damage, it is quite high than that of per cent pod damage recorded on the same culture in present study, almost similar per cent pod damage is reported by Sharma
(1985) on the culture JG-74. The variation in per cent pod damage on the same culture, may be explained due to ecological variation prevailing in periods in which observations were taken.

5.6.1.3.3. Per cent pod damage at 20 DAS (Table 14):

Maximum per cent pod damage was noticed on culture JG-74 (13.67) which was significantly higher than that observed on culture BG-198 (10.90). Minimum per cent pod damage was recorded on culture BDNG-9-3, which was significantly less as compared to culture Pant G-114 (7.52) and at par with culture RSG-2 (6.60), BG 438 (6.62) GL-769 (6.64), ICCC-37 (6.72) and K-959 (7.06).

The deviation in the results, as compared to the present findings are reported by Sharma (1985). On the cultures, JG-74, BDNG-9-3-, GL-1002, ICCC-37 and Annegiri-1 be found 9-20, 13.81, 17.25, 12.38 and 7.51 per cent pod damage, and these results are not in agreement.

5.6.1.3.4. Overall per cent pod damage (Table 14 and Fig. 4,12):

Culture JG-74 has shown the maximum per cent pod damage (9.75) followed by (8.53) and GL-1208 (8.43). Minimum per cent pod damage of 5.91 was noticed on culture GL 1002. Cultures ICCC 37, GL 1002, BDNG-9-3- and Annegiri-1 had
shown 7.40, 5.91, 6.75, and 6.53 per cent pod damage respectively.

Shrivastava et al. (1975) have reported 13.3 per cent pod damage on culture Annegiri, These findings are not in agreement with those of Lateef (1981) who observed higher per cent pod damage on culture Annegiri-1 than BDNG-9-3. Similarly disagreement was also observed between the present results and results of (Anonymous, 1984), screening of chick-pea cultivars, also undertaken by Singh and Sharma (1970), Chhabra and Kooner (1980) Borikar et al. (1982), Kaushik and Naresh (1983), Lateef et al. (1985), Patnaik et al. (1985), Singh et al. (1985), Pillai (1989), Sachan (1985) and Choudhary et al. (1989).

5.6.1.3.5. **Grain yield (Table 14 and Fig 4.19):**

In the present study, grain yield per plot varied between 416 gms (GL 1208) to 921 gms (PDG 83-84). Minimum grain yield was followed by 485 (K 959), 514 (JG-74), 575 (BG 312) and 534 gms (GL 1002), while maximum grain yield per plot was at par with the grain yield recorded on culture BG 298 (836 gms). Cultures Annegiri-1, ICCC-37, BDNG-9-3, JG-74 and GL 1208 were gave 737, 731, 631, 514 and 416 gms grain yield per plot.
These results contradict with the findings of Lateef et al. (1981) who recorded just double grain yield of culture Annegiri-1 in irrigated condition. This view is also supported by Singh and Sharma (1970), who sown chick-pea cultures in two different conditions and recorded similar type of variation. Almost similar results, in concern to grain yield were reported by Sharma (1985).