Chapter- III
MATERIALS AND METHODS
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In the present investigation an attempt has been made to study the bioecology and management of *H. armigera* (Hubner) in chickpea. Bioecology of this insect, depends on a large number of factors, which could be biotic and abiotic. The experimental details during the course of this investigations are described as under-

3.1. Test insect-

Gram pod borer, *Helicoverpa armigera* (Hubner)

Systematic position -

- **Phylum**: Arthropoda
- **Class**: Insecta
- **Order**: Lepidoptera
- **Family**: Noctuidae
- **Genus**: *Helicoverpa*
- **Species**: *armigera*

3.2. Diagnostic characters of *Helicoverpa armigera* (Hubner)

3.2.1. Egg-

The egg of *H. armigera* observed creamy white in colour and nearly spherical in shape with a flattened base giving some dome shape appearance and texture of the surface is sculptured in the term of longitudinal ribs. The
eggs were usually laid singly late in the evening mostly from 7 pm to midnight.

3.2.2. Larva-

The newly hatched larvae were translucent and yellowish white in colour, with taint yellowish orange longitudinal lines. The head thoracic and anal shields and legs were noticed brown in colour and the setae dark brown. The fully grown larvae were 40 mm long and were observed yellowish green in colour on chickpea crop.

3.2.3. Pupa-

The fully grown *H. armigera* larval bury themselves in the soil or among plant debris to pupate. The pupa-e was recorded about 15 to 18 mm long and mahogany brown in colour. The anterior and posterior tips were rounded with two tarpapering parallel spines at the posterior tip, which is common feature of its pupae.

3.2.4. Adult-

The adult of *H. armigera* was large brown moth (20 mm long) which was active at night. The male was smaller with the wing span of 35 mm. Whereas the wing spawn of normal female measured 40 mm. The forewing was pale brown in colour with marginal series of dots on its spur. Black kidney shape markers were found on the underside of forewings, whereas hind wing was light in colour with dark coloured patch at the apical end. Tufts of hair was found on the tip of abdomen in female.

The various stages (egg, larva, pupa and adult) of *H. armigera* have been displayed.
3.3. Experimental Site and Climatic Condition-

The field experiments were conducted at Research Farm, B.N.V.P.G. College; Rath, Hamirpur (U.P.) India during 2003-2004 and 2004-2005. Lab experiments were conducted at the Department of Zoology Dayanand Vaidic College, Orai (Jalaun) U.P.

Physiographic Situation-

Geographically this research centre is situated between the parallel of 25° and 26° North and attitude and 79.5° and 80° East meridian of longitude and situated. metre above the mean sea level. The mean annual rainfall is 867 mm. mainly through mansoon rains.

Rath has subtropical climate with hot day summer and cold winter. During the hot summer maximum temperature May reach 47. 0°C. The mean annual rainfall is 867 cm. nearly 80.90% of which is received from end of May to Oct. However, the total rainfall and its seasonal distribution is subjected to large variations. The mean relative humidity remains nearly constant about 65.5 to 81.5% (at 7 am) from July till the February and afterwards steadily decreases to 50.5 to 53.5% up to the May and remains at this level till June.

3.4. Experimental design and layout-

Field experiments were conducted at Research Farm, Rath. The chickpea cultivars i.e. KWR. 108 resistant and Annigeri (susceptible) were sown at 10 Nov. 2004 and 15 Nov. 2005. The layout of field experiments are given below:-

- Design: Randomized Block Design
- Replication: 3
Plot size - 4 m x 3 m = 12 m²
Plot bund - 0.5 m
Width of border - .15 m
Varieties - KWR – 108 resistant and Annigeri (susceptible)

3.5. Extent of damage-

Pod damage at maturity was taken from 10 randomly selected plants in each plot. Number of healthy pods, damaged pods and total number of pods were counted and percent pod damage was worked out. The total yield per plant including the yield of ten plants sampled earlier was taken and computed on kg/ha basis.

3.6. Studies on bioecology of *H. armigera* Hubner-

3.6.1. Biology-

Initial culture of *H. armigera* was established in the laboratory by collecting larvae from chickpea crop grown in the field. These larvae were reared separately in the clean specimen glass petridishes (15 x 1.5 cm) and fresh leaves and twigs as well as pods of chickpea were provided, daily in each petridishes as a food for the larvae. Grown up larvae were transferred into the rearing glass jar. One third part of the glass jar was filled with moist soil to help the grown up larvae for population in the soil. The pupae/cocoons when formed in the soil were collected and transferred into petridishes individually for the emergence of adults. A pair of newly emerged male and female was confirmed in a glass chimney cage prepared by placing the chimney on blotting paper in petridish and were fed with a liquid diet (solution of 50% sucrose fortified with vitamin E) soaked in cotton wool which was in the cage. The top of the chimney was covered
with muslin cloth secured firmly by a rubber band to per cent escape of adults. Fresh leaves, twigs and pods were provided in the chimney cage for egg laying and were replaced daily for oviposition and food was also given everyday in the morning till the adults died. These eggs were kept in separate petridishes and used for maintaining a pure culture of the pest. The incubation, larval and pupal period were studied. The previposition, oviposition and post oviposition periods, sex ratio and longevity of adults were also studied.

3.7. Population Dynamics of *H. armigera* on chickpea-

3.7.1 Larval population in the field-

In order to study the population dynamics of *H. armigera*, field collections were made daily starting from the early vegetative growth stage to the maturity on harvesting of the crop. Three large plots of chickpea meant for seed multiplication at Research Farm, B.N.V.P.G. College, Rath, Hamirpur were earmarked for this purpose. The above plots were kept totally free from insecticidal treatment throughout the season. The susceptible cultivar i.e. Annigeri was chosen for this purpose. With the help of 1 sq. meter grid made of iron, 10 sampling areas were chosen randomly on a day. All the plants in the sample were shaken thoroughly after spreading a piece of cloth on ground with the result that all the larvae were found falling on cloth sheet. The larvae were picked up carefully counted, kept individually in the glassvials and brought to the data were obtained from laboratory. The samples collected during a week were pooled and average values for a week was worked out. The data pertaining to temperature, maximum and minimum and relative humidity was recorded and calculated on weekly basis.
3.7.2. Population of male moth in pheromone trap -

A synthetic pheromone (97:3 mixture of \((z) - 11 - \text{Hexadecenal} \) \(z) - 9-11-\text{Hexadecenal}\) absorbed septa was made available from 1 mg for use in pheromone trap.

Trap Design-

It is a single funnel trap. Rubber septa impregnated with the pheromon was suspended above the surface of the plastic funnel protected by a circular plastic hood. Beneath the funnel a polythene bag was fixed to collect adult males attracted by the pheromon. Pheromone trap were palced in the research form of B.N.V.P.G. College, Rath, Hamirpur at the rate of 5 traps per hectare. Daily record of catches were made in the morning. The observations so collected were pooled and average value for a week was worked out. The weekly workload values were correlated with meteorological observations to workout the ecological effects on moth population in field.

3.7.3. Relationship between larval population of H. armigera and parasite / parasitoid-

The various stages of \(H. \text{armigera} \) viz. egg, larva, pupa and adult were closely worked out from early vegetative stage to maturity and harvesting to observed the presence of parasite, predator and parasitoid associated with it.
Number of parasitized larvae were recorded daily and after a week average value was worked out and were correlated with the larval population to observe the significance of parasitization.

3.8 Impact of integration of intercropping and varietal resistance against *H. armigera*- 

Field experiment were conducted on integration of intercrops with chickpea varieties, per cent pod damage by *H. armigera* and yield was recorded. These intercrops viz. mustard var. T₅₉, linseed var. Neelam and barley var. Jyoti were sown with main crop, chickpea. These intercrops were grown alongwith chickpea-resistant and susceptible cultivar in the following ratio of row

<table>
<thead>
<tr>
<th>Resistant chickpea</th>
<th>Mustard</th>
<th>-</th>
<th>4:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susceptible chickpea</td>
<td>Mustard</td>
<td>-</td>
<td>4:1</td>
</tr>
<tr>
<td>Resistant chickpea</td>
<td>Linseed</td>
<td>-</td>
<td>3:1</td>
</tr>
<tr>
<td>Susceptible chickpea</td>
<td>Linseed</td>
<td>-</td>
<td>3:1</td>
</tr>
<tr>
<td>Resistant chickpea</td>
<td>Barley</td>
<td>-</td>
<td>2:1</td>
</tr>
<tr>
<td>Susceptible chickpea</td>
<td>Barley</td>
<td>-</td>
<td>2:1</td>
</tr>
</tbody>
</table>

Data on pod damage and yield were recorded at crop maturity and were analysed. Per cent increase in yield over control was calculated by formula as given below:

\[
\text{Percentage increase in yield over control} = \frac{\text{Yield in treated plot} - \text{Yield in control plot}}{\text{Yield in control plot}} \times 100
\]
3.8.1 Interactive effect of chickpea resistant and susceptible genotypes against *H. armigera*-

For evaluation of chickpea resistant and susceptible genotypes against *H. armigera*, seven treatments viz. 1:1, 2:1, 3:1, 1:2, 1:3 resistant: susceptible genotypes, resistant sole and susceptible sole were grown in field. Each treatment was replicated thrice and ten plants were selected randomly in each replication from resistant and susceptible genotypes equally for observations were recorded at crop maturity and per cent increase in yield over control was calculated by formula as given earlier.

3.9. Efficacy of different biopesticides and insecticides against *H. armigera*

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Technical Name</th>
<th>Trade Name</th>
<th>Dose/Concentration a.i. (%)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>HaNPV</td>
<td>Heliocel</td>
<td>350 LE/ha</td>
<td>Excel Industries Ltd., Mumbai</td>
</tr>
<tr>
<td>2.</td>
<td><em>Beauveria bassiana</em></td>
<td>Dipel</td>
<td>1.5 kg/ha</td>
<td>Pesticides, Udaipur, India</td>
</tr>
<tr>
<td>3.</td>
<td><em>Bacillus thuringensis</em></td>
<td>Halt</td>
<td>1.0 kg/ha</td>
<td>Wockhardt Ltd., Mumbai</td>
</tr>
<tr>
<td>4.</td>
<td>Azadirachtin (0.03%)</td>
<td>Nimbecidine</td>
<td>2 ml/l</td>
<td>T. Stones &amp; Company Ltd., 8/23-24, Race Course Road, P.B.-3709, Coimbatore</td>
</tr>
<tr>
<td>5.</td>
<td>Azadirachtin (0.03%)</td>
<td>Multineem</td>
<td>2 ml/l</td>
<td>Karnataka Agro Chemicals, 180, 1st Main Road, Mahalakshmi Layout Extension, Bangalore</td>
</tr>
<tr>
<td>6.</td>
<td>Azadirachtin</td>
<td>Rakshak</td>
<td>2 ml/l</td>
<td>Murkumbi Bioagro Pvt. Ltd., B.C. 105, Havelock Raod, Cantoment, Belgaun</td>
</tr>
<tr>
<td>7.</td>
<td>Cypermethrin 40+Profenphos 400</td>
<td>Polytrin 44EC</td>
<td>0.04%</td>
<td>Novartis India, Ltd.</td>
</tr>
<tr>
<td>8.</td>
<td>Profenphos</td>
<td>Curacron</td>
<td>0.025%</td>
<td>Ciba-Geigy, Mumbai</td>
</tr>
<tr>
<td>9.</td>
<td>Dimethoate</td>
<td>Rogor</td>
<td>0.025%</td>
<td>Rallis India Ltd., Mumbai</td>
</tr>
<tr>
<td>10.</td>
<td>Endosulfan</td>
<td>Endocel 35EC</td>
<td>0.07%</td>
<td>Excel Industries Ltd., Mumbai</td>
</tr>
</tbody>
</table>
Three microbial insecticides *viz.*, *Bacillus thuringiensis* (B.t.), *Beauveria bassiana* (B.b) and *Helicoverpa* nuclear polyhedrosis virus (HaNPV), three neem based insecticides *viz.* Nimbicide, Multineem and Rakshak and three chemical insecticides *viz.* Polytrin, profenphos and dimethoate were tested against larvae of *H. armigera* in field. Source of all biopesticides and insecticides are given in Table 3.1, whereas, local strain of NPV were collected from the field and used after making its suspension in distilled water.

Infected larvae were collected and dipped in distilled water into a clean container for preparation of stock culture. Healthy larvae (preferably third instar onwards) collected from field and contaminated by stock. Healthy and cleaned gram seeds were soaked in viral suspension (2 ml stock solution in 100 ml water for 1000 seeds) for 8 hours, air dried and fed to larva. These infected larvae are then reared in a room with ambient temperature (27-30°C) and relative humidity (70-80%). Larvae ingest the virus through food and consumption reduced day by day finally larvae stop feeding become flaccid sluggish and inactive and die (about five days after inoculation) when the cadaver may become dark brown. These larvae were collected carefully with forcep and were put in distilled water for a week. The polyhedral occlusion body (POB) accumulated as a white layer on the bottom of container. The POB were separated by filtration through double layered muslin cloth with fine mesh to remove debris and other extraneous matter. The suspension was kept for 2-3 days so that particles settle down. The virus suspension was filled in dark coloured bottles.

Biopesticides and insecticides were sprayed 3 times at 15 days intervals after the appearance of larvae, *H. armigera* with foot sprayer in evening hours. Spray solutions were made @600 l/ha. in water. Each
treatment was replicated thrice in R.B.D. and observations on per cent pod damage and yield were taken at maturity of the crop and per cent increase in yield over control was calculated by formula as given earlier.

3.9.1. Interactive effect of chickpea genotypes with safer insecticides against *H. armigera-

Field trial were conducted to quantify the effect of chickpea resistant and susceptible, genotypes with safer insecticides. Twelve treatments i.e. Ha NPV + Resistant, HaNPV 350 LE + Resistant, Ha NPV 250 LE+ Susceptible, HaNPV 350 LE + Susceptible, *Bacillus thuringiensis*+ Resistant, *Bacillus thuringiensis* + Susceptible Neem Seed Karnal Extract (NSKE) + Resistant, NSKE + Susceptible, endosulfan + Resistant, endosulfan + Susceptible, Resistant sole and Susceptible sole were used. Each treatment was replicated three times in R.B.D. and observations were taken at crop maturity and per cent increase in yield over control was calculated by formula as given earlier.

3.10. Statistical Design-

Randomized block design were used for various field experiments on management practices viz. chickpea genotypes and Ha NPV, intercropping and chickpea genotypes, interactive effect of chickpea resistant and susceptible genotypes, biopesticides, botanical and chemical insecticides and chickpea genotypes with safer pesticides.