DEVELOPMENT OF INTEGRATED PEST MANAGEMENT STRATEGIES AGAINST *Helicoverpa armigera* (Hubner) ON CHICKPEA

BY

M. SUGANTHY B.Sc (Agri.)

THESIS SUBMITTED TO THE
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CERTIFICATE

This is to certify that the thesis entitled **"DEVELOPMENT OF INTEGRATED PEST MANAGEMENT ON STRATEGIES AGAINST *Helicoverpa armigera* Hubner ON CHICKPEA"** submitted in partial fulfilment of the requirements for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Ms M. Suganthy** under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by the author of the thesis.

(Dr S TEJ KUMAR)
Chairman of the Advisory committee

Thesis approved by the student Advisory committee

Chairman: **Dr S TEJ KUMAR**
Associate Professor
Dept. of Entomology
College of Agriculture
Rajendranagar, Hyderabad – 500 030.

Co-Chairman: **Dr G V RANGA RAO**
Special Project Scientist, NRMP, IFAD Project
International Crops Research Institute for the Semi-Arid Tropics.
Patancheru, Andhra Pradesh

Member: **Dr B NARASIMHA RAO**
Professor and Head
Dept. of Entomology
College of Agriculture
Rajendranagar, Hyderabad – 500 030.

Member: **Mr Y R B SARMA**
Associate Professor
Dept. of Statistics and Mathematics
College of Agriculture
Rajendranagar, Hyderabad – 500 030.

CERTIFICATE

Ms M. SUGANTHY has satisfactorily prosecuted the course of research and that the thesis entitled **"DEVELOPMENT OF INTEGRATED PEST MANAGEMENT STRATEGIES AGAINST *Helicoverpa armigera* Hubner ON CHICKPEA"** submitted is the result of original work done and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: 8.7.'99

S. Tej Kumar

(Dr S TEJ KUMAR)
Major Advisor

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(M.SUGANTHY)

DECLARATION

I, **Ms M. SUGANTHY** hereby declare that the thesis entitled **DEVELOPMENT OF INTEGRATED PEST MANAGEMEBNT STRATEGIES AGAINST** ***Helicoverpa armigera*** **Hubner ON CHICKPEA** submitted to Acharya N.G.Ranga Agricultural University for the degree of **'MASTER OF SCIENCE IN AGRICULTURE'** is the result of the original work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

Date: 8.7.'99
Place: Hyderabad

(M. SUGANTHY)

Title of the thesis	:DEVELOPMENT OF INTEGRATED PEST MANAGEMENT STRATEGIES AGAINST *Helicoverpa armigera* Hubner ON CHICKPEA
Author	: **M SUGANTHY**
Chairman	: **Dr S TEJKUMAR**
Co-Chairman	: **Dr G V RANGA RAO**
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ABSTRACT

A field experiment entitled **"Development of Integrated Pest Management strategies against *Helicoverpa armigera* Hubner on Chickpea"** was conducted during post-rainy season, 1998-99, at International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh to assess the relative efficacy of a neem product (AZA) 0.006 per cent, HNPV @ 250LE ha^{-1}, erecting bird perches, endosulfan 0.07 per cent and the combination of the above said four treatments (IPM) on the ovipositional preference of *H. armigera* and against the small (first and second instar), medium (third and fourth instar) and large (fifth and sixth instar) sized larvae of *H. armigera* on chickpea. Apart from these studies, the treatmental effects on the soil inhabiting and aerial natural enemies were evaluated. The seasonal incidence of *H. armigera* eggs, larvae and moths were also studied.

All the treatments were found to be significantly superior to control in reducing the oviposition of *H. armigera*. The maximum reduction in egg laying was observed with neem and IPM (37.00 per cent reduction over control). In managing the small, medium and large sized larvae IPM was concluded as the best treatment (37 per cent reduction

over control) followed by endosulfan (33), HNPV (29), neem (25) and erecting bird perches (23).

Endosulfan had profound effect on soil inhabiting and aerial natural enemies to a tune of 40 and 45 per cent over control, respectively followed by neem (8 and 15 per cent, respectively). All other treatments were adjudged as safer to the natural enemy fauna. The results of the observations made on field collected larvae for parasitisation revealed that all the treatments were found to be safe to *Campoletis chlorideae* and the maximum percentage of HNPV infection was observed in HNPV sprayed treatment followed by in IPM plots which received two HNPV sprays. 25 to 29 per cent natural infection of HNPV was observed in other treatments.

IPM registered the least percentage of pod damage (9.4), followed by endosulfan (10) as against the highest percentage of pod damage in control (18.8). The maximum yield of 11.7 q ha^{-1} was obtained with IPM, followed by endosulfan spray (10.5 q ha^{-1}) as against 7.4 q ha^{-1} in the control plots. The relationship between yield and pod damage was observed to be negative and significant. IPM was adjudged as the best treatment in terms of cost benefit ratio (1:6.3) followed by endosulfan treatment (1:6.1).

The investigations on the seasonal incidence of *H. armigera* on chickpea revealed that the maximum egg laying was observed in the last week of December i.e., 50 DAS and the larval population attained three peaks at 29, 57 and 85 days of crop age. The maximum moth catches were observed between 65 and 85 DAS i.e., third, fourth and fifth standard weeks.

LIST OF ABBREVIATIONS

°C	:	degree centigrade
CD	:	critical difference
cm	:	centimeter
DAS	:	days after sowing
DAT	:	days after treatment
EC	:	emulsifiable concentrate
et al	:	and others
Fig	:	figure
g	:	gram
g day^{-1}	:	gram per day
ha	:	hectare
HNPV	:	Helicoverpa Nuclear Polyhedrosis Virus
i.e.	:	that is
IPM	:	Integrated Pest Management
kg	:	kilogram
Kg ac^{-1}	:	kilogram per acre
Kg ha^{-1}	:	kilogram per hectare
LE ha^{-1}	:	Larval Equivalents per hectare
m	:	meter
m^2	:	meter square
mm	:	millimeter
NSKE	:	Neem Seed Kernel Extract
ppm	:	parts per million
q ha^{-1}	:	quintals per hectare
S.Ed	:	standard error of deviation
spp.	:	species
viz.,	:	namely
@	:	at the rate of
%	:	per cent
<	:	less than

INTRODUCTION

CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* Lin.) is an important food legume crop in the production system of Semi-Arid Tropics. World production of pulses is estimated as 58 million tonnes (1989-91 average). Chickpea ranks second among the pulses. India is the world's leading producer of chickpea with 68 per cent of the total production, followed by Turkey (11%) and Pakistan (8%). In India, it is cultivated in an area of 7.3 million hectares which is about 64.6% of world chickpea cultivation area with 5.5 million tonnes production and 753 kg ha^{-1} productivity (FAO, 1998).

Being a source of high quality protein chickpea enriches the cereal based diet of the people and improves their nutritional balance (Saxena, 1996). Besides it has medicinal importance, as the germinated gram seeds are recommended to cure scurvy and malic and oxalic acids in green leaves cure intestinal disorders (Singh, 1996). Chickpea is a very important component of cropping systems of the dry, rainfed areas, because it can fix 80 to 120 kg Nitrogen $hectare^{-1}$ through symbiotic nitrogen fixation (Papastylanou, 1987).

Per capita availability of pulses in India has declined from 24g day^{-1} to 16g day^{-1} which is about 1.2 per cent per year, since 1970. This is almost exclusively because of chickpea, which registered a steep 32% decline in per capita availability due to lower productivity mainly because of the pest problems (Kelley and Parthasarathy Rao, 1996). Among different insects, gram pod borer is a major pest attacking chickpea.

Gram pod borer *Helicoverpa armigera* Hubner, is a prolific and widespread pest, which feeds on at least 180 plant species spread across 47 botanical families (Pawar *et al*, 1986). Though pod borer larvae feed on both leaves and pods, yield losses are mainly due to pod damage.

The biological characteristics which contribute directly to the pest status of *Helicoverpa* are high degree of polyphagy, high mobility, facultative diapause, high fecundity and multi-generation (Fitt, 1989).

Plant protection in India and in most of the developing countries is mainly based on the use of chemical pesticides. Chemical control is one of the effective and quicker methods in reducing pest population, where farmers obtain spectacular result within a short period. However, over-reliance and indiscriminate use of pesticides resulted in a series of problems in the agricultural ecosystem, mainly the development of resistance in insects to the insecticides, resurgence of treated population, outbreak of secondary pests into primary nature, destruction of natural enemies, increase in inputs on chemicals, environmental pollution and toxicological hazards due to pesticide residues etc. All these problems contributed to a new way of thinking concerning pest management practices i.e., integrated approach of pest management.

Most of the cultural practices were curtailed when modern pesticides become available. It was thought that these chemicals alone could control pest, but now we know that, it is not possible and the single method of approach to pest control is not feasible. The best alternative is integrated pest management approach, which is based on the principles of managing the pest rather than aiming at complete eradication. This IPM approach will ultimately reduce the negative influence of insecticides on the natural enemies, that are present in the suitable ecological niche and will save the ecosystem and the environment from toxicological hazards.

The information available on cultural, varietal, biological and chemical methods of pest control has been critically reviewed in view of significant advances made so far in chickpea pest management strategies such as mixed or intercropping, host avoidance, use of sex pheromone trap, neem seed kernel extract and use of insect pathogens against the gram pod borer, *H. armigera* have generated enough scope to begin with IPM in chickpea (Lal, 1992).

Hence, the present study aims at finding out the contribution of the above components in the management of *H. armigera* and how to integrate various components effectively as integrated pest management strategy. The studies are contemplated with the following objectives.

1. To develop IPM strategies against *Helicoverpa armigera* on chickpea and
2. To evaluate the contribution of various components of IPM on *H. armigera*.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Available literature concerning the present study is categorised and presented under different headings as follows:

About 60 insect species have been reported to feed on chickpea (Reed *et al*, 1987), but only relatively few are considered as major pests. Also stated that *Helicoverpa armigera* Hubner is the major pod borer species on chickpea and was reported from almost all the chickpea growing countries.

2.1 Management strategies of *Helicoverpa armigera* Hubner:-

2.1.1 Botanical control methods – Efficacy of Neem products against *Helicoverpa armigera:*

Sinha and Mehrota (1988) reported that neem oil did not have a significant effect, even though it gave a higher yield of chickpea seed than an untreated control. On the basis of grain yield, the neem leaf extract at 5 per cent was found to be effective on chickpea and on the basis of profitability NSKE at 5 per cent was effective after the chemical pesticides. NSKE can be used in place of the highly toxic synthetic insecticides because of its safety to beneficial insects and its lower cost (Thakur *et al*, 1988).

Sehgal and Ujagir (1990) concluded that NSKE at 5 per cent was less effective on *H.armigera* on chickpea, but still significantly better than the control. According to Datkhile *et al* (1992) neem seed extract at 5 per cent was least effective on gram pod borer when compared to synthetic pyrethroids. Grain yield of chickpea was increased following treatment with neem seed kernel suspension (Butani and Mittal, 1993).

Sachan and Lal (1993) suggested that NSKE and neem leaf extract were more effective for controlling *H.armigera* on chickpea. Spraying of neem kernel extract of 5.0 per cent gave 40 per cent reduction in infestation and was comparable to endosulfan at 0.07 per cent on chickpea. There were no significant differences in the seed yields in plots treated with neem emulsion (0.125 per cent) and neem kernel extract (5 per cent) (Sinha, 1993).

Khan (1996) studied the use of newer insecticides for the control of pod borer on chickpea and reported that neem seed extract 5.0 per cent yielded equally as that of chemical insecticides and better than untreated control.

Ravi and Verma (1997) conducted a study on persistence and dissipation of insecticides against *H.armigera* on chickpea and concluded that azadirachtin as the least effective insecticide. According to Ujagir *et al* (1997) azadirachtin (Nimbicidine 0.03 per cent) did not show any yield increase by reducing the pod damage caused by *H.armigera* when compared to either HNPV or chemical insecticides in chickpea.

2.1.2 Biological control methods: Efficacy of Helicoverpa Nuclear Polyhedrosis Virus (HNPV) against *H.armigera:*

Dhamdhere and Khaire (1986) evaluated different doses of HNPV on *Cicer arietinum* against *H. armigera* and concluded that two applications of 450 larval equivalents hectare^{-1} at 10 days interval were most effective in reducing damage and resulted in the highest yield. According to Jayaraj *et al* (1987) application of 250 larval equivalents hectare^{-1} reduced the *H. armigera* larval population significantly and stated that control of *H. armigera* with nuclear polyhedrosis virus was more effective on chickpea.

Pawar *et al* (1987) compared the bioefficacy of HNPV with endosulfan against pod borer on chickpea and found that 2 sprays of NPV at 500 larval equivalents hectare^{-1} were as effective as 2 sprays of 0.05% endosulfan in reducing infestation by *H. armigera* (Hubner) larvae and pod damage and in increasing seed yield. Bilapate *et al* (1988) observed 1.98 per cent to 24.52 per cent larval mortality of *H. armigera* due to HNPV on chickpea.

The lowest pod damage and highest yields were obtained with the highest concentration of 500 LE ha^{-1} of nuclear polyhedrosis virus against *H. armigera* on chickpea (Pawar *et al*, 1990). Misra *et al* (1991) studied the use of NPV in management of the insect pest, *H. armigera* in gram and reported that NPV application of 250 LE ha^{-1} considerably reduced pod damage and larval populations of *H. armigera.*

Rabindra *et al* (1992) reported that the mortality of larvae of *H. armigera* caused by nuclear polyhedrosis virus was significantly higher on *H. armigera* susceptible varieties of chickpeas than on resistant accessions. The larval mortality rate was positively correlated with leaf consumption. According to Abhisek Shukla and Goydani

(1996) NPV applications produced a significantly higher seed yield compared to untreated control plots.

Sharma *et al* (1997) assessed different bio-pesticides for the management of *H. armigera* (NPV) in chickpea and concluded that nuclear polyhedrosis virus gave the best control of the pest. Application of HNPV resulted in increased grain yields in chickpea (Ujagir *et al*, 1997).

2.1.3 Mechanical control methods: Role of Bird perches in the management of gram pod borer:

Ghode *et al* (1988) observed the avian predation of gram pod borer *Helicoverpa armigera* (Hubner) in Orissa and reported that the cattle egret (*Bubulcus ibis*) and river tern (*Sterna aurantia*) were feeding on *H. armigera* on bengal gram (*Cicer arietinum*) in the third week of January. Due to the presence of the birds, the population of *Helicoverpa armigera* (Hubner) was reduced from 5-10 larvae per plant in mid January to a negligible number (<1 per plant) by the end of the month.

Patel (1988) organized studies on predation of *H. armigera* and *Spodoptera litura* by insectivorous birds with special emphasis on mynas *Acridotheres tristis (L)*. Joginder Singh *et al* (1990) while explaining the ecology of *H. armigera* mentioned the importance of house sparrows and myna as natural enemies in Ludhiana.

Besides parasites several birds are often observed in groundnut fields of which egrets, drongos and mynas are important predators that feed on *Helicoverpa* and

Spodoptera. Studies also revealed that cattle egret (*Babulcus ibis*) was found to be insectivorous consuming individuals of seven orders of insects. These birds were found to exert appreciable control, to the extent of 73 per cent of *H. armigera* resulting in an increased yield of 218 gram per meter square as against 120 gram per meter square on the area where no birds were allowed to prey. The birds were observed to reduce *Helicoverpa* population to the tune of 33% on wheat when allowed to prey during bullock ploughing for 3 consecutive days. Similarly in Kota, Rajasthan the House sparrows reduced the *Helicoverpa* population by 20 to 40 per cent (ICAR, 1992).

Wightman *et al* (1993) reported that predation by cattle egret might be increased by giving the birds easy access to the larvae by sowing on ridges or by optimizing row separation in a flat sowing.

Gunathilagaraj (1996) worked on the management of *H. armigera* in chickpea with common myna *Acridotheres tristis* and concluded that myna preyed upon larvae of *H. armigera* effectively.

Bhagwat (1997) provided bird perches to encourage predatory birds and stated that birds only visited plots that were not sprayed with chemical or botanical insecticides and their activity was intense in plots sprayed with NPV, where the birds were found feeding on the dead virus-infected larvae.

Parasharya (1995) noted that in chickpea *Campoletis chlorideae* parasitizes small larvae whereas birds prefer large and medium size larvae and birds have been demonstrated to assist in the spread of insect pathogens by eating infected insects. The birds indiscriminately feed on healthy as well as NPV infected *Helicoverpa* larvae and excrete viable particles of NPV.

2.1.4 Chemical control methods: Effect of Endosulfan against *Helicoverpa armigera:*

Dhurve and Borle (1985) recorded that treatment with endosulfan 0.5% was effective in reducing damage caused by *H. armigera* on chickpea and also revealed that it resulted in significantly higher yields. Treatment with endosulfan resulted in reductions of 75.26, 87.60 and 98.15 per cent of *H. armigera* on chickpea at 1,3 and 7 days after application, respectively (Gunasekaran and Balasubramanian, 1987).

According to Pawar *et al* (1987) populations of *H. armigera* were lowest in plots which received 2 applications of endosulfan and recorded the lowest percentage of pod damage and increased seed yield. Sanap and Deshmukh (1987) tested different insecticides for the control of *H. armigera* on chickpea and found that treatment with 0.07% endosulfan resulted in the least damage of 1.4 per cent and highest yield of 1209 kilogram per hectare.

On the basis of mean percentage damage at the dry pod stage, grain yield and profitability, endosulfan at 0.07% was the most effective treatment (Kaul *et al*,1 988 and Thakur *et al*, 1985). Neupane and Sah (1988) studied the efficacy of some insecticides against the chickpea pod borer, *H. armigera* and concluded that 0.10 per cent endosulfan gave 20 per cent initial kill of larvae one day after spray, which made the insecticide suitable for the control of this pest.

Application of endosulfan twice at different dilutions at an interval of 15 days revealed that all the treatments were more effective than control and there was no significant difference between the dilutions (Chauhan and Ombir, 1989). According to Deka *et al* (1989) endosulfan at 500 gram active ingredient hectare^{-1} was the most effective treatment in reducing larval populations (94.4 per cent) of *Helicoverpa armigera* Hubner 72 hours after spraying and recorded 159.63 per cent yield increase when compared to untreated control.

Ghosh *et al* (1989) stated that the lowest infestation and the highest grain yield were recorded with the application of endosulfan. Among various insecticides, endosulfan 0.07 per cent was effective. The highest cost benefit ratio of 1:5.15 was obtained with endosulfan spray (Parsai *et al* 1989).

Singla *et al* (1989) assessed the yield loss in gram by the pod borer, *H. armigera* Hubner and noticed that the mean reduction in the pest population in the protected crop ranged from 61.1 to 81.1 per cent at different locations and the avoidable loss in grain yield by applying endosulfan was 60.0 to 87.5 per cent. Endosulfan and some synthetic pyrethroids are being used in Punjab to manage the pest, *H. armigera* on chickpea (Chhabra, 1990).

Gupta *et al* (1990) tested the bio-efficacy and economics of certain insecticides and vegetable oils against gram pod borer *H. armigera* on chickpea and observed that treatment with endosulfan reduced the larval population and the highest grain yield was obtained with 0.07% endosulfan. They have also given endosulfan 0.06% and endosulfan 0.08% as the most cost effective treatments. According to Gupta and Thakur (1990) treatment of chickpea crops with endosulfan 0.08% gave good control of *Helicoverpa armigera* Hubner larvae and increased the yield by 67-70 per cent in November sown crops and by 103-113 per cent in December sown crops.

Panchabhavi and Kadam (1990) reported that treatment with endosulfan at one litre hectare^{-1} resulted in larval populations of 4.40 larvae per 5 plants and pod damage of 12.61 per cent. The lowest pod damage of 3.84 per cent and highest yield of 1379 kilogram hectare^{-1} were observed in plots treated with 2 sprays of endosulfan (Pawar *et al*, 1990).

Sehgal and Ujagir (1990) tested the effect of some insecticides for the control of pod damage by *H. armigera* on chickpea and found that endosulfan at 420 gram per hectare significantly and consistently reduced pod damage to less than 22.5% giving grain yields of more than 1.7 tonnes per hectare.

Barkhade *et al* (1991) assessed the effect of pesticidal application at different growth periods of the level of infestation of pod borer *H. armigera* on chickpea and concluded that damage to the pods was least following dusting with 4% endosulfan at 30 days after flowering, but spraying with 0.05% endosulfan at 10 days after flowering, dusting with 4 per cent endosulfan at initiation of flowering and 2 sprays of 0.05% endosulfan at 15 and 30 days after flowering gave similar results of reduced pod damage. Greatest yields were obtained on chickpea crops treated with 2 applications of 0.07 per cent endosulfan against *H. armigera* during pod formation stage (Chauhan and Dahiya, 1991).

Gupta *et al* (1991) investigated the spray schedule of endosulfan for gram pod borer *Helicoverpa armigera* Hubner in chickpea and observed that sequential spraying of 0.07 per cent endosulfan at the flowering followed by podding stage is most effective in terms of cost benefit ratio (1:12) although sequential spray of all the three stages vegetative, flowering and podding stage had least pod damage and maximum number of pods, its cost benefit ratio was much lower (3:9).

Khan *et al* (1993) evaluated different insecticides against *H. armigera* on gram and reported that endosulfan was more effective than methamidophos and fluvalinate against the pest and the yield averaged 32 kg in plots treated with endosulfan as against 4.97 kg in untreated plots. Sachan and Lal (1993) found that endosulfan was the most effective treatment in the management of chickpea pod borer *H. armigera*.

Endosulfan 0.07 per cent gave 70-72 per cent control, but there were no significant differences in the seed yield in plots treated with neem emulsion (0.125 per cent), neem kernel extract (5 per cent), flufenoxuron and endosulfan (Sinha, 1993).

Giraddi et al (1994) fixed the critical time of spray in chickpea for the effective control of gram pod borer, H. armigera as 2 sprays at 50% flowering followed by 2 sprays at green podding stage.

Noorani *et al* (1994) reported that after 2 applications of endosulfan larval populations plant^{-1} averaged 0.88 as compared with 26.72 for the control and the corresponding yield was 1573.67 kilogram/acre as compared with 251.64 kg/ac. According to Chaudhary and Sachan (1995) the crop treated with 0.07% endosulfan during 1990-91 and 1991-92 had significantly fewer insects, pod damage and the greatest yield.

Vyas and Lakhchaura (1996) stated that endosulfan at 0.07 per cent applied twice was the most effective treatment which gave the highest seed yield of 1.078 tonnes hectare^{-1}.

Ujagir *et al* (1997) evaluated some insecticides against *H. armigera* on chickpea and reported that endosulfan resulted in increased grain yields when compared to nimbicidine and dipel.

2.1.5 Integrated Pest Management strategies against *Helicoverpa armigera*:

Ahmed *et al* (1990) reviewed some recent approaches to manage *Helicoverpa armigera* (Hubner) on chickpea which covered population studies through pheromone traps, insecticide use, use of bacteria, viruses and parasitoids, cultural practices and host-plant resistance and breeding.

Lal (1990) has indicated some strategies for the management of *H. armigera* in chickpea which recommends the use of insecticides, neem seed kernel extract, pheromone traps, growing early maturing cultivars, advancing the sowing date to avoid the pest, opting for resistant varieties, use of parasitoids like *Campoletis chlorideae* Uchida, and pathogen like nuclear polyhedrosis virus.

Mahajan *et al* (1990) recommended light and pheromone traps for monitoring the population of *H. armigera.*

Mahajan *et al* (1990) recommended the use of natural enemies including *Campoletis chlorideae* Uchida, nuclear polyhedrosis virus and insecticides for the effective management of chickpea pod borer, *H. armigera* and light and pheromone traps to monitor the pest population and also stated that use of resistant varieties, inter cropping system and sowing dates are not much effective in the management of this pest. The lowest pod damage and highest yield were obtained in plots treated with the highest concentration of virus in combination with one spray of endosulfan (Pawar *et al*, 1990).

According to Sachan (1990) some of the pest control measures include, the use of synthetic pheromone traps and light traps, parasitoids like *Campoletis chlorideae* Uchida, predators like *Delta* species and nuclear polyhedrosis virus, breeding for host plant resistance, advancing the sowing date or using early maturing cultivars, mixed or intercropping with cereals or other legumes, use of phosphotic fertilizers and application of insecticides.

Thakur (1990) revealed that intercropping chickpea with wheat or linseed found *to be effective in the management of H. armigera. Among various treatments, nuclear polyhedrosis viruses plus two sprays of endosulfan (0.035 per cent) at first and third week of the chickpea crop recorded less pod damage and gave maximum yield.*

Use of parasitoids, *Campoletis chlorideae* Uchida and nuclear polyhedrosis viruses, opting for early maturing cultivars, advancing the sowing dates and mixed cropping were recommended in controlling *H. armigera* (Hubner) in chickpea (Yadava, 1990). According to Jayaraj (1992) the use of nuclear polyhedrosis virus in combination with jaggery, teepol etc., is found to be promising against *H. armigera* in chickpea and extensive use of sex pheromone and light traps for monitoring as well as control of *H. armigera* were also recommended. Also stated that application of neem seed kernel extract 5 per cent and inundative release of parasites is effective for the management of this pest.

Sarode *et al* (1995) concluded that application of the NPV at 500 LE per hectare plus the neem extract at 6 per cent gave the maximum reduction in larval numbers (79.8 and 65.2 per cent at 7 and 14 days after spraying respectively). Sarode and Sarnaik (1996) reported that the HNPV and the botanical product, neem seed kernel extract were found effective and the addition of half doses of insecticides in these material improve their efficacy to combat the gram pod borer *H. armigera*.

Improved agronomic package, seed treatment with Thiram plus Bavistin, hand weeding 25 days after sowing and spraying Thiodan (endosulfan) against *H. armigera* on chickpea increased yields by 16-81 per cent and significantly increased net returns (Yadav, 1996).

According to Bhagwat (1997), an integrated pest management strategy using a botanical insecticide, a host specific virus to protect chickpea from pod borer showed the efficacy of this approach over local practices of farmers in on-farm situation.

Sanap and Pawar (1998) evaluated integrated pest management, treatment comprising endosulfan 0.07 per cent, neem seed kernel extract 5 per cent and nuclear polyhedrosis virus at the rate of 250 larval equivalents per hectare and revealed that 3 spray applications starting from the initiation of flowering and subsequent 2 sprays at fortnightly intervals with first two sprays either with nuclear polyhedrosis virus at the rate of 250 larval equivalent per hectare or neem seed kernel extract followed by a third spray with endosulfan 0.07% were most effective in controlling *H. armigera* and resulted in a 26.94 and 27.29 per cent increase in yield respectively.

2.2 Activity of different natural enemies on gram pod borer and treatmental effects on predators and parasitoids:-

Yadava *et al* (1985) reported *Compoletis chlorideae* Uchida as a larval parasitoid of *Helicoverpa armigera* (Hubner) and stated that percentage parasitism was the highest during December, lowest during February and almost nil during March. Mehta *et al* (1986) recorded a total of 8 species of natural enemies including *Araneae*, *Coccinella septempunctata* and *Campoletis chlorideae* Uchida and noted *Campoletis chlorideae* Uchida as an effective parasitoid of *H. armigera.*

Prasad and Chand (1986) first time recorded *Campoletis chlorideae* Uchida as a parasitoid of *H. armigera* on chickpea in Bihar and noticed 14.3 to 58 per cent parasitism. According to Deka *et al* (1987) chickpea crops sown on 12 and 22 October recorded peak population of parasitoid in January (3.0 to 3.5 pupae per 2 meter row), while in those sown on 11 November the parasitoid population peaked on 12 February (2.0 pupae per 2 meter row) and the maximum rate of parasitism occurred in crops sown on 12 and 22 October and 11 November (45.00, 46.24 and 45.79 per cent, respectively).

Population of *Campoletis chlorideae* was maximum in plots treated with aldrin and parasitism was 37.0 to 42.7 per cent following treatment with monocrotophos and karanj oil (Prasad *et al*, 1987). According to Bilapate *et al* (1988) parasitism of Ist to 3rd instar larvae by the ichneumonid *Campoletis chlorideae* on *Cajanus cajan* was 1.38% and the tachinid *Carcelia* species caused 1.95, 1.08 and 2.89 per cent parasitism of 4th to 6th instar larvae in the Ist, 2nd and 3rd generations respectively. On *Cicer arietinum*, *Campoletis chlorideae* caused 14.73 per cent parasitism during the first generation.

Garg (1989) suggested that *Campoletis chlorideae* caused 25% per cent parasitism in larvae of *H. armigera* on chickpeas and recorded parasitism from the 3^{rd} week of April, gradually increased and reached a maximum in the Ist week of May, when host infestation also peaked.

Pawar *et al* (1989) concluded that *Campoletis chlorideae* was the most common parasitoid and in most years parasitism was highest in September and lowest in May. The average parasitism of Ist to 3^{rd} instar larvae by *Campoletis chlorideae* on chickpea was 33.1 per cent and parasitism was lower in pesticide-treated than in untreated crops.

Srinivas (1989) evaluated the extent of parasitism of gram pod borer *H. armigera* by *ichneumonid* larval parasitoids *Campoletis chlorideae* and *Eriborus* species and reported that both the parasitoids were active from October onwards. The maximum parasitization of *H. armigera* larvae (43.9 per cent) was recorded for *Campoletis chlorideae* during the first two weeks of December compared with 18 per cent for *Eriborus* species at the same time. Parasitization by *Campoletis chlorideae* was approximately 12 per cent during the last week of January. Both the species of parasitoid attacked Ist and 2^{nd} instar larvae only. Srinivas and Jayaraj (1989) reported 16 species of natural enemies belonging to the Trichogrammatidae, Braconidae, Ichneumonidae, Sarcophagidae, Coccinellidae, Chrysopidae and Eumenidae on chickpea pod borer and stated that early larval stages were more prone to attack than later stages.

The ichneumonid *Campoletis chlorideae*, house sparrows (*Passer domesticus*) and bank myna (*Acridotheres ginginianus*) were important natural enemies of *H. armigera* on chickpea (Joginder Singh *et al*, 1990). The ichneumonid *Campoletis chlorideae* and the tachinid *Carcelia illota* played a key role in suppressing the larval population during the podding stage (Patnaik *et al*, 1991).

Shrivastava and Yadav (1991) studied the distribution of *H. armigera* and its biocontrol agents in Chhattisgarh and recorded highest (61.9 per cent) parasitism by *Campoletis chlorideae* at Kawardha and lowest (16.66 per cent), at Almorah. Also stated that larval mortality due to microbial agents was highest (21.42 per cent) at Sigona and lowest (3.33 per cent) at Almorah. *Campoletis chlorideae*, *Carcelia illota* and *Apanteles spp.* were the main parasitoids attacking *Helicoverpa armigera* and the parasitoids were more active in the cooler months, i.e., December and January (Mishra *et al*, 1992). According to Romeis *et al* (1997), release of *Trichogramma chilonis* were ineffective for control of *H. armigera* on chickpeas.

2.3 Monitoring of *Helicoverpa armigera* using sex pheromone trap:-

Sah *et al* (1988) found that male moths of *H. armigera* were attracted to the traps from the first week of January to the last week of April, with peak numbers (more than 100 moths per trap/week) caught from the 4^{th} week of February to the first week of March. Also stated that during this peak period, the chickpea crop was either at the full blooming stage or the initiation of podding. Accoridng to Patnaik *et al* (1991) and Anwar and Shafique (1994), maximum numbers of moths were caught in pheromone traps in early March in chickpea crop.

Srivastava *et al* (1991) recorded maximum catches of moths of *H. armigera* in the first fortnight of April using pheromone traps in chickpea crop. Prasad and Neupane (1992) observed that males of *Helicoverpa armigera* Hubner were caught in the trap from the third week in January until the last week in April.

Maximum adult activity of *H. armigera* was recorded during the spring or summer season (6th to 28th weeks), while a minor peak was recorded in autumn (42nd to 50th weeks). The pattern of trap catches indicated the occurrence of 4 to 5 generations per year. Catches in pheromone traps were positively correlated with larval counts on chickpea after 1,2 and 3 weeks of trapping. Of various weather parameters, mean air temperature and relative humidity significantly influenced moth catches. No moths were caught below an average air temperature of 13.2 degree centigrade or below 80.3 per cent relative humidity (Sinha and Jain, 1992). According to Verma and Sankhyan (1993), the maximum temperature was negatively correlated and rainfall was positively correlated with adult activity.

Chaudhry *et al* (1995) studied the response of *H. armigera* to sex pheromone sources on chickpeas and reported that the populations of this insect were abundant from mid-March to the first week of May. Also stated that sex pheromone traps were useful indicator for timely insecticide application and monitoring the population on chickpeas. Correlation of weekly catch data with weather parameters showed that 6.0 to 78.0 per cent of change in populations was due to the combined effect of abiotic factors.

According to Srivastava and Srivastava (1995) peaks in the pheromone trap catches of *Helicoverpa armigera* were invariably followed by the peaks in egg and larval counts (early instars) of this insect on chickpea (*Cicer arietinum*).

The maximum number of moths were trapped in April, March and May in 1988, 1989 and 1990 respectively and the pest population increased between 10.5 and 25.6 degree centrigrade under the conditions of the trial (Duwadi *et al*, 1996). Subbarayudu and Singh (1997) concluded that a significant positive relationship was found between insect catches and duration of sunshine.

2.4 Seasonal incidence of *Helicoverpa armigera* in chickpea:-

According to Yadava and Lal (1988), there were two peaks in the population of *Helicoverpa armigera* Hubner during the 47th to 50th and 11th to 15th weeks in chickpea in northern India. Also reported that the population was negatively correlated with relative humidity and percentage parasitism by the ichneumonid *Campoletis chlorideae* Uchida. Chhabra (1990) and Chhabra and Kooner (1993) reported that the pest *H. armigera* attained peaks twice in a year i.e., March to April and October in Punjab.

In Punjab, *Helicoverpa armigera* Hubner of the non-diapausing type completed two generations between 5th November and 5th April, compared with one generation for diapausing population. The pupal stage lasted 14 to 23 and 140 days in non-diapausing and diapausing populations respectively. The larval population peaked in early April (Joginder Singh *et al*, 1990).

Verma and Sankhyan (1993) stated that adult activity started during 10th to 11th standard week in mid hills of Himachal Pradesh. Anwar and Shafique (1994) noted that the larval population remained low during December and January and increased during February to March and concluded that the flowering and pod formation stage of the crop and relatively high temperature favoured increase of the larval population in Pakistan.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Research on the "Development of Integrated Pest Management strategies against *Helicoverpa armigera* Hubner on chickpea" was conducted at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India during postrainy season 1998-99. The materials used and the methods employed in conducting these experiments are elucidated in this chapter.

3.1 Experimental Design:-

At ICRISAT research farm BP 7A, an area of $8000m^2$ was used to conduct the research. The entire area was divided into 24 plots, each plot measuring $292m^2$ (16.2X18m), for six treatments and four replications. Then the plots were randomized as randomized block design and the treatments were imposed (Fig. 1).

3.2 Sowing:-

A high yielding chickpea variety ICCC 37 (Kranthi) was used for this trial. To reduce the incidence of seed borne diseases such as collar rot, the seeds were treated with Mancozeb @2 grams $kilogram^{-1}$ of seed. The treated seeds were sown on 11.11.1998 with 60cm between rows and 20cm within a row.

3.3 Treatments:-

The following treatments were imposed to study the effect of these treatments on gram pod borer.

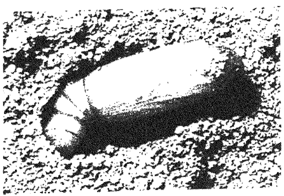
Fig. 1. LAYOUT PLAN OF THE EXPERIMENT

Crop :	Chickpea	Variety :	ICCC 37 (Kranthi)
Gross area :	8000 m2	Replications :	4
Plot size :	16.2 x 18 m	Treatments :	6
Gross plot area:	292 m^2	Design :	RBD
Net plot area :	117.6 m^2		

N

RI	T4	T3	T5	T6	T2	T1	18m
RII	T3	T6	T4	T2	T1	T5	18m
RIII	T5	T4	T1	T3	T2	T6	18m
RIV	T2	T6	T5	T3	T1	T4	18m
	16.2m	16.2m	16.2m	16.2m	16.2m	16.2m	


ADULTS (7-21 DAYS)


PUPA (7-10 DAYS)


LARVA (14-24 DAYS)


EGGS(2-4 DAYS)

T1 Spraying of 0.006% Neem product (AZA).

T2 Spraying of Nuclear Polyhedrosis virus 250 LE ha^{-1}.

T3 Fixing bird perches @ 1 perch $plot^{-1}$.

T4 Spraying of 0.07% endosulfan 35 EC.

T5 Integrated Pest Management (T1, T2, T3 and T4).

T6 Control.

3.3.1 Neem Product:

30,000 ppm stock solution of neem product (AZA) was prepared and supplied by Dr Baliga, Mumbai. This AZA was obtained through ICRISAT and used in the experiment.

The spray fluid requirement was standardized as 6 litres $plot^{-1}$ ($292m^2$) by using water. 0.006% concentration of AZA was made by mixing 2ml of 30,000 ppm stock solution in a litre of water. Thus 12ml of stock solution (AZA) was mixed in 6 litres of water to spray in a plot of $292m^2$ area.

3.3.2 Nuclear Polyhedrosis Virus (NPV):

Nuclear Polyhedrosis virus was produced at ICRISAT-NPV laboratory and used for the studies. The NPV stock solution was prepared in such a way that 1ml of NPV equals to one larval equivalent. Since the Ultra-violet rays deactivate the virus particles in NPV, the spray was carried out in the evening. In this experiment to have protection from UV rays, robin blue was mixed in the spray solution @ 1ml $litre^{-1}$ of spray fluid. NPV was used @ 1.3ml per litre of spray fluid.

Field view of the experiment

Bird perch in chickpea field meant for *Helicoverpa* management

So 8ml of stock solution (NPV) and 6ml of robin blue were mixed in 6 litres of water to spray in a plot of $292m^2$ area and sprayed after 4p.m.

3.3.3 Bird perches:

"T" shaped bird perches were prepared using two sticks and these perches were used as stands, over which the birds will rest and search for the larvae in crop canopy. The vertical stem of 'T' was about 45cm in length and the top bar measuring 30cm. The perches were installed just above the crop height and maintained @ one perch $plot^{-1}$ from 21 DAS till crop harvest.

3.3.4 Endosulfan:

Endosulfan 35 EC was obtained from ICRISAT. To prepare 0.07% concentration, 2ml of stock solution was mixed in a litre of water. So to spray in $292m^2$ area plot, 12ml of stock solution was mixed with 6 litres of water and sprayed.

The treatments were given five times at 15 to 20 days interval during the cropping period. The sprays were imposed on 21, 36, 54, 71 and 85 DAS. Thus all four replications of T1 received 5 sprays of AZA 0.006% on 21, 36, 54, 71 and 85 DAS.

Whereas T2 received 5 sprays of NPV 250 LE per hectare on the above said days after 4 p.m. to have protection of virus particles from UV rays. Likewise in T4 also 5 sprays of 0.07% endosulfan were given on the same days when T1 and T2 were applied.

In all the four replications of T3 bird perches were installed @ 1 perch per plot, on 21 DAS when first spray was given on other treatments and remained in the plot till last observation was taken, but no spray was given.

In T5 which is the Integrated Pest Management plot, bird perches were installed @ 1 perch plot^{-1} on 21 DAS and remained in the plot till last observation was taken. At the same time, T5 received 0.006% AZA (Neem Product) as first spray on 21 DAS. The second and third sprays were NPV and endosulfan on 36 and 54 DAS respectively. Once again AZA and NPV were given as fourth and fifth spray on 71 and 85 DAS respectively, to manage different stages of gram pod borer continuously starting from the cropping season.

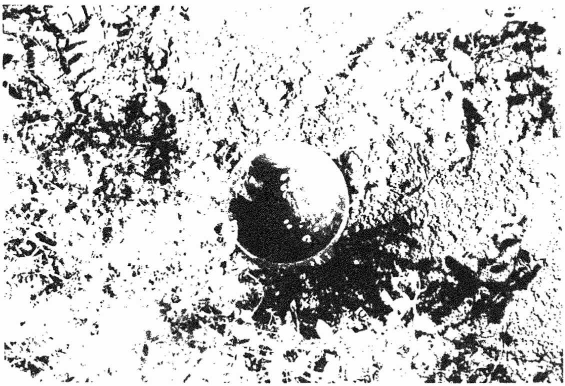
3.4 Method of recording observations:-

3.4.1 Insect pest population:

The number of eggs, small sized larvae (first and second instar), medium sized larvae (third and fourth instar), and large sized larvae (fifth and sixth instar) were counted on twenty randomly selected plants from each plot. The observations were taken at weekly interval starting from fifteen days after sowing and continued up to crop maturity.

3.4.2 Monitoring the activity of soil inhabiting natural enemies:

In this experiment, one litre plastic containers were used as pit fall traps. These containers were placed in the soil by burrying to the ground level, at the rate of three traps plot^{-1}. These traps were installed 22 DAS, at random in the plots. Since the traps were kept at ground level, it acted as a pit to collect the soil dwelling natural enemies.



Monitoring the soil inhabiting natural enemies live in chickpea fields with pitfall trap

Monitoring the natural enemy fauna live in chickpea crop canopy with DeVac trap

Formaldehyde and soap water were mixed with water @ 1 ml of each $litre^{-1}$ of water and poured in to the trap up to half of its volume. The natural enemies falling into the trap were killed immediately after falling and preserved well in the trap with out spoilage for a week to ten days.

Observations were taken once in 10 days from 36 DAS till 103 DAS. Individual traps were removed from the soil and the formaldehyde, soap water mixture along with collected dead insects were poured into a filter, to separate the insects from the collection fluid. Then individual insects were separated using camel hair brush and were identified. Among various insects, different groups of natural enemies such as ants, coccinellids, ground beetles, earwigs, spiders, crickets etc., were separated and counts were made. After counting, the insects were discarded and the filter was cleaned. Thus observations were made in all the treatments across the trial. The traps were then cleaned with water and placed once again in pits at ground level with formaldehyde soap water solution.

Total number of natural enemies in all the three traps of a treatment were worked out. Eight such counts were made.

3.4.3 Aerial natural enemies:

DeVac trap was used to assess the activity of various predators and parasitoids in different treatments, which were inhabiting on the crop canopy (aerial natural enemies). Because of the vacuum created inside the trap, all the insects found on the crop canopy were captured inside the trap.

DeVac trap was not operated until the crop canopy covered the soil, to prevent sucking of soil particles inside the trap. The trap was operated twice during the cropping period i.e. at 76 DAS and 99 DAS.

After starting the operation of the trap, by carrying it on the back, the operator walked twice on both the sides of any of the rows in a treatment for one minute period by holding the mouth of the trap near the crop canopy. The collected materials were transferred into a polythene cover and labelled immediately after collection. Thus collections were made from all the treatments and brought to the laboratory for counting and identification of the different groups of aerially active natural enemies belonging to the families ichneumonidae, braconidae, trichogrammatidae, tachinidae, formicidae, gryllidae, other hymenopterans, spiders etc.,

Three days after collection, the materials were observed under magnifying lens to identify and separate above said groups of natural enemies inhabiting on the crop canopy.

Total number of natural enemies caught in different treatments were calculated and two such counts were recorded.

3.4.4 Studies on egg and larval parasitisation:

To evaluate the percentage egg, larval and pupal parasitism, 100 eggs along with leaves and 100 larvae were collected from each plot. The eggs were kept individually in homeopathic vials and larvae were kept in individual glass tubes with cotton plugs.

The eggs were observed daily till the larvae or parasite hatched out. Larvae were fed with soaked chickpea grains and larval feed was changed on alternate days. The larvae were observed daily for parasitisation and for the infection of Nuclear Polyhedrosis Virus. The larvae pupated were observed daily till the emergence of adults or pupal parasitoids.

Two such collections were made at 30 days interval on 26 DAS and 56 DAS. Total number of parasitised eggs and dead larvae due to parasitoids and NPV were counted separately and the percentage parasitisation was worked out. The parasitoids were identified by comparing specimens with ICRISAT collections.

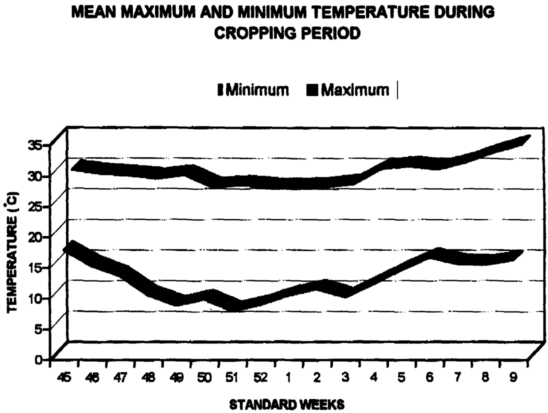
3.5 Pod damage:-

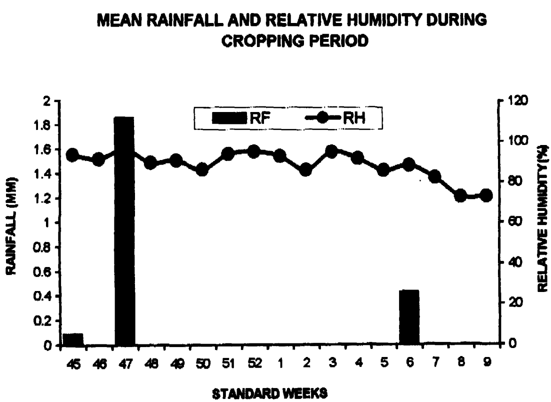
To avoid the border effects due to drift of the treatments, central 15 rows of 14 metres from each plot was considered as net plot for damage assessment and yield. So the net plot area was 8.4m x 14m i.e., $117.6m^2$.

From the net plot, 20 plants were selected randomly from each plot and all the pods (both healthy and pod borer damaged pods) were collected in a cover and labelled. In the laboratory, number of healthy pods and pod borer damaged pods were counted and the percentage pod damage was worked out for all the treatments and replications.

$$\text{Percentage pod damage} = \frac{\text{Number of damaged pods}}{\text{Total numbers of pods}} \times 100$$

FIG.2. WEEKLY METEOROLOGICAL DATA DURING CROP GROWTH PERIOD





3.6 Yield:-

113 DAS the plants in net plot area from each plot were harvested separately and threshed three days after harvesting. Threshed grains were cleaned, weighed and net plot yields were obtained. The pods collected from 20 plants which were removed from net plot area for working out percentage pod damage, were also threshed, cleaned and weighed and was added to the net plot yield.

Simple correlation and regression analyses were carried out using yield as dependent variable (Y) and percentage pod damage as independent variable (X).

3.7 Cost Benefit ratio:-

To know the economics of different treatments in the management of *H. armigera* cost benefit ratio was worked out taking into account the total cost of insecticidal application hectare^{-1} and the total income hectare^{-1}.

3.8 Weather data:-

The weather parameters viz., maximum, minimum temperatures (^oC), total rainfall (mm) and relative humidity (%) were recorded daily at 0710 hours in meteorological observatory at ICRISAT. These weather parameters were obtained from agroclimatology division of ICRISAT. The mean weather data that prevailed in every standard week during cropping season (45th to 9th standard week) were also calculated.

3.9 Monitoring of *Helicoverpa armigera* moth activity using sex pheromone trap:-

The sex pheromone of *Helicoverpa armigera* prepared at Natural Resources Institute, Chatham, U.K. were obtained through ICRISAT, Patancheru and used in the experiment. The lures were impregnated in polythene vial septa with 97:3 blend of (Z)-11-Hexadecenal and (Z)-9-Hexadecenal.

The vials containing pheromone were kept in dry funnel trap and were renewed once in thirty days. The sex pheromone trap was set up @ one trap hectare^{-1} at two meters height and maintained throughout the year. The number of male moths caught were counted and removed daily. Total number of moths caught per standard week were worked out, to monitor the peak moth emergence period.

3.10 Statistical Analysis:-

The laboratory observations of field collected larvae and field trials were analysed by using the standard analysis of variance procedures in completely randomized design and randomized block design, respectively. The data on percentage were transformed into arcsin values and the population into square root values before analysis. The test of significance was assessed using the critical difference obtained by following the RBD at 5% level (Gomez and Gomez, 1976). For the purpose of simple correlation and regression studies, since transformation was not required, the analyses were carried out as such with actual data.

RESULTS

CHAPTER IV

RESULTS

With a view to develop integrated pest management strategies against *Helicoverpa armigera* (Hubner) on chickpea, investigations were carried out in field and laboratory during post-rainy season 1998-99, at the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh and the results have been presented in this chapter.

4.1 EFFICACY OF DIFFERENT TREATMENTS ON THE OVIPOSITION PREFERENCE OF *Helicoverpa armigera*:-

In order to assess the performance of various treatments on the ovipositional behaviour of *H armigera*, studies were conducted during post-rainy, 1998-99. The results are presented in Table 1 and Fig.3.

The pre treatment count taken at fifteen days after sowing (DAS) revealed uniform ovipositional behaviour of *H. armigera* moths throughout the experimental area.

First spray:

One day after first spray, neem AZA treated plants recorded the lowest egg population (3.00/20 plants), which was on par with IPM plot which also received neem AZA as first spray (3.25). Endosulfan treated plots stood next in the order of efficacy (4.50), which was on par with IPM plots. The highest number of eggs were laid in control plots (9.50) which was at par with plots having only bird perches (7.50).

TABLE 1: EFFICACY OF DIFFERENT TREATMENTS ON THE OVIPOSITION PREFERENCE OF GRAM POD BORER *Helicoverpa armigera*

Sl No	Treatment		Number of eggs laid per 20 plants												
		DAS	15	22	29	36	43	50	57	64	71	78	85	92	99
		DAT	Pre T	1	7	14	7	14	7	14	21	7	14	7	14
1	T1-Neem product AZA 0.006%		43.25 (6.61)	3.00 (1.78)	6.50 (2.63)	17.75 (4.27)	22.75 (4.81)	34.25 (5.89)	17.25 (4.21)	33.00 (5.76)	3.75 (2.05)	11.00 (3.38)	0.25 (0.84)	0.00 (0.71)	0.00 (0.71)
2	T2-NPV 250 LE/ha		46.25 (6.83)	7.00 (2.66)	8.25 (2.96)	15.75 (4.02)	28.75 (5.39)	41.00 (6.44)	20.00 (4.52)	34.25 (5.87)	6.00 (2.55)	17.25 (4.18)	0.75 (1.06)	2.00 (1.56)	0.75 ((0.99)
3	T3-Bird perches		46.00 (6.82)	7.50 (2.82)	9.50 (3.16)	17.00 (4.17)	37.00 (6.10)	49.00 (7.03)	21.25 (4.66)	30.25 (5.54)	6.50 (2.65)	16.50 (4.12)	0.75 (1.06)	1.75 (1.48)	0.75 (1.10)
4	T4-Endosulfan 0.07%		43.75 (6.65)	4.50 (2.23)	7.25 (2.78)	18.75 (4.38)	33.00 (5.77)	56.00 (7.51)	16.25 (4.09)	32.25 (5.72)	5.75 (2.50)	14.75 (3.91)	0.25 (0.84)	0.75 (1.06)	0.00 (0.71)
5	T5-IPM		43.50 (6.63)	3.25 (1.83)	5.00 (2.34)	14.75 (3.90)	28.50 (5.37)	38.25 (6.21)	15.00 (3.92)	30.50 (5.55)	3.75 (2.06)	10.25 (3.28)	0.50 (0.97)	0.50 (0.97)	0.00 (0.71)
6	T6-Control		44.25 (6.69)	9.50 (3.07)	12.50 (3.60)	27.25 (5.26)	44.25 (6.68)	67.25 (8.23)	21.50 (4.69)	44.00 (6.66)	9.75 (3.20)	20.75 (4.61)	1.75 (1.44)	2.75 (1.80)	1.00 (1.22)
	S.Ed		0.17	0.43	0.14	0.17	0.32	0.22	0.19	0.28	0,11	0.17	0.24	0.19	0.18
	C.D (P=0.05)		-	0.91	0.29	0.36	0.63	0.47	0.41	0.61	0.24	0.36	-	0.41	0.38

Figures in parenthesis are square root transformed

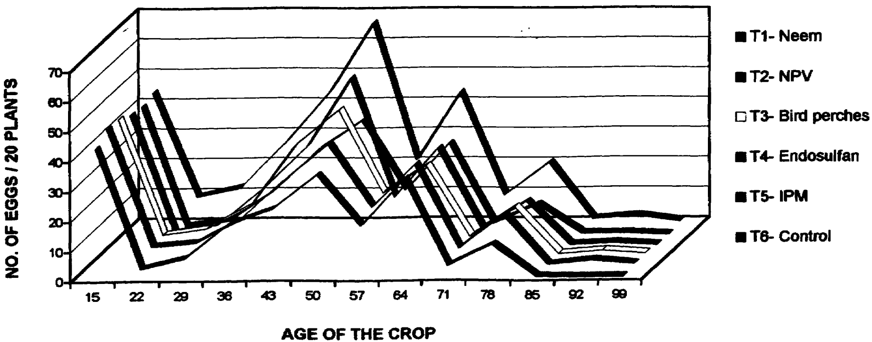
DAS: Days after sowing

DAT: Days after treatment

Pre T: Pre Treatment

*** Significant at 5% level**

FIG.3. EFFICACY OF DIFFERENT TREATMENTS ON THE OVIPOSITION OF *Helicoverpa armigera* ON CHICKPEA



Even at seven days after treatment (DAT) neem was found to be superior as an oviposition deterent, by registering the lowest number of eggs in IPM (5.00) which was not significantly different from neem treated plots (6.50), followed by endosulfan (7.25) and control with maximum number of eggs (12.50).

On fourteen DAT, IPM was significantly effective with reduced ovipositional preference (14.75), which was at par with neem treated plots (17.75). NPV treated plots and plots with bird perches, were not significantly different from neem treated plots. Endosulfan was found to be ineffective in reducing the egg laying of moths at fourteen DAT, though it recorded less number of eggs (18.75) when compared to control (27.25).

In general after giving first spray, the number of eggs laid were found to be gradually increasing one, seven and fourteen DAT, in all the treatments.

Second spray:

At seven and fourteen days after second spray also neem AZA stood first in the order of supremacy by having minimum number of eggs (22.75 and 34.25/20 plants respectively), which was closely followed by IPM plot which received NPV as second spray. Seven days after treatment NPV and endosulfan were found not significantly different, but recorded less number of eggs (28.75 and 33.00 respectively) when compared to plots with bird perches (37.0) and control (44.25). Fourteen days after second spray endosulfan recorded more number of eggs (56.00) when compared to bird perches (49.00), but less when compared to control (67.25). Fourteen days after II spray also the number of eggs laid increased gradually when compared to 7 DAT irrespective of the treatments.

Third spray:

At seven days after third spray IPM registered the lowest number of eggs (15.00) which was not significantly different from endosulfan (16.25) and neem AZA (17.25) treatments. Plots with bird perches registered more number of eggs (21.25), which was on par with NPV treatment (20.00), and control (21.50). Fourteen days after third spray there was no significant difference among the treatments but recorded less number of eggs when compared to control (44.00). Twenty one days after third spray i.e., 71 DAS, there was very low egg laying in all the treatments. Among the treatments neem spray and IPM plot recorded the lowest number of eggs (3.75) when compared to endosulfan (5.75) and NPV (6.00) treatments.

Fourth spray:

Seven days after fourth spray IPM was found to be highly effective by registering the lowest number of eggs (10.25) which was not significantly different from neem treatment (11.00). Endosulfan stood next in the order of efficacy (14.75), which was at par with NPV treatment. Fourteen days after fourth spray the treatments were found to be non significant in their efficacy.

Fifth spray:

Seven days after fifth spray no eggs were found in neem treatment, which was on par with IPM (0.50) and endosulfan (0.75) treatment. Fourteen days after fifth spray also no eggs were recorded in neem, IPM and endosulfan treated plots as against only one egg per twenty plants in control.

In general, throughout the cropping period neem and IPM were adjudged as the best effective treatments in suppressing the oviposition preference, followed by endosulfan which was effective up to 7-10 days but not up to fourteen days after spray. All the five treatments were significantly different from control. Even though the plots with bird perches recorded more number of eggs, it was not up to the level of control.

4.2 EFFICACY OF DIFFERENT TREATMENTS AGAINST SMALL SIZED LARVAE OF *Helicoverpa armigera*:-

The efficacy of different treatments on suppressing the small sized larvae (first and second instar) of *Helicoverpa armigera* was studied and the results are presented in Table 2 and Fig.4. There was no significant difference in the population of small sized larvae when counts were made at fifteen DAS, before imposing the treatments.

First spray:

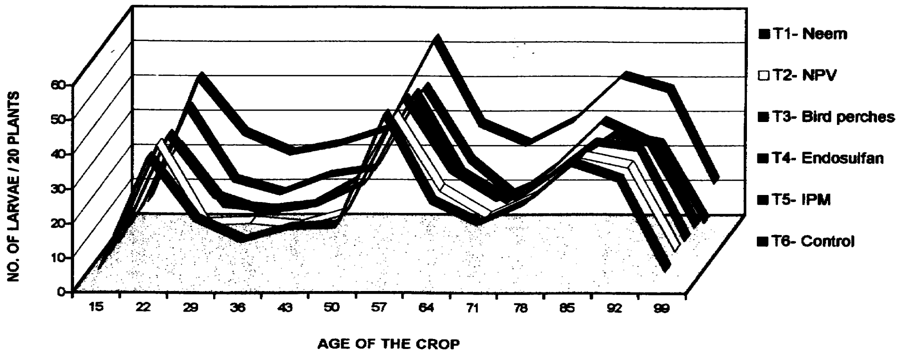
One day after first spray, endosulfan was found to be the best treatment by suppressing 30 per cent of the population of small sized larvae of *H. armigera* (29.75) over control (42.00), followed by bird perches (36.75), which was not significantly different from NPV (38.00), IPM (37.00) and neem AZA (38.00) treatments. Seven days after first spray endosulfan recorded 50 per cent population reduction over control (25.75), which was at par with NPV (15.00), followed by IPM (16.00) which was on par with bird perches. More number of small sized larvae were found in neem AZA treatments (20.00), but significantly less when compared to control. Fourteen DAT also

TABLE 2: EFFICACY OF DIFFERENT TREATMENTS AGAINST SMALL SIZED (1st & 2nd INSTAR) LARVAE OF GRAM POD BORER (*Helicoverpa armigera*)

Sl No	Treatment		Number of small sized larvae per 20 plants												
		DAS	15	22	29	36	43	50	57	64	71	78	85	92	99
		DAT	Pre T	1	7	14	7	14	7	14	21	7	14	7	14
1	T1-Neem product AZA 0.006%		5.75 (2.50)	38.00 (6.20)	20.00 (4.52)	13.75 (3.76)	17.50 (4.24)	18.00 (4.30)	50.50 (7.14)	25.25 (5.05)	18.75 (4.39)	24.75 (5.02)	36.00 (6.04)	31.50 (5.63)	5.50 (245)
2	T2-NPV 250 LE/ha		6.00 (2.55)	38.00 (6.19)	15.00 (3.93)	15.50 (3.99)	14.25 (3.82)	18.00 (4.30)	46.25 (6.84)	25.00 (5.03)	17.00 (4.18)	23.00 (4.82)	34.50 (5.91)	31.75 (5.67)	7.50 (2.82)
3	T3-Bird perches		5.75 (2.50)	36.75 (6.09)	19.00 (4.41)	14.50 (3.86)	16.00 (4.06)	23.75 (4.92)	47.25 (6.90)	26.50 (5.16)	18.25 (4.33)	23.75 (4.91)	34.50 (5.92)	32.75 (5.74)	6.75 (2.69)
4	T4-Endosulfan 0.07%		6.50 (2.65)	29.75 (5.48)	12.50 (3.60)	11.25 (3.41)	12.75 (3.60)	19.25 (4.44)	45.00 (6.74)	22.00 (4.74)	13.75 (3.77)	23.75 (4.92)	37.00 (6.12)	30.75 (5.58)	6.75 (2.68)
5	T5-IPM		6.75 (2.69)	37.00 (6.18)	16.00 (4.05)	12.25 (3.56)	17.25 (4.20)	19.25 (4.20)	43.00 (6.59)	21.75 (4.71)	10.50 (3.31)	20.00 (4.51)	29.00 (5.43)	26.75 (5.21)	4.25 (2.18)
6	T6-Control		6.25 (2.59)	42.00 (6.54)	25.75 (5.12)	20.00 (4.53)	22.50 (4.77)	26.75 (4.77)	53.25 (7.33)	28.50 (5.86)	22.75 (4.82)	29.75 (5.50)	42.50 (6.56)	38.50 (6.23)	11.75 (3.50)
	S.Ed		0.13	0.18	0.18	0.15	0.27	0.13	0.16	0.24	0.11	0.28	0.13	0.33	0.14
	C.D (P=0.05)		-	0.38	0.39	0.33	0.58	0.27	0.35	-	0.24	-	0.28	-	0.31

Figures in parenthesis are square root transformed
DAS: Days after sowing
DAT: Days after treatment
Pre T: Pre Treatment
*** Significant at 5% level**

FIG.4. EFFICACY OF DIFFERENT TREATMENTS AGAINST SMALL SIZED (FIRST & SECOND INSTAR) LARVAE OF *Helicoverpa armigera* ON CHICKPEA



endosulfan was found to be significantly superior by reducing the small sized larvae up to 44 per cent over control (20.00), which was not significantly different from IPM, which received neem as first spray along with bird perches. Neem, NPV and bird perches were at par and having similar effect on the small sized larvae when compared to control.

Second spray:

Seven days after second spray endosulfan was found to be significantly superior by registering the lowest population (12.75) i.e., up to 43 per cent reduction over control (22.50). Since NPV was given continuously, it was on par (14.25) with endosulfan showing its efficacy against small sized larvae, which was also on par with bird perches (16.00) since bird activity started from second fortnight of December. More number of small sized larvae were found in neem treated plants (17.50), which was not significantly different from IPM (17.25), but superior to control. But fourteen days after second spray NPV stood first in the order of efficacy by recording 33 per cent reduction of small sized larvae over control, which was on par with neem (18.00) endosulfan (19.25) and IPM (19.25). Even though, in plots with bird perches more larval population (23.75) was noticed it was significantly effective when compared to control (26.75).

Third spray:

Seven days after third spray, less number of small sized larvae were observed in IPM (43.00) which received endosulfan as third spray along with bird perches. This treatment was at par with endosulfan (45.00), NPV (46.25) and bird perches (47.25). More number of small sized larvae were observed in neem treated plots (50.50), which was at par with control (53.25).

Fourteen days after third spray, even though there was no significant difference in the efficacy of treatments, IPM registered 24% reduction in population over control, since it received all the treatments in cycle. But 21 days after third spray there was significant difference among the treatments in suppressing the population of *H. armigera*. In IPM and endosulfan treatments 54 per cent and 40 per cent reduction of population was observed, over control respectively, which were significantly different in their efficacy. The population of small larvae was high in neem treated plants (18.75) which was on par with NPV and bird perches (17.00 and 18.25 respectively), which showed some effect in managing the pest when compared to control (22.75).

Fourth spray:

Seven days after fourth spray, even though IPM recorded 33 per cent reduction of population over control, there was no significant difference between the treatments. IPM was found to be the best treatment even at fourteen days after fourth spray by registering 32 per cent reduction in population over control. While NPV (34.50), bird perches (34.50), neem (36.00) and endosulfan (37.00) were on par and significantly effective when compared to control (42.50).

Fifth spray:

Even though the treatments were not significantly different at seven days after fifth spray, IPM was observed to be the superior treatment since it recorded 34 per cent reduction of small sized larvae when compared to control. Whereas fourteen days after fifth spray IPM (4.25), neem (5.50), endosulfan (6.75) and bird perches (6.75) were found to be significantly not different in the management of small sized larvae and more number of larvae noticed in NPV treated plots (7.50) but significantly effective over control (12).

Among different treatments endosulfan was found to be the best in managing the small sized larvae up to second spray. But when third spray was given IPM dominated over endosulfan and ranked first in the order of efficacy in managing the first and second instar larvae of *H. armigera* till the crop was harvested.

4.3 EFFICACY OF DIFFERENT TREATMENTS AGAINST MEDIUM SIZED LARVAE OF *Helicoverpa armigera*:-

To assess the efficacy of different treatments against the third and fourth instar (medium sized) larvae of gram pod borer *Helicoverpa armigera*, studies were conducted and the results are presented in Table 3 and Fig.5. The larval counts were not significantly different in different treatments at 15 DAS, when pre-treatment counts were taken.

First spray:

One DAT, endosulfan was found to be significantly effective by registering the lowest number of larvae (5.50), which was on par with neem spray (6.00) and IPM (6.25) which received neem as first spray in addition to bird perches. NPV spray stood next in the order of efficacy with 7.25 larvae which was on par with IPM as well as bird perches (7.50). All the five treatments were significantly effective when compared to control (10.25). On seven DAT, IPM was found to be effective since it recorded the minimum number of larvae (14.25). Neem spray (16.00), endosulfan (18.50) and NPV spray

TABLE 3: EFFICACY OF DIFFERENT TREATMENTS AGAINST MEDIUM SIZED (3rd & 4th INSTAR) LARVAE OF GRAM POD BORER (*Helicoverpa armigera*)

SI No	Treatment		Number of medium sized larvae per 20 plants												
		DAS	15	22	29	36	43	50	57	64	71	78	85	92	99
		DAT	Pre T	1	7	14	7	14	7	14	21	7	14	7	14
1	T1-Neem product AZA 0.006%		0.25 (0.84)	6.00 (2.55)	16.00 (4.02)	4.50 (2.24)	10.75 (3.35)	9.50 (3.16)	23.75 (4.92)	7.00 (2.72)	23.75 (4.90)	9.25 (3.10)	16.50 (4.12)	17.75 (4.26)	6.50 (2.64)
2	T2-NPV 250 LE/ha		0.75 (1.06)	7.25 (2.79)	19.75 (4.40)	4.50 (2.23)	10.00 (3.24)	10.75 (3.35)	20.25 (4.55)	7.75 (2.78)	19.25 (4.43)	7.00 (2.73)	13.50 (3.74)	17.75 (4.26)	3.75 (2.05)
3	T3-Bird perches		0.50 (0.97)	7.50 (2.82)	26.25 (5.16)	6.25 (2.60)	10.50 (3.31)	11.00 (3.39)	21.00 (4.63)	9.00 (3.07)	23.25 (4.84)	9.50 (3.15)	17.50 (4.24)	19.00 (4.40)	5.25 (2.38)
4	T4-Endosulfan 0.07%		1.00 (1.18)	5.50 (2.45)	18.50 (4.29)	4.00 (2.11)	7.00 (2.73)	10.50 (3.31)	20.75 (4.61)	6.50 (2.64)	20.25 (4.49)	8.50 (2.99)	12.75 (3.63)	18.00 (4.30)	4.50 (2.22)
5	T5-IPM		1.25 (1.27)	6.25 (2.60)	14.25 (3.73)	4.25 (2.17)	10.75 (3.35)	10.75 (3.34)	18.75 (4.39)	6.25 (2.55)	14.25 (3.81)	6.50 (2.65)	12.50 (3.59)	19.00 (4.40)	3.50 (1.99)
6	T6-Control		1.00 (1.18)	10.25 (3.28)	27.75 (5.23)	10.25 (3.27)	13.00 (3.67)	14.25 (3.84)	27.25 (5.27)	11.75 (3.47)	30.00 (5.50)	12.25 ((3.57	20.00 (4.52)	27.25 (5.28)	8.00 (2.92)
	S.Ed		0.27	0.09	0.47	0.14	0.15	0.13	0.11	0.13	0.30	0.19	0.14	0.24	0.17
	C.D (P=0.05)		-	0.19	1.00	0.29	0.32	0.27	0.23	0.28	0.65	0.40	0.29	0.51	0.37

Figures in parenthesis are square root transformed

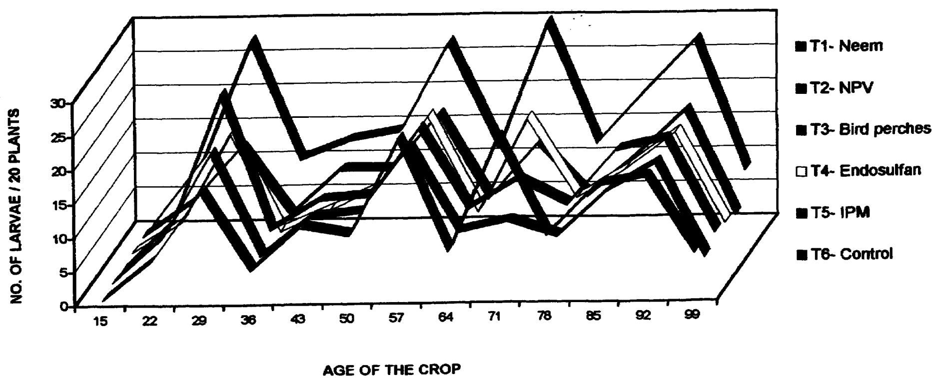
DAS: Days after sowing

DAT: Days after treatment

Pre T: Pre Treatment

*** Significant at 5% level**

FIG.5. EFFICACY OF DIFFERENT TREATMENTS AGAINST MEDIUM SIZED (THIRD & FOURTH INSTAR) LARVAE OF *Helicoverpa armigera* ON CHICKPEA



(19.75) were found to be as good as IPM and were not significantly different. Bird perches were not effective when the crop was of 30 days old, as it recorded more larvae (26.25), which was on par with control (27.75). While fourteen DAT, endosulfan spray recorded the minimum number of larvae (4.00) which was not significantly different from IPM, NPV and neem spray, which were equally effective as that of endosulfan spray.

Since bird activity started in the second fortnight of December, even though plots with bird perches recorded more number of larvae (6.25), it was found to be significantly superior over control (10.25).

Second spray:

On seven DAT, endosulfan spray recorded the minimum number of larvae (7.00) and found to be significantly superior among all the treatments, followed by NPV (10.00) which was on par with plots with bird perches (10.50), IPM (10.75) and neem spray (10.75). These were significantly effective over control (13.00). Fourteen DAT even though the lowest and the highest number of larvae were noticed in neem and bird perches respectively (9.50 and 11.00), endosulfan spray, IPM and NPV were found to be on par with neem and bird perches. All the treatments were found to be significantly effective over control (14.25).

Third spray:

At seven DAT, IPM was found to be highly effective treatment which registered the minimum number of larvae (18.75) which was at par with NPV (20.25) and endosulfan (20.75) spray, followed by bird perches (21.00) which was on par with endosulfan spray. Neem spray recorded more number of larvae (23.75), but had little effect over control (27.25). While fourteen DAT, IPM was significantly effective with less number of larvae (6.25), which was not significantly different from endosulfan spray (6.50), neem and NPV spray (7.00 and 7.75 respectively). Bird perches were found to be significantly inferior by registering more number of larvae (9.00), but superior over control (11.75). Twenty one DAT, IPM stood first in the order of efficacy by recording less number of larvae (14.25) which was on par with NPV spray (19.25), followed by endosulfan spray (20.25).

Bird perches and neem spray were found to be at par with endosulfan. Neem spray was found to be significantly inferior since it recorded more number of larvae (23.75) and significantly not different from control (30.00).

Fourth spray:

At Seven days after treatment, IPM, NPV spray and endosulfan spray were found to be equally effective and maintained their supremacy. Whereas bird perches recorded more number of larvae (9.50) which was at par with neem spray and also with endosulfan spray, but significantly effective over control (12.25). Fourteen days after treatment also IPM maintained its supremacy which was on par with endosulfan and NPV spray (12.75 and 13.50 respectively), followed by neem spray (16.50). Bird perches were found to be significantly inferior since it registered more number of larvae (17.50) which was on par with neem spray and also with control (20.00) since the bird activity started decreasing.

Fifth spray:

Seven days after treatment, NPV, neem, endosulfan, IPM and bird perches were found to be effective, but not significantly different among themselves by recording 17.75, 17.75, 18.00, 19.00 and 19.00 larvae respectively and were found to be significantly superior over control (27.25). Fourteen days after treatment, IPM, NPV and endosulfan spray were found to be on par with bird perches and also with control (8.00).

In general, throughout the cropping season IPM maintained its supremacy in managing the third and fourth instar larvae (medium sized) of *H. armigera*, followed by endosulfan spray. NPV and neem spray stood next in the order of efficacy. Bird perches were found to be effective from second fortnight of December till second fortnight of February. All the treatments were significantly superior to control.

4.4 EFFICACY OF DIFFERENT TREATMENTS AGAINST LARGE SIZED LARVAE OF *Helicoverpa armigera*:-

Studies were conducted to assess the efficacy of different treatments in the management of large sized larvae (fifth and sixth instar) of *Helicoverpa armigera* and the results are present in Table 4 and Fig.6. No single large sized larvae were observed when counts were taken before imposing the treatments at fifteen DAS, so no significant difference was observed between treatments.

First spray:

One day after treatment the lowest population was observed in endosulfan and NPV treated plants (0.50), which were not significantly different from plots with IPM (0.75) and neem spray (1.00). In plots with bird perches comparatively more number of

TABLE 4: EFFICACY OF DIFFERENT TREATMENTS AGAINST LARGE SIZED (5th & 6th INSTAR) LARVAE OF GRAM POD BORER (*Helicoverpa armigera*)

Sl No	Treatment		Number of large sized larvae per 20 plants												
		DAS	15	22	29	36	43	50	57	64	71	78	85	92	99
		DAT	Pre T	1	7	14	7	14	7	14	21	7	14	7	14
1	T1-Neem product AZA 0.006%		0.00 (0.71)	1.00 (1.18)	3.25 (1.92)	1.75 (1.49)	3.50 (1.91)	1.50 (1.38)	1.75 (1.49)	3.75 (2.06)	1.50 (1.36)	3.75 (2.00)	7.25 (2.78)	1.25 (1.31)	0.75 (1.06)
2	T2-NPV 250 LE/ha		0.00 (0.71)	0.50 (0.97)	4.00 (2.12)	2.00 (1.54)	3.00 (1.85)	2.75 (1.79)	1.75 (1.47)	4.00 (2.09)	1.50 (1.40)	2.50 (1.70)	5.00 (2.34)	2.00 (1.55)	0.25 (0.84)
3	T3-Bird perches		0.00 (0.71)	1.50 (1.40)	5.25 (2.39)	3.00 (1.86)	1.5 (1.38)	2.50 (1.67)	1.75 (1.49)	4.00 (2.06)	1.25 (1.19)	2.50 (1.68)	7.75 (2.87)	2.00 (1.56)	1.25 (1.27)
4	T4-Endosulfan 0.07%		0.00 (0.71)	0.50 (0.97)	4.00 (2.12)	1.00 (1.22)	2.25 (1.61)	2.25 (1.64)	1.00 (1.22)	2.75 (1.72)	1.75 (1.41)	2.50 (1.72)	6.75 (2.69)	1.75 (1.49)	1.00 (1.18)
5	T5-IPM		0.00 (0.71)	0.75 (1.10)	3.75 (2.05)	1.75 (1.47)	2.00 (1.54)	2.25 (1.63)	1.25 (1.31)	1.50 (1.40)	0.75 (1.06)	2.25 (1.63)	5.25 (2.39)	2.00 (1.56)	1.00 (1.18)
6	T6-Control		0.00 (0.71)	3.50 (1.99)	6.75 (2.69)	4.25 (2.34)	7.00 (2.74)	5.50 (2.44)	5.00 (2.34)	7.50 (2.83)	4.75 (2.21)	7.00 (2.74)	11.75 (3.50)	4.75 (2.27)	2.50 (1.70)
	S.Ed		0.00	0.13	0.09	0.20	0.22	0.24	0.15	0.27	0.29	0.28	0.14	0.15	0.25
	C.D (P=0.05)		-	0.28	0.20	0.42	0.47	0.52	0.31	0.57	0.62	0.59	0.30	0.32	-

Figures in parenthesis are square root transformed

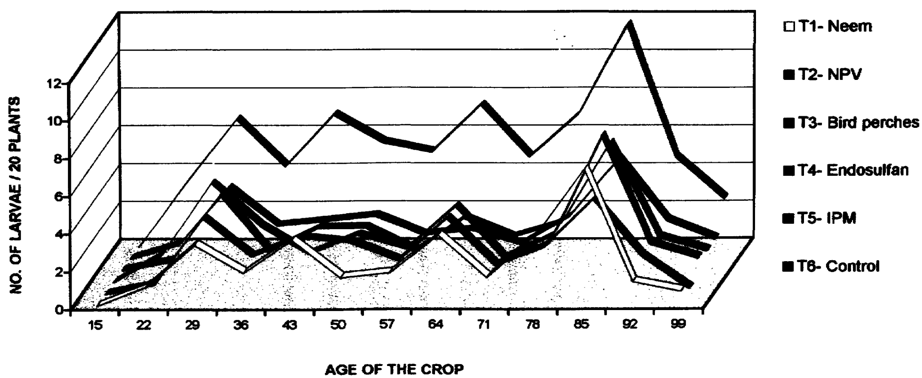
DAS: Days after sowing

DAT: Days after treatment

Pre T: Pre Treatment

*** Significant at 5% level**

FIG.6. EFFICACY OF DIFFERENT TREATMENTS AGAINST LARGE SIZED (FIFTH & SIXTH INSTAR) LARVA OF *Helicoverpa armigera* ON CHICKPEA



larvae were observed (1.50), but significantly effective when compared to control (3.50). Whereas at seven days after treatment, neem (3.25), IPM (3.75), endosulfan (4.00) and NPV (4.00) were found to be equally effective without any significant difference among themselves. Bird perches were found to be least effective (5.25), but superior over control (6.75). Endosulfan, IPM and neem spray closely followed by NPV spray maintained their supremacy even at fourteen days after treatment with 1.00, 1.75, 1.75 and 2.00 larvae respectively, without differing significantly among themselves. Bird perches were as good as NPV spray, but on par with control (4.25).

Second spray:

At seven days after treatment, bird perches recorded the lowest population (1.50) and IPM, endosulfan and NPV spray were found be equally effective as that of bird perches by recording 2.00, 2.25 and 3.00 larvae respectively. Neem spray was found to be on par with endosulfan and NPV spray. Even though neem recorded more larvae (3.50), significantly better when compared to control (7.00). Fourteen days after treatment, neem (1.50), IPM (2.25) and NPV (2.75) were found to be equally effective without differing significantly among themselves, but significantly different from control (5.50).

Third spray:

On seven days after treatment, even though endosulfan recorded the lowest number of larvae (1.00), it was on par with IPM (1.25), NPV (1.75), bird perches (1.75) and neem (1.75) spray and found to be equally effective and significantly superior over control (5.00). Whereas fourteen days after treatment, IPM was observed to be the most effective treatment with less number of larvae (1.50) and was on par with endosulfan spray (2.75) in its efficacy. NPV spray registered more number of larvae (4.00) but was not significantly different from endosulfan, bird perches and neem spray (3.75) and observed to be effective when compared to control (7.50). Twenty one days after treatment, IPM, bird perches, neem, NPV and endosulfan were found to be equally effective, with 0.75, 1.25, 1.50, 1.50 and 1.75 larvae respectively without differing significantly among themselves, but were significantly superior over control (4.75).

Fourth spray:

Seven days after treatment, even though IPM and neem registered the lowest and the highest larval population of 2.25 and 3.75 respectively, were found to be equally effective without differing significantly among themselves and were also found to be on par with bird perches (2.50), NPV (2.50) and endosulfan (2.50). All the five treatments were found to be significantly superior and effective over control (7.00). Fourteen days after treatment NPV spray recorded the lowest larval population (5.00) which was on par with IPM (5.25). Endosulfan spray stood next in the order of efficacy (6.75) which was found to be at par with IPM as well as with neem spray (7.25) and bird perches (7.75), and all were found to have some effect in managing the fifth and sixth instar larvae of *H. armigera* when compared to control (11.75).

Fifth spray:

At seven days after treatment, even though neem recorded the lowest number of larvae (1.25) was found to be equally effectively as endosulfan (1.75), NPV (2.00), IPM (2.00) and bird perches (2.00). When compared to control (4.75) all the treatments were effectively suppressing the larval population. Whereas at fourteen days after treatment eventhough NPV recorded less number of larvae (0.25) there was no significant difference among the treatments in the management of large sized larvae of gram pod borer, *H. armigera*.

In general, IPM was concluded as the best and effective treatment in the management of large sized larvae of *H. armigera* closely followed by endosulfan, throughout the season. From forty five DAS birds were found to be effective in managing large sized larvae of *H. armigera*.

4.5 EFFICACY OF DIFFERENT TREATMENTS AGAINST THE LARVAL POPULATION OF GRAM POD BORER:-

To assess the efficacy of different treatments against the larval population of gram pod borer *Helicoverpa armigera* studies were conducted. The results are elucidated in Table 5 and Fig.7. The data revealed that there was no significant difference between the treatments, when counts were made before imposing the treatments.

First spray:

One day after first spray endosulfan was found to be superior among the treatments by recording a population of only 35.75 as against 56.25 in control, followed by IPM (44.75) which was on par with neem (45.00), NPV (45.75) and bird perches (47.75). Whereas 7 days after first spray, the lowest population was recorded in IPM (34.00) which was not significantly different from endosulfan (35.00), NPV (38.75) and neem (39.25). More number of larvae were observed in plots with bird perches (50.50), but significantly better when compared to control (60.25). While at fourteen days after

TABLE 5: EFFICACY OF DIFFERENT TREATMENTS AGAINST THE GRAM POD BORER (*Helicoverpa armigera*) LARVAE

Sl No	Treatment		Total number of larvae per 20 plants												
		DAS	15	22	29	36	43	50	57	64	71	78	85	92	99
		DAT	Pre T	1	7	14	7	14	7	14	21	7	14	7	14
1	T1-Neem product AZA 0.006%		6.00 (2.55)	45.00 (6.74)	39.25 (6.29)	20.00 (4.52)	31.75 (5.68)	29.00 (5.43)	76.00 (8.75)	36.00 (6.02)	44.00 (6.65)	37.75 (6.18)	59.75 (7.76)	50.50 (7.13)	12.75 (3.63)
2	T2-NPV 250 LE/ha		6.75 (2.68)	45.75 (6.79)	38.75 (6.23)	22.00 (4.74)	27.25 (5.25)	31.50 (5.66)	68.25 (8.29)	36.75 (6.09)	37.75 (6.18)	32.50 (5.72)	53.00 (7.31)	51.50 (7.21)	11.50 (3.45)
3	T3-Bird perches		6.25 (2.60)	47.75 (6.79)	50.50 (7.14)	23.75 (4.92)	28.00 (5.33)	37.25 (6.14)	70.00 (8.39)	39.50 (6.30)	42.75 (6.55)	35.75 (6.01)	59.75 (7.76)	53.75 (7.34)	13.25 (3.69)
4	T4-Endosulfan 0.07%		7.50 (2.82)	35.75 (6.00)	35.00 (5.94)	16.25 (4.08)	22.00 (4.71)	32.00 (5.70)	66.75 (8.20)	31.25 (5.63)	35.75 (5.99)	34.75 (5.94)	56.50 (7.55)	50.00 (7.10)	12.25 (3.55)
5	T5-IPM		8.00 (2.90)	44.75 (6.72)	34.00 (5.85)	18.25 ((4.32)	30.00 (5.51)	32.25 (5.72)	63.00 (7.97)	29.50 (5.46)	22.50 (5.09)	28.75 (5.40)	46.75 (6.87)	47.75 (6.94)	8.75 (3.04)
6	T6-Control		7.25 (2.79)	56.25 (7.52)	60.25 (7.77)	34.50 (5.92)	42.50 (6.55)	46.50 (6.86)	85.50 (9.27)	47.75 (6.93)	57.50 (7.60)	49.00 (7.04)	74.25 (8.64)	70.75 (8.43)	22.25 (4.77)
	S.Ed		0.16	0.18	0.28	0.12	0.27	0.12	0.16	0.24	0.24	0.28	0.11	0.29	0.21
	C.D (P=0.05)		-	0.38	0.61	0.25	0.57	0.26	0.34	0.52	0.51	0.60	0.23	0.63	0.46

Figures in parenthesis are square root transformed

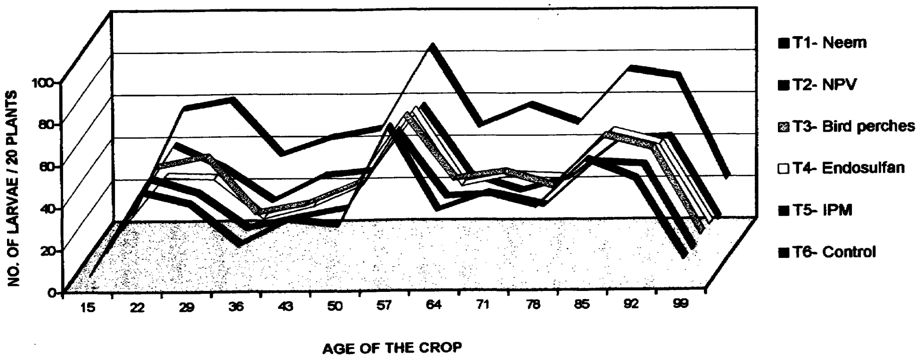
DAS: Days after sowing

DAT: Days after treatment

Pre T: Pre Treatment

*** Significant at 5% level**

FIG.7. EFFICACY OF DIFFERENT TREATMENTS AGAINST THE TOTAL LARVAL POPULATION OF *Helicoverpa armigera* ON CHICKPEA



treatment, endosulfan had some effect in managing the pest by registering the minimum number of larvae (16.25) which was on par with IPM (18.25), followed by neem (20.00), which was at par with NPV (22.00). Plots with bird perches had very little effect since more number of larvae were observed (23.75) in it, but significantly superior to control (34.50).

Second spray:

Seven days after second spray endosulfan was found to be highly effective in managing the larvae of *H. armigera* (22.00) which was at par with NPV (27.25). Neem recorded the highest population (31.75) which was on par with NPV (27.25), bird perches (28.00) and IPM (30.00). So these were the least effective, but significantly superior treatments when compared to control (42.50). While fourteen days after treatment, bird perch was found to be significantly inferior (37.25) and neem was observed to be significantly superior (29.00) treatments. NPV was at par with neem as well as with endosulfan (22.00) and IPM (30.00). So both at seven and fourteen days after treatment, all were found to be significantly effective when comparing with control.

Third spray:

Seven days after treatment, IPM stood first in the order of efficacy (63.00) and was observed to be on par with endosulfan (66.75) and NPV (68.25). Since the bird activity started 50 DAS, it was found to have better effect and on par with NPV and endosulfan. Neem was noticed as significantly least effective treatment (76.00), but superior to control (85.50). Fourteen days after treatment IPM with low population (29.50) exhibited the highest efficacy which was at par with endosulfan (31.25). Neem and NPV were found to be moderately effective and were on par with bird perches (39.50), which recorded more larvae, but significantly superior over control. IPM maintained its supremacy even at twenty one days after treatment with 61 per cent reduction of larval population over control, followed by endosulfan (35.75), which was on par with NPV (37.75). Neem was found to be least effective by registering more number of larvae (44.00) and was on par with NPV and bird perches (42.75), but significantly different from control.

Fourth spray:

IPM was found to be highly effective in the management of *H. armigera* larvae (28.75), which was at par with NPV (32.50) and endosulfan (34.75) at seven days after treatment. Neem was observed to be the least effective treatment (37.75) but was on par with NPV, endosulfan and bird perches (35.75). IPM closely followed by NPV spray maintained their supremacy even at fourteen days after treatment with 37 and 29 per cent reduction over control respectively. While endosulfan (56.50), bird perches (59.75) and neem (59.75) were the least effective treatments but significantly superior over control (74.25).

Fifth spray:

Even though IPM recorded less population (47.75) it was found to be at par with endosulfan (50.00), neem (50.50), NPV (51.50) and bird perches (53.75) at seven days after treatment, but significantly effective over control (70.75). Fourteen days after treatment also IPM was highly effective (8.75) in managing the larvae which was at par with NPV (11.50). Bird perches were found to be least effective (13.25) at 90 DAS, but on par with NPV, endosulfan (12.25) and neem (12.75), but significantly effective over control.

In general even though up to 50 DAS i.e., up to second spray, endosulfan gave very good control, IPM was concluded as the best effective treatment which maintained its supremacy in suppressing the population of *H. armigera* till the crop was harvested, followed by endosulfan, NPV and neem. Bird perches were also found to be effective from second fortnight of December till the end of February.

4.6 EFFICACY OF DIFFERENT TREATMENTS ON SOIL INHABITING NATURAL ENEMIES IN CHICKPEA CROP:-

Studies were conducted to assess the efficacy of different treatments on the soil inhabiting natural enemies and the results are presented in Table 6 and Fig.8. Natural enemies belonging to the orders Hymenoptera, Coleoptera, Orthoptera, Dermaptera, such as ants, braconid wasps, ichneumonid wasps, and ground beetles (Carabidae), Coccinellids, spiders, crickets (Orthoptera), earwigs (Dermaptera) etc., were collected from the pitfall traps fixed in each treatment.

First spray:

While comparing the treatments at fourteen days after treatment, endosulfan spray was found to have more effect on soil inhabiting natural enemies by registering the lowest population (106.50), followed by IPM and neem spray which were on par. The highest number of natural enemies were recorded in control (208.5) which was at par with plots with bird perches (200.50) and NPV spray (207.50).

TABLE 6: EFFECT OF DIFFERENT TREATMENTS ON SOIL INHABITING NATURAL ENEMIES LIVE IN CHICKPEA FIELDS

Sl No	Treatment	Number of natural enemies per three pit fall traps							
		36 DAS	43 DAS	50 DAS	61 DAS	70 DAS	2 DA	92 DA	103 DAS
		14 DAT	7 DAT	14 DAT	11 DAT	20 DAT	1 DA	7 DAT	18 DAT
1	T1-Neem product AZA 0.006%	182.00 (13.51)	117.50 (10.86)	122.75 (11.08)	182.00 (13.51)	96.75 (9.86)	55.00 (7.44)	46.50 (6.84)	80.50 (8.99)
2	T2-NPV 250 LE/ha	207.50 (14.42)	118.75 (10.91)	126.00 (11.22)	184.75 (13.61)	95.75 (9.81)	72.00 (8.51)	49.00 (7.02)	81.50 (9.05)
3	T3-Bird perches	200.50 (14.18)	121.25 (11.02)	128.75 (11.35)	183.00 (13.54)	105.50 (10.29)	76.00 (8.74)	42.25 (6.53)	85.50 (9.27)
4	T4-Endosulfan 0.07%	106.50 (10.34)	92.75 (9.62)	100.75 (10.03)	109.25 (10.46)	51.25 (7.18)	27.75 (5.31)	25.50 (5.07)	63.75 (8.01)
5	T5-IPM	175.75 (13.28)	117.00 (10.84)	130.50 (11.44)	183.00 (13.55)	100.75 (10.06)	57.00 (7.58)	47.50 (6.92)	84.00 (9.19)
6	T6-Control	208.50 (14.45)	111.00 (10.55)	130.50 (11.44)	188.50 (13.75)	112.75 (10.64)	74.50 (8.66)	46.25 (6.83)	89.75 (9.50)
	S.Ed	0.18	0.36	0.45	0.2	0.26	0.21	0.29	0.15
	C.D (P=0.05)	0.39	0.77	-	0.43	0.55	0.45	0.63	0.31

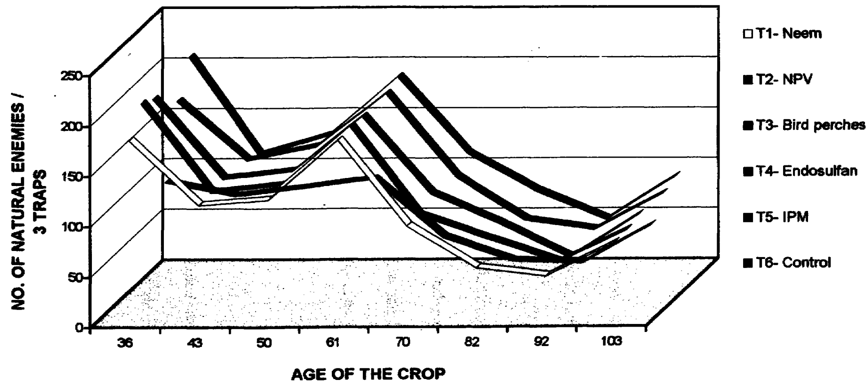
Figures in parenthesis are square root transformed

DAS: Days after sowing

DAT: Days after treatment

*** Significant at 5% level**

FIG.8. EFFECT OF DIFFRENT PLANT PROTECTION OPTIONS ON SOIL INHABITING NATURAL ENEMIES IN CHICKPEA FIELDS



Second spray:

Seven days after treatment when counts were made and treatments were compared, the lowest population of natural enemies were observed in endosulfan spray (92.75) and there was no significant difference among the other treatments. Whereas at fourteen days after treatment, the treatments were found to be non-significant, showing that the treatments had no effect on the soil inhabiting natural enemies.

Third spray:

Eleven days after treatment, only endosulfan spray was found to have some effect on the natural enemies population (109.25) and all other treatments were found to be on par, showing that except endosulfan no other treatments were affecting the ground dwelling natural enemies population. While twenty days after treatment, endosulfan spray had some effect by registering the minimum number of natural enemies (51.25) as against the maximum number in control (112.75). NPV spray, neem and IPM were found to have little effect (95.75, 96.75 and 100.75 respectively). Bird perches were found to be on par with control as well as with IPM.

Fourth spray:

Eleven days after treatment, endosulfan maintained its effect on the natural enemies population (27.75) followed by neem spray and IPM which received neem as fourth spray (55.00 and 57.00 respectively). NPV, control and bird perches were found to have no effect and were significantly on par.

Fifth spray:

Seven days after treatment, all the treatments except endosulfan (25.50) were found to have no effect on the population of ground dwelling natural enemies and were found to be on par among themselves. Whereas at eighteen days after treatment, once again endosulfan was found to have some effect by recording only 63.75 natural enemies as against 89.75 natural enemies in control. Neem, NPV spray and IPM were found to have little effect (80.50, 81.50 and 84.00). Bird perches had negligible effect and were found to be on par with both control as well as IPM.

In general, the results revealed that throughout the cropping period endosulfan had maximum suppressing effect on the population of natural enemies and neem spray was found to have insignificant effect. So it is observed that in IPM whenever it received neem spray (first and fourth) it had very little effect on ground dwelling natural enemies. NPV and bird perches did not in anyway affect them and were found to be on par with control, which recorded more number of natural enemies.

4.7 EFFICACY OF DIFFERENT TREATMENTS ON AERIAL NATURAL ENEMIES IN CHICKPEA CROP:-

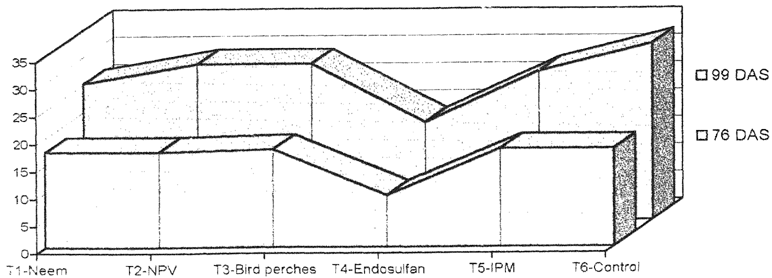
To assess the treatmental effects on aerial natural enemies, DeVac trap was used and the following natural enemies were observed in the trap collection. Natural enemies belonging to the order hymenoptera such as braconids, chalcids, ichneumonids, trichogrammatids, ants, and others such as spiders, small crickets, tachinids etc., were collected in DeVac trap and the results are presented in Table 7 and Fig.9.

TABLE 7: EFFECT OF DIFFERENT PLANT PROTECTION OPTIONS ON NATURAL ENEMIES LIVE IN CHICKPEA CROP CANOPY

Sl No	Treatment	Natural enemies population		Overall effect	Percentage reduction over control
		76 DAS 5 DAT	99 DAS 14 DAT		
1	T1-Neem product AZA 0.006%	25.25 (5.07)	17.50 (4.24)	21.38	14.92
2	T2-NPV 250 LE/ha	28.75 (5.41)	17.50 (4.24)	23.13	7.96
3	T3-Bird perches	28.75 (5.41)	18.00 (4.27)	23.38	6.96
4	T4-Endosulfan 0.07%	18.00 (4.30)	9.50 (3.16)	13.75	45.28
5	T5-IPM	27.25 (5.27)	18.00 (4.30)	22.63	9.95
6	T6-Control	32.25 (5.72)	18.00 (4.30)	25.13	-
	S.Ed	0.1	0.11	-	-
	C.D (P=0.05)	0.21	0.24	-	-

Figures in parenthesis are square root transformed
DAS: Days after sowing
DAT: Days after treatment
*** Significant at 5% level**

FIG.9. EFFECT OF DIFFERENT PEST MANAGEMENT STRATEGIES ON NATURAL ENEMIES LIVE IN CHICKPEA CROP CANOPY



When the treatments were compared at 5 days after fourth spray, endosulfan recorded the lowest population (18.00) as against the highest in control (32.25). Neem and IPM were found to be least effective. Bird perches, NPV and control had no effect on the population of natural enemies inhabiting on the crop canopy.

Whereas fourteen days after fifth spray, only endosulfan (9.50) was found to have some effect and all other treatments were observed to be safe to the aerial natural

Overall effect showed that endosulfan reduced the aerial natural enemies population by 45.28 per cent over control. Where as neem spray was found to have little effect by registering 14.92 per cent reduction over control. Since IPM received two neem sprays it had around 9.95 per cent reduction over control. HNPV spray and bird perches had negligible effect (7.96 and 6.96 per cent respectively) on the population of natural enemies inhabiting on the crop canopy. While observing for eggs and larvae every week, around 10-15 per cent of the plants were noticed with dead *Trichogramma* wasps.

4.8.1 EFFECT OF VARIOUS IPM OPTIONS ON NATURAL PARASITISM BY *Campoletis chlorideae* ON THE LARVAE OF *Helicoverpa armigera*:-

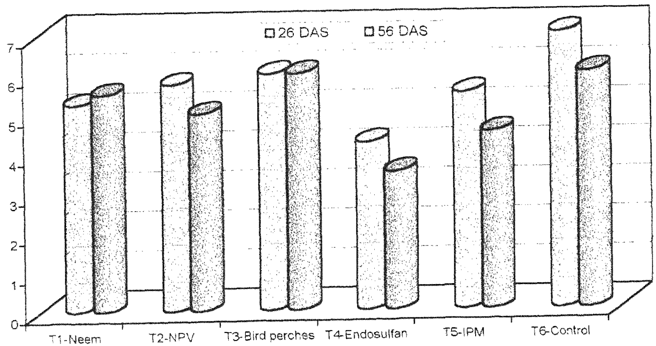
The treatments were compared to assess the effect of various plant protection options on natural parasitism by *C. chlorideae* Uchida, on the larvae of *H. armigera* and the results are presented in Table 8 and Fig.10.

TABLE 8: EFFECT OF VARIOUS PLANT PROTECTION STRATEGIES ON THE EFFICIENCY OF *Campoletis chlorideae* AND HNPV

Sl.No.	Treatments	Percentage parasitisation		Percentage infection	
		Campoletis chlorideae		HNPV	
		26 DAS	56 DAS	26 DAS	56 DAS
		4 DAT	6 DAT	4 DAT	6 DAT
1	T1-Neem product AZA 0.006%	5.25 (13.03)	5.50 (13.52)	18.50 (25.39)	23.00 (28.63)
2	T2-NPV 250 LE/ha	5.75 (13.84)	5.00 (12.86)	52.25 (46.29)	46.50 (42.99)
3	T3-Bird perches	6.00 (14.08)	6.00 (14.08)	20.50 (26.80)	25.00 (29.98)
4	T4-Endosulfan 0.07%	4.25 (11.84)	3.50 (10.69)	18.00 (24.97)	23.50 (28.92)
5	T5-IPM	5.50 (13.50)	4.50 (12.01)	22.00 (27.96)	37.50 (37.75)
6	T6-Control	7.00 (14.33)	6.00 (14.08)	21.50 (27.57)	24.00 (29.25)
	S.Ed	1.05	1.38	1.91	1.51
	C.D (P=0.05)	-	-	4.07	3.21

Figures in parenthesis are arcsin transformed
DAS: Days after sowing
DAT: Days after treatment
*** Significant at 5% level**

FIG.10. EFFECT OF VARIOUS PLANT PROTECTION STRATEGIES ON THE EFFICACY OF *Campoletis chloridae*



In both the collections at 26 DAS and 56 DAS, the egg parasitisation was observed to be nil. From the field collected parasitised larvae of *H. armigera*, small, cylindrical, dirty white cocoons came out. The results revealed that both at 26 DAS and 56 DAS, (4 days after first spray and 6 days after third spray, respectively), the treatments were found to be non-significant for the parasitisation by *C. chlorideae* and showed that the treatments have no effect on the parasitisation by *C. chlorideae*. The percentage parasitism in control was observed to be 7.00 and 6.00 at 26 and 56 DAS respectively.

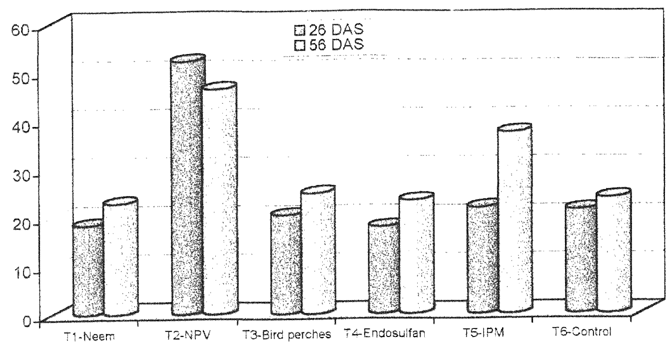
Apart from this larval parasitoid, pupal parasitoid *Carcelia illota* Curran (Tachinidae: Diptera) was also observed in control during this laboratory study. However its incidence was low (1 per cent).

4.8.2 TREATMENTAL EFFECTS ON THE PATHOGENICITY OF Nuclear Polyhedrosis Virus ON *Helicoverpa armigera* LARVAE:-

Laboratory studies were conducted to assess the treatmental effects on the pathogenicity of NPV on *H. armigera* larvae and the results are presented in Table 8 and Fig.11.

The field collected, NPV infected larvae became dark and soft after death. Mass of polyhedral inclusion bodies oozed out of the infected larvae. Four days after first spray, the highest per cent of infection by NPV was observed in the larvae collected from NPV sprayed plots (52.25).

FIG.11. INCIDENCE OF NPV INFECTION IN DIFFERENT TREATMENTS AT VARIOUS CROP STAGES IN CHICKPEA



Whereas, at 6 days after third spray, the pathogenicity was observed to be the highest in the larvae collected from NPV sprayed plots (46.50), followed by in IPM plots (37.50), which received NPV as second spray. In control also 25 to 30 per cent pathogenicity was observed. All other treatments were found to be on par with control, without differing among themselves.

4.9 EFFECT OF VARIOUS PLANT PROTECTION OPTIONS ON THE POD DAMAGE BY *Helicoverpa armigera* ON CHICKPEA:-

The effect of different treatments on the pod damage by *Helicoverpa armigera* was assessed and the results are given in Table 9 and Fig.12. The results revealed that the maximum percentage of pod damage was observed in control (18.76). While comparing the treatments, IPM was found to be the best treatment by registering the lowest percentage of pod damage (9.37) which was about 50.05 per cent less over control. Endosulfan stood next in the order of efficacy (10.21) which recorded 45.58 per cent reduction over control. Neem spray (10.98) and NPV spray (11.55) were observed to be on par by recording 41.47 per cent and 38.43 per cent reduction over control respectively. Among the treatments, eventhough bird perches recorded maximum percentage of pod damage (13.45), it was found to be significantly effective over control, by registering 28.30 per cent reduction over control.

4.10.1 EFFECT OF DIFFERENT PLANT PROTECTION STRATEGIES ON THE GRAIN YIELD OF CHICKPEA:-

To assess the efficacy of different treatments on the grain yield of chickpea studies were conducted and the results are elucidated in Table 10 and Fig.12. The results revealed that IPM was found to be the best effective treatment, which recorded 11.7 q ha^{-}

TABLE 9: EFFECT OF VARIOUS PLANT PROTECTION OPTIONS ON THE POD DAMAGE CAUSED BY *Helicoverpa armigera* ON CHICKPEA

Sl.No	Treatments	Percentage pod damage	Percentage reduction over control
1	T1-Neem product AZA 0.006%	10.98 (19.33)	41.47
2	T2-NPV 250 LE/ha	11.55 (19.86)	38.43
3	T3-Bird perches	13.45 (21.51)	28.3
4	T4-Endosulfan 0.07%	10.21 (18.63)	45.58
5	T5-IPM	9.37 (17.81)	50.05
6	T6-Control	18.76 (25.66)	-
	S.Ed	0.55	-
	C.D (P=0.05)	1.18	-

Figures in parenthesis are arcsin transformed.
*** Significant at 5% level**

FIG.12. EFFECT OF VARIOUS IPM OPTIONS ON THE YIELD AND POD DAMAGE IN CHICKPEA

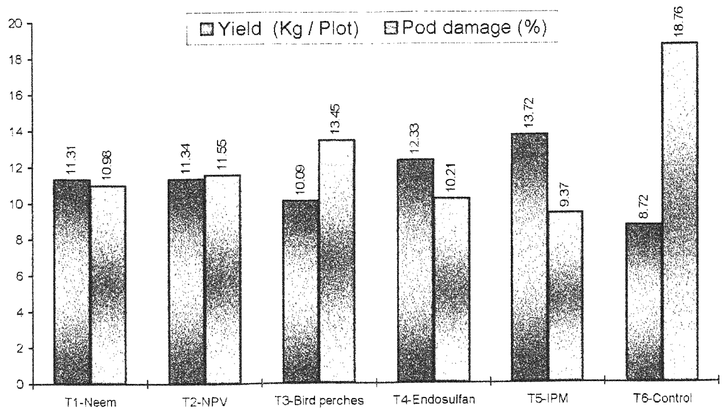


TABLE 10: EFFECT OF DIFFERENT PLANT PROTECTION STRATEGIES ON THE GRAIN YIELD OF CHICKPEA

Sl No	Treatment	Grain Yield (kg/ha)	Percentage increase over control
1	T1-Neem product AZA 0.006%	961.820	29.67
2	T2-NPV 250 LE/ha	963.858	29.94
3	T3-Bird perches	858.015	15.67
4	T4-Endosulfan 0.07%	1048.173	41.32
5	T5-IPM	1167.025	57.33
6	T6-Control	741.838	-
	S.Ed	34.147	-
	C.D (P=0.05)	72.767	-

*** Significant at 5% level**

^{1}, which was around 57.33 per cent increase over control (7.4 q ha^{-1}), followed by endosulfan spray (10.5 q ha^{-1}) which recorded 41.32 per cent yield increase over control. Neem (9.61 q ha^{-1}) and NPV spray (9.63 q ha^{-1}) were found to be significantly effective and on par, which recorded 29.67 and 29.94 per cent yield increase over control respectively. Even though plots with bird perches recorded significantly less yield (8.6 q ha^{-1}) than neem, IPM and endosulfan but found to be effective by registering 15.67 per cent yield increase over control.

4.10.2 CORRELATION BETWEEN YIELD AND POD DAMAGE:-

It was found that there was a significant negative correlation (r = -0.9228**) between the yield and pod damage both at one per cent and five per cent levels. So, when pod damage decreases, yield will increase. Pod damage contributed 85.16 per cent towards yield (R^2 = 0.8516). The simple linear regression equation for yield and pod damage was derived as, Y = 17.05 – 0.49x (Fig.13).

4.11 ECONOMICS OF DIFFERENT TREATMENTS IN THE MANAGEMENT OF *Helicoverpa armigera*:-

To know the economics of different treatments, cost benefit ratio was worked out and are presented in Table 11. The results revealed that IPM was the most economical treatment which registered the highest cost benefit ratio of 1:6.3 followed by endosulfan treatment (1:6.1). Neem spray stood next with the cost benefit ratio of 1:5.5 and the lowest cost benefit ratio was obtained with HNPV spray (1:4.8). Without any investment, simply by erecting the bird perches fifteen per cent more yield was obtained over control, which recorded Rs.1162.00 extra income over control as against the highest additional income of Rs.4252.00 recorded in IPM.

FIG.13. RELATIONSHIP BETWEEN YIELD AND POD DAMAGE IN CHICKPEA

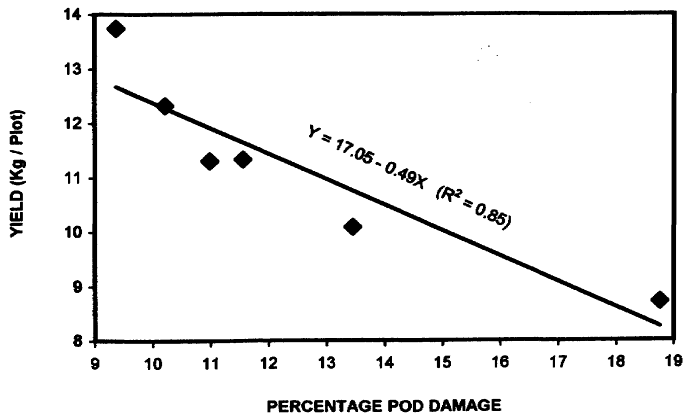


TABLE 11:COST BENEFIT RATIO OF DIFFERENT TREATMENTS AGAINST *Helicoverpa armigera* MANAGEMENT IN CHICKPEA

Sl. No.	Treatments	Grain yield (Kg/ha)		Total cost of insecticidal application (Rs.)	Additional income (Rs.)	Total income (Rs.)	C:B cost benefit ratio
		Gross	Extra yield over control				
1	Neem (AZA) 0.006%	961.8	220.0	1750.00	2200.00	9618.00	01:05.5
2	NPV 250 LE/ha	963.8	222.0	2000.00	2220.00	9638.00	01:04.8
3	Endosulfan 0.07%	1048.1	306.3	1725.00	3063.00	10481.00	01:06.1
4	IPM	1167.0	425.2	1845.00	4252.00	11670.00	01:06.3
5	Bird perches	858.0	116.2	-	1162.00	8580.00	-
6	Control	741.8	-	-	-	7418.00	-

4.12 SEASONAL INCIDENCE OF *Helicoverpa armigera* ON CHICKPEA:-

Studies on seasonal incidence of *H. armigera* were carried out with a view to find out the peak period of activity of the gram pod borer during post-rainy season and also the population fluctuations in relation to age of the crop.

4.12.1 Oviposition in relation to age of the crop:

The number of eggs laid were recorded on twenty plants at weekly intervals starting from 15 DAS. Eggs were seen on the plants even at 10 DAS.

A perusal of the data in Table 12 and Fig14. revealed that the number of eggs laid per twenty plants were more (44.25) at 15 DAS and gradually increased and reached the highest number (67.25) at 50 DAS. The eggs started disappearing 99 DAS. So the egg laying was observed to be the maximum at second fortnight of December.

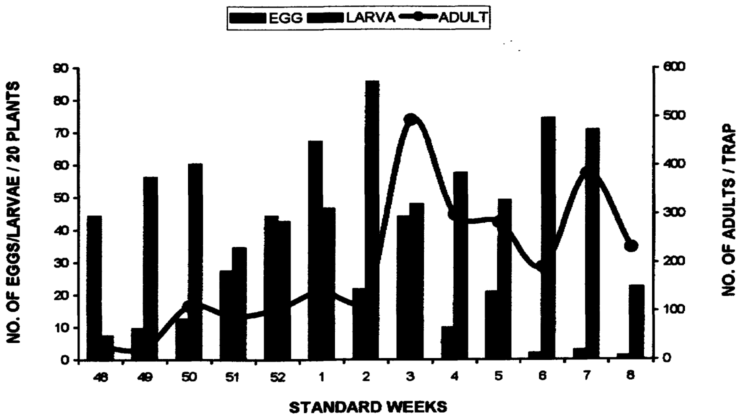
4.12.2 Larval population in relation to age of the crop:

The larval population was recorded on twenty plants, at weekly intervals from 15 DAS. The pest incidence started in the seedling stage itself (15 DAS). A perusal of the data in Table 12 and Fig.14 revealed that the larval population was very less at 15 DAS (7.25 per 20 plants). A gradual increase in larval population was observed thereafter and attained the first peak at 29 DAS, second and third peak at 57 and 85 DAS with 60.25, 85.50 and 74.25 larvae respectively. The larval population started disappearing at 99 DAS. The peak activity of pest was observed in first fortnight of December, January and February when the crop was at peak podding stage.

TABLE 12. MONITORING OF *Helicoverpa armigera* ADULTS, EGGS, AND LARVAE AT DIFFERENT STAGES OF CHICKPEA CROP AT ICRISAT CENTER DURING 1998-99

Date of count	Age of the crop (days)	Pheromone trap catches/week/trap	Population/20 plants (Mean of four replications)	
			Eggs	Larvae
26.11.98	15	11.00	44.25	7.25
03.12.98	22	27.00	9.50	56.25
10.12.98	29	24.60	12.50	60.25
17.12.98	36	110.90	27.25	34.50
24.12.98	43	89.80	44.25	42.50
31.12.98	50	105.00	67.25	46.50
07.01.99	57	141.80	21.50	85.50
14.01.99	64	129.00	44.00	47.75
21.01.99	71	493.40	9.75	57.50
28.01.99	78	298.80	20.75	49.00
04.02.99	85	283.20	1.75	74.25
11.02.99	92	190.80	2.75	70.75
18.02.99	99	382.80	1.00	22.25

FIG.14. SEASONAL INCIDENCE OF *Helicoverpa armigera* ADULTS, EGGS AND LARVAE IN CHICKPEA CROP AT ICRISAT CENTRE DURING 1998-99



4.13 MONITORING OF *Helicoverpa armigera* ADULTS USING SEX PHEROMONE TRAP:-

To monitor the peak emergence of *H. armigera* moths, the number of moths caught in the traps were counted daily and the total number of moths caught per standard week was calculated and are presented in Table 12 and Fig.14.

A perusal of the data in Table 12 and Fig.14 revealed that the maximum moth emergence was observed during the second, third and fourth week of January and also in the first week of February, with the moth catches of 129.0, 493.4, 298.8 and 283.2 $trap^{-1}$ $week^{-1}$, respectively.

DISCUSSION

CHAPTER V

DISCUSSION

Helicoverpa armigera Hubner is a major pest on chickpea. It assumed major status because of its high fecundity, multiple generation, high generation turnover, polyphagy and migratory behaviour. With a veiw to develop Integrated Pest Management strategies against *H. armigera* on chickpea, present studies were carried out during post-rainy 1998-99 at ICRISAT Asia Centre, Patancheru, A.P. The results of experiments have been discussed in this chapter.

MANAGEMENT STRATEGIES OF GRAM POD BORER *Helicoverpa armigera*:-

Heavy use of chemical pesticides led to several adverse effects like development of pesticide resistance, resurgence, emergence of new pests and health hazards. The best alternative, ecofriendly approach is IPM. Studies were undertaken to assess the efficacy of different treatments on the ovipositional behaviour of *H. armigera* moths and against small, medium and large sized larvae of *H. armigera*.

5.1 EFFICACY OF DIFFERENT TREATMENTS ON THE OVIPOSITIONAL PREFERENCE OF *Helicoverpa armigera*:

The overall effect of all the five sprays (Table 1 and Fig.3) revealed that neem was the effective treatment in reducing the ovipositional preference of *H. armigera* by registering 37 per cent reduction in egg laying over control. IPM stood next in the order of efficacy with 36.79 per cent reduction over control, since it received neem as first and fourth spray. Endosulfan was found to be effective in reducing the ovipositional preference of moths only up to seven days after treatment, which recorded 24 per cent reduction over control. Since IPM is the combination of neem (aza), HNPV, bird perches and endosulfan spray, it was found to be equally effective as that of neem (aza) as ovipositional deterrent.

Saxena and Rembold (1984) reported that contact of females of chickpea pod borer with neem oil inhibited oviposition.

Ayyangar and Rao (1989) found total inhibition of oviposition on the treated area with methanol extract of neem by *Spodoptera litura* moths. The observations made by Ramachandra Rao *et al* (1990) on the ovipositional repellent effects of neem products also proved this findings that neem products can be successfully exploited as ovipositional repellents. The report given by Rosaiah (1992) on the maximum ovipositional repellency of repelin a neem product, to *H. armigera* on cotton strengthen the present observations on the ovipositional repellency of neem aza to *H. armigera* on chickpea.

Anwar *et al* (1993) observed 50 per cent reduction in oviposition by the *H. armigera* females treated with neem oil compared to untreated females.

5.2 TREATMENTAL EFFECTS ON THE LARVAL POPULATION OF *Helicoverpa armigera*:

5.2.1 Small Sized Larvae:

From the overall effect of all the five sprays (Table 2 and Fig.4) it was inferred that IPM was the effective treatment since it registered 29 per cent reduction in small sized larval population over control, followed by endosulfan (27). HNPV spray stood next in the order of efficacy (21). Narayanan (1979) observed significant reduction in larval population, when NPV was sprayed thrice at weekly interval after the appearance of early instars. Erecting bird perches was also found to be as effective as that of neem aza spray. Since IPM is the combination of all the treatments, it was observed to be superior over all the treatments.

5.2.2 Medium Sized Larvae:

IPM was adjudged as the superior treatment among all, which recorded 40 per cent reduction in medium sized larval population over control, followed by endosulfan spray (35.30). The sprays of HNPV was also found to be equally effective as that of chemical spray (33.20). Because of the antifeedant effect of neem, there was 29 per cent reduction over control, followed by bird perches (22) (Table 3 and Fig.5).

5.2.3 Large Sized Larvae:

IPM maintained its supremacy in managing the fifth and sixth instar larvae of *H. armigera*, by registering 65 per cent reduction in large sized larval population over control, followed by endosulfan (61). HNPV spray was found to be as effective as chemical spray (58). Neem aza spray was also observed to be effective (56). Even though erecting bird perches was found to be inferior among all the treatments, it registered 51 per cent reduction over control. So bird perches should be included as one of the tools in pest management in chickpea. Since the bird activity started from second fortnight of December, it was found to be highly effective in managing the late larval population of *H. armigera* (Table 4 and Fig.6).

5.3 EFFICACY OF VARIOUS PLANT PROTECTION OPTIONS AGAINST THE TOTAL LARVAL POPULATION OF *Helicoverpa armigera*:-

The overall effect of all the five sprays (Table 5 and Fig.7) highlighted the supremacy of IPM, which recorded 37 per cent reduction in total larval population over control. In IPM the spray schedules were fixed in such a way that the first spray neem took care in reducing the oviposition of *H. armigera* and HNPV was given as second spray to manage the first and second instar larvae. The larvae which escaped the HNPV treatments were managed by giving endosulfan 0.07 per cent as third spray. Once again neem was sprayed since it has both antifeedant as well as ovipositional deterrent nature for next generation, to manage the remaining larvae in IPM plots and also to repel the *H. armigera* moths from egg laying. HNPV was once again given as fifth spray to manage the remaining larval population till harvest. Apart from these five sprays bird perches were installed @ one perch $plot^{-1}$ which helped in managing the larval population up to certain extent in IPM plots. Since the bird activity was more from second fortnight of December (45 DAS) till first fortnight of February (90 DAS), bird perches were found to be effective in reducing the larval population, especially medium and large sized larvae. So the present IPM strategy with neem as first and fourth spray, HNPV as second and fifth spray and third spray with endosulfan at fifteen days interval in addition to bird perches, was found to be the best schedule in managing the larval population and also in reducing the egg laying of *H. armigera* moths.

Endosulfan spray stood next in the order of efficacy in managing the larval population of *H. armigera*, with 33 per cent reduction over control, followed by HNPV spray (29).

Neem also found to be effective (25) in reducing the larval population because of its antifeedant nature. Eventhough bird perches were found to be inferior among the treatments, it registered 23 per cent reduction in larval population over control.

Thakur *et al* (1988) reported that neem kernel and neem leaf extract treatments recorded significantly less larval population in comparison to control, however less effective when compared to chemical pesticides. Sehgal and Ujagir (1990) also stated that NSKE at 5 per cent was less effective on *H. armigera* on chickpea, but significantly better than control. These support the present findings that neem (aza 0.006 per cent) was effective on *H. armigera* larval population when compared to control, but less effective when compared to endosulfan 0.07 per cent spray.

Jayaraj *et al* (1987) found significantly reduced larval population when HNPV was sprayed @ 250 LE/ha, which was observed to be more effective on chickpea. The observations of Pawar *et al* (1987) on the effectiveness of HNPV on chickpea pod borer, which was comparable with endosulfan spray is supporting the present study. Bilapate *et al* (1988) observed 1.98 to 24.52 per cent larval mortality of *H. armigera* due to HNPV on chickpea.

The findings of Ghode *et al* (1988) on the high avian predation of *H. armigera* by cattle egret and river tern in the month of January support the present study. Birds reduced 33 per cent of *H. armigera* population on wheat and 20 to 40 per cent reduction was observed by House sparrows (ICAR, 1992).

Bhagwat (1997) observed intense bird activity in plots sprayed with HNPV on chickpea. Parasharya (1995) noted that the birds prefer medium and large size larvae and assist in the spread of insect pathogens by eating NPV infected larvae. These, support the present findings of heavy reduction in larval population of *H. armigera* in IPM plots, where HNPV sprayed twice apart from neem and endosulfan sprays with bird perches, which were erected to encourage the predatory birds.

Gunasekaran and Balasubramanian (1987) recorded 75 to 98 per cent reductions of *H. armigera* larvae after endosulfan spray. The report of Neupane and Sah (1988) revealed 20 per cent initial kill of *H. armigera* larvae on chickpea after endosulfan spray. Sinha (1993) observed 70 to 72 per cent control of *H. armigera* larvae after 0.07 per cent endosulfan spray. Noorani *et al* (1994) reported 96 per cent reduction in *H. armigera* population after two applications of endosulfan.

All the above findings confirmed that neem products, HNPV, endosulfan sprays and birds effectively control the larval population of *H. armigera* on chickpea. These results strengthen the present findings of effective management of *H. armigera* when bird perches were erected and endosulfan, HNPV and neem aza were given as separate treatments and also when these were given in rotations (combinations) in IPM plots.

5.4 EFFECT OF DIFFERENT PEST MANAGEMENT STRATEGIES ON SOIL INHABITING NATURAL ENEMIES:-

The overall effect of all the five sprays (Table 6 and Fig.8) revealed that endosulfan treatment was found to affect the ground dwelling natural enemies heavily, by recording 40 per cent reduction in natural enemies population over control. Neem spray was found to have little effect, with 8 per cent reduction. In IPM treatment, the percentage reduction was observed to be 7 per cent. It was mainly because of the endosulfan, which was given as third spray and also due to neem aza treatment which was given as first and fourth spray.

Even though HNPV and bird perches recorded 3 and 2 per cent reduction over control, throughout the cropping period, these two were observed to be on par with control and were concluded as safer to the soil inhabiting natural enemies.

Thus it is concluded that except chemical spray all other treatments were found to be safer to the soil inhabiting natural enemies.

5.5 EFFECT OF DIFFERENT PLANT PROTECTION OPTIONS ON AERIAL NATURAL ENEMIES:-

DeVac trap was operated twice in the cropping period at 76 DAS and 99 DAS. At seventy six DAS, more number of natural enemies were caught when compared to the captures at 99 DAS. The activity of natural enemies were observed to be more in the month of December-January because of reduced day temperature (26-27°C) when compared to in February because of slightly high day temperature (30-32°C).

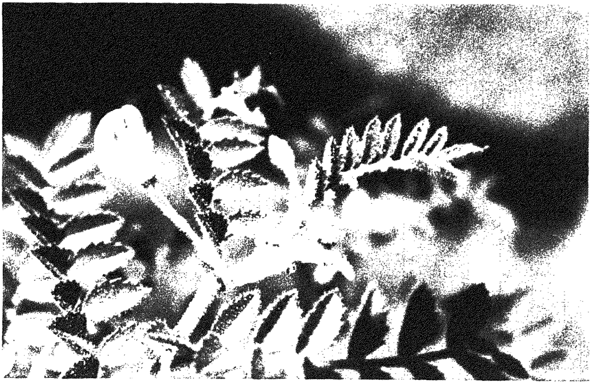
The overall effect showed that (Table 7 and Fig.9) among the treatments endosulfan spray was found to have more suppressing effect, which recorded 45 per cent reduction over control, followed by neem spray which registered 14.92 per cent reduction in the natural enemy population respectively. The percentage reduction over control was comparatively less in IPM (9.95), since it received only one spray of endosulfan and two sprays of neem aza 0.006 per cent. HNPV spray and bird perches were observed to have negligible effect on the natural enemies inhabiting on the crop canopy.

Thakur *et al* (1988) reported that NSKE 5 per cent can be used as it is cheaper and safer to beneficial insects in comparison to highly toxic synthetic insecticides.

5.6.1 EFFECT OF DIFFERENT PLANT PROTECTION OPTIONS ON THE PARASITISATION BY *Campoletis chlorideae* Uchida:-

A perusal of the data in Table 8 and Fig.10 revealed that the percentage parasitisation was observed to be 7.00 and 6.00 at 26 and 56 DAS i.e., at the first fortnight of December and January respectively. The parasitisation was found to be nil in the field collected larvae at first fortnight of February.

In both the collections, the egg parasitisation was observed to be nil. While taking the pest population counts at weekly interval, 10 to 15 per cent of the plants were noticed



Pupa of *Campoletis chlorideae*, the larval parasitoid of *Helicoverpa armigera*

HNPV infected *Helicoverpa armigera* larva

with dead *Trichogramma*, which also indicated the non suitability of chickpea habitat for the survival and effectiveness of *Trichogramma* species.

There was no significant difference among the treatments for the larval parasitisation by *C. chlorideae* on both the collections made at 26 and 56 DAS. So all the treatments were found to be safe to the larval parasitisation by *C. chlorideae*. Even though the treatments were found to be non significant, the percentage parasitisation was observed to be less in endosulfan sprayed plots.

Bhatnagar (1981) confirmed the deterrent role of leaf exudates of chickpea on the activity of the egg parasitoid *Trichogramma* species and observed no egg parasitisation of *H. armigera* in chickpea. The results obtained in the present study on egg parasitisation were coinciding with the results of Bhatnagar (1981).

Nagarkatti (1981) observed 20 to 80 per cent larval parasitisation by *C. chlorideae* and also observed the maximum parasitisation in the month of December and January. Yadav (1990) reported 10 per cent parasitisation by *C. chlorideae* on *H. armigera* on chickpea and observed its activity between September and February. These observations strengthen the results obtained in the present studies.

5.6.2 EFFECT OF DIFFERENT TREATMENTS ON THE PATHOGENICITY BY NUCLEAR POLYHEDROSIS VIRUS ON *Helicoverpa armigera*:-

The results (Table 8 and Fig.11) revealed that there was about 25 to 30 per cent infection by NPV on the field collected larvae of *H. armigera* in control. In larvae which were collected at 26 DAS i.e., 4 days after first spray, maximum larval mortality was observed in HNPV treatment and all other treatments were observed to be on par with control. In second collection (6 days after third spray) also the maximum larval mortality was observed in HNPV treatment, followed by IPM, which received HNPV as second spray. All other treatments (neem, endosulfan sprays and bird perches) were found to be on par with control.

Shrivastava and Yadav (1991) observed 3 to 21 per cent pathogenicity by the microbial agent HNPV on *H. armigera* in chickpea in nature, also stated that *C. chlorideae* and NPV effectively check the *Helicoverpa* population during crop stage and they recommended the use of only selective insecticides on need based level. The results of present investigations are strengthened by the findings of Shrivastava and Yadav (1991).

5.7 EFFECT OF VARIOUS PLANT PROTECTION STRATEGIES ON THE POD DAMAGE CAUSED BY *Helicoverpa armigera*:-

A perusal of the data in Table 9 and Fig.12 revealed that IPM was the best treatment by recording the lowest percentage of pod damage (9.7), which was about 50 per cent reduction over control, followed by endosulfan spray and neem (aza) spray, which registered 46 and 42 per cent reduction in pod damage over control. HNPV spray stood next to neem with 38 per cent reduction over control. Since the bird activity was observed to be more and appreciable at ICRISAT, the pod damage in plots with bird perches was found to be significantly low when compared to control, which recorded about 28 per cent reduction in pod damage over control. Since all the treatments i.e., neem, NPV, endosulfan spray and bird perches contributed significantly, the percentage pod damage was observed to be low in IPM, which was concluded as the superior method in managing the gram pod borer, *H. armigera*.

The pod damage over 15% and to the maximum extent of 84% have been reported by several workers (Sithananthan *et al*, 1984; Lal *et al*, 1985; Anonymous, 1989 and Singla *et al*, 1989). Thakur *et al* (1988) reported 13 and 5 per cent pod damage at green pod stage and harvest respectively in neem leaf extract 5% treatment and 3 and 4 per cent in NSKE 5% spray.

Pawar *et al* (1990) observed 7 per cent pod damage i.e., 46 per cent reduction in pod damage over control when HNPV 250 LE/ha was sprayed twice. While Sharma *et al* (1997) recorded 43 per cent reduction in pod damage over control. Saxena (1980) stated that provision of perching for birds have shown some promise to reduce the pod damage caused by *H. armigera*.

The pod damage of 1.4 per cent to 14 per cent have been reported by several workers when endosulfan 0.07 per cent was sprayed (Sanap and Deshmukh, 1987; Panchabhavi and Kadan (1990); Pawar *et al*, 1990 and Ujagir *et al*, 1997).

The pod damage was observed to be 6.66 per cent when endosulfan 0.05% was sprayed after NPV 250 LE/ha on chickpea against *H. armigera* (Pawar *et al*, 1990).

In view of the above findings, the results on the pod damage of present study revealed that all the treatments reduced the pod damage when given seperately and contributed significantly to reduce the pod damage when given in combinations in IPM Plots.

5.8 EFFECT OF DIFFERENT PEST MANAGEMENT STRATEGIES ON THE GRAIN YIELD OF CHICKPEA:-

From the results (Table 10 and Fig.12) IPM was adjudged as the superior strategy among all the treatments, by recording the highest yield of 11.67 q ha^{-1}, which was about 57 per cent increase in yield over control, followed by endosulfan spray, which registered 41 per cent increase over control. Neem and HNPV sprays were found to be equally effective, which recorded about 29.67 and 29.90 per cent increase over control respectively. Plots with only bird perches also recorded 15.70 per cent increase in yield over control, mainly because of increased bird activity at ICRISAT. This 15.70 per cent yield increase over control may not be expected at farmer's fields only with bird perches, until unless such an appreciable bird activity is observed. But it can be used as one of the tools in IPM programme to increase the productivity.

Thakur *et al* (1988) reported 31 per cent yield increase when NSKE 5% was sprayed on chickpea against *H. armigera*. The yield increase of 14.00 to 47.00 per cent was recorded when HNPV 250 LE/ha was sprayed on chickpea (Pawar *et al*, 1990 and Mistry *et al*, 1984). Birds were found to exert appreciable control of *H. armigera*, resulting in an yield increase of 218 g/m^2 as agianst 120g/m^2 in control (ICAR, 1992).

Thakur *et al* (1988) reported 45 per cent yield increase in chickpea, when endosulfan 0.07 per cent was sprayed against *H. armigera*.

So the above results confirmed the findings of present study that all the treatments significantly increased the yield and contributed significantly to increase the yield in IPM plots also.

The yield obtained showed negative relationship with pod damage (r = -0.9228**) by *H. armigera* on chickpea. Rosaiah (1992) also reported similar relationship in cotton.

Based on the results obtained, it is inferred that as the pod damage increased there was a progressive decrease in yield. The regression analysis showed that pod damage contributed about 85 per cent with reference to yield (Fig.13).

5.9 ECONOMICS OF DIFFERENT TREATMENTS:-

The highest cost benefit ratio was obtained with IPM strategy (1:6.30), followed by endosulfan spray (1:6.10) (Table 11). Parsai *et al* (1989) reported the highest cost benefit ratio of 1:5.15 was obtained with endosulfan spray. Gupta *et al* (1991) observed that sequential spraying of 0.07 per cent endosulfan at the flowering followed by podding stage is most effective in terms of cost benefit ratio (1:12) although the sequential spray of all the three stages vegetative, flowering and podding stage has least pod damage and maximum number of pods, its cost benefit ratio was much lower (1:3).

Thakur *et al* (1988) also recorded the highest cost benefit ratio of 1:9.99 with endosulfan 0.07% spray and the cost benefit ratio of NSKE 5% spray was 1:7.69 and 1:3.93 with neemleaf 5% extract spray.

If the farmers use the neem products that are prepared in their backyard and HNPV spray, which are prepared from field collected larvae, the cost of treatment of neem and HNPV will be reduced substantially. But the productivity will not be much. So these botanical and bio pesticides should be used along with one chemical spray in addition to bird perches (IPM), to have maximum productivity and to obtain the highest cost benefit ratio.

5.10 SEASONAL INCIDENCE:-

A sound knowledge on the seasonal activity of the chickpea pod borer *Helicoverpa armigera* and the weather factors conducive for the build up of the pest helps to evolve suitable pest management strategies against this pest.

Maximum number of eggs were observed at 50 DAS which coincided with the flowering and pod initiation stage of the crop.

The larvae were observed in the field from 15 DAS to 99 DAS. Even though it attained three peaks at 29, 57 and 85 DAS, maximum population was observed at 57 DAS (first week of January) which coincided with pod initiation and grain development stage. The pest activity started in the second fortnight of November and continued till the end of February (Table 12 and Fig.14).

Monitoring *Helicoverpa armigera* in chickpea with sex pheromone trap

Thakur (1990) observed the infestation of *H. armigera* on chickpea from third week of October and first week of November up to the middle of March. He recorded the highest population in second week of December and the second peak in first and third week of January. The findings of the present studies were in conformity with the results of Thakur (1990).

5.11 MONITORING OF *Helicoverpa* ADULTS USING PHEROMONE TRAPS:-

The maximum moth catches in pheromone trap was observed during third, fourth and fifth standard weeks i.e., between 65 and 85 DAS (Table 12 and Fig.14).

Mahajan *et al* (1990) observed the maximum pheromone trap catches during third and fifth meteorological week. This study confirmed the present findings. Patel *et al* (1990) also observed the maximum pheromone trap catches in January at S.K.Nagar, which strengthen the present study. So the pest out break of *H. armigera* peak activity can be forecasted by using this pheromone traps as a monitoring device.

SUMMARY

CHAPTER VI

SUMMARY

A field experiment was conducted during post rainy season 1998-99 at International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh to assess the relative efficacy of a botanical pesticide neem (AZA) 0.006 per cent, a bio-control agent HNPV @ 250 LE/ha, erecting bird perches, a chemical insecticide endosulfan 0.07 per cent and the combinations of above said four treatments (IPM) against gram pod borer *Helicoverpa armigera* Hubner on chickpea.

In addition, the following other aspects were also studied:-

i) Evaluating the treatmental effects on the soil inhabiting natural enemies using pitfall trap.

ii) Evaluating the treatmental effects on the aerial natural enemies using DeVac trap.

iii) Evaluating the treatmental effects on the efficacy of *Campoletis chlorideae.*

iv) Monitoring of *Helicoverpa* adults using pheromone traps in the field.

v) Studying the seasonal incidence of gram pod borer *H. armigera.*

In the present studies all the treatments were found to be significantly superior to control in reducing the oviposition of *H. armigera*. The maximum reduction in egg laying was observed with neem followed by IPM (37.00 and 36.79 per cent reduction over control respectively).

IPM was adjudged as the best effective treatment in managing the small, medium and large sized larval population, followed by endosulfan. HNPV spray stood next in the

order of efficacy. Because of its antifeedant nature neem was also observed to be effective. Among all the treatments, erecting bird perches was found to be inferior, still it contributed effectively in managing the larval population. The same trend was observed in managing the total larval population with 36.60 per cent reduction in larval population over control in IPM plots, followed by endosulfan (33.20), HNPV (29.10), neem (25.40) and erecting bird perches (22.50).

Endosulfan reduced the soil inhabiting natural enemies population up to 39.95 per cent over control, followed by neem (8.19). All other treatments were observed to be on par with control. Endosulfan had profound effect on aerial natural enemy fauna to a tune of 45 per cent over control followed by neem (14.90). All other treatments were observed to be on par with control.

The results on parasitisation of *H. armigera* larvae by *Campoletis chlorideae* revealed that there was no significant difference among the treatments. So all the treatments are adjudged as safe to *Campoletis chlorideae*. The egg parasitisation was observed to be nil. The results on the pathogenicity by NPV on *H. armigera* showed that maximum percentage infection was observed in NPV sprayed treatment followed by in IPM since it received NPV as second spray. All other treatments were found to be on par with control (25.00 to 29.00 per cent).

The least per cent pod damage was obtained with IPM (9.37), followed by endosulfan 0.07 per cent (10.21), neem 0.006 per cent (10.98) and HNPV (11.55). Bird perches recorded the maximum per cent pod damage (13.45) as against 18.76 in control.

The maximum yield of 11.67 q ha^{-1} was obtained with IPM, followed by endosulfan (10.48 q ha^{-1}), HNPV (9.63 q ha^{-1}) and neem 0.006 per cent (9.61 q ha^{-1}). The plot with bird perches received 8.58 q ha^{-1} as against 7.41 q ha^{-1} in the control plots. The yield and pod damage were observed to be significantly negatively correlated (r= -0.9228**).

In terms of cost benefit ratio IPM was found to be the best treatment which recorded the highest cost benefit ratio of 1:6:3, followed by endosulfan (1:6.1), neem (1:5.5) and HNPV spray (1:4.8).

The investigations on the seasonal incidence of *H. armigera* on chickpea revealed that maximum number of eggs were laid in the last week of December i.e., at 50 DAS.

The larval population attained three peaks at 29, 57 and 85 days of crop age, even though maximum population was observed at 57 DAS (during first standard week), which coincided with pod formation stage.

The pheromone trap catches revealed that the maximum moth catches were observed between 65 and 85 DAS i.e., third fourth and fifth standard weeks.

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