Studies on gram pod borer, *Helicoverpa armigera* (Hub.) on Chickpea and its control with insecticides and biopesticides

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(ENTOMOLOGY)

By

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2013

CERTIFICATE - I

This is to certify that the thesis entitled ***"Studies on gram pod borer, Helicoverpa armigera (*****Hub.) on Chickpea and its control with insecticides and biopesticides*****"** *submitted in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURE (Entomology)*** *of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by* ***Miss Babita Kumari Chejara*** *under my guidance and supervision.The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.*

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been acknowledged by her.

(Dr. O.P. Veda)
Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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CERTIFICATE - II

*This is to certify that the thesis entitled "**Studies on gram pod borer, Helicoverpa armigera (Hub.) on chickpea and its control with insecticides and biopesticides**" submitted by **Miss Babita Kumari Chejara** to the J.N. Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** in the **Department of Entomology** has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination of the same.*

Place : Jabalpur

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Place : Jabalpur

Date : / / 2013. **(Babita Kumari Chejara)**

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Symbol	Abbreviation	Stand for
@		At the rate of
±		Plus or minus
%		Percentage
^0C		Degree centigrade
	CD	Critical difference
	cm	Centimeter
	ha	Hectare
	hrs	Hours
	SC	Suspension Concentrate
	Kg	Kilogram
	l	Litre
	mrl	Meter row length
	gm	Gram
	Max	Maximum
	Min	Minimum
	NS	Non significant
	RH	Relative humidity
	SEm ±	Standard error of mean
	SL	Soluble Concentrate
	SW	Standard week
	Temp	Temperature
	a.i.	Active ingradiant
	mg	Miligram
	SG	Water Soluble Granules
	EC	Emulsifiable Concentrated
	ppm	Parts Per Million
	mm	Millimeter

CHAPTER-I

INTRODUCTION

Chickpea (*Cicer arietinum* Linn., Leguminacae) is one of the most important *rabi* pulse crop of India, cultivated in 9.01 million hectare with an annual production of 7.58 million tonnes with productivity of 841 kg/ha.(FAOSTAT 2012). In Madhya Pradesh chickpea is cultivated in 3.04 million hectare with an annual production of 3.29 million tonnes and productivity of 1082 kg/ha.(FAOSTAT 2012). It has an important place in the diet of Indian people because it gives comparatively more protein, vitamins and minerals than any other food grains. It has 21.1% protein, 6.15% carbohydrate and 4.5% fat (Ahlawat and Omprakash, 1995). Production of chickpea in our country is low, one of the major reason is the losses caused by several pests and diseases, both in field and in storage. It is attacked by number of insect pest among them, the pod borer (*Helicoverpa armigera*) is the most serious insect pest in the most of the chickpea growing areas of the country (Begum *et. al*. 1992). It damages various plant parts at different stage of growth. Due to its polyphagous nature, it is also known as American cotton boll warm, corn ear worm, tomato fruit borer, tobacco bud worm, carnation worm etc. It has been recorded feeding on 181 cultivated and uncultivated plants species belonging to 45 families. It is an established serious pest of gram in all the state of Indian union. The attack of this pest starts from vegetative stage and continue up to crop maturity Singh and Yadav, (2006) & Sarwar *et al.*(2009-2011). In M.P., it infested mainly chickpea and linseed in *rabi* and pigeonpea, tomato and cotton in *kharif*. In chickpea on an average about 30-40% pods were found to be damaged by the pod borer resulting in the yield loss of 400 Kg/ha (Rahman, 1990) under favourable weather condition the damage to pods could increase upto 90-95% (Shengal and Ujagir, 1990; Sachan and Katti, 1994).

The early instar larva of gram caterpillar devours the chlorophyll from the leaves epidermis which resulted in netty whitish patches in leaves. In their later stage, they nibble the leaf sheaths leaving their mid ribs only. In case of heavy infestation only bare stem and branches are left on the plants. The last instar larvae make scratches on the green pod by feeding it green matter, while the later instar make a more or less circular hole in the pods and insert its head and former portion of body into it and feed upon the developing grains. The larvae also feed on the flowers resulting in less pod setting. A single larvae can infest the several pods and neatly, eats away the developing grains resulting in substantial yield loss. In this scenario, pod borer can be considered as the major constraint in chickpea cultivation.

Plant growth regulators are widely used for regulating plant architecture, biomass production, flower behaviour and control of flower and pod drop and enhancing yield potential of the crops. Hormones like auxins, gibberlins, ethylene, cytokinin and abscisic acid are required in proper proportion to combat imbalance in the hormonal content to arrest abscission process and shedding of reproductive organs. Among several growth hormones Napthelene acetic acid (NAA) and Traicontanol are known to reduce greatly the abscission of flowers and control the flower and pod drops and help in accumulation of higher dry matter besides increasing seed yield (Gali, 1995).

During the years of outbreak it may damage severely almost all major Rabi crops, i.e. gram, lentill, pea, lathyrus, linseed and even wheat. In such situations chemical control is the only way to manage the losses caused by this pest. In recent years use of conventional insecticides, such as Endosulfan, Monocrotophos, Quinalphos etc, failed to control the pest damage. The probable reasons for this may be, the development of resistance to conventional insecticides, possible immigration of *Helicoverpa armigera* biotype resistant to these insecticides from coastal area, commencing the control operation only at grown up larval stage, injudicious use of insecticides by the farmers etc.

To tackle such ticklish problems some newer insecticides having quick knock down effect, growth disrupting characters etc. should be recognized and used against such a dreaded pest in special circumstances.

Some of the newly introduced insecticides chosen for present investigations have already been studied in different parts of the country against the same pest, but because of variation in climatic conditions it was deemed necessary to study them at this location also to evaluate them for their comparative efficacy and to confirm the findings of other workers. In light of above facts, the present investigation will be conducted with the following objectives.

Objectives:

1. To study the population dynamics of *Helicoverpa armigera* (Hubner) on chickpea.
2. Effect of different insecticides with NAA and Urea in spray mixture on chickpea infesting *Helicoverpa armigera* (Hubner).

CHAPTER-II

REVIEW OF LITERATURE

Chickpea is mainly attacked by gram pod borer, *Helicoverpa armigera* (Hubner), which causes heavy loss in the yield. An attempt has made to review the available literature on population dynamics, per cent parasitization and efficacy of the different insecticides against *H. armigera* infesting chickpea. Brief account of the previous work is given under the following sub heads.

2.1 To study the population dynamics of *Helicoverpa armigera* (Hubner) on chickpea.

2.2 Effect of different insecticides with NAA and Urea in spray mixture on chickpea infesting *Helicoverpa armigera* (Hubner).

For, population dynamics

Prasad *et al.,* (1989) studied the population dynamics of *Heliothis armigera* (*Helicoverpa armigera*) on chickpea (*Cicer arientinum*).The larval population was fairly low during December, during this month the minimum daily temperature was a mean of 7.5% and the rate of parasitism by the ichneumonid *Campoletis chlorideae* was high (50-53.3%). The population of *H. armigera* was highest in the first week of March, when the chickpea crop was sown on 22 October, 1 or 21 November or 1 December. However, peaks of the pest also occurred on 25 January and 11 February on the crops sown on 12 October and 11 November, resp. These peaks occurred when the minimum daily temperature was between 10.4 and 14.4 degrees C, rainfall was 17, 30 and 12 mm during December, January and February, resp., and the rate of parasitism was below 20%.

Dubey *et al.,* (1993) studied the population dynamics of *Helicoverpa armigera* in Madhya Pradesh, India, over 2 years (1983-84 and 1984-85). The pest fed on various crops (chickpea, pigeonpea, pea, lentil and tomato in the cropping season). The pest showed peak activity in February and March during both years. Chickpea and pigeon pea were the most preferred hosts. Environmental factors (temperature, relative humidity and rainfall) had an impact on the development of the pest population. The larval parasitoid, *Campoletis chlorideae* reduced the larval population.

Ali and Kumar (2001) reported that *H. armigera* was found most active between 47th to 16th standard week on chickpea and attained peak density 5th to 11th standard week

Rao *et al*., (2001) studied on the seasonal incidence and host preference of *H. armigera* in bhendi, cotton, pigeon pea and chickpea. Larvae on each plant were counted at 7-day intervals from 1 November 1996 to 31 January 1997. The incidence of *H. armigera* on bhendi was recorded on the first week of November when the crop was 47 days old (20 larvae per 10 plants). The pest population was zero when the temperature was 25 degrees C during the last week of December through January. The peak population was observed on 128-day-old crop (25 larvae per 10 plants) during the third week of November through the second week of December. The incidence of pod borer on pigeon pea was observed at the flowering stage. Its incidence on chickpea was observed at the flowering stage 38 days after sowing (two larvae per 10 plants). The peak incidence was recorded on 87-day-old crop (20 larvae per 10 plants) in January.

Rao *et al*., (2002) reported that the influence of current and one week lag weather factors (maximum and minimum temperatures, rainfall, relative humidity and sunshine hours) on the head borer (*H. armigera*) incidence on sunflower crops. In the November-sown crop, the population increased gradually, reaching its peak of (1.7 larvae/plant) in the 1st week of January and then declined. In the December-sown crop, the population reached its peak of (1.9 larvae/plant) in the 3rd week of January and then subsequently declined. In the January-sown crop, a maximum of (1.8 larvae/plant) was recorded in the 1st week of March and then disappeared towards the end of the crop growth period. In the February-sown crop, the population peaked (1.4 larvae/plant) during the 4th week of March and disappeared after the 1st week of April.

Gupta *et al*., (2004) studied the population dynamics of *H. armigera* during 2001 and 2002 in Pantnagar, Uttar Pradesh, India, by deploying pheromones traps in the fields of chickpea and sunflower using sex pheromones in the ratio of 97:3 and 25:1 ((Z)-11-hexadecenal:(Z)-9-hexadecenal). The results showed relatively higher trap catches in 97:3 ratio and maximum moth catches in both the ratios during the first fortnight of April. The major infestation by *H. armigera* was recorded in March and April.

Singh *et al*., (2005) experiment was conducted on the incidence of *H. armigera* in chickpea (cv. GNG 469) sown in the first week of November during 1996-97, 1997-98 and 1998-99 at Sriganganagar, Rajasthan, India,. The larval population, initially observed at 15 days after sowing (0.2-0.8 larvae/m^2), increased gradually until the first week of December (3.00-3.40 larvae/m^2), then declined until the end of January. The population started to increase again from mid-February (1.0-1.8 larvae/m^2) until the second week of April (8.0-10.8 larvae/m^2), then declined abruptly. The first peak of larval population was recorded on the first week of December (3.26 larvae/m^2), whereas the second peak was registered on the second week of April (4.40 larvae/m^2).

Shah and Shahzad (2005) reported that the pest population was low during 49th to 6th standard weeks but increased from 7th standard week onwards and declined again during 14th standard week. A positive correlation existed between the eggs, larval instars and overall density of *H. armigera* and the average maximum and minimum temperatures. However, a negative correlation existed between the eggs, larval instars and overall density of *H. armigera* and the average morning relative humidity.

Chandel *et al*., (2005) studied on population dynamics of *Helicoverpa armigera* on chick pea *(Cicer arietinum*), pigeon pea (*Cajanus cajan)*, tomato (*Lycopersicum esculentum*), sunflower

(*Helianthus annus*) and okra (*Abelmoschus esculentus*). It was observed that, from October onwards, the pest infected chick pea and pigeon pea only and was not traceable on other host plants. After the harvest of chick pea in March, the pest was found infesting sunflower and lowest population in tomato in June. Later on, the pest migrated to okra. Among natural enemies, an Ichneumonid parasitoid, *Campoletis chloridae* was found to be parasitizing *H. armigera* larvae.

Jagtap *et al.,* (2008) studied on the population of *Earias vittella, Helicoverpa armigera, Agrotis ypsilon [A. ipsilon*], *Condica illecta* and *Pectinophora gossypiella* varied from 0.6 to 8.6, 0 to 3.2, 1.4 to 15.0, 7.0 to 15.8 and 0.8 to 4.0 larvae per quadrat on okra during summer 2005. Before noon relative humidity and number of rainy days had highest direct positive and negative influences on larval population of *H. armigera*.

Krishna Kant and Kanaujia (2008) reported that larval and pupal *Helicoverpa armigera* populations in chickpeas sown at different crop densities and determine the effect of weather factors on the population dynamics of the pest. The population dynamics of *H. armigera* on chickpea revealed higher populations of larvae and pupae during the first year compared to the second year. A higher crop density harbored larger populations than the low density crop. Larval population buildup in chickpea started during standard week 9 at the vegetative stage of the crop and reached its maximum during standard weeks 14 and 15. Thereafter, the larval population declined and disappeared after standard week 19. Pupal population could be observed from standard week 12 with highest population at the pod maturation stage, i.e. during standard weeks 14 and 16. Pod damage at crop maturation stage ranged between 17 and 45%.

Reddy *et al*., (2009) reported that the rainfall and larval population of *H*. *armigera* showed positive correlation coefficient (0.03) but it was not-significant. The wind velocity and the sunshine hours showed positive non significant correlation with larval population.

Yadav and Jat (2009) studied on the seasonal incidence of *Helicoverpa armigera* (Hubner) on chickpea and revealed that the infestation of *H. armigera* on chickpea started in the second fortnight of November and reached its peak in the end of February. The larval population of the pest occurred throughout the growth period of crop and was maximum at pod formation and grain developmental stages.

Chatar *et al*., (2010) investigated the population dynamics of chickpea pod borer, *Helicoverpa armigera* (Hubner) on chickpea revealed that the pest appeared from 2nd week of December and attained a peak of 3.12 larvae per plant during 2nd week of January. The pest was active during the last week of December to 3rd week of January. Later on, the pest population declined gradually towards the maturity of the crop.

Bajya *et al*., (2010) reported that the population dynamics of *Helicoverpa armigera* in chickpea .the larval population of *Helicoverpa armigera* stated during the third week of November. The highest population ((9.2 larvae/10 plants) was recorded during the second week of March and gradually decreased .The pest was active from November to March on this crop. In chickpea, minimum temperature, rain, vapour pressure and relative humidity in the morning and evening were positively correlated with the increase in *H. armigera* population..

For, parasitization (%)

Kaur *et al*., (2000) found that the larval parasitoid *Campoletis chlorideae* was the most important mortality factor for the larvae of *H. armigera* parasitism due to *C. chlorideae* ranged from 0.98 to 68.50% throughout the crop season. The maximum parasitism was recorded during the third week of February 1999 when the minimum mean temperatures and relative humidity were 11.9 ^{o}C and 95%, respectively.

Devi *et al*., (2003) studied the incidence of the pest began from February and continued till May. They found 5 parasitoids were found associated with *H. armigera* and among the parasitoids, *Campoletis chlorideae* was recorded as the most important natural enemy of this pest. The percentage of parasitism ranged from 0.18 to 23.81% from March to May. The maximum incidences of the parasitoids were recorded during the first and second week of April 1998-2000.

Gupta and Desh (2003) conducted experiment of *H. armigera* larvae on chickpea were parasitized by *Campoletis chlorideae* at Palampur, Himachal Pradesh, India, during two consecutive years (1997-98 and 1998-99). The extent of parasitism by *C. chlorideae* ranged from 8.33 to 28.00 per cent. The parasitoid remained active from the second week of April to the first week of May.

Rai *et al.,* (2003) studied the extent of natural larval parasitization by *C. chlorideae* on *H. armigera* varied from 5 to 41 per cent during 1999-2000 and 3 to 40 per cent during 2000-2001 on a standard week basis. Parasitization recorded during 1999-2000 was 33, 37.3, and 9 per cent during February, March and April, respectively. During 2000-2001 it was 36 and 5 per cent in March and April, respectively.

Kaur *et al.*, (2004) studied the natural parasitism of *H. armigera* by *C. chlorideae* on chickpea cultivars at different locations in India during 2002-03. The parasitoid population varied from 0.02-1.50 cocoons per metre row length and the larval population ranged between 0.86 and 14.50 larvae per metre row length. The highest number of cocoons were recorded on PBG 5 (0.88) followed by L 550 (0.74). The *H. armigera* population was also high on PBG 5 (9.38 larvae/m row length) followed by L 550 (6.75 larvae/m row length).

Pandey *et al*., (2005) conducted and concluded that experiment on chickpea (*Cicer arietinum* cv. K-850) sowing of gram after 20th October, reduced the grain yield as the infestation increased rapidly due to decreased parasitic activity by *Campoletis chlorideae.* Crops harvested in 3rd week of February escaped infestation caused by larva because of highest parasitic activity of *Campoletis chlorideae* (80.5%) but in crop harvested in first week of April infestation increased rapidly due to sudden decrease the activity of *Campoletis chlorideae* (40.3%).

Singh and Ali (2006) studied on seasonal activity of the gram pod borer, *Helicoverpa armigera,* and its parasitoid, *Campoletis chlorideae,* on chickpea cv. K-850, using pheromone traps, during rabi 2000/01 and 2001/02. The larval activity of *H. armigera* continued throughout the crop season with two peaks in both years, first from 45 to 49 standard weeks and the second from 5th to 13th standard weeks. The Maximum parasitization by *C. chlorideae* was observed in 4th standard weeks. Parasitization declined from 44th to 50th standard weeks.

Pandey and Kumar (2006) conducted the field expriment in *rabi* season of 2004-2005 and concluded that *Campoletis chlorideae* parasitoid preferred the late instar or early 2nd instar host larvae for parasitization, and pupated outside the host in the form of cocoon within a week. A survey conducted in the chickpea fields during 15 November to 5 December 2005 revealed that the parasitism ranged from 25.0 to 59.2%. *C. chloridae* has proved to be a potent parasitoid in chickpea ecosystem and has a great significance in biological control of *H. armigera* on chickpea.

Singh and Battu (2006) studied on some (377) *Helicoverpa armigera* larvae collected from January 1998 to May 1999, on chickpea, Egyptian clover, sunflower and tomato crops, in and around Ludhiana District, Punjab state, India, were analyzed symptomatically (retarded growth, decreased feeding, tendency to remain at the bottom of the rearing containers and sluggishness) for detecting any incipient parasitization during laboratory rearing. *Campoletis chlorideae* was the only parasitoid detected, causing 20.9+or-2.9, 24.9+or-1.8, 20.0 and 25.9% natural mortality of *H. armigera* larvae from chickpea, Egyptian clover, sunflower and tomato crops, respectively.

Bohria and Shukla (2006) conducted a field surveys in chickpea crop to record the parasitization of *Helicoverpa armigera* larvae by *Campoletis chlorideae*. They reported the peak parasitization (19%) in the second week of January.

Sharma *et al.,* (2008) reported that the incidence of *H. armigera* larvae was first observed on chickpea in the 2nd week of December (50th SW) *i.e*. at vegetative stage of crop. The activity of the pest continued till 10th SW. (March 2007) *i.e.* maturity of the crop, achieving only one peak (7.75 larvae m row length). The larval population exhibited significant correlation with rainy days only. Two parasites *C. chlorideae* (Uchida Hymenoptera) ichnumonidae and *Carcelia sp*. (Diptera Tachnidae) were found to parasitized the *H. armigera* larvae from vegetative to pod initiation stage. *H. armigera* larval parasitization by *C. chloridae* ranges from 3.69 to 14.83%,maximum parasitization was observed during 4th SW *i.e.* vegetative stage.

Bisane *et al*., (2008) studied the parasitization of *Helicoverpa armigera* (Hubner) larvae and pupae during 2004-05 and 2005-06 from field collected life stages on pigeonpea. The other ichneumonid, *Campletis chlorideae* was observed to be active in December (16.67 per cent). Parasitism by a Braconid, *Bracon sp.*, noticed from 45th to 47th SMW and 50th SMW, was up to an extent of 7.89 per cent. on pigeonpea, these parasitoids contributed to approximately two-third of the total mortality of early instar *H. armigera* larvae.

Pandey *et al*., (2009) reported that *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae), commonly called gram pod borer, is a serious pest of pulse crops in India and damages chickpea (*Cicer arietinum* L) on average a 30%. One of the potential natural enemies reported for its biological control is *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae).

Pandey and Ujagir (2009) conducted the field experiment to determine the effect of coriander, linseed and barley as intercrop in chickpea on the larval parasitoid, *Campoletis chloridae* (Uchida) of *Helicoverpa armigera* (Hubner) in chickpea at Pantnagar during *rabi* 2003-04 and 2004-05. at the flowering and early pod stage of the crop, there was higher parasitization by *C. chloridae* compared with crop reaching maturity. During 2003-04, mean larval parasitization ranged from maximum of 30.16 per cent in chickpea+coriander (4:1) to minimum of 15.73 per cent in chickpea+barley (6:1) compared with 15.98 per cent in chickpea sole crop.

Sujata *et al*., (2010) studied on natural mortality of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) due to different natural enemies on chickpea (*Cicer arietinum* L.) in India during the period of 1st fortnight of January to 1st fortnightly of April, 2007. *H. armigera* larvae were collected from insecticide-free chickpea fields at fortnightly interval. Living and dead larvae showing characteristic disease symptoms were transported aseptically to the laboratory and healthy larvae were reared on the chickpea pod and twigs. The highest parasitism was recorded during 1st fortnight of January to 1st fortnight of February due to low temperature. It can be concluded that among different natural enemies, parasitoids are the most promising naturally occurring biocontrol agents of *H. armigera* in Punjab.

Agnihotri *et al*., (2011) studied on seasonal incidence of *Campoletis chloridae* Uchida, a larval parasitoid of *Helicoverpa armigera* (Hubner), in chickpea crop. The parasitoid made its first appearance during 3rd standard metereological week (SMW) of the year in both the cropping seasons with parasitization of 78.57 and 80.00 per cent larval population respectively. The peak period of activity of *C. chloridae* in both the years (2008-09 and 2009-10) was during 6th standard week parasitizing 89.56 and 90.93 per cent larval population of *H. armigera*, in both the cropping season respectively.

For, chemical effects

Gupta *et al.,* (1991) used endosulfan 0.07% to control *Helicoverpa armigera* on chickpea in the winter season of 1988-90 at Kolipura, Madhya Pradesh, India. Crop was sprayed at the vegetative and /or flowering and/ or pod stages such that 7 different spraying schedules were followed. Result indicated that sequential spraying at the flowering followed by pod stage was most effecting in- terms of cost- benefit ratio (12.1); although sequential spraying of all 3 stage had least pod damage and maximum number of pods, its cost- benefit ratio was much lower (9.3).

Shrivastava *et al.*, (2001) conducted field experiment to study the effect of plant growth regulators (PGRs; triacontanol, microcil, cycocel, grocel, triacontanol, hico-emulsion, miraculan, ergostim, spic cytozyme, phytofix (NAA), tone up) on chickpea cv. JG 315. Foliar application of 250 ml triacontanol (Vipul)/ha at 30, 40 and 50 days after sowing (DAS) produced the highest growth and yield components with 25.8% increase in grain yield compared to the control. Treatment with tricontanol (Vipul) also recorded the highest total N (190.86 kg/ha), P (17.40 kg/ha) and K (72.38 kg/ha) uptake. The second best PGR was N-triacontanol (Grocel) followed by triacontanol (TATA) or NAA.

Dudhade *et al.,* (2003) studied on basal dose vs. no application of such basal dose comprised the 2 treatments of soil application. Six treatments of foliar application of fertilizer were superimposed on the treatments of soil application, i.e. absolute control, water spray, urea at 2% and 3%, diammonium phosphate (DAP) at 2% and KCl at 2%. The first and second foliar sprays, respectively, were given on the 30^{th} and 40^{th} days after sowing. The crop without fertilizer produced grain yield of 771 kg/ha, whereas the crop that received soil application of fertilizer gave grain yield of 1085 kg/ha. Among the foliar sprays, urea at 2% and 3% were equally effective treatments, recording 1062 kg grain yield/ha. The untreated crop gave 698 kg grain yield/ha, which was at par with the yield from water spray treatment.

Reddy *et al*., (2004) studied on the effects of foliarspray (at 50% flowering and podding stages) on seedling vigour, growth, yield and yield components of black gram cultivars LBG 645 and LBG 709 in a rice fallow ecosystem. The treatments comprised: 2.5 ppm GA3 (T1); 5.0 ppm GA3 (T2); 10 ppm NAA (T3); 15 ppm NAA (T4); 1% KNO3 (T5); 2% urea (T6); water soaking (T7); and the control (T8). T3 gave the maximum mean plant height (44.67 cm) while T4 gave the earliest days to 50% flowering (56.00). The highest mean early seedling vigour (4.88), leaf area index (3.35), dry matter (347.75 g/m^2), number of pods per plant (40.03), number of seeds per pod (6.75), 100-seed weight (5.93 g), seed yield (12.22 q/ha) and harvest index (35.15), and the lowest weed count per m^2 was obtained with T5.

Kumar *et al.,* (2005) investigated the nutrient management strategies and infestation of *H. armigera* on chickpea cv. PBG-1. The treatments done in 1998-99 were farmyard manure (FYM) at 0 and 8 t/ha; and lime (calcium oxide) at 0, 2, 4 and 5 t/ha. The treatments done in 2001-02 included: urea at 2% and 3% spray, diammonium phosphate at 2% and muriate of potash at 2%. Chickpea did not show any positive response to foliar spraying of fertilizers. FYM and diammonium phosphate increased pod damage by the pest, while PSB and lime had no effect. Potassium spraying at 2% reduced pest population and damage, while urea at 2% and 3%, and diammonium phosphate at 2% increased pod damage.

Murray *et al.,* (2005) studied on the insecticide resistance in *Helicoverpa armigera* has led to the reduced efficacy of some older insecticide groups (pyrethroids and carbamates) and serious crop losses. Eight small-plot experiments were conducted in the Darling Downs, southeastern Queensland, Australia, to evaluate new insecticides for the management of *H. armigera* in grain crops (chickpea, soyabean, mung bean and faba bean). The insecticides tested were indoxacarb (Steward), methoxyfenozide (Prodigy), pyridalyl (Symphony), spinosad (Tracer), petroleum oil (D-C-Tron Plus) and thiodicarb (Larvin) or methomyl (Lannate) (standard). Several products showed efficacy equivalent to or better than the commercial standard thiodicarb. Indoxacarb and spinosad at rates 50% or less of the registered rates for cotton were consistently superior to other tested products across the range of crops treated and provided residual protection for up to 14 days.

Rahman *et al*., (2006) tested the efficacy of Steward 150 EC (indoxacarb), Proclaim 19 EC (emamectin benzoate), Proclaim 5 SG (emamectin benzoate), Ripcord 10 EC (cypermethrin), Tracer 240 SC (spinosad) and Match 50 EC (lufenuron) against gram pod borer

(*H. armigera*) on chickpea (cv. CMN-257) was evaluated in Tarnab, Peshawar, Pakistan, during 2004. at 3, 7 and 10 days after treatment, all the insecticides were significantly effective in reducing the pest population compared to the untreated control. Steward 150 EC was the most effective, resulting in the lowest number of larvae (0.33) and highest larval mortality (97.38%), closely followed by Proclaim 19 EC, Proclaim 5 SG and Match 50 EC (96.51, 96.51 and 93.89% larval mortality, respectively).

Yadav and Bharud (2006) evaluated the response of kabuli chickpea to foliar applications of gibberellic acid (10 ppm), naphthalene acetic acid (20 ppm), cycocel [chlormequat] (25 ppm), benzyladenine (25 ppm), Bioforce (2 ml/litre) and Biopower (2 ml/litre), given at 10-day intervals starting from the initiation of flowering. Observations were recorded for plant height, number of primary and secondary branches per plant, chlorophyll a and b, total chlorophyll content, seed protein content, number of pods per plant, seeds per plant, 100-grain weight, grain yield per plant, grain yield per hectare and harvest index. All treatments were significantly superior to both water spray and absolute controls. However, Bioforce and Biopower recorded the highest values for the growth, yield and quality characters studied.

Bhowmick (2006) studied on the effect of basal and foliar application of nutrients on the growth and yield of rainfed chickpea cv. Mahamaya-I (B-108). The results revealed that foliar spray of eitherurea or diammonium phosphate (DAP) 2% solution twice at flower initiation and 10 days thereafter remarkably increased sprays were 30.23 and 19.48%, respectively, compared with absolute control (no spray) the crop growth and yield. The yield increases due to urea and DAP

Bahr (2007) conducted the field experiment during the winter of 2004-05 and 2005-06 in Al Nagah village, South Al Tahrir province, Al Beheira Governorate, Egypt, to study the effect of low (26 plants/m^2, recommended) and high (50 plants/m^2) plant densities, and urea foliar treatments (unsprayed control, and 1.0% urea sprayed at the flowering stage, pod set stage or pod filling stage) on the performance of chickpea (cv. Giza- 531).The foliar application of 1.0% urea at the pod filling stage recorded the highest values for yield and all yield attributes. The interaction between high plant density and foliar application of 1.0% urea at the pod filling stage was optimum for all characters.

Tripathi *et al.,* (2007) studied the effects of TIBA (20 ppm), Alar [daminozide] (1000 ppm), Miraculan [triacontanol] (5 ppm), IAA (50 ppm), GA [gibberellic acid] (50 ppm), cytokinin (5 ppm), naphthoxyacetic acid [2-naphthoxyacetic acid] (NOA; 50 ppm), Planofix [NAA] (50 ppm), Mixtalol [triacontanol] (10 ppm) and CCC [chlormequat] (4000 ppm) on the incidence of flower drop and yield of chickpea (cv. Avrodhi) were studied in Kanpur, Uttar Pradesh, India. During the winter of 1995-96 and 1996-97, TIBA resulted in the highest number of flowers per plant (248.00 and 258.50, respectively), percentage of pod set per plant (50.64 and 52.41%), number of pods per plant (125.50 and 135.50), number of seeds per pod (2.11 and 2.51), 1000-seed weight (204.10 and 207.10), seed yield (2767.8 and 2840.6 kg/ha), and productivity (18.37 and 18.74 grains day-1 ha-1). The number of flowers shed per plant was lowest for Planofix (94.00 and 94.50)

Ameta and Bunker (2007) conducted the field experiments on relative efficacy of flubendiamide (24, 36 and 48 g a.i.\ha) along with indoxacarb (75 g a.i\ha) and spinosad (75 g a.i l\ha) against *Helicoverpa armigera* (Hubner) in tomato during 2005-06 and 2006-07, revealed that all the three insecticides were significantly superior to untreated control in reducing *H. armigera* infestation in tomato. However, Flubendiamide at 48 g a.i.\ha caused significantly higher reduction in the population of fruit borer larvae and recorded the lowest fruit damage than the remaining treatments during both the years of experimentation. The marketable yield recorded in flubendiamide @ 48g a.i\ha was also significantly higher than that recorded in other treatments. The insecticidal treatments did not cause adverse effect on the population of natural enemies and phytotoxicity to tomato crop.

Kumar and Kumar (2008) studied on the effect of different management practices on the growth and yield of rainfed chickpea. In 1st experiment recommended dose of fertilizer produced significantly higher grain yield of chickpea. Among the different nutrient sources used as foliar nutrition, 2% and 3% urea at pre-flowering stage and its repetition at 10 days after 1st spray was found superior to other nutrient sources. Evaluation of stages of foliar nutrition in chickpea revealed that 2% urea spray at flower initiation + 10 days produced higher grain yield as compared to its spray at other stages in rainfed condition.

Choudhary *et al*., (2008) conducted the field experiments during the 2006-07 *rabi* season in Chhindwara, Madhya Pradesh, India, to study the bioefficacy of different insecticides against *Helicoverpa armigera* infesting chickpeas (cv. JG-315). The treatments comprised: 0.5 ml indoxacarb/litre; 2.0 ml quinalphos/litre; 0.5 ml cypermethrin/litre; 2.0 ml chlorpyrifos/litre; 2.0 ml endosulfan/litre;1.5 g cartap hydrochloride/litre; 0.7 g acephate/litre; water spray. Indoxacarb gave the highest percentage of reduction on pod and seed damage followed by cypermethrin while the lowest was observed from quinalphos-treated plants.

Rao *et al*., (2008) studied on the American bollworm, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae), is the most destructive pest of cotton. The status of new insecticides vis-a-vis conventional insecticides in Kurnool population of *H. amigera* was estimated. The LC_{50} (expressed in micro g per larva) values of emamectin benzoate, indoxacarb, spinosad, profenophos, methomyl, quinalphos, endosulfan, deltamethrin, acephate, thiodicarb, chlorpyriphos, triazophos, monocrotophos, fenvalrate and cypermethrin were 0.0061, 0.22, 0.11, 0.38, 0.45, 0.53, 0.81, 1.07, 1.09, 1.86, 1.86, 1.86, 3.25, 4.16, and 8.70 respectively. Of all the insecticides tested emamectin benzoate is the most toxic and cypermethrin was the least toxic.

Parmar and Borad (2009) studied the efficacy and economics of insecticides endosulfan 35 EC, indoxacarb 14.5 SC, chlorpyriphos 20 EC, ethofenprox 10 EC, profenophos 50 EC, emamectin 5 WG, diafenthiuron 50 WP, quinalphos 25 EC, cypermethrin 10 EC and fenvalerate 20 EC at Anand Agricultural University, Anand (Gujarat) during *kharif* 2004 and 2005, against *Helicoverpa armigera* (Hubner) Hardwick infesting okra. Among the tested insecticides, indoxacarb 14.5 SC (0.0075%), emamectin 5 WG (0.001%) and diafenthiuron 75 WP (0.05%) performed better to protect the okra fruits from *H. armigera*.

Kumar *et al*., (2009) studied the IPM for pod borer management in the fields of Nimbur and Malchapur villages of Bidar district, Karnataka, India. The IPM package included (1) autumn ploughing during summer to expose the pupae to hot sun and natural enemies, (2) mixing of sorghum seeds (250 g/ha) as live bird perches, (3) installation of pheromone traps at 5/ha, (4) spraying of ovicide Profenophos 50 EC at 2000 ml/ha, (5) spraying of botanical insecticide (neem at 1500 ppm) at 2000 ml/ha, (6) spraying of bioagent (HaNPV at 250 LE/ha), and (7) spraying of effective molecule (Indoxacarb 14.5 SC at 300 ml/ha). The number of pods damaged by the *H. armigera* in IPM fields was less compared to non-IPM fields in both the villages. The pod damage in IPM fields was 8.49 and 7.81% compared to 12.12 and 12.23% in non-IPM fields at Nimbur and Malchapur, respectively. The average seed yield of 18.03 and 18.81 q/ha was recorded in IPM fields and 16.91 and 17.05 q/ha was recorded in non-IPM fields, respectively, at Nimbur and Malchapur villages.

Ghodki *et al*., (2009) studied the determination of Indoxacarb efficacy using a log-dose probit (LDP) bioassay against third instars collected from cotton (*Gossypium arborium*) fields near Akola, India. Monthly levels of toxicity of Indoxacarb were determined from July 2005 to March 2007. The maximum tolerance level of Indoxacarb was reported for the Amaravati strain (5.09 p.p.m.) and the minimum tolerance level for the Fatehbad strain (0.22 p.p.m.). Seasonal monitoring of Indoxacarb toxicity revealed an increased trend in tolerance from July 2005 to February 2006, which decreased from March 2006. The LC50 of Indoxacarb was 2.71 p.p.m. in July 2005 and 17.14 p.p.m. in February 2006. During 2006-2007, the LC50 was 3.84 p.p.m. at the start of the season and in March 2007 it was 13.51 p.p.m. The minimum LC50 of Indoxacarb was reported for *H. armigera* larvae fed on *Legasca spp.* (1.62 p.p.m.) and the maximum LC50 was reported for *H. armigera* reared on chickpea (*Cicer arietium*) (8.45 p.p.m.).

Dodia *et al.*, (2009) reported that efficacy of 5 insecticides (spinosad 45% SC at 56 and 73 g, emamectin benzoate 5 WSG at 8, 9.5 and 11 g, flubendiamide 20 WDG at 50 g, bifenthrin 10 EC at 80 g,indoxacarb 14.5 SC at 50 g/ha) against *H. armigera* infesting pigeon pea in Sardarkrushinagar, Gujarat, India, during kharif 2004-05 to 2006-07. All the treatments were significantly superior over the untreated control year-wise as well as in pooled analysis. Flubendiamide was the most effective with 5.98% damage by the pest, which was at par with emamectin benzoateat 11 g/ha (6.35%) and spinosad at 73 g/ha (7.35%). The maximum grain yield was recorded with emamectin benzoate at 11 g/ha (1761 kg/ha) followed by spinosad at 73 g/ha (1717 kg/ha), indoxacarb at 50 g/ha (1598 kg/ha) and bifenthrin at 80 g/ha (1573 kg/ha). The maximum monitory return was gained in indoxacarb (ICBR=1:6.88) followed by bifenthrin (ICBR=1:5.94), flubendiamide (ICBR=1:4.56), spinosad at 73 g/ha (ICBR=1:3.61) and emamectin benzoate at 11 g/ha (ICBR=1:3.41).

Yadav and Bharud (2009) reported that the effects of plant growth regulators (GA3, NAA, CCC [chlormequat], benzyladenine and Bioforce) on the performance of kabuli chickpea (cv. Virat) in Maharashtra, India, during the *rabi* of 2001. The foliar application of growth regulators increased the seed yield and yield components. However, the foliar application of Bioforce at 2.0 ml litre-1 was the most effective in increasing the yield (by 24%) over the control (water), followed by Biopower (19.00%). The foliar application of Bioforce also increased the yield components, *i.e.* number of seeds per plant, number of pods per plant, and 100-grain weight over the control.

Kumar and Shivaraju (2009) evaluated the newer insecticide molecules against pod borers of black gram (*Helicoverpa armigera* (Hubner) and *Etiella zinckenella* Treit), larvin 75 WP @ 468.75 g a.i./ha, larvin 75 WP @ 562.5 g a.i/ha, flubendiamide 480 SC @ 36 g a.i./ha and flubendiamide 480 SC @ 48 g a.i./ha were superior in recording less larval populations of both the pod borers, followed by indoxacarb 14.5 SC @ 75 g a.i./ha. Further, flubendiamide 480 SC @ 48 g a.i./ha (6.04%), larvin 75 WP @ 562.5 g a.i./ha (6.47%), flubendiamide 480 SC @ 36 g a.i./ha (7.62%) and larvin 75 WP @ 468.75 g a.i./ha (8.25%) were superior by recording less pod damage by *H. armigera* and were on par; but differed significantly with rest of the treatments. The total yield was higher in larvin 75 WP @ 562.5 g a.i./ha (11.27 q/ha) followed by larvin 75 WP @ 468.5 g a.i./ha (10.12 q/ha), flubendiamide 480 SC @ 48 g a.i./ha (9.28 q/ha), flubendiamide 480 SC @ 36 g a.i./ha (9.07 q/ha), indoxacarb (8.14 q/ha) chlorpyriphos (7.23 q/ha), quinalphos (7.10 q/ha), spinosad (6.93 q/ha) and endosulfan (6.86 q/ha).

Chowdary *et al.,* (2010) Studied on the susceptibility of third instar larvae of okra fruit borer *Helicoverpa armigera* (Hubner) to rynaxypyr 20 SC was determined by topical bioassay technique using potter's tower under laboratory conditions at University of Agricultural Sciences, Raichur during 2009-2010. The results revealed that, susceptibility of *H. armigera* increased after five generations in insecticide free exposure culturing, the susceptibility index for LC_{50} was 0.66.

Prasad *et al*., (2010) conducted the field experiments at Regional Agricultural Research station, Lam, Guntur to evaluate the efficacy of chlorantraniliprole at different doses along with standard insecticides against *H. armigera* on cotton for two consecutive seasons. The mean data over two years revealed that chlorantraniliprole @ 40 g a.i/ha and spinosad @75 g a.i/ha recorded lowest square damage inflicted by *H. armigera*. Chlorantraniliprole @ 40 g a.i/ha and 30 g a.i/ha, spinosad and indoxacarb exhibited similar efficacy in reducing bolt damage. Among the insecticide treatments all the insecticidal treatments led to higher yields. The yield data was at par with each other except lower dose of chlorantraniliprole @ 10 g a.i/ha. The results conclude that chlorantraniliprole @ 30 g ai/ha as optimum dose for the effective control of *H. armigera* on cotton.

Shinde *et al*., (2010) tested the six insecticides for their persistence and residual toxicity against first instar larvae of *H. armigera* on okra fruits. The order of residual efficacy of different insecticides against first instar larvae of *H. armigera* on fruits based on LT_{50} and PT values was spinosad 0.005 per cent (12.44 days and 1146.46) followed by indoxacarb 0.01 per cent (12.22 days and 1138.2), profenofos 0.08 per cent (11.42 days and 1082.2) and imidacloprid 0.004 per cent (9.74 days 1016.9). The spinosad was found to be most effective insecticide against *H. armigera.*

Deshmukh *et al.,* (2010) determined the efficacy of different insecticides against *Helicoverpa armigera* (Hubner) infesting chickpea at Junagadh Agricultural University campus, Junagadh during *rabi* season of 2008-09. The results revealed that flubendiamide 0.007 per cent, indoxacarb 0.0075 per cent, spinosad 0.009 per cent and emamectin benzoate 0.0015 per cent were found the most effective in reducing the *H.armigera* population and pod damage of chickpea. The highest yield was also recorded in the treatment of flubendiamide 0.007 per cent (1850 kg/ha) followed by indoxacarb 0.0075 per cent (1805 kg/ha), spinosad 0.009 per cent (1760 kg/ha) and emamectin benzoate 0.0015 per cent (1665 kg/ha). The highest cost benefit ratio was obtained in the treatment of indoxacarb 0.0075 per cent (1:7.08), followed by flubendiamide 0.007 per cent (1:6.10) and spinosad 0.009 per cent (1:5.24).

Aslam *et al*., (2010) reported that the response of chickpea (*Cicer arietinum* L.) to Phytofix - plant growth regulator (GR - naphthalene acetic acid 4.5% a.i.) and four available soil moisture depletion levels i.e. ASMDL1 (50%), ASMDL2 (65%), ASMDL3 (80%) and ASMDL4 (95%) were studied in split plot arrangements. Main plot consisted of plant growth regulator (GR1) with a Control (GR0) whereas available soil moisture depletion levels (ASMDL) were kept in sub-plots. Chickpea yield and yield components were significantly affected by NAA and ASMDL. Plant growth regulator (Naphthalene acetic acid 4.5% a.i.) applied at 200 ml per hectare in three split doses at 45, 90 and 135 days after sowing (DAS) increased number of pods per plant, seeds per pod, 100 seed weight, biological yield and seed yield by 12.50, 6.98, 9.59, 2.61 and 13.98%, respectively over control. Crop growth rate was maximum in GR1 x ASMDL3. It was concluded that plant growth regulator (NAA) with 80% Available soil moisture depletion level may be better to achieve higher seed yield and yield components in chickpea.

Anandhi *et al.,* (2011) conducted field trail in Uttar Pradesh, India, in 2008-09, to determine the efficacy of different chemical and botanical insecticides (emamectin benzoate, spinosad, indoxacarb and quinalphos and pongamia, neem seed kernel and garlic extracts) against *Helicoverpa armigera* on chickpea cv. Udai. Two sprays of each insecticide were given at the time of occurrence of *H. armigera* larval incidence at 15-day intervals. The numbers of *H. armigera* larvae were counted on 5 randomly selected plants in each plot. The pre-treatment count was made a day before the first and second sprays, whereas the post-treatment counts were made on third and fifth days after each spray. Results showed that the population reduction after spraying in all treatments were superior compared to the control. Among the treatments, indoxacarb recorded the highest reduction of pod borer population in first and second spray, followed by spinosad. A cost benefit ratio was recorded in indoxacarb and proved to be effective among the treatments.

Mahendra *et al.,* (2011) evaluated seven different treatments along with untreated check and the efficacy of new insecticides against *H.armigera*. Among them spinosad (0.006%) and indoxacarb (0.007%) were proved to be effective, which were followed by emamectin benzoates (0.001%), flubendiamide (0.004%) and novaluron (0.0075%) in reducing the larval population as compared to endosulfan (0.07%) and untreated check

Sahoo *et al.,* (2011) determined the disappearance trends of flubendiamide residues on chickpea under field conditions and thereby, ensure consumer safety. Average initial deposits of flubendiamide on chickpea pods were found to be 0.68 and 1.17 mg kg[1], respectively, following three applications of flubendiamide 480SC @ 48 and 96 g a.i. ha^{-1} at 7 d intervals. Half-life of flubendiamide on chickpea pods was observed to be 1.39 and 1.44 d, respectively, at single and double dosages whereas with respect to chickpea leaves, these values were found to be 0.77 and 0.86 d.

Singh and Kumar (2012) conducted the field experiment during *rabi* season on various IPM modules evaluated on cv. 'JG-315' of Chick pea. Module M_5 (pheromone traps @ 20/ha, bird perch @ 40/ha, chlorantriniliprole @ 0.15 lit/ha & water spray) followed by M_4 (pheromone traps @ 20/ha, bird perch @ 40/ha, emamectine benzoate 5 SG @ 0.15 kg/ha and *Ha*NPV@400 LE/ha+Teepol+sugar) and M_3(pheromone traps @ 20/ha, bird perch @ 40/ha, flubendiamide 39.35 SC 0.08 lit/ha and*Ha*NPV@400 LE/ha+Teepol+sugar) were found effective to reducing the population of *H. armigera*. The highest yield (1592 kg/ha in 2009 & 1607 kg/ha in 2010) was obtained from M_5 followed by M_4 (1545 kg/ha in 2009 & 1558 kg/ha in 2010) in comparison to control and other modules including farmer's practice. The highest B:C ratio were obtained from M_5(1:3.47) followed by M_3 (1:3.35), M_4 (1:3.18), M_1 (1:2.52), M_2 (1:2.28) and M_6-farmer practice (1:1.89) and the trend was almost similar in the succeeding year.

Kambrekar *et al*., (2012) studied on bio-efficacy of Emamectin benzoate 5% SG and Indoxacarb 14.5 SC on pod borer, *Helicoverpa armigera*. Application of Emamectin benzoate 5% SG @ 13 g a.i/ha resulted in maximum larval reduction, lesser pod damage and higher grain yield of chickpea which was followed by the same insecticide @ 11 g a.i/ha without any adverse effects of different dosages on the three natural enemies and no phytotoxic effects on chickpea crop. Further, Indoxacarb 14.5% SC @ 75 g a.i/ha has recorded maximum larval reduction, lesser pod damage and higher grain yield of chickpea which is followed by Indoxacarb 14.5% SC @ 50 g a.i/ha.

CHAPTER-III

MATERIAL~~S~~ AND METHODS

This chapter includes details of the material used and methodology followed during the course of present investigations. In accordance with the objectives, the studies were divided into two sections as detailed below.

1) To study the population dynamics of *Helicoverpa armigera* (Hubner) on- chickpea.
2) Effect of different insecticides with NAA and Urea in spray mixture on chickpea infesting *Helicoverpa armigera* (Hubner).

3.1 Location

The present investigation entitled, "Study the effect of different insecticides with plant growth regulators on *Helicoverpa armigera* (Hubner) in chickpea." was carried out in the experimental field of Department of plant breeding, livestock Farm, Adhartal, JNKVV, Jabalpur (M.P.) during *rabi* 2012-13.

3.2 Climatic condition

Jabalpur is situated between $22^0$49' and $24^0$8' North latitude and $78^0$2' and $80^0$58' East longitude, at an altitude of 411.78 m above the mean sea level. The climate of the region is typically semi-humid and sub tropical. Jabalpur comes under the agro climatic region of kymore plateau and Satpura hill and lies in rice-wheat crop zone of the state. The mean annual rainfall is nearly 1423 mm which is received mostly between mid-June and Mid-September. The mean of maximum and minimum temperature ranges from 45.5^0C and 7.3^0C, respectively.

3.3 Climatic condition during the crop season

The weather condition during the course of studies from December, 2012 to April, 2013 is presented in table 1.

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Table: - 1 Weekly meteorological data of Jabalpur (MP) during *rabi* season 2012-2013

S.W.	Temp. (^{0}c)		Sun Shine (Hr.)	Rainfall (mm)	Relative humidity (%)		Wind Speed (km/hr)	Vapour pressure (mm)		Evapo (mm)	Rainy days
	Max.	Min.			Mor.	Eve.		(Mor)	(Eve)		
49	28.7	10.6	9	0	85	26	2.1	9.4	7.8	2.4	0
50	29	14	7.2	3.2	92	41	2.2	12.3	11.8	2.7	1
51	25.3	7.1	8.6	0	88	29	2.3	7.3	6.7	2.4	0
52	23.8	5	9.1	0	90	30	2.2	6.8	7.4	2.3	0
1	23.3	7.2	5.9	0	87	42	3.6	7.7	8.7	2.2	0
2	23	5.2	9.2	0	87	32	2.6	6.7	7.3	2.6	0
3	26.7	10.1	8.1	0	84	36	4	9	9.1	3.1	0
4	21.4	5	7.6	0	86	36	2.9	6.6	7	2.5	0
5	24.6	7.4	7.4	2	91	36	2.3	7.9	8.8	2.5	0
6	25.9	11.3	6.2	1	88	49	4.4	10.1	12	3	0
7	25.2	13	4.1	0	91	60	4.4	11.5	12.7	3.1	0
8	25	11	9.3	55.4	93	49	3.2	10.4	11.5	2.7	3
9	28	9.2	9.8	4.8	87	37	3.1	9.3	10.6	3.6	1
10	30.7	9.9	9.6	0	83	28	2.6	9	9.2	4.1	0
11	31.6	14.7	7.4	26.1	84	39	4.6	12.2	12.7	4.6	2
12	33.4	16.2	8.2	0	77	28	3.6	12.6	10.6	4.5	0
13	33.8	16.2	7.8	7.2	76	30	3.7	13.3	11.2	4.9	1
14	35.3	15.2	8.9	3.2	68	20	4.2	12.1	8.1	6.1	1
15	39.5	19.9	8.7	0	57	14	4.5	12.6	7.1	10.7	0
16	36.5	20.1	8.6	10.6	51	22	5.2	11.3	8.8	6.9	1
17	37.6	20.6	9	0	64	21	4.2	15.5	10.2	5.8	0

1) To study the population dynamics of *Helicoverpa armigera* (Hubner) on chickpea.

Details of experiment

Variety	: JG-315
Replications	: 3
Plot size	: 5m. x 3m.
Row to row distance	: 0.30m.
Plant to plant distance	: 0.10m.
Plot to plot distance	: 1.5m.
Replication to replication distance	: 1.5m.
Seed treatment	: Thirum @ 2g/kg seed + Bavistin @ 2gm/kg seed + Rizobium culture @ 5 g/kg seed.
Date of Sowing	: 03/12/2012
Date of Emergence	: 09/12/2012

Observation for Experiment No.1

(i) The observations on seasonal incidence of *Helicoverpa armigera* was recorded by counting the number of larvae on plants of one meter row length at 5 random places in each plot without any insecticidal treatment.

(ii) The observation of natural enemies (parasite/predators of *Helicoverpa armigera*) were also recorded by counting the number of infested larvae/cacoon of *Campoletis chlorideae* on one meter row length of 5 random places.

(iii) Observations on the pest population was recorded at each meteorological week, from one week after germination to harvest of the crop.

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1.1) To study the parasitization (%) of *Helicoverpa armigera* by *Campoletis chlorideae* in the laboratory.

Observation for Experiment no. 1.1

i) The observation of natural enemies (*Campoletis chlorideae*) were also recorded by collecting the larvae from one meter row length and reared in the laboratory. The number of healthy and parasitized larvae were recorded and calculate the per cent parasitization of *Helicoverpa armigera* larvae under field condition.

ii) Second instar larvae of *Helicoverpa armigera* were collected from the untreated chickpea plot and put separately into the Petridis. Fresh leaves were provided daily and counted the parasitized larvae.

iii) No. of *Helicoverpa armigera* larvae were changed weekly and parasitization (%) per week were calculated.

2) Effect of different insecticides with NAA and Urea in spray mixture on chickpea infesting *Helicoverpa armigera* (Hubner).

Details of experiment

Design	: RBD
Variety	: JG-315
Replications	: 3
No. of treatments	: 12
Plot size	: 5m. x 3m.
Row to row distance	: 0.30m.
Plant to plant distance	: 0.10m.
Plot to plot distance	: 1.5m.
Replication to replication distance	: 1.5m
No. of rows/plot	: 11

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Seed treatment : Thirum @ 2g/kg seed + Bavistin @ 2 gm /kg seed + Rizobium culture @ 5 g/kg seed.

Date of Sowing : 03/12/2012

Date of Emergence : 09/12/2012

Application dates : Total two spraying/application

(1)First application : February 21, 2013

(2)Second application : March 11, 2013

Date of Harvesting : 24/04/2013

Table:-2 Technical details of experiment No. 2

Treatment	Chemical Name	Trade name	Dose a.i(gm/ml) /ha	Formulation (gm/ml)/ha
T_1	Chlorantraniliprole 18.5%SC	Coragen	30 ml a.i.	150 ml
T_2	Emamectin benzoate 5% SG	Chemdoot	11 g a.i.	220 g
T_3	Flubendiamide 39.36% SC	Fame 480SC	60 ml a.i.	125 ml
T_4	Profenophos 50% EC	Profex	750 ml a.i.	1500 ml
T_5	Indoxacarb 14.5%SC	Kaal	60 ml a.i.	400 ml
T_6	NAA 40ppm + Chlorantraniliprole 18.5%SC	-	-	40 ppm+150 ml
T_7	NAA 40ppm+Emamectin benzoate 5% SG	-	-	40 ppm+220 g
T_8	NAA 40ppm+Flubendiamide 39.36% SC	-	-	40 ppm+125 ml
T_9	NAA 40ppm+Profenophos 50% EC	-	-	40 ppm+1500 ml
T_{10}	NAA 40ppm+Indoxacarb 14.5% SC	-	-	40 ppm+400 ml
T_{11}	NAA 40ppm+Urea 2%	-	-	40 ppm+2%
T_{12}	Control (Untreated)	-	-	-

Observation for Experiment no. 2

i) The first foliar spray of treatment was imposed based on ETL, subsequent spraying were given at fortnightly intervals.

ii) Observation on *H. armigera* larvae were recorded one day before treatment and 3, 5, 7, 10 and 15 days after treatment from one meter row length at 3 random places in each plot.

iv) Observation on total number of pod, healthy pod and damage pod were recorded from 10 randomly selected plants/plot at harvest.

v) Grain yield from each plot were recorded at harvest and cost benefit ratio was worked out.

Analysis of data

i) Correlation and regression studies

Correlation and regression of the abiotic factors on major insect pests were worked out by using the formula as suggested by Snedecor and Cochran (1967).

$$\text{Correlation 'r'} = \frac{\sum xy - \frac{\sum x . \sum y}{n}}{\sqrt{\frac{\{\sum x^2 - (\sum x)^2\}}{n} \frac{\{\sum y^2 - (\sum y)^2\}}{n}}}$$

Where,

Regression Y = a + b x (R^2)

a = Intercept

b = Régression coefficient

R^2 = Coefficient of multiple détermination

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ii) ~~Analysis~~Analysais of variance

The data were subjected to statistical analysis after tabulation in to transformed values. The population data of larvae were transformed to $\sqrt{X+0.5}$ w~~W~~hile data in percentages were transformed to their angular values. The data so obtained were analyzed by using the analysis of variance techniques as given below

Following analysis of variance were used.

Skeleton of "Analysis of Variance" is given below

Sources of variance	D.F.	S.S.	M.S.S.	F. Cal	F. Table
Replications	(r-1)	SSR	VR	VR / VE	
Treatments	(t-1)	SST	VT	VT / VE	F at 5% (t-1), (r-1) (t-1)
Errors	(r-1) (t-1)	SSE	VE	-	-
Total	(r.t-1)	-	-	-	-

Where,

r = number of replications

t = number of treatments

VR = replication mean sum of square

VT = treatment mean sum of square

VE = error mean sum of square

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The significance among different treatment means was judged by critical difference (C.D) at 5% level of significance for comparison among the treatments, for which the marginal means of each treatment was considered. The following formula was used for various estimations.

(1) Standard error of mean = S.Em ± = $\sqrt{\frac{E.ms}{r}}$

(2) Critical difference (C.D.) = SEm X √ 2 x t 0.05

Where,

Ems = error mean sum of square

t = ‘t’ value at 5 % level at error d.f.

r = number of replications

SEm± = standard error of any treatment mean

CD = Critical Difference

(3) Per cent pod damage

Per cent pod damage was calculated under different treatments as per formula.

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$$\text{Per cent pod damage} = \frac{\text{Damaged pod}}{\text{Total number of pod}} \times 100$$

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(4) Grain yield

Grain yield was calculated under different treatments as per formula

Yield kg/ha = Factor x grain yield / plot

Where,

$$\text{Factor} = \frac{10000}{\text{Net plot size}} \text{ in sq. m.}$$

(5) B~~:C~~: C Ratio

B:C ratio was calculated under different treatments as per formula

$$\text{B:C Ratio} = \frac{\text{Net profit}}{\text{Cost of treatment}}$$

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CHAPTER-IV

RESULTS

The findings of the experiment on "Study the effect of different insecticides with plant growth regulators on *Helicoverpa armigera* (Hubner) in chickpea." is describe in this chapter under respective objectives.

4.1 Experimrnt No.1 To study the population dynamics of *Helicoverpa armigera* (Hubner) on chickpea.

For population dynamics studies, weekly observations were recorded from germination (Dec. 2012) to crop maturity stage (Mar. 2013). Following major insects were recorded during the study period. (Table3)

Table:- 3 Insects and Parasitoid with chickpea crop at Jabalpur (2012-2013)

Common Name	Scientific Name	Order	Family
1) Gram Pod borer	*Helicoverpa armigera* (Hubner)	Lepidoptera	Noctuideae
2) Larval parasitoid	*Campoletis chlorideae* (Uchida)	Hymenoptera	Ichneumonidae

The results obtained in the study indicate that chickpea crop was attacked by only one insect pest on different stages of the crop. To know the effect of different abiotic factors on the population of *Helicoverpa armigera* on chickpea crop, observations on activity of *Helicoverpa armigera* on chickpea crop were recorded during *rabi* season of (2012-2013). The data obtained are presented in Table 4 and depicted in Fig.2

The early instar larvae of *H. armigera* were found feeding on chickpea plants during 52th SW, fifth week of December 2012 at vegetative stage of the crop (0.20 larva/mrl), during this period maximum and minimum temperature were (23.8^{o}C & 5^{0}C),respectively and relative humidity in the morning and evening were 90% and 30%, respectively. The population increased slightly, in the 1st SW, first week of January 2013 (0.93 larva/mrl) was observed, when maximum temperature was 23.3^{0}C and minimum temperature was 7.2^{0}C, respectively and relative humidity in the morning and evening were 87% and 42%, respectively. Thereafter the population slightly decrease in 2nd SW, second week of January 2013 (0.80 larva/mrl) was observed, when maximum temperature was 23^{0}C and minimum temperature was 5.2^{0}C, respectively and relative humidity in the morning and evening were 87% and 32%, respectively. The larval population was gradually increase from 3rd SW, third week of January 2013 (0.93 larva/mrl) was observed, when the maximum temperature was 26.7^{0}C and minimum temperature was 10.1^{0}C, respectively and relative humidity in the morning and evening were 84% and 36%, respectively.

The population reached at peak during 8th SW (2.93 larvae/mrl), fourth week of February 2012 when maximum temperature 25^{0}C and minimum temperature 11^{0}C, respectively and relative humidity in the morning was 93% and evening was 49%, respectively. While larval population declined gradually in 9th SW, first week of March 2013 and 10th SW, second week of March 2013 (2 larvae/mrl) was observed When maximum temperature (28^{0}C & 30.7^{0}C) minimum (temperature 9.2^{0}C & 9.9^{0}C) were respectively and relative humidity in the morning was 87% & 83% and evening was 37% & 28% respectively.

Slight increase in larval population (2.67 larvae /mrl) was observed in the 11th SW (third week of March 2013), when the maximum temperature and minimum temperature was 31.6^{0}C & 14.7^{0}C, respectively and relative humidity in the morning and evening were 84% and 39%, respectively.

Thereafter, again larval population declined gradually (2.33, 1.53 larvae/mrl in the 12th and 13th SW, fourth & fifth week of March 2013). During this period the maximum & minimum temperature showed increasing trend and relative humidity in the morning & evening showed decreasing trend, respectively.

In this way *H. armigera* larval activity peaked in 8th SW at pod formation stage of the crop. Later on population declined gradually towards the maturity of the crop.

In the initial stage (vegetative)) early instars were noted in high ratio but in the later at flowering and pod stages the late instars of *H. armigera* were observed in high ratio which continued till maturity of crop.

Table:- 4 Effect of biotic and abiotic factors on the population dynamics of *Helicoverpa armigera* (Hub.) and per cent parasitization due to *Campoletis chlorideae* on chickpea. (2012-2013)

SW	Abiotic factors											Biotic factors	
	Temperature		Relative humidity (%)		Rainfall (mm)	Rainy days (hrs.)	Sunshine (hrs)	Wind speed (km/hrs.)	Evaporation (mm)	VP mor. (mm)	VP eve. (mm)	Larval population of *H. armigera*/mrl	~~Per cent (%)~~ Parasitization (%)
	Max. (^{0}C)	Min. (^{0}C)	R.H. (mor)	R.H. (eve)									
51	25.3	7.1	88	29	0	0	8.6	2.3	2.4	7.3	6.7	0.00	00
52	23.8	5	90	30	0	0	9.1	2.2	2.3	6.8	7.4	0.20	35
1	23.3	7.2	87	42	0	0	5.9	3.6	2.2	7.7	8.7	0.93	20
2	23	5.2	87	32	0	0	9.2	2.6	2.6	6.7	7.3	0.80	13.33
3	26.7	10.1	84	36	0	0	8.1	4	3.1	9	9.1	0.93	22.5
4	21.4	5	86	36	0	0	7.6	2.9	2.5	6.6	7	1.27	13.33
5	24.6	7.4	91	36	2	0	7.4	2.3	2.5	7.9	8.8	1.67	16.33
6	25.9	11.3	88	49	1	0	6.2	4.4	3	10.1	12	1.70	10
7	25.2	13	91	60	0	0	4.1	4.4	3.1	11.5	12.7	2.07	20
8	25	11	93	49	55.4	3	9.3	3.2	2.7	10.4	11.5	2.93	13.33
9	28	9.2	87	37	4.8	1	9.8	3.1	3.6	9.3	10.6	2.00	16
10	30.7	9.9	83	28	0	0	9.6	2.6	4.1	9	9.2	2.00	16
11	31.6	14.7	84	39	26.1	2	7.4	4.6	4.6	12.2	12.7	2.67	16.66
12	33.4	16.2	77	28	0	0	8.2	3.6	4.5	12.6	10.6	2.33	20
13	33.8	16.2	76	30	7.2	1	7.8	3.7	4.9	13.3	11.2	1.53	10

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4.1.1 Correlation of *H. armigera* with meteorological parameters

The correlation coefficient results of *H. armigera* larval population and abiotic factors during *rabi* season (Table 5) showed that the maximum temperature had non significant positive correlation with population dynamics of *H. armigera* on chickpea crop is (r = 0.47) and showed significant positive correlation with minimum temperature (r = 0.66*). Similarly, it was found positive correlation with evening relative humidity and *H. armigera* incidence was (r=0.40). The rainfall had positive correlation with *H. armigera* population and it was found significant such as (0.60*). Similarly morning and evening vapour pressure had significant positive correlation with population dynamics of *H. armigera* was (0.69*) and (0.80*).

Table:- 5 Correlation co-efficient between abiotic factors and *Helicoverpa armigera* activity on chickpea crop.

Abiotic Parameters	r value	t-calculated
Temp. Max.	0.47 NS	1.94
Temp. Min.	0.66*	3.18
R.H. morning	-0.09 NS	0.34
R.H. evening	0.40 NS	1.61
Rainfall	0.60*	2.76
Sunshine	-0.08 NS	0.30
Wind speed	0.49 NS	2.05
Vap. Pre. (mor.)	0.69*	3.47
Vap. Pre. (eve.)	0.80*	4.85

* Significant at 5 % level of significance
(NS-Non significant)

The regression equation being:

$$\hat{Y} = 0.08 + 0.14\ x\ (R^2 = 0.43)$$

$$\hat{Y} = 1.31 + 0.03\ x\ (R^2 = 0.37)$$

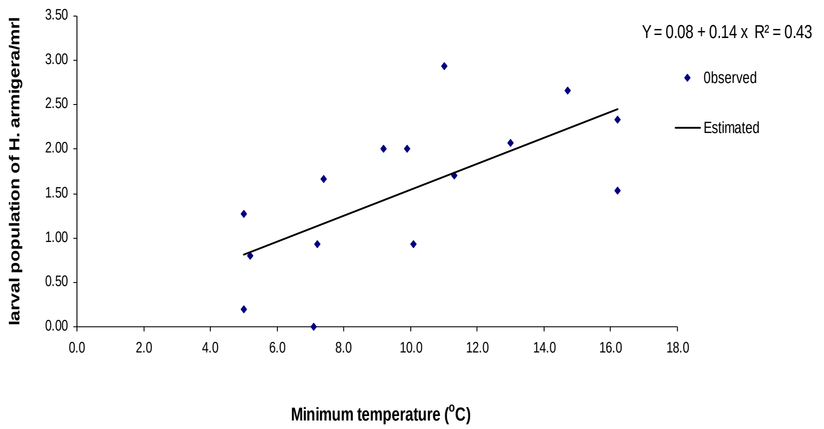

Fig. 3: Regression of minimum temperature (^{0}C) on *H. armigera* larval population in chickpea at Jabalpur during *rabi* 2012-2013

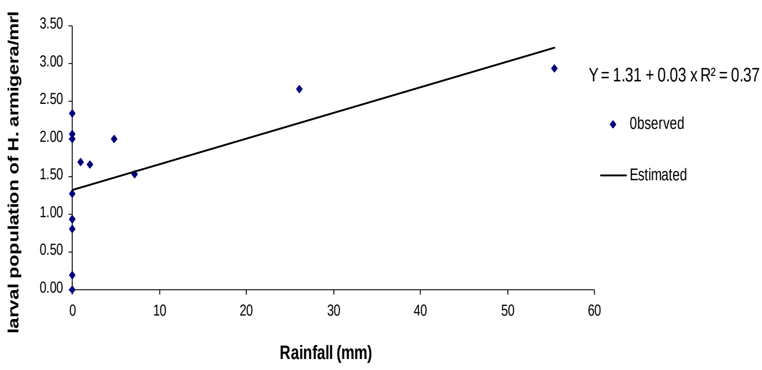

Fig. 4: Regrassion of rainfall (mm) on *H. armigera* larval population in chickpea at Jabalpur during *rabi* 2012-13

From the above equations it may be expressed that with every unit increase in minimum temperature and rainfall there was a increase of (0.08 and 1.31) *H. armigera* larvae/mrl, respectively. (fig.3 and 4)

The regression equation being:

$$\hat{Y} = - 0.91 + 0.26 x \ (R^2 = 0.48)$$

$$\hat{Y} = - 1.65 + 0.32 x \ (R^2 = 0.64)$$

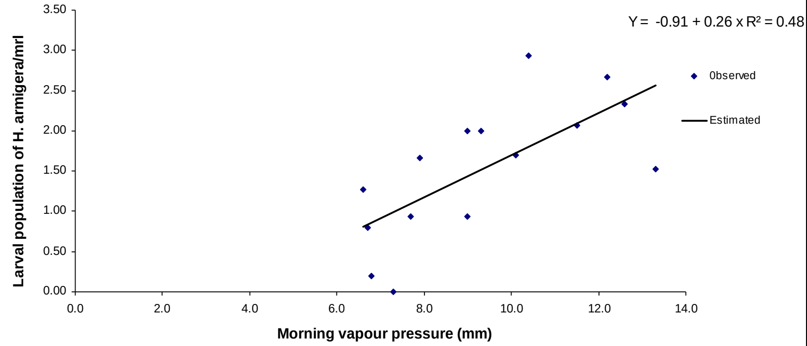

Fig. 5: Regression of morning vapour pressure (mm) on *H. armigera* larval population in chickpea at Jabalpur during *rabi* 2012-2013

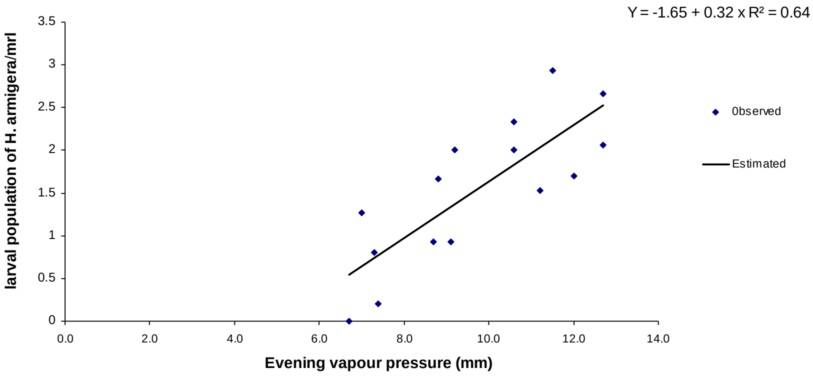

Fig.6: Regression of evening vapour pressure (mm) on *H. armigera* larval population in chickpea at Jabalpur during *rabi* 2012-2013

From the above equations it may be expressed that with every unit increase in morning and evening relative humidity there was a decreased of (-0.91and -1.66) *H. armigera* larvae/mrl, respectively. (fig.5 and 6)

4.1.2 Parasitization (%) due to *Campoletis chlorideae* on *Helicoverpa armigera* in chickpea crop.

Only one species of parasitoid *Campoletis chlorideae,* Uchida (Hymenoptera: Ichneumonidae) was observed parasitizing early instar larvae of *H. armigera* on chickpea under field conditions*.* The per cent parasitization of *H. armigera* by *C. chlorideae* was observed ranging from 10% to 35% during the period of investigation. In the 1st SW, (first week of January 2013) 20% parasitization was observed, when the maximum and minimum temperature was (25.3^{0}C & 7.1^{0}C) respectively, and morning & evening relative humidity was (88% & 29%) respectively.

The peak per cent parasitization was observed in the 52nd SW, fifth week of December when the maximum and minimum temperature was (23.8^{0}C & 5.0^{0}C) respectively, and morning & evening relative humidity was (90% & 30%) respectively and there was no rainfall. Thenafter the per cent parasitization was decreased in the 1st and 2nd SW, (20% & 13.33%) respctively was observed when the maximum and minimum temperature showed decreasing trend and morning & evening relative humidity also showed decreasing trend.

The per cent parasitization was increased in the 3rd SW, (third week of January 2013) 22% was observed when the maximum and minimum temperature was (26.7^{0}C & 10.1^{0}C) respectively, and morning & evening relative humidity was 84% & 36% respectively and there was no rainfall. In the 8th SW, (fourth week of February 2013) the per cent parasitization was observed decrease 13.33% when the maximum and minimum temperature was (25^{0}C & 11^{0}C) respectively, and morning & evening relative humidity was (93% & 49%) respectively and there was 55.4mm rainfall.

The per cent parasitization was constant in the 9th and 10th SW, (last week of February 2013 & first week of March 2013) 16% was observed when the maximum and minimum temperature was showed increasing trend and morning & evening relative humidity was showed decreasing trend and there was 4.8mm rainfall in the 9th SW. The minimum per cent parasitization was observed in the (6th and 13th SW), 10% when the maximum temperature was (25.9^{0}C & 33.8^{0}C) and minimum temperature was (11.3^{0}C & 16.2^{0}C) respectively, and morning & evening relative humidity was (88% & 76%) and (49% & 30%) respectively, and there was (1mm & 7.8mm) rainfall.

Table:- 6 Parasitization (%) due to *Campoletis chlorideae* on larvae of *Helicoverpa armigera*. (2012-2013)

SW	Date	No. of Larvae	No. of Parasitized Larvae	Parasitization (%)
52	26/12/12-01/01/13	20	7	35
1	02/01/13-08/01/13	20	4	20
2	09/01/13-15/01/13	30	4	13.33
3	16/01/13-22/01/13	40	9	22.5
4	23/01/13-29/01/13	30	4	13.33
5	30/01/13-05/02/13	30	5	16.33
6	06/02/13-12/02/13	30	3	10
7	13/02/13-19/02/13	30	6	20
8	20/02/13-26/02/13	30	4	13.33
9	27/02/13-05/03/13	25	4	16
10	06/03/13-12/03/13	25	4	16

11	13/03/13-19/03/13	30	5	16.66
12	20/03/13-26/03/13	30	6	20
13	27/03/13-02/04/13	30	3	10

4.1.3 Correlation co-efficient between abiotic factors and per cent parasitization due to *Campoletis chlorideae* on *Helicoverpa armigera* in chickpea crop.

The correlation coefficient results of per cent parasitization of *Helicoverpa armigera* larvae and abiotic factors during *rabi* season (Table 7) showed that the maximum and minimum temperature had negative correlation with per cent parasitization of *H. armigera* is (r = -0.18) and (r = -0.32). It was found positive correlation was established in morning relative humidity and per cent parasitization of *H. armigera* was (r= 0.16) and negative correlation was found with evening relative humidity and per cent parasitization of *H. armigera* was (r= -0.24). The rainfall as well as vapour pressure (morning and evening) had negatively correlated with per cent parasitization of *H. armigera* and it was found non significant such as (r= -0.01) and (r= -0.35 & -0.36).

Table:- 7 Correlation co-efficient between abiotic factors and per cent parasitization due to *C. chlorideae* on *Helicoverpa armigera* in chickpea crop.

Abiotic Parameters	r value	t-calculated
Temp. Max.	-0.18 NS	0.63
Temp. Min	-0.32 NS	1.20
R.H. morning	0.16 NS	0.58
R.H. evening	-0.24 NS	0.89
Rainfall	-0.01 NS	0.05
Sunshine	0.26 NS	0.94
Wind speed	0.23 NS	0.82

Vap. Pre. (mor.)	-0.35 NS	1.30
Vap. Pre. (eve.)	-0.36 NS	1.36

(NS- Non significant)

Experiment:- 2 Effect of different insecticides with NAA and Urea in spray mixture on chickpea infesting *Helicoverpa armigera* (Hubner).

An experiment comprising twelve treatments (11 insecticides with plant growth regulators + 1 untreated control) was laid out with JG-315 variety of chickpea on 3 December, 2012. The first application of insecticides with plant growth regulators was made on 21 February, 2013 when the maximum population 4.25 larvae/mrl at flowering stage was observed. Second application was made on 11^{th} March, 2013 at podding stage. Effect of insecticides with plant growth regulators on larval population, pod damage and yield is being described as follows.

4.2.1 Effect on larval population

1. Pre-treatment

The observation was recorded, on larval population of *Helicoverpa armigera* which was well distributed in all the experimental plots of chickpea. The population ranged from 2.44 to 4.25 larvae/mrl which differ non significantly.

2. Post treatment

A. After first treatment/spray:

(i) Three day after first spray:

Three day after first insecticides with plant growth regulators application all the treatments were significantly superior to untreated control. Chlorantraniliprole recorded the minimum larval population (1.07 larvae/mrl) followed by Emamectin benzoate (1.30 larvae/mrl), Flubendiamide (1.43 larvae/mrl), Indoxacarb (1.69 larvae/mrl), NAA + Flubendiamide (1.71 larvae/mrl), Profenophos (1.85 larvae/mrl), NAA +

Emamectin benzoate (1.89 larvae/mrl) NAA + Urea (1.91 larvae/mrl) and NAA + Chlorantraniliprole (1.95 larvae/mrl) which was at par with each other. The treatment, NAA + Profenophos (2.11 larvae/mrl) and NAA + Indoxacarb (2.11 larvae/mrl) were intermediate in effectiveness and were significantly superior to untreated control (3.16 larvae/mrl).

(ii) Fifth day after first spray:

Indoxacarb having lowest larval population (0.66 larva/mrl) closely followed by Chlorantraniliprole (0.78 larva/mrl), Emamectin benzoate (0.89 larva/mrl), Flubendiamide (0.89 larva/mrl), NAA + Chlorantraniliprole (0.89 larva/mrl), Profenophos, NAA + Flubendiamide, NAA + Prpfenophos, NAA + Indoxacarb (each 1.00 larva/mrl) and NAA + Emamectin benzoate (1.11 larvae/mrl) which was at par with each other. The treatment NAA + Urea (2.77 larvae/mrl) and control which recorded the maximum larval population (3.39 larvae/mrl).

(iii) Seven days after first spray:

At seven days after spray Emamectin benzoate, NAA + Chlorantraniliprole, NAA + Emamectin benzoate (each 0.22 larva/mrl), closely followed by Chlorantraniliprole (0.33 larva/mrl), Indoxacarb (0.44 larva/mrl), NAA + Flubendiamide (0.54 larva/mrl), NAA + Indoxacarb (0.55 larva/mrl), Flubendiamide (0.89 larva/mrl), NAA + Profenophos (0.67 larva/mrl) and Profenophos (0.77 larva/mrl) which was at par with each other. The treatment NAA + Urea (2.22 larvae/mrl) was intermediate in effectiveness and significantly superior to control which recorded the maximum larval population (3.95 larvae/mrl).

(iv) Ten day after first spray:

At ten days after spray the most effective treatment was Chlorantraniliprole, NAA + Chlorantraniliprole, NAA + Indoxacarb having zero larval population and it was at par with Flubendiamide (0.11 larva/mrl), Indoxacarb (0.11 larva/mrl), NAA + Profenophos (0.67 larva/mrl), Profenophos (0.22 larva/mrl) and NAA + Flubendiamide (0.22 larva/mrl). The treatment Emamectin benzoate and NAA + Emamectin benzoate (each 0.33 larva/mrl), were intermediate in effectiveness and which was differ significantly from the treatment NAA + Urea (1.66 larvae/mrl) and control which recorded the maximum larval population (3.64 larvae/mrl).

(v) Fifteen days after first spray:

NAA + Indoxacarb again proved its effectiveness in recording zero population but it was at par with NAA + Chlorantraniliprole (0.11 larva/mrl), Flubendiamide (0.22 larva/mrl), Chlorantraniliprole (0.32 larva/mrl), NAA + Flubendiamide (0.22 larva/mrl). The population was increased after the fifteen days of spraying. The treatment NAA + Emamectin benzoate (0.44 larva/mrl), Emamectin benzoate (0.55 larva/mrl), Profenophos (0.66 larva/mrl), Indoxacarb (0.66 larva/mrl) and NAA + Profenophos (0.78 larva/mrl) which was at par with each other and intermediate in effectiveness. The treatment NAA + Urea (3.00 larvae/mrl) was differ significantly from the control which was noted the maximum population (4.33 larvae/mrl).

After second spray:

(i) Three day after second spray:

All the insecticidal treatments were significantly superior to untreated control. Flubendiamide (1.55 larvae/mrl), NAA + Indoxacarb (1.55 larvae/mrl), NAA + Profenophos (1.66 larvae/mrl), NAA + Flubendiamide (1.77 larvae/mrl),. Profenophos (1.77 larvae/mrl), Indoxacarb (1.88 larvae/mrl), NAA + Chlorantraniliprole (1.88 larvae/mrl), NAA + Urea (2.00 larvae/mrl) and Chlorantraniliprole, Emamectin benzoate, NAA + Emamectin benzoate (each 2.22 larvae/mrl), which was at par with each other. These treatments were differ significantly from control which was noted the maximum population (4.29 larvae/mrl).

(ii) Fifth day after second spray:

Chlorantraniliprole (0.99 larva/mrl) having a lowest larval population in all the insecticidal treatments and followed by Flubendiamide (1.22 larvae/mrl), NAA + Indoxacarb (1.22 larvae/mrl), Emamectin benzoate (1.33 larvae/mrl), Profenophos (1.33 larvae/mrl), Indoxacarb (1.44 larvae/mrl), and NAA + Chlorantraniliprole (1.44 larvae/mrl), which was at par with each other. NAA + Profenophos (1.66 larvae/mrl), NAA + Emamectin benzoate (2.22 larvae/mrl) and NAA +

Flubendiamide (1.66 larvae/mrl), were next effective treatment. The treatment NAA + Urea (2.00 larvae/mrl) was differ significantly from the control which was noted the maximum population (4.29 larvae/mrl).

(iii) Seven days after second spray:

After seven days of second spraying the treatment NAA + Chlorantraniliprole (0.22 larva/mrl) was found most effective than other treatments. The treatments Chlorantraniliprole (0.44 larva/mrl), Emamectin benzoate (0.66 larva/mrl), NAA + Profenophos (0.66 larva/mrl), Flubendiamide (0.77 larva/mrl), and NAA + Emamectin benzoate (0.77 larva/mrl) were intermediate in effectiveness and at par with each other. The treatment Profenophos (0.89 larva/mrl), Indoxacarb (1.01 larvae/mrl), NAA + Flubendiamide (1.22 larvae/mrl) and NAA + Indoxacarb (1.22 larvae/mrl) were also intermediate in effectiveness. The treatment NAA + Urea (2.77 larvae/mrl) was least effective and maximum larval population noted in control (4.55 larvae/mrl).

(iv) Ten days after second spray:

All the insecticides with plant growth regulators treatments were significantly superior to NAA + Urea and untreated control. Chlorantraniliprole had most effective treatment having zero larval population followed by NAA + Chlorantraniliprole (0.11 larva/mrl), Emamectin benzoate (0.33 larva/mrl), Flubendiamide (0.33 larva/mrl), NAA + Profenophos (0.33 larva/mrl), NAA + Emamectin benzoate, NAA + Flubendiamide (each 0.44 larva/mrl), NAA + Indoxacarb (0.55 larva/mrl), and Indoxacarb (0.55 larva/mrl) which was at par with each other. Next intermediate effective treatment was Profenophos (0.77 larva/mrl) but differ non significantly from the treatment NAA + Urea (2.89 larvae/mrl) and control which was noted maximum population (4.72 larvae/mrl).

(iv) Fifteen days after second spray:

After fifteen days of spraying the treatment Chlorantraniliprole had zero larval population and differ significantly with Flubendiamide, NAA + Chlorantraniliprole (each 0.11 larva/mrl), Emamectin benzoate (0.33 larva/mrl) and NAA + Flubendiamide (0.33 larva/mrl). The treatments Profenophos (0.44 larva/mrl), Indoxacarb (0.44 larva/mrl), NAA + Indoxacarb (0.44 larva/mrl), NAA + Emamectin benzoate (0.66 larva/mrl), and NAA + Profenophos (0.66 larva/mrl) was at par with each other and intermediate in effectiveness. The treatment NAA + Urea (3.00 larvae/mrl) was very least effective as compare to above treatments. The control still recorded significantly highest (4.72 larvae/mrl) larval population.

Over all mean:

In overall performance, all insecticides with plant growth regulators treatments recorded significantly lower larval population (0.61 to 0.97 larva/mrl) in comparison to treatment NAA + urea (2.42 larvae/mrl) and untreated control (4.09 larvae/mrl). Chlorantraniliprole out rightly performed best recording lowest population (0.61 larva/mrl), closely followed by NAA + Chlorantraniliprole, Flubendiamide, Emamectin benzoate, NAA + Indoxacarb, Indoxacarb, NAA + Flubendiamide, NAA + Profenophos, NAA + Emamectin benzoate and Profenophos (0.69, 0.72, 0.81, 0.87, 0.88, 0.92, 0.93, 0.96 and 0.97 larvae/mrl) respectively. (Table-8).

Table:- 8 Efficacy of different insecticides with plant growth regulators on larvae of *Helicoverpa armigera* infesting chickpea. (2012-2013)

Treatment	Pre treatment	Mean larval population of *H. armigera*/mrl.										Overall average mean
		After first spray					After second spray					
		3rd day	5th day	7th day	10th day	15th day	3rd day	5th day	7th day	10th day	15th day	
Chlorantraniliprole 18.5% SC	3.37 (1.96)	1.07 (1.25)	0.78 (1.12)	0.33 (0.90)	0.00 (0.71)	0.32 (0.91)	2.22 (1.65)	0.99 (1.21)	0.44 (0.97)	0.00 (0.71)	0.00 (0.71)	0.61 (1.01)
Emamectin benzoate 5% SG	2.55 (1.74)	1.30 (1.34)	0.89 (1.18)	0.22 (0.83)	0.33 (0.91)	0.55 (1.02)	2.22 (1.64)	1.33 (1.35)	0.66 (1.07)	0.33 (0.90)	0.33 (0.90)	0.81 (1.11)
Flubendiamide 39.35% SC	3.61 (2.02)	1.43 (1.39)	0.89 (1.18)	0.66 (1.07)	0.11 (0.78)	0.22 (0.83)	1.55 (1.43)	1.22 (1.31)	0.77 (1.13)	0.33 (0.90)	0.11 (0.78)	0.72 (1.08)
Profenophos 50% EC	3.10 (1.88)	1.85 (1.52)	1.00 (1.22)	0.77 (1.13)	0.22 (0.84)	0.66 (1.08)	1.77 (1.51)	1.33 (1.35)	0.89 (1.18)	0.77 (1.13)	0.44 (0.97)	0.97 (1.19)
Indoxacarb 14.5% SC	2.66 (1.78)	1.69 (1.48)	0.66 (1.06)	0.44 (0.95)	0.11 (0.78)	0.66 (1.07)	1.88 (1.53)	1.44 (1.39)	1.00 (1.22)	0.55 (1.02)	0.44 (0.97)	0.88 (1.14)
NAA+ Chlorantraniliprole 18.5% SC	3.25 (1.94)	1.95 (1.55)	0.89 (1.16)	0.22 (0.83)	0.00 (0.71)	0.11 (0.78)	1.88 (1.54)	1.44 (1.39)	0.22 (0.84)	0.11 (0.78)	0.11 (0.78)	0.69 (1.03)
NAA+ Emamectin benzoate 5% SG	2.44 (1.71)	1.89 (1.54)	1.11 (1.26)	0.22 (0.84)	0.33 (0.91)	0.44 (0.97)	2.22 (1.65)	1.55 (1.43)	0.77 (1.13)	0.44 (0.97)	0.66 (1.08)	0.96 (1.17)
NAA+ Flubendiamide 39.35% SC	2.44 (1.71)	1.71 (1.48)	1.00 (1.22)	0.54 (1.02)	0.22 (0.84)	0.33 (0.90)	1.77 (1.50)	1.66 (1.47)	1.22 (1.31)	0.44 (0.97)	0.33 (0.91)	0.92 (1.16)
NAA+ Profenophos 50% EC	2.89 (1.84)	2.11 (1.59)	1.00 (1.22)	0.67 (1.05)	0.11 (0.78)	0.78 (1.12)	1.66 (1.47)	1.33 (1.35)	0.66 (1.08)	0.33 (0.90)	0.66 (1.08)	0.93 (1.16)
NAA+ Indoxacarb 14.5% SC	3.01 (1.87)	2.11 (1.61)	1.00 (1.22)	0.55 (1.02)	0.00 (0.71)	0.00 (0.71)	1.55 (1.43)	1.22 (1.31)	1.33 (1.35)	0.55 (1.02)	0.44 (0.97)	0.87 (1.13)
NAA+Urea 2%	3.10 (1.90)	1.91 (1.54)	2.77 (1.81)	2.22 (1.65)	1.66 (1.47)	3.00 (1.87)	2.00 (1.58)	2.00 (1.58)	2.77 (1.81)	2.89 (1.84)	3.00 (1.87)	2.42 (1.70)
Control	4.25 (2.18)	3.16 (1.91)	3.39 (1.97)	3.95 (2.11)	3.64 (2.03)	4.33 (2.19)	4.29 (2.19)	4.29 (2.19)	4.55 (2.25)	4.66 (2.27)	4.72 (2.28)	4.09 (2.13)
Sem±	0.088	0.105	0.069	0.107	0.055	0.074	0.073	0.064	0.055	0.070	0.064	0.073
CD at 5 %	0.287	0.332	0.223	0.350	0.179	0.242	0.237	0.209	0.180	0.229	0.207	0.230

DAS = Days after spraying

() = Figures in parentheses are square root transformed values

4.2.4 Percent Pod Damage:

All the treatments of insecticides with plant growth regulators recorded significantly lower pod damage (0.90 - 6.81 %) than untreated control (12.21 %). Among the treatment, chlorantraniliprole recorded minimum (0.90 %) pod damage followed by NAA + chlorantraniliprole, Flubendiamide, Emamectin benzoate, Indoxacarb, NAA + Flubendiamide and NAA + Indoxacarb. (1.57, 1.68, 1.70, 1.75, 1.98 and 2.78) % pod damage and they were at par with each other. NAA + Emamectin benzoate, NAA + Profenophos and Profenophos recorded slightly higher pod damage having 3.13, 3.50 and 3.86 per cent, respectively and they were at par with each other, where as NAA + Urea recorded higher pod damage (6.81 %). Looking to the results it may be concluded that insecticides with plant growth regulators like, Chlorantraniliprole,NAA+ chlorantraniliprole, Flubendiamide, Emamectin benzoate, Indoxacarb were more effective in reducing pod damage caused by *Helicoverpa armigera* larvae. Where as among newer insecticides, Chlorantraniliprole was to be the best followed by Flubendiamide, Emamectin benzoate and indoxacarb. (Table 9)

4.2.5 Grain yield:

All the insecticidal treatments with plant growth regulators recorded significantly higher yield than untreated control. Chlorantraniliprole recorded maximum grain yield (2453.33 kg/ha) and it was at par with the NAA+chlorantraniliprole, Flubendiamide, Emamectin benzoate, Indoxacarb, NAA + Flubendiamide and NAA + Indoxacarb 2333.33, 2273.33, 2173.33, 2166.66, 2120.00 and 2093.33 kg/ha yield, respectively. The next treatments NAA + Emamectin benzoate, NAA + Profenophos and Profenophos recorded slightly lower grain yield having 2033.33, 1926.66 and 1866.66 kg/ha respectively. NAA + Urea treated plot recorded minimum yield (1706.66 kg/ha).

With respect to yield, the newer insecticides with plant growth regulators Chlorantraniliprole, NAA + chlorantraniliprole Emamectin benzoate, Flubendiamide and indoxacarb were best performing insecticides. (Table 9).

Table:- 9 Efficacy of different insecticides with plant growth regulators on chickpea pod damage by *Helicoverpa armigera* and grain yield.

Treatments	Pod damage (%)	Grain yield (kg/ha)
Chlorantraniliprole 18.5% SC	0.90 (5.44)	2453.33
Emamectin benzoate 5% SG	1.70 (7.49)	2173.33
Flubendiamide 39.35% SC	1.68 (7.44)	2273.33
Profenophos 50% EC	3.86 (11.33)	1866.66
Indoxacarb 14.5% SC	1.75 (7.60)	2166.66
NAA+ Chlorantraniliprole 18.5% SC	1.57 (7.19)	2333.33
NAA+ Emamectin benzoate 5% SG	3.13 (10.19)	2033.33
NAA+ Flubendiamide 39.35% SC	1.98 (8.08)	2120.00
NAA+ Profenophos 50% EC	3.50 (10.78)	1926.66
NAA+ Indoxacarb 14.5% SC	2.78 (9.59)	2093.33
NAA+Urea 2%	6.81 (15.12)	1706.66
Control	12.21 (20.45)	1590.00
SEm±	1.011	0.043
CD at 5 %	3.298	0.139

() Figures in parentheses are arcsine transformed value.

4.2.6 Economics:

The maximum increase in yield (863.33 kg/ha) over control was obtained with Chlorantraniliprole treated plots (Table 10) followed by NAA + Chlorantraniliprole (743.33 kg/ha), Flubendiamide (683.33 kg/ha), and rest of tratments. The lowest increase yield was recorded in the tratment NAA + Urea (116.66 kg/ha).

The maximum net return of Rs. 20599.9 per ha was obtained with Chlorantraniliprole followed by NAA + Chlorantraniliprole Rs. 16869.9 Flubendiamide Rs. 15449.9 and rest of treatments per ha. The lowest net return Rs. 2339.8 per ha was obtained in NAA + Urea.

However, maximum cost benefit ratio of 1:4.01 was obtained with Chlorantraniliprole. The lowest cost benefit ratio was obtained with NAA + Urea (1:2.01). Considering the mean larval population, pod damage and yield, the treatments Chlorantraniliprole, NAA + Chlorantraniliprole, Indoxacarb, Flubendiamide and Emamectin benzoate were found superior among all treatments.

Table:- 10 Economics of insecticides with plant growth regulators against *H. armigera* on chickpea (2012-2013)

Treatments	Dose/ha	Grain yield (Kg/ha)	Increase in yield over control (Kg/ha)	Cost of treatmen t (Rs)	Cost of increase yield over control	Net profit (Rs./ha)	Cost benefit ratio
Chlorantraniliprole 18.5% SC	150 ml	2453.33	863.33	5300	25899.9	20599.9	1:4.01
Emamectin benzoate 5% SG	220 g	2173.33	583.33	3880	17499.9	13619.9	1:3.51
Flubendiamide 39.35% SC	125 ml	2273.33	683.33	5050	20499.9	15449.9	1:3.05
Profenophos 50%EC	1500 ml	1866.66	276.66	2300	8299.8	5999.9	1:2.60
Indoxacarb 14.5% SC	400 ml	2166.66	576.66	3600	17299.8	13699.8	1:3.80
NAA+chlorantraniliprole 18.5% SC	40 ppm+150 ml	2333.33	743.33	5430	22299.9	16869.9	1:3.90
NAA+Emamectin benzoate 5% SG	40 ppm+220 g	2033.33	443.33	4010	13299.9	9289.9	1:2.31
NAA+Flubendiamide 39.35% SC	40 ppm+125 ml	2120.00	530.00	5180	15900.0	10720	1:2.06
NAA+Profenophos 50% EC	40 ppm+1500 ml	1926.66	336.66	2466	10099.8	7633.8	1:3.09
NAA+Indoxacarb 14.5% SC	40 ppm+400 ml	2093.33	503.33	3730	15099.9	11369.9	1:3.04
NAA+Urea 2%	40 ppm+2%	1706.66	116.66	1160	3499.8	2339.8	1:2.01
Control	-	1590.00	-	-	-	-	-

Market rate of chickpea @ Rs. 30/Kg

Rate of insecticides & plant growth regulators (Kg/lit) :

(1) Clorantraniliprole 18.5% SC = Rs 15000/-
(2) Emamectin benzoate 5% SG = Rs 7000/-
(3) Flubendiamaide 39.35% SC = Rs 17000/-
(4) Profenophos 50% EC = Rs 500/-
(5) Indoxacarb 14.5% SC = Rs 3500/-
(6) NAA 4.5% SL = Rs 65/- (100 ml)
(7) Urea = Rs 65/- (10 kg)

Labour rate per day @ Rs 200/- (Two labours required for spraying 1 ha chickpea crop in 1day) pt

6/26/2013 7:57:00 PM

2 pt, After: 2 pt

6/26/2013 7:59:00 PM

6/26/2013 7:58:00 PM

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CHAPTER-V

DISCUSSION

The investigation on the population dynamics of *H. armigera* and evaluation of insecticides are necessary to formulate pest management strategies. Heavy dependence on chemical for the purpose of plant protection has created lot of problems. *Helicoverpa armigera* (Hubner) is major pest in chickpea. Present investigation was carried out with two objectives *i.e.* to study the population dynamics of *Helicoverpa armigera* (Hubner) on chickpea and to evaluate the effect of different insecticides with NAA and Urea in spray mixture on chickpea infesting *Helicoverpa armigera.* The results obtained are discussed in the light of available literature.

5.1 Population dynamics of *Helicoverpa armigera* (Hubner) on chickpea.

In the present investigation the early instar larvae of *H. armigera* were observed on chickpea plants during 52^{nd} (fifth week of December 2012), at vegetative stage of the crop (0.20 larva/mrl). Pest activity continued till 13^{th} SW (fifth week of March, 2013) *i.e*. maturity of the crop. Maximum (2.93) larvae/mrl were observed during 8^{th} SW. Thereafter gradual decreasing trend in larval population was observed. Prasad *et al*., (1989) have mentioned the active period of *Helicoverpa armigera* from vegetative to podding stage of chickpea which support the present findings. Dubey *et al.,* (1997) showed the peak activity of *Helicoverpa armigera* in February and March. Shah and Shahzad (2005) have mentioned that the pest population was low during 49^{th} to 6^{th} standard weeks but increased from 7th standard week onwards and declined again during 14^{th} standard week. Ali and Kumar (2011) reported that *H. armigera* was found most active between 47^{th} to 16^{th} standard week on chickpea and attained peak density 5^{th} to 11^{th} standard week. Sharma *et al.,* (2008) reported that the incidence of *H.*

armigera larvae was first observed on chickpea in the 2nd week of December (50th SW) *i.e.* at vegetative stage of crop. The activity of the pest continued till 10th SW. (March 2007) *i.e.* maturity of the crop.

Non significant negative correlation between larval population of *Helicoverpa armigera* and relative humidity morning and sunshine hours was observed. Significant positive correlation were observed between *Helicoverpa armigera* larval population and minimum temperature, rainfall, Vapour pressure morning and evening, was observed. Non significant positive correlation between *Helicoverpa armigera* larval population and maximum temperature, relative humidity evening, and wind speed was observed. Bajya *et al*., (2010) reported that the pest was active from November to March on this crop. In chickpea, minimum temperature, rain, vapour pressure and relative humidity in the morning and evening were positively correlated with the increase in *H. armigera* population which is also contrary to the present findings.

5.2 For, parasitization (%)

In natural per cent parasitization studies only one species of parasitoid i.e *Campoletis chlorideae* was found to parasitize on *Helicoverpa armigera* on chickpea. The peak per cent parasitization (35%) was recorded in the month December, 2012 (5th SW) at vegetative stage of crop. Prasad *et al.,* (1989) have mentioned the larval population was fairly low during December and the rate of parasitism by the ichneumonid *Campoletis chlorideae* was high. Sujata *et al.,* (2010) studied on natural mortality of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) due to different natural enemies on chickpea (*Cicer arietinum* L.). It can be concluded that among different natural enemies, parasitoids *Campoletis chlorideae* are the most promising naturally occurring biocontrol agents of *H. armigera*. Pandey and Kumar (2006) have mentioned *C. chloridae* has to be a potent parasitoid in chickpea ecosystem and has a great significance in biological control of *H. armigera* on chickpea.

5.3 For, chemical effects

5.3.1 Effect of larval population

The regular use of particular chemical insecticide against the specific insect-pests endangers appearance of insecticide resistance in them and the other problems like resurgence, hazards to other beneficial insect species and environmental pollution are the additional disadvantages. To overcome these problems, some newer, more effective and economical insecticides are the need of the day, along with the conventional insecticides. Some uncommon insecticides like Profenophos and newer insecticides like Chlorantraniliprole, Flubendiamide, Emamectin benzoate, and Indoxacorb, were tested against *Helicoverpa armigera* on chickpea. To control the *Helicoverpa armigera* larvae, two applications of insecticides were given, one at following and second at podding stage of chickpea. All insecticide significantly reduced the larval population as compared to untreated control. Gupta *et al.*, (1991) found the sequential spraying of insecticides at flowering and pod stage was most effective in chickpea. The result of present findings indicated that newer insecticide with plant growth regulators like Chlorantraniliprole, NAA + Chlorantraniliprole, Flubendiamide, Emamectin benzoate and Indoxacarb reduce the larval population effectively only at initial stage. Prasad *et al*., (2010) conclude that chlorantraniliprole @ 30 g ai/ha as optimum dose for the effective control of *H. armigera* on cotton. Sahoo *et al.,* (2011) determined the disappearance trends of flubendiamide residues on chickpea under field conditions and thereby, ensure consumer safety. Dodia *et al.*, (2009) reported that the efficacy of 5 insecticides against *H. armigera* which is contrary to the present findings. The treatment NAA + Urea was found non effective due to higher pod damage. Kumar *et al.,* (2005) investigated the nutrient management strategies and infestation of *H. armigera* on chickpea and concluded that foliar spraying of urea at 2% and 3%, increased pod damage.

5.3.2 Pod damage

With regard to pod damage chlorantraniliprole recorded minimum (0.90 %) pod damage followed by NAA + chlorantraniliprole, Flubendiamide, Emamectin benzoate, Indoxacarb, NAA + Flubendiamide and NAA + Indoxacarb. (1.57%, 1.68%, 1.70%, 1.75%, 1.98% and 2.78%) pod damage respectively and they were at par with each other. NAA + Emamectin benzoate, NAA + Profenophos and Profenophos recorded slightly higher pod damage having 3.13, 3.50 and 3.86 per cent, respectively and they were at par with each other, where as NAA + Urea recorded higher pod damage (6.81 %), and the untreated control recorded significantly highest pod damage (12.21%).

Choudhary *et al*., (2008) and Dodia *et al.*, (2009) found that all the above cited treatments were significant in reduction of damaged pods due to *Helicoverpa armigera* as compared with higher per cent damaged pods in untreated plots.

5.3.3 Yield

Chlorantraniliprole recorded maximum grain yield (2453.33 kg/ha) and it was at par with the NAA + chlorantraniliprole, Flubendiamide, Emamectin benzoate, Indoxacarb, NAA + Flubendiamide and NAA + Indoxacarb 2333.33, 2273.33, 2173.33, 2166.66, 2120.00 and 2093.33 kg/ha grain yield, respectively. Kambrekar *et al*., (2012) studied on bio-efficacy of Emamectin benzoate 5% SG and Indoxacarb 14.5 SC on pod borer, *Helicoverpa armigera*. In these cases slightly higher dose might be responsible for good results.

5.3.4 Economics

However, maximum cost benefit ratio of 1:4.01 was obtained with Chlorantraniliprole followed by NAA + Chlorantraniliprole, Indoxacarb, Emamectin benzoate and Flubendiamide. The lowest cost benefit ratio was obtained with NAA + Urea (1:2.01). Dodia *et al.*, (2009) obtained highest cost benefit ratio of Indoxacarb, flubendiamide and Emamectin benzoate at 11g a.i./ha.

Keeping in view the above results it may be connected that price of insecticide should be borne in mind at the time of treatment. However, many other points such as crop stage pest status number of insecticidal application and doses irrigated/ non-irrigated condition of crop, purity of insecticide, etc, also play a vital role in insect control which indirectly influences the cost benefit ratio.

Chapter-VI

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORK

Gram or chickpea (*Cicer arietinum Linn.)* is an important *rabi* pulse crop of Madhya Pradesh. It is grown in 9.01 million ha with annual production of 7.58 million tones and productivity 841 kg/ha in India (2012). It is grown in 3.04 million ha with annual production of 3.29 million tones and productivity 1082 kg/ha in Madhya Pradesh (2012). The pod damage by gram pod borer *Helicoverpa armigera* is one of the factors for lowering the yield of gram. Therefore investigation were conducted at J.N.K.V.V. Jabalpur during *rabi* 2012-2013 on succession of insect complex, population dynamics, per cent parasitization and control of the gram pod borer with some newer insecticides and biopesticides

Studies on insect pest complex revealed that Aphid, *Aphis craccivora* (Hemiptera:*Aphididae*), Gram pod borer, *Helicoverpaarmigera*(Hub.) (Lepidoptera: *Noctuidae*) and Larval parasitoid, *C. chlorideae* (Hymenoptera: *Ichneumonidae*). *H.armigera* as major pests infesting chickpea crop. Among them, Aphid appeared when the crop age was about 18 days old *i.e.* during vegetative stage and remained active up to 32 days old crop. Gram pod borer appeared on 18 days old crop *i.e.* during vegetative stage and remained active up to maturity of crop. *C.chloridae* appeared on 25 days old *i.e.* during vegetative stage and remained active up to maturity of crop.

To record the population dynamics of pest, weekly observations on eggs and larval population were made on per mrl. The eggs of *H.armigera* were first observed on chickpea crop during 51^{st} (third week of December, 2012), at vegetative stage of the crop (0.48 eggs/mrl) and active till 11^{th}SW(third week of March) *i.e*. maturity stage of the crop(0.14eggs/mrl). Maximum (0.80 eggs/mrl) were observed during

1st SW. There after alternate decreasing and increasing in eggs population were observed.

Correlation studies carried out between abiotic factors and egg population revealed that morning relative humidity was positively correlated but was found to be non –significant. Maximum and mimimum, Morning relative humidity Evening vapour pressure, evaporation, evening relative humidity, wind speed, sunshine and rainfall were negative correlated but found to be non-significant.

The larvae of H.armigera *H. armigera* were first observed on chickpea crop during 51^{st} (third week of December, 2012), at vegetative stage of the crop (0.22 larvae/mrl) and active till 12^{th}SW(fourth week of March) *i.e*. maturity stage of the crop. (0.72 larvae/mrl). Maximum (1.50 larvae/mrl) were observed during 9^{th} SW *i.e* podding stage.

Correlation studies carried out between abiotic factors and larval population revealed that maximum and minimum temperature , Morning and evening vapour pressure and evaporation were positively correlated but was found to be significant . Further was positively correlated but was found non-significant .Rainfall , evening relative humidity and wind speed were positively correlated but was found non-significant . Negative correlation was observed between larvae and morning relative humidity, sunsine but were found to be non- significant.

The Campoletis chlorideae were first observed on chickpea crop during 52^{nd}(forth week of December, 2012), at vegetative stage of the crop and active till 12^{th}SW(fourth week of March) *i.e*. maturity stage of the crop. (0.02pupae/mrl). Maximum (0.24pupae/mrl). Correlation studies carried out between abiotic factors and pupal population of *C.chlorideae* revealed eveining relative humidity was positively correlated but were found to be significant .

Further minimum temperature, morning relative humidity rainfall, morning and evening vapour pressure, wind speed evaporation were positively correlated but were found to be non-significant. Maximum temperature and sunshine were negatively correlated but found to be non- significant

The peak per cent parasitization (30%) was recorded in the month February, 2013 (7^{th} SW) at vegetative stage of crop.

Correlation studies carried out between abiotic factors and parasitization by *C.chlorideae* revealed evening relative humidity was positively correlated but were found to be significant .

Further morning relative humidity and wind speed were positively correlated but were found to be non-significant. Minimum temperature, Maximum temperature and sunshine humidity rainfall, morning and evening vapour pressure, evaporation were negatively correlated but found to be non- significant.

In the field study on efficacy of different biopesticides and one chemical check were tested against *Helicoverpa armigera* larvae in the field. All the biopesticidal treatments proved to be effective in reducing overall larval population, Among the treatments HaNPV@ 250 LE/ha was found to be most effective as it recorded lowest larval population (0.50 larvae/mrl) followed by *Baeuveria bassiana* 1× 10^{12} spores/ ml (0.60 larvae/mrl), *Metarhizium anisopliae*@1×10^{12}spores/ml (0.65 larvae/mrl), *Verticillium lecanii* 1× 10^{12} spores/ ml (0.67larvae/mrl), Pongamia soap10g/L(0.70 larvae/mrl) and Neem soap 10g/L(0.77larvae/mrl) Which were at par to each other . The maximum larval population noted in control(2.51larvae/mrl).

With regard to pod damage, all the treatment significant reduced the pod damage by *Helicoverpa armigera as* compared to control(21.56%). Among the treatment , HaNPV@250LE/ha was found to be most effective as it recorded lowest pod damage (5.52%).The treatment *Baeuveria bassiana* 1× 10^{12} spores/ ml was intermediate in effectiveness it recorded pod damage higher than HaNPV(7.89%). The treatment *Verticillium lecanii* 1× 10^{12} spores/ ml was intermediate in effectiveness it recorded pod damage(9.58%) followed by *Metarhizium anisopliae*@1×10^{12}spores/ml(9.59) which were at par with each other.The treatment Pongamia soap10g/L recorded pod damage(11.21%) and Neem soap 10g/L was least effective, pod damage was found (12.63%) .

All the treatments recorded high yield than control(700 kg/ha).Highest grain yield (1712kg/ha) was obtained with HaNPV@250LE/ha followed by *Baeuveria bassiana* @ 1× 10^{12} spores/ ml (1640kg/ha), *Metarhizium* *anisopliae*@1×10^{12}spores/ml (1637kg/ha), *Verticillium lecanii* 1× 10^{12} @ spores/(1634kg/ha), Pongamia soap10g/L(1401kg/ha) and Neem soap 10g/L (1395 kg/ha).

Computation of the economics of biopesticides against insect pest complex of chickpea revealed that highest cost benefit ratio was recorded in HaNPV @ 250LE/ha (1:12.80) followed by *Baeuveria bassiana*@1×10^{12}spores/ml(1:11.53),*Metarhiziumanisopliae*@1×10^{12}spores/ml (1:11.49) *Verticillium lecanii* 1× 10^{12} @ spores/ml (1:11.45), Pongamia soap10g/L (1:9.50) and Neem soap 10g/L (1:8.95).

In the field study on efficacy of different insecticides and one chemical check were tested against *Helicoverpa armigera* larvae in the field. All the insectisidal treatments proved to be effective in reducing overall larval population.

Among the treatments Novaluron5.25%+Indoxacarb4.5%SC was found to be most effective followed by as it recorded lowest larval population (0.34 larvae/mrl) followed by Emamectin Benzoate5%SG@11 *g a.i* / ha(0.38 larvae/mrl), Lambda-cyhalothrin 5%EC @25 *g a.i/*(0.40larvae/mrl) ,Novaluron 10%EC @ 75 *g a.i /* ha (0.46larvae/mrl)was Indoxacarb14.5%SC@60 *g a.i* / ha(0.48 larvae/mrl) Quinalphos 25%EC 250 *g a.i* / ha (0.51larvae/mrl) which were at par to each other. The maximum larval population noted in control (2.91 larvae/mrl). All the treatments significant reduced the pod damage by *Helicoverpa armigera as* compared to control(21.56%). Among the treatment Novaluron5.25%+Indoxacarb4.5%SC was found to be most effective as it recorded lowest pod damage (1.87%) . Emamectin Benzoate5%SG@11 *g a.i* / ha (2.78%) and Lambda-cyhalothrin 5%EC @25 *g a.i/*ha (3.37%) were intermediate in effectiveness. Novaluron 10%EC 75 *g a.i* / ha also was intermediate in effectiveness it recorded pod damage (5.11%). Indoxacarb14.5%SC@60 *g a.i* / ha was intermediate in effectiveness it recorded pod damage(5.95%) . Quinalphos 25%EC 250 *g a.i* / ha was higher in pod damage(8.60%).

All the treatments recorded high yield than control(700kg/ha). Novaluron5.25%+Indoxacarb4.5%SC recorded maximum grain yield (2780 kg/ha) , followed by Emamectin Benzoate5%SG@11 *g a.i* / ha, Lambda-cyhalothrin 5%EC @25 *g a.i/*ha, Novaluron 10%EC 75 *g a.i* / ha, Indoxacarb14.5%SC@60 *g a.i* / ha and Quinalphos 25%EC 250 *g a.i* / ha 1830,1800,1798,1600 and 1130 kg/ha grain yield, respectively.

Highest cost benefit ratio was obtained with Novaluron5.25%+Indoxacarb4.5%SC(1:9.54) followed by, followed by Emamectin Benzoate5%SG@11 *g a.i* / ha(1:9.52), Lambda-cyhalothrin 5%EC @25 *g a.i*/ha(1:9.31), Novaluron 10%EC 75 *g a.i* / ha(1:5.39) and Indoxacarb14.5%SC@60 *g a.i* / ha(1:5.26) .The lowest cost benefit ratio was obtained in Quinalphos 25%EC 250 *g a.i* / ha (1:5.14).

Conclusion

Thus, it is concluded that *Helicoverpa armigera* larvae remained active on chickpea crop at vegetative stage, from 51st SW (third week of December, 2012) to 12th SW (fourth week of March, 2013), with two peak first at flowering and second at podding stages of chickpea crop, suggesting that the first spray of biopesticides and insecticides may be given some where at flowering stage and second at podding stage of chickpea crop. In biopesticide the lowest larval population highest grain yield, maximum net return and highest B:C ratio was record in that treatments hence to control the *Helicoverpa armigera* pests HaNPV250LE/ha, *Baeuveria bassiana* @ 1× 10^{12} spores/ ml and *Metarhizium* @ 1× 10^{12} can be recommended.

In insecticides the lowest larval population highest grain yield, maximum net return and highest B:C ratio was record in that treatments hence to control the *Helicoverpa armigera* pests Novaluron5.25%+Indoxacarb4.5%S, Emamectin Benzoate5%SG@11 *g a.i* / ha and Lambda-cyhalothrin 5%EC @25 *g a.i/*ha can be recommended.

SUGGESTION FOR FURTHER WORK

1. In view of the changing climatic conditions, the studies on succession of insect pests, population dynamics of major insect pests, testing of biopesticides and insecticides, plant protection methods against *gram pod borer* should be carried out consecutively for 3 years in order to arrive at any concrete conclusion.
2. From the present study evident that damage of gram pod borer appeared at vegetative stage. Hence the research work regarding correlation study with abiotic factor should be carried out for further years.
3. Looking to heights cost of insecticides and hazards for environment as well as human being plant protection methods should be tested frequently against insect pests of chickpea.
4. A monitoring programme should be made for gram pod borer by using light trap.
5. In the present investigation only one location was selected with sample scope of multi location trials.

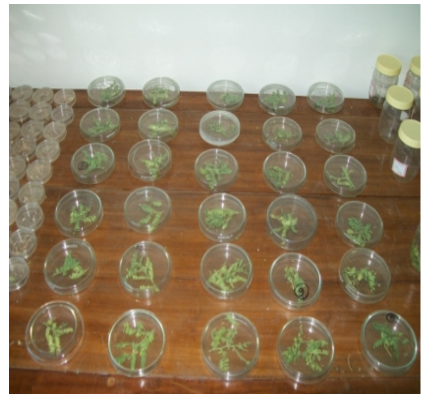
Eggs of gram pod borer

Larva of gram pod borer

Pupa of gram pod borer

Adult of gram pod borer

Cocoon of *Campoletis chlorideae* (Uchida)



Parasitization of field collected *H. armigera* (Hub.) larvae by *Campoletis chlorideae* (Uchida) studied under laboratory

Adult of *Campoletis chlorideae* (Uchida)

Aphids, *Aphis craccivora* (Koch) on chickpea crop

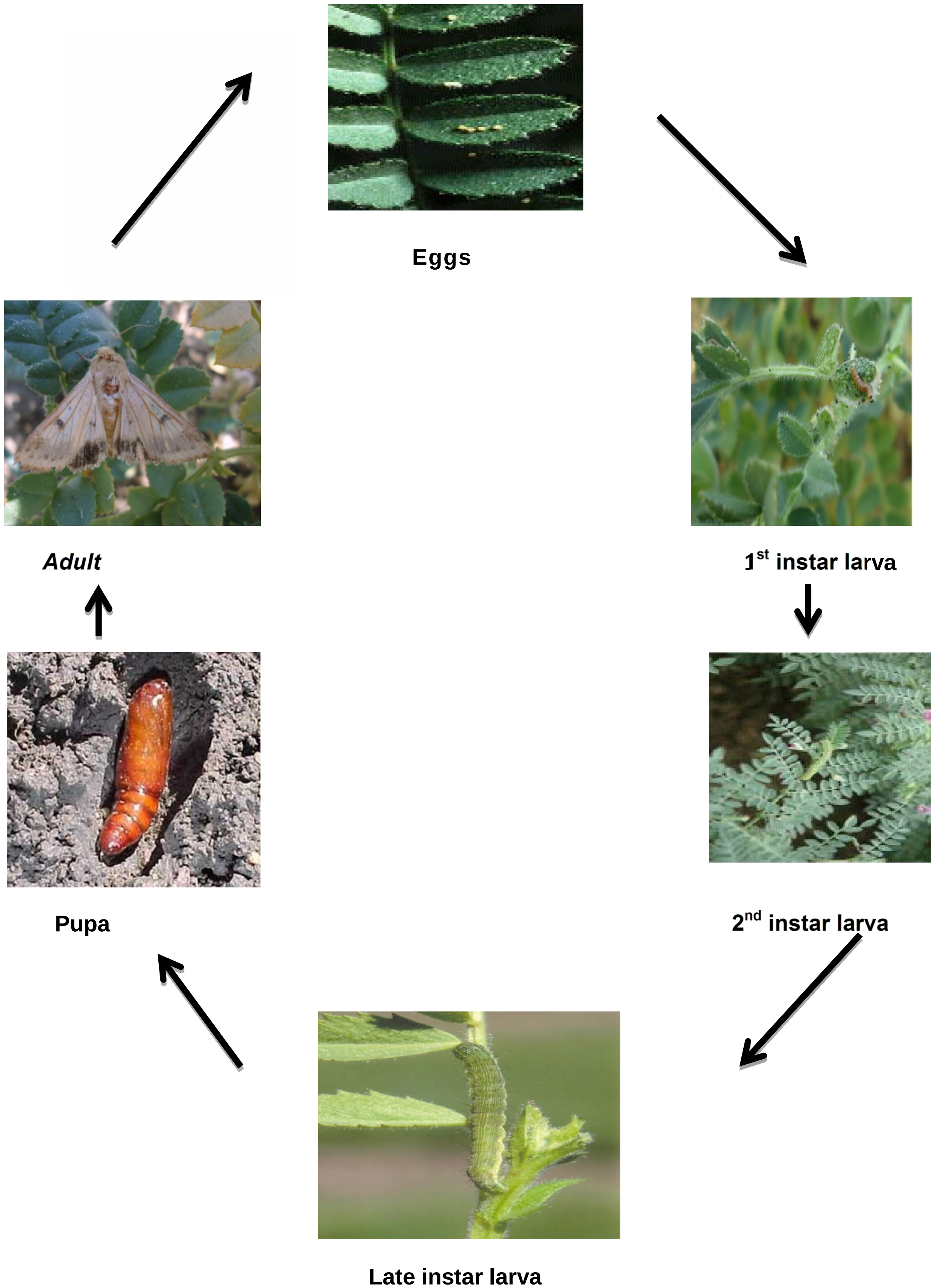


Plate 1 : Life cycle of gram pod borer, *H. armigera* (Hub.) infesting chickpea crop

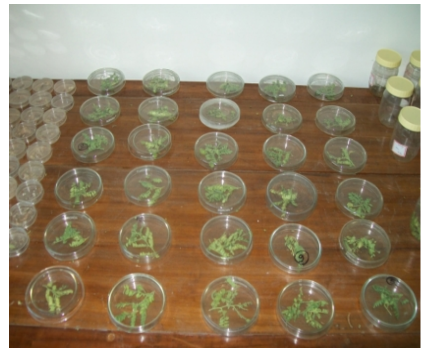
(a)

(b)

Plat 2 (a) Pod damaged by *Helicoverpa armigera* (Hub.)

(b) Aphids, *Aphis craccivora* (Koch) on chickpea crop

(a)



(b)

(c)

Plat : 3 **(**a) Cocoon of *Campoletis chlorideae* (Uchida)

(b) Parasitization of field collected *H. armigera* (Hub.) larvae by *Campoletis chlorideae* (Uchida) studied under laboratory

(c) Adult of *Campoletischlorideae* (Uchida)

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APPENDIX

Weekly meteorological data of Live- stock Farm, Adhartal, JNKVV, Jabalpur 2012-13

SW	Temp. (°C)		Relative Humidity (%)		Vapour pressure (mm)		Wind Speed (km/hr)	Sunshine (Hours)	Rain Fall (mm)	Rainy days (hrs)
	Max.	Min.	Mor.	Eve.	Mor.	Eve.				
51	25.3	7.10	88	29	7.3	6.7	2.3	8.6	0	0
52	23.80	5.00	90	30	6.8	7.4	2.2	9.1	0	0
1	23.3	7.2	87	42	7.7	8.7	3.6	5.9	0	0
2	23	5.2	87	32	6.7	7.3	2.6	9.2	0	0
3	26.7	10.1	84	36	9.0	9.1	4	8.1	0	0
4	21.4	5	86	36	6.6	7.0	2.9	7.6	0	0
5	24.6	7.4	91	36	7.9	8.8	2.3	7.4	2	0
6	25.9	11.3	88	49	10.10	12.0	4.4	6.2	1	0
7	25.2	13	91	60	11.5	12.7	4.4	4.1	0	0
8	25	11	93	49	10.4	11.5	3.2	9.3	55.4	3
9	28	9.2	87	37	9.3	10.6	3.1	9.8	4.8	1
10	30.7	9.9	83	28	9.0	9.2	2.6	9.6	0	0
11	31.6	14.7	84	39	12.2	12.7	4.6	7.4	26.1	2
12	33.4	16.2	77	28	12.6	10.6	3.6	8.2	0	0

Biopesticides treatments : *H. armigera* larval population

ANOVA 1: Pre-treatment

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.001	0.005	0.50	3.89
Treatments	6	0.005	0.0008	0.08	3.00
Error	12	0.012	0.01	-	-
Total	20	-	-	-	-
SEm± = 0.02					CD at 5% = NS

ANOVA 2: Three days after first spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.001	0.005	1.25	3.89
Treatments	6	0.005	0.0008	2.00	3.00
Error	12	0.044	0.004	-	-
Total	20	-	-	-	-
SEm± = 0.04					CD at 5% =NS

ANOVA 3: Seven days after first spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.005	0.0025	1.48	3.89
Treatments	6	0.118	0.02	11.76	3.00
Error	12	0.021	0.0017		-
Total	20	-	-	-	-
SEm± = 0.024					CD at 5% = 0.074

ANOVA 4: Ten days after first spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.029	0.01	4.17	3.89
Treatments	6	0.587	0.10	41.66	3.00
Error	12	0.029	0.0024	-	-
Total	20	-	-	-	-
SEm± = 0.028				CD at 5% = 0.088	

ANOVA 5: Three days after second spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.030	0.015	0.75	3.89
Treatments	6	0.059	0.01	0.50	3.00
Error	12	0.217	0.02		-
Total	20	-	-	-	-
SEm± = 0.08				CD at 5% = NS	

ANOVA 6: Seven days after second spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.008	0.004	2.67	3.89
Treatments	6	0.696	0.12	8.00	3.00
Error	12	0.019	0.0015	-	-
Total	20	-	-	-	-
SEm± = 0.023				CD at 5% = 0.072	

ANOVA 7: Ten days after second spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.022	0.01	2.00	3.89
Treatments	6	2.846	0.47	94.00	3.00
Error	12	0.061	0.005	-	-
Total	20	-	-	-	-
SEm± = 0.04				CD at 5% = 0.12	

ANOVA 8: Mean of two spraying

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.003	0.0015	0.88	3.89
Treatments	6	0.411	0.07	41.18	3.00
Error	12	0.021	0.0017	-	-
Total	20	-	-	-	-
SEm± = 0.024				CD at 5% = 0.075	

ANOVA 9: Pod damage

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.235	0.12	0.786	3.89
Treatments	6	351.96	58.66	391.823	3.00
Error	12	1.797	0.15	-	-
Total	20	-	-	-	-
SEm± = 0.22				CD at 5% = 0.68	

ANOVA 10: Yield

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	2846.38	1423.19	1.91	3.89
Treatments	6	1756402	292733	393.97	3.00
Error	12	8916.28	743.02	-	-
Total	20	-	-	-	-
SEm± = 15.74				CD at 5% = 48.51	

Insecticide treatments : *H. armigera* larval population

ANOVA 11: Pre-treatment

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.001	0.005	0.50	3.89
Treatments	6	0.005	0.0008	0.08	3.00
Error	12	0.012	0.01	-	-
Total	20	-	-	-	-
SEm±= 0.02				CD at 5% = NS	

ANOVA 12: One day after first spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.0001	0.00005	0.055	3.89
Treatments	6	0.129	0.0200	22.22	3.00
Error	12	0.011	0.0009	-	-
Total	20	-	-	-	-
SEm± =0.02				CD at 5% = 0.06	

ANOVA 13: Three days after first spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.0001	0.0005	0.38	3.89
Treatments	6	0.358	0.06	46.76	3.00
Error	12	0.016	0.0013	-	-
Total	20	-	-	-	-
SEm±=0.02					CD at 5% = 0.07

ANOVA 14: Seven days after first spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.005	0.0025	0.62	3.89
Treatments	6	0.504	0.08	20.00	3.00
Error	12	0.052	0.004	-	-
Total	20	-	-	-	-
SEm±=0.04					CD at 5% = 0.12

ANOVA 15: Ten days after first spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.037	0.02	3.02	3.89
Treatments	6	1.078	0.18	29.06	3.00
Error	12	0.074	0.01	-	-
Total	20	-	-	-	-
SEm±=0.04					CD at 5% =0.14

ANOVA 16: One day after second spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.006	0.003	1.46	3.89
Treatments	6	0.744	0.12	60.00	3.00
Error	12	0.024	0.002	-	-
Total	20	-	-	-	-
SEm±=0.03					CD at 5% = 0.08

ANOVA 17: Three days after second spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.07	0.03	1.62	3.89
Treatments	6	0.56	0.09	4.64	3.00
Error	12	0.24	0.02	-	-
Total	20	-	-	-	-
SEm± =0.08				CD at 5% = 0.25	

ANOVA 18: Seven days after second spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.014	0.07	2.33	3.89
Treatments	6	1.585	0.26	8.66	3.00
Error	12	0.041	0.03	-	-
Total	20	-	-	-	-
SEm± =0.03					CD at 5% = 0.11

ANOVA 19: Ten days after second spray

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.06	0.03	1.25	3.89
Treatments	6	4.54	0.76	29.53	3.00
Error	12	0.31	0.03	-	-
Total	20	-	-	-	-
SEm±=0.09					CD at 5% = 0.28

ANOVA 20: Mean of two spraying

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.001	0.005	0.005	3.89
Treatments	6	10.52	1.75	1.84	3.00
Error	12	11.45	0.95	-	-
Total	20	-	-	-	-
SEm±=0.08					CD at 5% =0.24

ANOVA 21: Pod damage

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	0.36	0.18	1.29	3.89
Treatments	6	801.45	133.58	967.48	3.00
Error	12	1.66	0.14		-
Total	20	-	-	-	-
SEm±=0.22					CD at 5% = 0.66

ANOVA 22: Yield

Sources of variance	D.F.	S.S.	M.S.S.	F.Cal	F.Table
Replications	2	14158.95	7079.48	2.85	3.89
Treatments	6	4343610	723935	291.58	3.00
Error	12	29793.71	2482.81	-	-
Total	20	-	-	-	-
SEm± = 28.77					CD at 5% = 88.69

ABSTRACT

a) Title of the thesis	**:**	**"Study the effect of different insecticides with plant growth regulators on *Helicoverpa armigera* (Hubner) in chickpea."**
b) Full Name of Student	**:**	**Mr. BARASKAR JAGADISH SHRIRAMJI**
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e) Degree awarded	**:**	M.Sc. (Agriculture)
f) Year of award of Degree	**:**	2013
g) Major Subject	**:**	Entomology
h) Total number of page in the thesis	**:**	
i) Number of words in the abstract	**:**	360

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(Advisor)	(Professor and head)	(Student)

The present research experiment entitled: "**Study the effect of different insecticides with plant growth regulators on *Helicoverpa armigera* (Hubner) in chickpea**" was conducted during *rabi* season 2012-13 at breeding farm, Adhartal college of Agriculture, JNKVV Jabalpur (M.P.).The research experiment was analyzed in a R.B.D. design. The research experiment studied on population dynamics, per cent parasitization and control of the gram pod borer with some insecticides with plant growth regulators.

To record the population dynamics of pest, weekly observations on larval population were made on per mrl. The early instar larvae of *H. armigera* were observed on chickpea plants during 52^{nd} (fifth week of December 2012), at vegetative stage of the crop (0.20 larva/mrl). Pest activity continued till 13^{th} SW (fifth week of March, 2013) *i.e*. maturity of the crop. Maximum (2.93) larvae/mrl were observed during 8^{th} SW. Thereafter gradual decreasing trend in larval population was observed. Significant positive correlation between *Helicoverpa armigera* larval population and minimum temperature, rainfall, Vapour pressure morning and evening, (0.667, 0.608, 0.992 and 0.806) was observed.

In natural per cent parasitization studies only one species of parasitoid *Campoletis chlorideae* was found to parasitize on *Helicoverpa armigera* on chickpea. The peak per cent parasitization (35 %) was recorded in the month December, 2012 (5^{th} SW) at vegetative stage of crop. The minimum per cent parasitization (10 %) was recorded two times in the 6^{th} SW (2^{nd} week of February 2013) and 13^{th} SW (5^{th} week of March 2013).

All the insecticidal treatments proved to be effective in reducing overall larval population, chlorantraniliprole performed best recording lowest population (0.61 larva/mrl), followed by NAA + Chlorantraniliprole, Flubendiamide, Emamectin benzoate, NAA + Indoxacarb, Indoxacarb, NAA + Flubendiamide, NAA + Profenophos, NAA + Emamectin benzoate and Profenophos (0.69, 0.72, 0.81, 0.87, 0.88, 0.92, 0.93, 0.96 and 0.97 larva/mrl) respectively. Where as NAA + Urea treated plots recorded higher larval population i.e. (2.42 larvae/mrl). The untreated control recorded significantly highest larval population (4.09 larvae/mrl).

The lowest larval population, highest seed yield, maximum net return and highest B:C ratio was recorded in that treatments hence to control the *Helicoverpa armigera* pest Chlorantraniliprole, NAA + Chlorantraniliprole, Flubendiamide Emamectin benzoate and Indoxacarb can be recommended.