INTERNATIONAL JOURNAL OF PLANT PROTECTION | VOLUME 7 | ISSUE 1 | APRIL, 2014 | 28-34
e ISSN-0976-6855 | *www.researchjournal.co.in* | Open Access

IJPP

RESEARCH ARTICLE

Role of bird predators in the management of *Helicoverpa armigera* Hubnr

■ G.G. KHINCHI[1] **AND** M.K. YADAV[2]*

[1]Department of Agricultural Zoology and Entomology, Rajasthan College of Agriculture, UDAIPUR (RAJASTHAN) INDIA

[2]Mechanized Agriculture Farm, MPUAT Campus, Ummedganj, KOTA (RAJASTHAN) INDIA

ARITCLE INFO

Received : 26.12.2013
Revised : 25.01.2014
Accepted : 08.02.2014

Key Words :
Bird predators, Management, Chickpea, *Helicoverpa armigera*

***Corresponding author:**
Email: manoj_kadali11@gmail.com

ABSTRACT

Studies on role of bird predators in the management of *Helicoverpa armigera*, were carried out at Mechanized Agriculture Farm, Ummedganj, Kota during the two consecutive years (2004-05 and 2005-06). The net installed at 1 m height above ground level on the gram crop facilitated the movement of *H. armigera* moths across the net. The bird activity (predation) was started at the time of pest appearance (third week of January) and continued till harvesting of the crop in both the years. During both the experimentation years, total number of larvae (G_1, G_2 and G_3) was observed minimum in T_6 (60 cm row distance + T shape perch) as compared to control / netted plot T_8 at the time of pod formation, mainly due to the bird predation in T_6. Two sprays of endosulfan @ 0.07 per cent significantly reduced the larval number but yield was higher only in the treatment T_4 (60 cm row distance + insecticide). The maximum per cent larval reduction was observed in the period P_{11} (third week of March) in the treatment T_6. However, it was statistically at par with T_4. Slightly more inter row distance *i.e.* 60 cm improved the efficiency of predatory birds. In bird protected (netted) area, pod damage was always higher and hence the yield was very poor compared to the open area (T_1 to T_6), where, birds controlled the pest. Installation of T perch also increased the searching efficiency of predatory birds as seen in T_6. The activity of predatory birds was comparatively less during the morning hours (7 to 8.30 am) compared to evening hours (4 to 6.00 pm) and no activity was observed in between. Due to the bird preference to forage in 60 cm spaced crop, larval population was significantly less compared to 45 cm spaced area. Five important bird predators *viz.*, cattle egret, house sparrow, common myna, bank myna and black drongo were recorded in treatment T_1 to T_6 during investigation period.

How to view point the article : Khinchi, G.G. and Yadav, M.K. (2014). Role of bird predators in the management of *Helicoverpa armigera* Hubnr. *Internat. J. Plant Protec.*, **7**(1) : 28-34.

INTRODUCTION

The preponderance and species diversity of birds are not uniform over time and space in the ecosystems in general, and in agro-ecosystems in particular since the populations are influenced by several biotic as well as abiotic factors. Availability of food is one such biotic factors, which determines the size of the insect population, the composition of insectivorous bird species and ultimately also the reproductive success of the bird species in question. The irrigated agro-ecosystems determine the composition of tree species, bushes and the cropping pattern, while in rain fed or limited irrigated conditions, the cropping pattern is more or less uniform and the bird species composition is restricted to a smaller number. Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops of the country. Being qualitatively and quantitatively rich in proteins, it provides an ideal dietary source of proteins to a large part of population (Bhati and Patel, 2001). Among several factors which adversely affect the production of chickpea, the damages caused by insect pests are important. About 60 insect species have been reported to feed on chickpea (Reed and Pawar, 1982). Gram pod borer, *Helicoverpa armigera* is the major pest, which has been reported from almost all chickpea growing countries. The pest appears throughout the year on different crops, depending upon the cropping pattern. Its high biotic potential, polyphagous food habit and suspected migratory behaviour make it a more serious pest. The use of synthetic insecticides has been an effective tool in the management of insect pest problems for the last four or five decades. However, the sole reliance on insecticides for combating the insect pest problems in crops has given rise to many environmental problems like pollution, destruction of beneficial insects, development of resistance to insecticides in insect pests, insecticide residues on crop plants and the resurgence of insect pests. In view of these problems, several alternative tools of pest management like the use of beneficial insect predators, parasitoids and pathogens have been tried with varied success in combating the pest problems. The concept of integrated pest management came into vogue about four decades ago when alternative tools were effectively applied with minimum or restricted use of chemical insecticides. The biological methods of pest control have a greater scope in economics of pest control and ecofriendly management. As enemies of insect pests birds stand supreme among vertebrates (Sweetman, 1958), due to their efficiency to capture and consume an enormous number of insects resulting in the control of local outbreaks at times. Several studies have shown that they play a dominant role in maintaining many insect pests at innocuous level in forest ecosystem (Tinbergen, 1960; Dickson, 1979; Torgersen and Campbell, 1982; Torgersen *et al*., 1984; Torgersen and Mason, 1987). Bird-insect relationship in relation to insect pest management is the basis of present investigation. Therefore, the development and refinement of suitable procedure for the management of chickpea pod borer, *Helicoverpa armigera* (Hub.) by exploiting the presence of insectivorous bird species in the agro-ecosystem of chickpea has been done.

MATERIAL AND METHODS

The main objectives of the present studies were to refine the method to assess the predation of *Helicoverpa armigera* (Hubner) by birds and to evolve suitable method by which performance of predatory birds could be improved with slight alternation in agronomical practices and installation of T-shape perch. To fulfill these objectives, studies were carried out at Mechanized Agriculture Farm Ummedganj, Kota zone during the consecutive years 2004-05 and 2005-06.

Assessment of the ability of predator birds to reduce *Helicoverpa armigera* population in chickpea :

The gram variety RSG-44 was sown and row to row distance was maintained according to the experimental treatments with three replications. Plots (each measuring10 m × 10 m) were separated from each other by maintaining gaps of 2 meter. Control (netted) plots were covered with nylon net (mesh size 2 cm × 2 cm) during January. The net was installed (Plate 3 and 4) with the help of wooden stakes having height of about 1.0 m. Net with such a mesh size facilitated the easy entry of adult moths for oviposition inside the netted area at the ground level. The net was fixed with wooden pegs in order to prevent the entry of birds through ground. Rest of the experimental field or plots remained open to expose birds. Statistically the experiment was designed in Randomized Block Design with eight treatments and three replications. The treatments were T_1- Inter row distance 45 cm (row to row distance was maintained 45 cm), T_2- Inter row distance 60 cm (row to row distance was kept 60 cm), T_3- Pesticide endosulfan @ 0.07 per cent/ha at 45 cm inter row distance (Two sprays of endosulfan were given after the pod formation) (on 1^{st} week of Feb. and last week of Feb.), T_4- Pesticide endosulfan @ 0.07 per cent/ha at 60 cm inter row distance (Two sprays of endosulfan were given after the pod formation) (on 1^{st} week of Feb. and last week of Feb.), T_5- T-shape perch at 45 cm inter row distance (perch was installed at the time of pest appearance @ 80 perch/ha), T_6- T-shape perch at 60 cm inter row distance (perch was installed at the time of pest appearance @ 80 perch/ha), T_7- Control (Netted) 45 cm inter row distance + (Nets were installed during January in the both crop seasons, T_8- Control (netted) 60 cm inter row distance.

The following observations were recorded during study :

Assessment of bird predation on Helicoverpa armigera :

Larval groups :

Different size of *Helicoverpa armigera* larvae *i.e.*, G_1 - Small sized larval (1^{st} and 2^{nd} instar), G_2 -Medium sized larvae (3^{rd} and 4^{th} instar), G_3 - Large sized larval (5^{th} and 6^{th} instar) were recorded at weekly interval in all above treatments during both the crop seasons.

Period of observation :

P_1 = 2^{nd} week of Jan., P_2 = 3^{rd} week of Jan., P_3 = 4^{th} week of Jan., P_4 = 5^{th} week of Jan., P_5 = 1^{st} week of Feb., P_6 = 2^{nd} week of Feb., P_7 = 3^{rd} week of Feb., P_8 = 4^{th} week of Feb., P_9 = 1^{st} week of March, P_{10} =2^{nd} week of March, P_{11} =3^{rd} week of March, P_{12} = 4^{th} week of March, P_{13} = 1^{st} week of April.

Estimation of Helicoverpa armigera density :

Population density of *H. armigera* was estimated in treated as well as control plots at weekly interval. For this purpose, 15 quadrates (1 m^2) were randomly selected from each experimental plot and small larvae (1^{st} and 2^{nd} instar), medium larvae (3^{rd} and 4^{th} instar) and large larvae (5^{th} and 6^{th}

instar) were counted separately. The observations were made until the harvest. However, the difference observed in larval density at later stages was attributed to the factors being tested.

Estimation of other mortality factors, parasitism and pathogen :

Different factors causing natural mortality of eggs, larvae were worked out by rearing them in the laboratory. For this, 100 larvae (2nd and 3rd instar) of *H. armigera* were randomly collected from the experimental plot at monthly interval. These larvae were reared individually on its natural food (gram leaves) in plastic vials (7.5 cm × 2.5 cm) until the eggs/larvae completed their development or yielded parasite. The percentage of parasitism and incidence of pathogen were recorded.

Estimation of pod damage caused by H. armigera :

In order to determine the extent of pod damage by *H. armigera*, five quadrates were selected randomly from experimental and control plots and counts of healthy and damage pods were taken. Besides grain yield of 20 quadrates from each plot, was also recorded at the time of harvest.

Cost/benefit ratio :

The economics of different treatments were calculated by taking into consideration the cost of application of different treatments and prevailing market price of seed and straw. The total grain yield obtained from net (all) plots was computed on hectare basis. The increase in grain yield was calculated as yield increased in treated plots compared with untreated plots as follows :

$$\text{Per cent increased yield} = \frac{\text{Increased yield in treated plot}}{\text{Yield in untreated plot}} \times 100$$

Cost benefit ratio was calculated by deducting the cost of insecticides and perch treatment from price of increased yield over control by using formula :

$$\text{B : C control} = \frac{\text{Returns in treatment (Rs.ha}^{1}\text{)}}{\text{Returns in control (Rs.ha}^{1}\text{)} + \text{Cost of insecticide, perch and labour}}$$

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Assessment of bird predation of *H. armigera* Hubner in chickpea :

Assessment of depredation :

The depredation by birds was studied in terms of reduction in the population of *H. armigera* larvae in chickpea. The observation on the predation of *H. armigera* larvae by bird in chickpea was recorded by counting the total number of larvae and the number of larvae belonging to different size groups *viz.*, small, medium and large sized at weekly intervals initiating from second week of January (P_1) at two row spacing (45 and 60 cm) with or without insecticidal spray and T- shape perch. The insecticide was applied during first and fourth week of February (P_5 and P_8, respectively) during both the years of experimentation (Table 1). During both the years of experimentation, all the treatments observed non significant number of small, medium and large sized larvae, in second week of January (P_1). While period from P_2 to P_{13}, maximum number of small medium and large size larvae were obtained from T_7 and T_8 treatments (Netted/control plots). During both the years from P_2 to P_{13} weeks, the treatment T_6 comprised of sowing of chickpea at 60 cm row spacing and installation of T-shape perch recorded the lowest number of larvae. The larval population of *H. armigera* has been reported to build up slowly and reach the peak at the pod formation stage and decline at later stage (Anonymous, 1981). Kushik and Naresh (1984) also reported 0.81 larvae /m^2 at foliage stage and 19.02 larvae/m^2 at the time of pod formation in gram. A similar growth trend of *H. armigera* in gram was observed by Bhardwaj *et al.* (1987). Similarly, Parashara (1989) reported more number of larvae in crop sown with 45 cm row distance and netted plot as compared to 60 cm. which was attributed to the better hiding facility for the pests and poor searching ability of bird in dense crop (45 cm).

Estimation of other mortality factors :

In order to know the mortality factors other than insectivorous birds, eggs and larvae of *H. armigera* were periodically examined throughout the period of activity of the pest and it was found that the eggs of *H. armigera* were free from egg parasitoids (Table 2). Similar result of parasitism free egg stage in *H. armigera* was also observed by Jayaraj (1981) and Yadav and Patel (1981). The larval stage was also observed free from any parasitism. In the present investigation, however, the larvae were infected by NPV and other bacteria during both the years. The larval collection on three dates showed an average of 18.00 and 13.67 per cent infection (based on 100 larvae collected on each observation). A varying degree (20.84 to 39.83 %) of natural parasitism by *Campoletis chlorideae* has been reported in gram field in Anand (Yadav *et al.*, 1982; Koshiya, 1984 and Patel, 1988) who observed very little parasitism (8 %) in gram field when birds fed actively on *Heliotis* larvae.

Estimation of pod damage and yield :

In order to assess the impact of bird predation, the data on pod damage and yield (Table 3) were recorded from experimental as well as control plots. Minimum per cent pod damage due to *H. armigera* was recorded with T_6 followed by T_4 as compared to control plots (T_7). The values were 14.37

Table 1 : Population of *H. armigera* as influenced by treatments during study

Treatments	January 2004-05				January 2005-06				February 2004-05		February 2004-05	
	II	III	IV	V	II	III	IV	V	I	II	I	II
T_1 (45 cm row distance)	2.943	3.365	3.646	3.775	3.245	3.559	3.669	3.837	3.911	4.033	3.960	3.825
	(8.161)	(10.824)	(12.795)	(13.749)	(10.031)	(12.165)	(12.963)	(14.225)	(14.793)	(15.766)	(15.184)	(14.132)
T_2 (60 cm row distance)	2.927	3.178	3.453	3.591	3.256	3.386	3.449	3.665	3.726	3.795	3.781	3.559
	(8.065)	(9.598)	(11.425)	(12.398)	(10.099)	(10.962)	(11.398)	(12.931)	(13.382)	(13.899)	(13.800)	(12.164)
T_3 (45 cm row distance +	2.926	3.389	3.560	3.807	3.291	3.511	3.618	3.884	3.937	2.915	3.958	2.620
insecticide)	(8.063)	(10.985)	(12.177)	(13.993)	(10.331)	(11.828)	(12.592)	(14.587)	(14.999)	(8.000)	(15.167)	(6.366)
T_4 (60 cm row distance +	2.955	3.151	3.366	3.562	3.245	3.332	3.425	3.722	3.727	2.547	3.786	2.174
insecticide)	(8.232)	(9.432)	(10.831)	(12.188)	(10.033)	(10.600)	(11.231)	(13.351)	(13.392)	(5.987)	(13.832)	(4.225)
T_5 (45 cm row distance + T	2.980	3.291	3.113	3.143	3.276	3.198	3.169	3.204	3.146	3.087	3.167	2.910
shape perch)	(8.380)	(10.328)	(9.194)	(9.380)	(10.233)	(9.729)	(9.545)	(9.765)	(9.398)	(9.033)	(9.531)	(7.966)
T_6 (60 cm row distance + T	2.915	3.044	2.880	2.738	3.219	3.022	2.954	2.786	2.707	2.657	2.742	2.522
shape perch)	(7.999)	(8.765)	(7.797)	(6.997)	(9.862)	(8.633)	(8.225)	(7.264)	(6.829)	(6.559)	(7.018)	(5.860)
T_7 Netted/control (45 cm row	2.977	3.558	3.834	4.061	3.305	3.724	3.909	4.276	4.374	4.457	4.407	4.524
distance)	(8.360)	(12.162)	(14.199)	(15.993)	(10.421)	(13.365)	(14.783)	(17.785)	(18.631)	(19.361)	(18.925)	(19.965)
T_8 Netted/control (60 cm row	2.982	3.507	3.754	3.905	3.264	3.641	3.808	4.115	4.179	4.726	4.249	4.328
distance)	(8.393)	(11.797)	(13.592)	(14.745)	(10.152)	(12.756)	(13.999)	(16.431)	(16.962)	(17.785)	(17.556)	(18.231
SEM±	0.055	0.052	0.062	0.073	0.050	0.040	0.063	0.057	0.056	0.052	0.061	0.030
C.D. (P=0.05)	NS	0.157	0.189	0.223	NS	0.122	0.191	0.174	0.170	0.156	0.186	0.191

N.B.: G_1=Small, G_2=Medium, G_3=Large size larvae, *Values in parenthesis are original values of their respective Angular transformed values

Table 1 Contd..........

***Table 1 Contd*.........**

Treatments	February 2004-05 February 2004-05				March 2004-05				March 2005-06				April 2004-05	April 2006-06
	III	IV	III	IV	I	II	III	IV	I	II	III	IV	I	I
T_1	3.929	4.185	4.016	4.233	4.296	4.415	4.087	3.235	4.321	4.460	4.033	3.210	2.334	2.386
	(4.939)	(17.018)	(15.625)	(17.419)	(17.995)	(18.996)	(16.200)	(9.964)	(18.172)	(19.388)	(15.762)	(9.805)	(4.949)	(5.192)
T_2	3.743	3.909	3.781	3.958	4.041	4.159	3.803	2.983	4.062	4.250	3.853	2.903	2.089	2.127
	(13.512)	(14.782)	(13.798)	(15.167)	(15.831)	(16.798)	(13.962)	(8.399)	(15.996)	(17.563)	(14.347)	(7.929)	(3.864)	(4.024)
T_3	2.846	3.366	2.914	3.420	2.694	3.080	2.915	2.927	2.781	3.103	2.988	2.880	2.386	2.429
	(7.599)	(10.828)	(7.990)	(11.197)	(6.759)	(8.984)	(7.999)	(8.066)	(7.233)	(9.130)	(8.425)	(7.797)	(5.192)	(5.399)
T_4	2.549	3.060	2.668	3.116	2.137	2.671	2.549	2.575	2.165	2.708	2.625	2.626	2.228	2.187
	(5.998)	(8.863)	(6.594)	(9.208)	(4.067)	(6.632)	(6.000)	(6.131)	(4.189)	(6.831)	(6.391)	(6.398)	(4.465)	(4.283)
T_5	2.840	2.612	2.808	2.663	2.503	2.476	2.212	2.064	2.548	2.510	2.352	2.015	1.905	1.931
	(7.566)	(6.322)	(7.385)	(6.593)	(5.766)	(5.629)	(4.393)	(3.761)	(5.991)	(5.798)	(5.033)	(3.562)	(3.129)	(3.231)
T_6	2.433	2.264	2.352	2.258	2.065	2.033	1.814	1.702	2.113	2.084	2.025	1.581	1.557	1.590
	(5.419)	(4.627)	(5.223)	(4.598)	(3.763)	(3.632)	(2.791)	(2.398)	(3.963)	(3.843)	(3.600)	(1.999)	(1.925)	(2.027)
T_7	4.743	4.848	4.784	4.871	4.941	4.950	4.636	4.008	4.966	5.052	4.615	3.894	2.650	2.732
	(21.998)	(22.999)	(22.384)	(23.226)	(23.911)	(24.000)	(20.994)	(15.563)	(24.163)	(25.027)	(20.799)	(14.666)	(6.523)	(6.964)
T_8	4.526	4.617	4.657	4.635	4.742	4.743	4.396	3.832	4.763	4.843	4.397	3.701	2.607	2.435
	(19.984)	(20.820)	(21.192)	(20.987)	(21.983)	(21.997)	(18.828)	(14.188)	(22.184)	(22.953)	(18.833)	(13.195)	(6.295)	(5.429)
SEM±	0.073	0.066	0.066	0.067	0.065	0.046	0.049	0.043	0.066	0.066	0.053	0.053	0.060	0.054
CD (P=0.05)	0.221	0.202	0.199	0.202	0.198	0.141	0.149	0.130	0.200	0.199	0.160	0.162	0.182	0.163

N.B.: G_1=Small, G_2=Medium, G_3=Large size larvae, *Values in parenthesis are original values of their respective Angular transformed values and 15.80 for T_6 and 15.18 and 16.27 for T_4 during study periods, respectively. Whereas, in case of seed yield of gram, these above mentioned treatments recorded highest yield (16.10 and 15.15 and 15.64 and 14.85). Bhalani *et al.* (1987) observed the similar trend of pod damage as 11.30 per cent mean pod damage over a season in Dahod Pila gram variety. Similarly, Patel (1988) reported 30 per cent and 68.75 per cent pod damage in variety Dohod yellow in experimental and control (netted) plots, respectively. The percentage pod damage was at least three times more in control plot (T_8), which was resulted due to the predation by birds only. In treatment T_1, T_2, T_5 and T_6 only birds were responsible for reducing the medium and large sized larvae which are the most damaging stage having migratory habits from one pod to another. The difference in per cent pod damage was further reflected on grain yield, which was 16.10 q/ha and 15.64 q/ha in T_6 and T_4, respectively and was two times higher as compared to that of control plot T_8 (Table 4). During the initial stage of crop growth, the birds searched their pray while walking between the rows. However, at a later stage when the crop became dense, the searching efficiency of birds reduced because they were not able to walk freely in passage. This suggests that the dense growth of the crop provided hiding site to the larvae and provided protection against bird predators. Once the pods were formed the medium and large larvae were found to enter completely inside the pod and therefore they were almost safe from the birds reach. This situation led to a fairly high percentage of pod damage in the experimental area. Patel (1988) reported that also the dense growth of the crop hinders with the free movement of the birds and thus larvae escape predation.

Cost benefit ratio (C : B ratio) :

Normally farmers grow gram crop at 30 cm inter row spacing, however, for variety RSG 44, it is recommended to grow at 30 to 45 cm row distance. The yield recorded for the variety RSG 44 has never been recorded more than 16 q/ha. The present study showed yield 16.10 q/ha and 15.15 q/ha, respectively during the study (Table 4 and 5) from crop sown at 60 cm inter row distance. There was no monetary gain to spray endosulfan when the crop was grown at 45 cm row distance. Though the difference in mean larval number was significant between T_3 and T_4 treatments, suggesting the

Table 2 : Percentage of infection of *H. armigera* by NPV and bacteria during study in chickpea

Date of study	No. of larvae examined			No. of larvae infected		Total % of infection
	G_1	G_2	Total	G_1	G_2	
4th Feb. 2005	74	26	100	28	0	28
20th Feb. 2005	70	30	100	14	0	14
19th March 2005	81	19	100	12	0	12
Total	225	75	300	54	0	54
Average						18.00
3rd Feb, 2006	72	28	100	20	0	20
21st Feb, 2006	100	-	100	12	0	12
20th March, 2006	100	-	100	09	0	09
Total	272	28	300	41	0	41
Average						13.67

G_1 = Small size larvae G_2 = Medium size larvae

Table 3 : Extent of pod damage by *H. armigera*

Treatments	Mean % pod damage	
	2004-05	2005-06
T_1 (45 cm row distance)	17.65 (9.20)	18.99 (10.59)
T_2 (60 cm row distance)	16.21 (7.79)	17.83 (9.37)
T_3 (45 cm row distance + insecticide)	16.63 (8.19)	18.17 (9.72)
T_4 (60 cm row distance + insecticide)	15.18 (6.85)	16.27 (7.85)
T_5 (45 cm row distance + T shape perch)	15.64 (7.27)	17.00 (8.55)
T_6 (60 cm row distance + T shape perch)	14.37 (6.16)	15.80 (7.42)
T_7 Netted/control (45 cm row distance)	42.55 (45.73)	45.10 (50.18)
T_8 Netted/control (60 cm row distance)	39.50 (40.45)	41.55 (43.99)
SEM±	0.436	0.405
CD (P=0.05)	1.323	1.229

*Values in parenthesis are original values of their respective Angular transformed values effectiveness of the pesticide in pest management, however, it was not sufficient to improve yield component significantly. The favourable impact of pesticide spray could be clearly seen by only in the crop grown at 60 cm distance (T_4). Treatment 60 cm row distance + T shape perch recorded significantly higher grain yield, return profit over control and C B ratio which was closely followed by treatment T_4. Considering higher yield in 60 cm inter row distance crop (T_6) and better control of damaging stage of *H. armigera* larvae, there is a need to alter the agronomical practices. These, alteration would

Table 4: Economics and cost benefit ratio during 2004-05

Treatments	Formulation of insecticide (ml/ha) / No. of T- perch / ha require	No. of applications	Average yield q/ha	Return (Rs./ha)	Profit over control	Cost of insecticide and labour/ Cost of T-perch	Net profit (Rs./ha)	C : B Ratio
T_1 (45 cm row distance)	–	–	13.37	15990.0	10320.0	–	–	1.98
T_2 (60 cm row distance)	–	–	14.84	18641.0	11165.0	–	–	2.31
T_3 (45 cm row distance + insecticide)	700	2	14.30	16962	11292.0	720	10572.0	1.98
T_4 (60 cm row distance + insecticide)	700	2	15.64	19655.0	11879.0	720	11159.0	2.20
T_5 (45 cm row distance + T shape perch)	80	–	12.99	15217.0	9547.0	101	9446.0	1.86
T_6 (60 cm row distance + T shape perch)	80	–	16.10	20815.0	13339.0	101	13238.0	2.55
T_7 Netted/control (45 cm row distance)	–	–	7.63	5670.0	–	–	–	0.70
T_8 Netted/control (60 cm row distance)	–	–	8.64	7476.0	–	–	–	0.93
SEM ±			0.505	909.7				0.106
CD (P=0.05)			1.533	2759.3				0.233

Rate of Endosulfan 35 Ec @ 360 / l, Perch cost @ 1.25/perch total cost Rs. 101, Sale price of chikpea @ 1800/q and Labour charge @ 80/ha/application

Table 5 : Economics and cost benefit ratio during year 2005-06

Treatments	Formulation of insecticide (ml/ha) / No. of T- perch / ha require	No. of applications	Average yield q/ha	Return (Rs./ha)	Profit over control	Cost insecticide and labour / Cost of T-perch	Net profit (Rs./ha)	C : B Ratio
T_1 (45 cm row distance)	–	–	12.87	24096.7	14541.7	–	–	2.99
T_2 (60 cm row distance)	–	–	13.60	25937.3	13940.6	–	–	3.21
T_3 (45 cm row distance + insecticide)	700	2	13.13	24043.3	14488.3	720	13768.3	2.74
T_4 (60 cm row distance + insecticide)	700	2	14.85	28325.7	16329.0	720	15609.0	3.22
T_5 (45 cm row distance + T shape perch)	80	–	12.48	233020.7	13465.7	101	13364.7	2.82
T_6 (60 cm row distance + T shape perch)	80	–	15.15	29704.0	17707.3	101	17606.3	3.64
T_7 Netted/control (45 cm row distance)	–	–	7.05	9555.0	–	–	–	1.84
T_8 Netted/control (60 cm row distance)	–	–	8.02	11996.7	–	–	–	1.49
SEM ±			0.552	1379.2				0.166
C.D. (P=0.05)			1.673	4183.4				0.504

Rate of Endosulfan 35 Ec @ 360/l, Perch cost @ 1.25/perch total cost Rs. 101, Sale price of chikpea @ 2500 /q and Labour charge @ 80/ha/application require less seed rate and the cost of seed might be reduced. This alteration would lead towards higher yield with less investment on seed and pesticides (or avoidance). Parasara (1989) also obtained similar result.

Conclusion :

Based on the results of two years field experiments, it may be concluded that treatment T_4 and T_6 recorded minimum per cent pod damage, higher seed yield of gram, net return and B :C ratio over control. (15.18 and 14.37; 16.27 and 15.80; 15.64 and 16.10; 14.85 and 15.15 q/ha, Rs 11879 and 13339; 16329 and 17707.3 /ha and 2.20 and 2.55, 3.22 and 3.64). T_3 and T_4 treated with endosulfan 0.07 per cent during both the years, reduced the larval number significantly but that did not affect the yield in 45 cm distance. However, higher yield was recorded in 60 cm (T_4) and the spray turned out to be profitable when converted on hectare basis. The egg laying of H. *armigera* Hub. did not differ significantly in crop sown with 45 and 60 cm inter row distance (T_1 to T_8), but the total larval population was higher in crop sown with 45 and row distance which was attributed better hiding facility for the pest and poor searching ability of bird in dense growth (45 cm).

REFERENCES

Anonymous (1981). Insect pest survey. Annual Report, ICRISAT, p. 98.

Bhalani, P.A., Parsana, G.J. and Yadavendra, J.P. (1987). Susceptibility of chickpea genotypes to *H. armigera* (Hub.) under field conditions. *Internat. Chickpea Newsletter*. June, **16** : 7.

Bhardwaj, D., Kaushik, U.K. and Pawar, A.D. (1987). Incidence of *Helicoverpa armigera* (Hb.) and parasitism by *Campoletis chlorideae* (Uchida) in Chattishgarh, Madhya Pradesh. *J. Biol. Control,* **1**(2) : 79-82.

Bhati, N.J. and Patil, R.K. (2001). Biology of chickpea pod borer, *H. armigera*. *Indian J. Entomol.,* **63**(3) : 225- 259.

Derek, A. Russell. (1999). Insecticides resistance and its management in *Helicoverpa armigera* (Lepidoptera: Noctudae) in India. *Indian J. Plant Prot.,* **27**(1&2) : 32-36.

Jayaraj, S. (1981). Biological and ecological studies of *Heliothis*. Proc. Internat. Workshop on Heliothis management ICRISAT, Patancheru, India. 15-20. Nov., pp. 17-28.

Kaushik, S.K. and Naresh, J.S. (1984). Population dynamics, distribution pattern and damage of *H. armigera* Hub. on chickpea. *Indian J. Agric. Sci.,* **54**(4) : 325-328.

Koshiya, D.J. (1984). Studies on biometerical analysis, growth and life table of *Helicoverpa armigera* Hubner (Lepidoptera : Noctuidae) on different hosts. Ph.D. Thesis, Gujrat Agriculture University, Anand, GUJARAT (INDIA).

Parashara, (1989). Studies on prepation of *Helicoverpa armigera* Hb. By birds. M.Sc. Thesis, Gujrat Agriculture University, Anand, GUJARAT (INDIA).

Patal, M.H. (1988). Studies on predation of *H. armigera* Hubner and *Spodoptera litura* Fab. by Insectivorous Birds with Special Reference to Acridotheres Tristis l. Master of Science Thesis Gujarat Agricultural University, Anand, 7, 77.: hb.

Reed, W. and Pawar, C.S. (1982). *Heliothis*: A global problem. In: Proc. Internat. Workshop on Helothis management. 15-20 November, 1981 ICRISAT, India, pp. 9-14.

Sweetman, H.L. (1958). *The principles of biological control*. (Dubuque, Iowa: Wm. C. Brown Co., 1958).

Tinbergen, L. (1960). The natural control of insects in pinewoods. I. Factors influencing the intensity of predation by songbirds. *Arch. Neer*. 2001, **13**: 265-343.

Torgerson, T.R. and Campbell, R.W. (1982). Some effects of avian predators on the western spruce bud worm in north central Washington. *Environ*. *Entomol*., **11**(2) : 429-431.

Torgerson, T.R., Thomas, J.W. Mason, R.R. and Itorn, D.V. (1984). Avian predators of Doughlass fir Tussock moth, *Orgyia psecdotsugata* (Mc Dunnough) (Lepidoptera, Lymantriidae) in south western Oregon. *Environ. Entomol*., **13** : 1018-1022.

Torgerson, T.R. and Mason, R.R. (1987). Predation on egg masses of the Douglas fir Tussock moth (Lepidoptera : Lyanantriidae). *Environ. Entomol*., **16** (1) : 90-93.

Yadav, D.N. and Patel, R.C. (1981). Egg parasitism of *H. armigera* (Hb.) (Lepidoptera: Nactuidae) in Gujarat. *G.A.U. Res. J.,* **7**(1) : 19-22.

Yadav, D.N., Patel, R.C. and Patel, D.S. (1982). Seasonal activity of *Compoletis chlorideae* Uchida (Hymenoptera: Ichneumonidar), a larval parasite of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctudac) in Anand (Gujarat). *J. Entomological Res.,* **6**(2):175-178.