Indian Journal of Plant Protection Vol. 33. No. 1, 2005 (17-22)

Integrated Pest Management Strategy Against *Helicoverpa armigera* Hubner in chickpea

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Abstract

Investigations on the effect of various integrated pest management (IPM) components on Helicoverpa armigera *and their impact on natural enemies present in chickpea were carried out during 1998-2000 cropping seasons. Application of neem effectively reduced the oviposition by* H. armigera *through out the cropping period. The integration of various IPM components was found to be the best in reducing the pod damage (10.4%) with highest grain yield (1264.4 kg/ha) with 58.5% increase in yield over control (797.9 kg/ha). Among various IPM components, neem,* Helicoverpa *Nuclear Polyhedrosis Virus were as effective as endosulfan in reducing the larval population and pod damage. Endosulfan was found to be more harmful to the natural enemy population present in chickpea canopy. Among various treatments highest cost-benefit ratio (1:3.01) was obtained in plots treated with IPM. The effect of various IPM components individually or as a package to evolve the best alternate to chemical control of the chickpea pod borer were discussed.*

Keywords: Integrated pest management, chemical control, chickpea, *Helicoverpa* Nuclear Polyhedrosis Virus (HNPV), neem, bird perches, natural enemies

Introduction

Chickpea (*Cicer arietinum*) is one of the most important pulse crops grown in about 9 million hectares worldwide and of which about 70% is grown in India (FAO–production yearbook 2001). The current productivity level of chickpea (200-700 kg ha^{-1}) is far below the yields realized in research fields (>3.0 t ha^{-1}). Of the several constraints affecting the yield, insect pests were recognized as most important. Among various insect pests of chickpea, the gram pod borer *Helicoverpa armigera* Hubner is the major biotic constraint (Srivastava and Srivastava, 1990). *H. armigera*, assumed major pest status across number of crops because of its high fecundity, migratory behaviour, high adaptation to various climatic conditions and development of resistance to range of insecticides. Although it attacks chickpea throughout the crop growth, the damage caused during flowering and pod formation stages results in substantial yield loss. To combat this pest till now the thrust was given mainly on chemicals, however their indiscriminate use resulted in the development of resistance, resurgence and environmental pollution (Armes *et al.*, 1992).

In order to minimize the negative effects of chemical pesticides, the integration of various plant protection options such as resistant cultivars, cultural, physical, biological, and chemical approaches was well recognized and put into practice in several crops (Lal, 1990 and Jayaraj, 1992). Though the results from the recent plant protection research are encouraging, there is still need to further strengthen the IPM area through both basic as well as applied research to overcome the ill effects of chemical plant protection (Ranga Rao *et al.*, 2004). Hence the present studies were carried out to generate information on the role of various IPM components in the management of pod borer in chickpea ecosystem.

Materials and methods

Research was conducted at ICRISAT, Patancheru during post-rainy seasons of 1998-99 and 1999-2000 using chickpea variety ICCC37 (Kranti). The crop was sown on November 11 in 1998-99 and October 22 in 1999-2000 with a row and plant spacing of 60x15 cm in randomized block design (RBD) with six treatments and four replications. Each treatment was sown in a plot measuring 288 sq m. The effect of various treatments on gram pod borer was studied using the following treatments. 1. Neem 0.006 (Aza 3%), 2. *Helicoverpa* Nuclear Polyhedrosis Virus (HNPV) @ 250 LE/ha, 3.Fixing of bird perches @ one/plot, 4.Endosulfan

35EC @ 0.07%, 5.Integrated pest management (IPM) (combination of treatments 1, 2, 3 and 4), 6. Control (Unsprayed).

A total of five sprays were given starting from fourth week after emergence (DAE) and subsequently at 15-day interval during cropping period. In IPM plot, bird perches were installed @ one/plot on the day of first spray. The spray schedule was as follows: first spray with neem, followed by HNPV, endosulfan, subsequently neem and HNPV as fourth and fifth sprays.

Helicoverpa adult activity was monitored through pheromone traps at ICRISAT farm throughout the cropping period. Observations were recorded on number of eggs, small (first and second), medium (third and fourth) and large size (fifth and sixth instar) larvae per plant at weekly interval in each treatment on 20 randomly selected plants. In order to differentiate the treatment effects the data were subjected to square root transformation for analysis in randomized block design (RBD).

To monitor soil inhabiting natural enemies one-litre plastic containers were randomly buried into the soil to ground level in each plot at 21 days after sowing (DAS). These jars were filled with water up to ¾ volume of the jar and added 1ml of formaldehyde and soap water for effective killing and preservation of the collection. The soil inhabiting natural enemies such as ants, ground beetles (carabids), crickets, earwigs and spiders were collected from these pitfall traps in each treated plot to calculate the number of natural enemies per treatment. Observations were taken at 10-day interval till the crop maturity. The mean numbers of natural enemies present during different crop stages in different treatments were calculated. The data were analyzed in RBD after transforming into square root values to get the effect of different treatments on the activity of soil inhabiting natural enemies.

To monitor the activity of various aerial natural enemies in different treatments, De Vac was operated at 22 and 54 DAS during post-rainy season 1998-99 near the crop canopy on the middle two rows for one-minute duration in a plot. From the collection, total number of natural enemies in different treatments was calculated. The data were analyzed by using RBD to assess the effect of different treatments on the natural enemies.

To record the yield, a net plot measuring 84 sq m was marked and 20 randomly selected plants were collected to assess the pod damage in various treatments. To determine the insecticidal residues of endosulfan, 10 plants were collected at random per replication at harvest. The collected samples were preserved in a refrigerator before analyzing for residue by G C analyzer.

Results and Discussion

During the study period (in both the seasons) the incidence of pod borer in chickpea was severe in ICRISAT farm inflicting 20-40% pod damage under unprotected situations. Observations on adult activity showed peak catches around flower initiation phase followed by peak oviposition. In general larval population was more at pod formation and pre-harvest stages resulted in severe pod damage. The results on the oviposition brought out the significance of neem as oviposition deterrent throughout the cropping period. The IPM treatment had shown significant effect in reducing the ovoposition during vegetative and pod formation stages where it received neem as first and fourth spray. The plots treated with endosulfan though had low oviposition compared to untreated control plots, but were inferior to neem treated plots. This clearly depicts the superiority of neem in reducing the oviposition by *Helicoverpa* (Table 1). Warthen (1979), Ramachandra Rao *et al.*, (1990), Rosaiah (1992) and Jeyakumar & Gupta (1999) drew similar inference on oviposition deterrent effect of neem in *H. armigera* on other crops.

The effect of all the IPM components except bird perches (neem, HNPV and endosulfan) was evident on early instar larvae through out the cropping period. Bird perches were found ineffective in the management of early instar larvae and were on par with control plots (Table 2). This is primarily due to invisibility of small larvae to avian predators in the crop canopy. In general the pest incidence was comparatively high during post-rainy 1999-2000 season compared to post-rainy 1998-99, which could be due to early sowing of the crop. The present results contradicted the findings of Chaudary and Sachan (1995) and Prasad and Singh (1997) who had confirmed that high pest incidence in October sown crop than early sown crop with lower yields irrespective of insecticidal use in northern locations of India. This contradiction might be due to variation in weather conditions, prevailing population dynamics of the pest between southern and northern regions. The results from Table 2 also showed the significant effects of neem, HNPV, endosulfan and the combination of these components as IPM package in reducing the small larvae (first and second instars) in chickpea system. This is quite encouraging to note that one should focus the management of *Helicoverpa* at early stage in order to attain the maximum advantage. Since all the options proved effective in managing the small larvae, the farmers can opt any one of these options for effective management of this pest.

During vegetative stage endosulfan and HNPV were equally effective in reducing larval load (1.25, 1.33 larvae/plant,

Table 1. Efficacy of different IPM components on oviposition behaviour of *H. armigera* during post-rainy 1998-2000 seasons

Treatment/Crop stage	Mean no. of eggs/plant			
	Vegetative	Flowering	Pod formation	Pre-harvest
Neem 0.006%(AZA 3%)	0.35(0.5874)[a]	0.72(0.8485)[a]	0.31(0.5522)[a]	0.0(0.2236)[a]
HNPV250 LE/ha	0.49(0.7000)[bc]	0.83(0.9082)[b]	0.41(0.6403)[c]	0.05(0.3162)[bc]
Bird perches One/plot	0.60(0.7714)[cd]	0.96(0.9772)[c]	0.42(0.6442)[c]	0.07(0.3391)[c]
Endosulfan 0.07%	0.52(0.7211)[c]	0.97(0.9823)[c]	0.38(0.6164)[bc]	0.03(0.2738)[ab]
IPM	0.39(0.6204)[ab]	0.82(0.9027)[ab]	0.32(0.5656)[ab]	0.01(0.2345)[a]
Control	0.76(0.8689)[d]	1.17(1.0793)[d]	0.55(0.7416)[d]	0.08(0.3505)[c]
SED	0.046	0.027	0.030	0.028
CD	0.098	0.058	0.063	0.059

Figures in parentheses are square root transformed values
Values followed by same letters in each column are statistically not significant

Table 2. Efficacies of different IPM components in managing early instar larvae of *H. armigera* during post-rainy 1998-2000 seasons

Treatment/Crop stage	Mean no. of larvae/plant			
	Vegetative	Flowering	Pod formation	Pre-harvest
Neem 0.006%(AZA 3%)	0.90(0.9460)[b]	1.11(1.0535)[a]	1.01(1.0024)[b]	0.76(0.8689)[b]
HNPV250 LE/ha	0.81(0.8972)[ab]	1.18(1.0839)[a]	0.97(0.9848)[ab]	0.74(0.8573)[b]
Bird perches One/plot	1.08(1.0368)[b]	1.57(1.2529)[b]	1.16(1.0747)[c]	0.90(0.9460)[bc]
Endosulfan 0.07%	0.69(0.8306)[a]	1.13(1.0630)[a]	1.00(0.9874)[ab]	0.73(0.8544)[b]
IPM	0.84(0.9165)[ab]	1.12(1.0583)[a]	0.89(0.9433)[a]	0.35(0.5916)[a]
Control	1.20(1.0954)[C]	1.61(1.2668)[b]	1.26(1.1224)[C]	1.08(1.0368)[C]
SED	0.042	0.042	0.02	0.045
CD	0.088	0.089	0.059	0.095

Figures in parentheses are square root transformed values
Values followed by same letters in each column are statistically not significant

respectively). In treatments with neem and IPM, (which has received neem as first spray) were next best in reducing larval population. During flowering, IPM treatment (which had received HNPV as second spray) was found superior with 1.58 larvae/plant than endosulfan with 1.66, and HNPV with 1.67 larvae/plant. During pod formation also IPM treatment (which had received endosulfan as third spray) was found superior with 1.74 larvae/plant and was on par with HNPV with 1.87 larvae. During pre-harvest phase IPM maintained superiority with 1.0 larva/plant followed by bird perches with 1.63 larvae/plant and were significantly superior over control (2.06 larvae/plant). During this study IPM showed it's efficiency in reducing larval population at flowering, pod formation and pre-harvest phases over control plots (39.9, 36.7 and 51.5% reduction) (Table 3). Based on average larval population in different crop stages the effect of endosulfan was on par with HNPV. Bird perches even though were inferior in reducing larval population compared to other treatments, but were found superior to control (24.4, 13.7, 17.5 and 20.9% reduction) during vegetative, flowering, pod formation and pre-harvest crop stages, respectively. The previous studies emphasized the importance of thresholds and their knowledge as an important pre-requisite for decision-making in plant protection (Ranga Rao *et al*., 2002). Sanap and Pawar (1998) suggested the IPM treatment involving three sprays from initiation of flowering and

Table 3. Efficacy of different IPM components on *H. armigera* larval population (all stages) during post-rainy 1998-2000 seasons

Treatment/Crop stage	Mean no. of larvae/plant			
	Vegetative	Flowering	Pod formation	Pre-harvest
Neem 0.006% (AZA 3%)	1.44(1.1979)[b]	1.75(1.3228)[c]	2.00(1.4124)[b]	1.30(1.1401)[b]
HNPV 250 LE/ha	1.33(1.1532)[a]	1.67(1.2922)[b]	1.87(1.3656)[ab]	1.21(1.0977)[b]
Bird perches One/plot	1.58(1.2549)[c]	2.27(1.5049)[d]	2.27(1.5066)[c]	1.63(1.2767)[c]
Endosulfan 0.07%	1.25(1.1157)[a]	1.66(1.2884)[b]	1.97(1.4035)[b]	1.39(1.1768)[b]
IPM	1.47(1.2124)[b]	1.58(1.2569)[a]	1.74(1.3190)[a]	1.00(0.9998)[a]
Control	2.09(1.4439)[d]	2.63(1.6217)[e]	2.75(1.6568)[d]	2.06(1.4352)[d]
SED	0.019	0.011	0.025	0.046
CD	0.041	0.024	0.053	0.096

Figures in parentheses are square root transformed values
Values followed by same letters in each column are statistically not significant

subsequent two sprays at 15-day interval for controlling *H. armigera* in chickpea. The usage of eco-friendly pesticides like neem and HNPV along with endosulfan in the present study was most effective and these were in confirmation with the present findings.

The effect of various IPM components (neem, HNPV, endosulfan) individually and the IPM treatment showed their superiority in reduction of pod damage. The IPM treated plots had the lowest pod damage (10.4%) and on par with chemical treated plots (11.2%). Neem and HNPV treated plots were the next best treatments with 12.0 and 12.6% pod damage, respectively. The treatment with bird perches had 14.5% damage and found superior to untreated control (19.8%). IPM treatments realized 1264 kg ha^{-1} yield, which was 58.5% increase over control. The plots treated with neem, HNPV, bird perches and endosulfan provided 41.6%, 42.9, 22.5, 53.3% increased yield over control, respectively. Even though the bird perches (977.0 kg/ha) were inferior to the other treatments, it was also found to be significantly effective by registering 22.5% yield increase over control (Table 4).

IPM provided maximum protection by lowest pod damage (10.4%) due to cumulative effect of various components and highest grain yield followed by endosulfan (11.2% pod damage). Neem and HNPV gave similar protection to crop against pod damage and provided better yields over control (Table 4).

Although bird perches recorded the highest cost-benefit ratio (1:6.40), the overall productivity was not encouraging. Among the remaining treatments highest cost-benefit ratio (1:3.01) was obtained in IPM. The treatment with

Table 4. Effect of different IPM components on pod damage and grain yield of chickpea during post-rainy 1998-2000 seasons

Treatment	Pod damage (%)	Grain yield (kg/ha)	% increase over control
Neem 0.006% (AZA 3%)	11.98 (20.23)[b]	1129.9[b]	41.6
HNPV 250 LE/ha	12.55 (20.72)[b]	1140.4[b]	42.9
Bird perches 1/plot	14.45 (22.32)[c]	977[c]	22.5
Endosulfan 0.07%	11.21 (19.56)[ab]	1223[a]	53.3
IPM	10.38 (18.77)[a]	1264.4[a]	58.5
Control	19.76 (26.41)[d]	797.9[d]	-
SED	0.550	34.26	-
CD	1.180	72.02	-

conventional insecticide, endosulfan provided a cost benefit ratio of 1:2.74. The treatments with neem were found economical (1: 2.05) compared to HNPV (1:1.84) (Table 5). Earlier studies conducted by Reddy, and Manjunatha (2000) at two locations demonstrated superiority of IPM strategy in terms of both C: B ratio and environmental safety over the farmer's practice. During these studies, neem and HNPV products were procured from the market but the production of both these bio-products at farm level were possible and the recent attempts showed good progress.

Table 5. Cost benefit ratio of IPM components in chickpea during post-rainy 1998-2000 seasons (mean of two years)

Treatment	Grain Yield (kg/ha) Gross yield	Grain Yield (kg/ha) Additional yield over control	Gross Income (Rs.)	Cost of Insecticidal application (Rs.)	Net income (Rs.)	Cost benefit ratio (C:B)
Neem	1129.9	332.0	14,544	2023.5	12,520.5	1:2.05
HNPV 250 LE/ha	1140.45	342.55	14,697	2322.5	12,374.5	1:1.84
Bird perches one/plot	977.00	179.1	12,510	350.0	12,160.0	1:6.40
Endosulfan 0.07%	1223.05	425.15	15717.5	1,942.0	13,775	1:2.74
IPM	1264.35	466.45	16,048	1935.0	13,907.5	1:3.01
Control	797.9	-	10,114	-	10,114.0	-

Cost of each spray/ha: Neem = Rs 405/-, HNPV = Rs 465/-, Bird perches = Rs 350/-, Endosulfan = Rs 388/-, Chickpea = Rs 12.5/kg

Imparting training to farmers about its preparation can further reduce its cost which inturn improves the C: B ratio of HNPV and neem.

Studies on residues on seed and haulms indicated that the plants treated with endosulfan contained 0.81 mg/kg residues in seed and 1.35 mg/kg in husk at harvest but no residues were detected in plant samples from IPM treated plots where endosulfan was sprayed as third spray in five-spray schedule. Pandey (1997) reported higher residual levels in chickpea seed even 25 days after the application of endosulfan. This clearly indicates the importance of spray sequence to minimize the chemical residues in the seed and haulms of chickpea. Hence considering the environmental safety, one should adopt the present spray schedule for effective management of the chickpea pod borer with out any residues problem.

There was a significant reduction in number of soil dwelling natural enemies during vegetative phase in plots treated with endosulfan (107.8/trap). The plots treated with neem, IPM that received neem as first spray stood next with lowest number of natural enemies (199.5, 230.8/trap). HNPV (267.1/trap) and bird perches (245/trap) did not show any significant effect on natural enemies and were on par with control (302.4/trap). Similarly, during flowering and pod formation stages also endosulfan had profound effect on the natural enemies (Table 6).

The results suggested considerable reduction in aerial natural enemies present on foliage in plots treated with endosulfan, neem, and IPM (55, 43, 41%, respectively). There was no

Table 6. Efficacy of different IPM components on soil inhabiting natural enemies during post-rainy 1998-2000 seasons and aerial natural enemies on chickpea during post-rainy 1998-99 season

Treatment/ Crop stage	Mean no. of natural enemies/trap Vegetative	Mean no. of natural enemies/trap Flowering	Mean no. of natural enemies/trap Pod formation	Mean no. of natural enemies/trap Pre-harvest	No. of aerial natural enemies 22 DAS	No. of aerial natural enemies 54 DAS
Neem 0.006% (AZA 3%)	199.5(14.1)[B]	234.6(15.3)[AB]	101.4(10.1)[AB]	64.7(8.0)[AB]	50.0(7.1)[AB]	20.8(4.6)[B]
HNPV250 LE/ha	267.1(16.3)[bc]	404.6(20.1)[cd]	124.9(11.2)[bc]	58.0(7.6)[ab]	69.7(8.4)[bc]	21.5(4.6)[b]
Bird perches One/plot	245.0(15.7)[bc]	280.1(16.7)[bc]	134.3(11.6)[bc]	59.5(7.7)[ab]	84.7(9.2)[c]	23.8(4.9)[b]
Endosulfan 0.07%	107.8(10.4)[a]	162.0(12.7)[a]	60.3(7.8)[a]	36.6(6.1)[a]	39.5(6.3)[a]	9.8(3.1)[a]
IPM	230.8(15.2)[bc]	262.9(16.2)[abc]	93.2(9.7)[ab]	79.5(8.9)[b]	51.0(7.1)[ab]	11.4(3.4)[a]
Control	302.4(17.4)[c]	455.4(21.3)[d]	178.3(13.4)[c]	87.8(9.4)[b]	87.1(9.3)[c]	23.8(4.9)[b]
SED	1.268	1.904	1.119	1.012	0.630	0.341
CD	2.658	3.989	2.345	2.121	1.343	0.726

Values followed by same letters in each column are statistically not significant
Mean of 4 replications; DAS = Days after sowing
Figures in parentheses are square root transformed values

significant reduction of number of natural enemies present in plots treated with HNPV and bird perches, which were found on par with control during vegetative phase of the crop. The second sampling of aerial natural enemies suggested the similar trend with significant reduction in natural enemies in the plots treated with endosulfan and IPM treatments (59.0 and 52.0% reduction against control). No significant reduction of natural enemies was observed in plots treated with neem, HNPV and bird perches compared to control (Table 6).

One of the main reasons for failure of pest control with chemicals is the destruction of natural enemies present in the agro-ecosystem, which leads to pest resurgence. The reduction of natural enemies in IPM treatment was mainly due to application of endosulfan and neem sprays. Thus it was concluded that endosulfan had significant affect on the natural enemy fauna in chickpea. So it is necessary to consider the eco-friendly plant protection options into IPM strategy, which are safer to natural enemies of the pest.

These studies clearly suggested the efficacy of various IPM components individually or in integrated approach in the management of pod borer in chickpea. Now based on the resources available and the level of management required, the farmers could opt various control strategies with no deleterious effects on the system as well as the products.

Acknowledgements

The facilities provided by ICRISAT crop improvement program to conduct this research were highly appreciated.

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Received : 03-08-2004 Accepted : 23-04-2005