COMPARITIVE EFFICACY OF VARIOUS COMPONENTS OF IPM WITH SPECIAL REFERENCE TO *Helicoverpa armigera* (Hubner) IN PIGEONPEA

BY

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CERTIFICATE

Mr. G. ARAVIND REDDY, has satisfactorily prosecuted the course of research and that the thesis entitled "**COMPARITIVE EFFICACY OF VARIOUS COMPONENTS OF IPM WITH SPECIAL REFERENCE TO *Helicoverpa armigera* (Hubner) IN PIGEONPEA**" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university

Date 16 2 2001

Place Rajendranagar

(Dr. G.V. RANGA RAO)

Major advisor

CERTIFICATE

This is to certify that the thesis entitled "**COMPARITIVE EFFICACY OF VARIOUS COMPONENTS OF IPM WITH SPECIAL REFERENCE TO *Helicoverpa armigera* (Hubner) IN PIGEONPEA**" is submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the Acharya N G Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Mr. G. ARAVIND REDDY** under our guidance and supervision The subject of the thesis has been approved by the student's advisory committee

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

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(G. ARAVIND REDDY)

DECLARATION

I, **G. ARAVIND REDDY**, hereby declare that the thesis entitled **"COMPARITIVE EFFICACY OF VARIOUS COMPONENTS OF IPM WITH SPECIAL REFERENCE TO *Helicoverpa armigera* (Hubner) IN PIGEONPEA"** submitted to Acharya N.G. Ranga Agricultural University for the degree of **MASTER OF SCIENCE IN AGRICULTURE** is a result of original research work done by me. I also declare that the thesis or part thereof has not been published earlier elsewhere in any manner.

Date: **(G. ARAVIND REDDY)**

Place. Rajendranagar

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ABSTRACT

A field experiment entitled "Comparitive efficacy of various components of IPM with special reference to *Helicoverpa armigera* (Hubner) in pigeonpea" was conducted during *kharif* season 1999, at International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India. During this study the effect of various IPM components such as mechanical shaking of pigeonpea plants, neem 0.006%, HNPV @ 500 LL/ha, and endosulfan 0.07%, independently and in different combinations on *H. armigera* as well as its natural enemies on pigeonpea was studied.

The investigations on seasonal abundance of *H. armigera* on pigeonpea during 41-42 standard week when the crop was at flower initiation phase (137 to 144 DAS) revealed peak adult activity followed by maximum oviposition in the second fortnight of October. Peak oviposition in the second fortnight of October translated into larval peak around 144 days after sowing.

Neem sprays induced a maximum of 58 per cent reduction in oviposition by *Helicoverpa* followed by IPM treated plots (55%). The combination of endosulfan and manual shaking was found to be the best with 62 per cent reduction in larval population followed by shaking alone (60%), HNPV (53.3), IPM (51.5), neem (48.4) and endosulfan (46.6%).

Endosulfan has adverse effect on natural enemies population resulting in 36 per cent reduction over control Though neem was found safer than endosulfan it also had deleterious effect on predatory insect fauna that inhabit pigeonpea canopy

IPM registered the least percentage pod damage (15), followed by endosulfan (18), endosulfan + shaking (19) as against highest pod damage in control (28) The maximum yield was obtained with IPM (632 kg/ha) as against control (410 kg/ha) Shaking was adjudged as the best treatment in terms of safety to natural enemies with highest cost benefit ratio (1 7) followed by endosulfan + shaking (1 6 4)

Rabi pigeonpea in Gulladurthi village showed highest oviposition (13 6 eggs/plant) and larval population (7 4 larvae/plant) at 93 DAS in IPM plots against 7 4 eggs/plant and 8 2 larvae/plant in non IPM plots at peak flowering phase (i e 93 DAS)

Maximum per cent reduction in larval population was found in shaking to the tune of 72 to 82 per cent at Gulladurthi with a high cost benefit ratio (1 10 4)

The cultural practice of manual shaking induced 72 – 82 per cent reduction in larval population instantaneously in farmers fields of Gulladurthi village of A P This operation resulted in highest cost benefit ratio of about 1 10 in the above endemic areas

INTRODUCTION

CHAPTER I

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsspaugh) is one of the most important grain legume crops in tropics and sub tropics. This crop is adaptable in a number of cropping systems and is grown on marginal to rich lands. Pigeonpea is cultivated in almost 4 million hectares world wide. In India, it is grown over 2.9 million hectares for the grain, feed and fuel (Nene and Sheila, 1990). Insect pests are in the fore front of various pigeonpea production constraints. There are more than 200 species of insects known to live and feed on this crop. Of these the pod borer *Helicoverpa armigera* (Hubner)is the most notorious (Lateef and Reed, 1992).

Pigeonpea crop losses due to *Helicoverpa* alone are estimated to be more than US $310 million annually world wide. Recent crop surveys indicate that before 1975 only 20 per cent of the pigeonpea farmers were using insecticides but by 1993, 100 per cent used chemical control in India (Shanower *et al.*, 1994). Continuous use of chemicals has led to the development of insecticidal resistance in this species which resulted in several crop failures (Armes *et al.*, 1992). The economic thresholds have not been well defined and most often calendar based sprays are followed with the onset of flowering. Thus there is a gap in the understanding of the pest density and damage or yield loss relationships which is very important in developing any pest management strategy.

A large number of parasites and predators have been reported to attack this species in nature (Manjunath *et al.*, 1981), however, *Helicoverpa* had less natural enemy attack on Pigeonpea than on other crops like sorghum (Bhatnagar *et al.*, 1983). In view of the increasing misuse of chemical insecticides and their effects on non targets and environment the present research is concentrated on maximum utilization of natural resources by integrating various non-chemical pest management strategies.

In order to sustain productivity of pigeonpea based system with minimal adverse affects on the environment there is an urgent need to develop and evaluate various IPM strategies. Hence the present studies are undertaken with the following objectives.

1. To study the impact of various components of IPM on *Helicoverpa armigera* management

2. To evaluate the economics of various IPM components on *Helicoverpa* management in pigeonpea.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The literature concerning the present study is categorised and presented under different headings as follows.

2.1 CONTROL MEASURES OF *Helicoverpa armigera*

2.1.1 Integrated Pest Management (IPM)against *H. armigera*

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

Badaya *et al.* (1990) observed a high yield and cost benefit ratio in the plots receiving cultural and plant protection measures, followed by those receiving plant protection measures only.

Mahajan *et al.* (1990) recommended the use of natural enemies including *Campoletis chlorideae* (Uchida), HNPV and insecticides for the effective management of chickpea pod borer, *H. armigera* and light and pheromone traps to monitor the pest population and also stated that the use of resistant varieties, intercropping system and sowing dates are effective in management of this pest.

According to Sachan (1990), some of the pest control measures include the use of synthetic pheromone traps and light traps, NPV, breeding for Host Plant Resistance advancing the sowing date or using early maturing cultivars, use of parasitoids like *Campoletis chlorideae* Uchida, mixed or intercropping with cereals or other legumes, use of Phosphorous fertilizers and application of insecticides.

Ballal *et al.* (1992) studied the effect of pesticide applications based on pheromone trap catches and distribution pattern of *H armigera* in pigeonpea and found that it caused change in distribution pattern, performance and development of IPM.

Besides parasites, several birds are often observed in groundnut fields of which egrets, drongos and mynas are important that feed on *Helicoverpa* and *Spodoptera* (ICAR, 1992).

Bijjur *et al.* (1994) showed that 3 sprays in pigeonpea at fortnightly intervals with half the recommended dose of endosulfan + HNPV @ 250 LE/ha were as effective as an endosulfan spray in reducing the larval population and damage. The virus infection increased the susceptibility of *H armigera* to endosulfan thereby giving better control.

Khan *et al.* (1994) conducted a questionnaire survey on crop protection practices adopted by farmers at a village in Karnataka against *H armigera* control on redgram and reported that 62 per cent used non-recommended insecticides, few farmers used hand picking of larvae. Recommendations for integrated control including use of predators, pathogens and botanical insecticides were briefly discussed.

Shantaram *et al.* (1995) reported from the results of the 2 experimental fields (SA-1 in rainfed and CO-5 in irrigated conditions) of pigeonpea

Plate 1: Larval, pupal and adult stages of *Helicoverpa armigera*

Plate 2: *Helicoverpa armigera* eggs on the flower's of pigeonpea plant

and revealed that *Bacillus thuringiensis* sp. Kurstaki and its combination with HNPV and predator *Chrysoperla carnea* was effective as endosulfan in reducing the *H. armigera* populations.

Sarode *et al.* (1995) concluded that application of the NPV at 500 LE per ha plus neem extract at 6 per cent gave the maximum reduction in larval numbers. Sarode and Sarnaik (1996) reported that the NPV and botanical product (NSKE) were found effective and the addition of half doses of insecticides in these material improved their efficacy to combat the gram pod borer *H. armigera.*

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

2.1.2 Efficacy of *Helicoverpa* nuclear polyhedrosis virus (HNPV) against *H. armigera*

Natarajan *et al.* (1991) found the two treatments with endosulfan alone recorded highest yields (259.6 kg/ha) followed by virus and endosulfan (215.6 kg/ha). Least pod damage (5.6 per cent) was recorded in treatment with virus followed by endosulfan with an interval of one week in pigeonpea.

Muthaiah and Rabindra (1991) concluded that there was no significant difference between ULV and wettable formulations of NPV and endosulfan for the control of *H. armigera* in pigeonpea.

Santharam *et al.* (1994) observed that virus at 250 LE/ha + *B. thuringiensis* (Delfin) at 2.5Kg/ha gave better control of *H. armigera* damage to flowers and pods than Delfin alone on pigeonpea.

Giraddi *et al.* (1994) reported that lowest pod damage and highest seed yield were obtained in treatments receiving 3 rounds of sequential sprays of NPV. Pyrethroids – NPV while NPV or insecticide alone failed to give appreciable control of *H. armigera* in pigeonpea. The cost benefit ratios in the spray sequence treatments involving NPV and pyrethroids were moderate.

Sharma *et al.* (1997) evaluated NPV, *T. chilonis*, monocrotophos and endosulfan against *H. armigera* in chick pea and concluded that NPV gave the best control of pest.

Neharkar *et al.* (1999) reported that in the control of *Helicoverpa* among 9 insecticidal treatments on pigeonpea cv. BDN-2, HNPV treatment recorded lowest pod damage (26.51%) and highest yield (18.24 q/ha).

2.1.3 Efficacy of neem products against *H. armigera*

Rao and Rao (1993) observed that 3 applications of 1.5 per cent Replin at 10 days interval at flower initiation, 50 per cent flowering and pod maturity on pigeonpea against *H. armigera* was found effective in reducing oviposition, larval number and pod damage as compared to untreated plots.

Sadawarte *et al.* (1997) reported that in the experiment with neem seed extract, cow dung, cow urine and combinations with and without insecticides were tested for control of *Helicoverpa* on pigeonpea. Combinations of neem seed extract, dung and urine were moderately effective when compared to NSKE with insecticide which was more effective.

Jaglan *et al.* (1997) conducted test of methanol, chloroform : methanol (9:1), extracts of neem seeds and green leaves against *H. armigera* in pigeonpea and chickpea and concluded that neem seed and leaf extracts showed promising results in causing morphogenic effects on larvae.

Das (1998) reported that 4 insecticides and NSKE alone or in combination in half doses were tested against *H. armigera* and *Melanagromyza obtusa* Malloch on pigeonpea. Lowest pod damage and highest yield were obtained by using dimethoate at 0.15 per cent + NSKE at 5 per cent.

Akhowri *et al.* (1999) evaluated some phyto extracts and endosulfan 0.07 per cent against *H. armigera* in pigeonpea and concluded that none of the plant extracts (NSKE 5 per cent, green cartar(phyto extract) 10 per cent) were comparable with endosulfan, but they were significantly better than untreated control in decreasing pest damage and increasing seed yield.

2.1.4 Effect of endosulfan against *H. armigera*

Kabaria *et al.* (1988) reported that the mean damage caused by *H. armigera* and *M. obtusa* in 11 different districts of Gujarat ranged from 3.6 – 9.1 and from 2.6 – 11 per cent, respectively.

Thakur *et al.* (1989) reported that 21.6 per cent of the pods of pigeonpea and 12.1 per cent of grains were damaged by *H. armigera* in treated fields as compared with 43.7 per cent and 37.2 per cent, respectively in untreated fields.

Sinha *et al.* (1989) reported that by using two sprays of endosulfan 0.07 per cent at maximum flowering and 50 per cent podding gave effective control and formed an appropriate spray schedule for pigeonpea.

Patil *et al.* (1990) reported that endosulfan 2 per cent dust @ 25 kg/ha proved most effective against the 3 pests viz., *H. armigera*, *M.obtusa* and *Exelastis atomosa(*walsingham*)*.

Raju *et al.* (1991) showed that in control of *H. armigera* in pigeonpea, application of endosulfan 0.07 per cent at 50 per cent flowering stage gave good protection with minimal yield losses.

Gosalwad *et al.* (1992) determined the most critical growth period of pigeonpea crop was between 90 and 134 days and application of insecticides during this period resulted in greatest yields.

Sachan *et al.* (1993) reported that among various botanical insecticides and synthetic insecticides tested against *H. armigera* in pigeonpea endosulfan was found to be most effective in controlling the pest.

Yadav *et al.* (1993) reported that the 2 sprays of endosulfan 0.07 per cent, one at 50 days after first spraying resulted in the least damage to pods (6.8%) and seeds (5.4%) and greatest grain yield 22.35 q/ha.

Patil and Dethe (1993) assessed the efficacy of single and double sprays of endosulfan 0.07 per cent, fenvalerate 0.015 per cent and cypermethrin 0.015 per cent and found less pod damage in treated plants. Double spray at 15 per cent flowering and 15 days later was more effective than single spray with mean yields higher in double (26.24% q/ha) than single (19.36 q/ha).

Makar *et al.* (1994) found that the most effective schedule of application for control of *H. armigera* in pigeonpea was 0.07 per cent endosulfan at 50 per cent flowering, maximum flowering and maximum pod maturity.

Mishra *et al.* (1995) reported that 3 sprays with endosulfan @ 5 kg a.i./ha at early vegetative stage, at 50 per cent flowering and 15 days after 50 per cent flowering reduced infestation by *H. armigera* to a minimum level of 18.7 per cent compared to 38.7 per cent in untreated control. This schedule produced highest seed yield of 8.9 q/ha compared to 4.1 q/ha in untreated control on hill arhar (*Cajanus cajan*).

Chaudhary *et al.* (1995) reported that endosulfan spray applied at the reproductive stage of the crop effectively reduced pod damage, giving a significant increase in seed yield and maximum economic return compared with untreated control against *H armigera* in pigeonpea.

Borkar *et al.* (1996) found that endosulfan 0.07 per cent was the most effective insecticide in minimising the infestation of *H armigera* on pigeonpea. Similarly parathion methyl with NSKE at 5 per cent resulted in minimum pod damage by *M. obtusa.*

Singh *et al.* (1997) reported on the economics of use of insecticides against pod borer complex and pod fly in pigeonpea that 2 sprays of endosulfan resulted in greater cost benefit ratio (4:15.6) as compared to 3 sprays of quinalphos.

Patel *et al.* (1997) evaluated efficacy of synthetic and botanical insecticides for the control of *H. armigera* in pigeonpea and concluded that endosulfan 0.035 per cent gave highest cost:benefit ratio 1.14.1 and NSKE 3 per cent gave a cost:benefit ratio of 1:11.7 which was less effective in controlling insect pests and less economical.

Gouse Mohammed *et al.* (1999) evaluated 13 insecticides against *Helicoverpa* on pigeonpea between 1990-97 and found that the pod damage at maturity differed significantly between treatments. Least pod damage was recorded in teflubenzuron (4.4%) and carbosulfan (6.1%). The yield also differed significantly being highest in sulrophos (620 kg/ha) and pyraclofos (610 kg/ha).

Patel *et al.* (1999) conducted labotatory studies on the efficacy of 4 pesticides against eggs and larvae of *H. armigera*. Results showed that mixture of deltamethrin 0.8 per cent + endosulfan 0.03 per cent gave 97-100 per cent mortality of larvae after 4 days and 90-93 per cent mortality of eggs.

2.2 ACTIVITY OF DIFFERENT NATURAL ENEMIES ON GRAM POD BORER AND TREATMENTAL EFFECTS ON PREDATORS AND PARASITES

Bilapate (1989) from the life tables studies of *H. armigera* reported that the key mortality factors on pigeonpea were the parasitoids *C. chloridae* and *Goniophthalmus halli* Mesnil in larval and pupal stages, respectively.

Sanap et al (1990) reported that natural enemy population was safe when strip application of Endosulfan was done on pigeon pea to control *H.armigera.*

Mahajan *et al.* (1990) recommended the use of natural enemies including *Campoletis chlorideae* Uchida, NPV and insecticides for the effective management of chickpea pod borer, *H armigera* and light and pheromone traps to monitor the pest population and also stated the use of resistant varieties, intercropping system and sowing dates as effective in management of this pest.

Species of parasitoids present and the extent of parasitization on *H. armigera* were studied in pigeonpea fields by Dayakar *et al.* (1997) and found that eggs and early stage larvae were parasitized by hymenopterans and later instars were attacked by dipterans and pathogens.

Dayakar *et al.* (1999) observed that the egg and larva of *H armigera* were parasitized by Hymenopterans, later instars by dipterans and pathogens. Bacterial and viral diseases were observed on matured larvae.

Sisgsgaard *et al.* (1999) noted that intersowing of cowpea with pigeonpea increased the natural control of *H. armigera* in pigeonpea. Insecticidal application on pigeonpea had no significant effect on the number of *H. armigera* larvae but had a strong adverse effect on natural enemies generalist predators like anthisids and *Chrysoperla inornatum.*

Shanower *et al.* (1999) summarised the biology and ecology of three most important groups of pests of pigeonpea in the semi-arid and subtropics, flower and pod feeding Lepidoptera (*H. armigera* and *Maruca vitrata* Geyer), pod sucking

Hemiptera, and seed feeding Diptera and Hymenoptera (mainly *Melanagromyza obtusa*). The recent research investigating the complex interactions among pigeonpea, its key pests and their natural enemies was also reviewed. Pigeonpea pest management research has focussed until recently on the identification and development of resistant cultivars and on chemical control.

Minja *et al.* (1999) reported the natural enemies belonging to Coleoptera, Hymenoptera, Diptera and Hemiptera on three pest groups, pod borers (*Helicoverpa armigera, Maruca vitrata* and *Etiella zinckenella* Treitschke pod sucking bugs (*Clavigralla tomentosicollis*) and pod fly (*Melanagronyza chalcosoma*). These natural enemies were found more frequently in Kenya.

Population of *Campoletis chlorideae* was maximum in plants treated with aldrin and parasitism was 37.0 to 42.7 per cent following treatment with monocrotophos and Karanj oil (Prasad *et al.*, 1987).

According to Bilapate *et al.* (1988), parasitism of 1^{st} to 3^{rd} instar *Helicoverpa* larvae by Ichneumonid *Campoletis chlorideae* on *Cajanus cajan* was 1.38 and tachnid *Carcelia* species caused 1.95, 1.08 and 2.89 per cent parasitism of 4^{th} to 6^{th} instar larvae in 1^{st}, 2^{nd} and 3^{rd} generations respectively.

Srinivas (1989) evaluated the extent of parasitism of gram pod borer *H. armigera* by ichneumonid larval parasitoids *Campoletis chlorideae* and *Eriborus* species and reported that both are active from October onwards. The maximum parasitization of *H armigera* larvae (43 9%) was recorded for *Campoletis* *chlorideae* during 1st two weeks of December compared with 18 per cent for *Eriborus* species at the same time.

2.3 SEASONAL INCIDENCE OF *H. armigera* IN PIGEONPEA.

Khaire *et al.* (1989) found that the seasonal incidence of noctuid *H. armigera* on pigeonpea (var ICPL-87) in Maharastra was at 3rd week of October in *kharif* crop and during August on ratoon crop.

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

Verma and Sankhyan (1993) stated that adult activity started during 10th to 11th standard week in the mid hills of Himachal Pradesh.

Chhabra and Kooner (1993) reported that the pest *H. armigera* attained peaks twice in a year i.e., March to April and October in Punjab.

Subbarayudu and Singh (1997) concluded that there is a significant positive relationship between insect catches and duration of sunshine in Andhra Pradesh.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The research was conducted at International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Patancheru, India during the *kharif* season 1999-2000. The materials used and methodology in conducting these experiments are elucidated in this chapter.

3.1 EXPERIMENTAL DESIGN

At ICRISAT farm BW-7 which is a black soil in the watershed area was chosen for the experiment. The soil is clayey with more water holding capacity and the watershed serves the purpose for moisture. A total area of 1512 m^2 was divided into 21 plots, each plot measuring 72 m^2 (8 x 9 m) for seven treatments and three replications. The experiment was conducted in a randomised block design.

3.2 SOWING

A high yielding pigeonpea variety ICPL-87119 (Asha) was used for this trial. The seed was sown in the early *kharif* season on 21-6-1999. The spacing adopted was 150 cm between the rows and 30 cms within the row.

3.3 TREATMENTS

The following treatments were imposed to study their effect on gram pod borer.

a) IPM

This treatment received neem Aza as the first spray at 113 days after sowing (DAS). The second and third sprays were *Helicoverpa* Nuclear Poly Hedrosis Virus HNPV and endosulfan at 132 and 152 DAS respectively. The last one was shaking which was supposed to be done, but due to the decline in the larval population this practice was not done. T-Shapped bird perches(2 mts in height) were installed @ 1 perch/plot on 120 DAS and remained in the plot till the harvest..

b) Helicoverpa Nuclear polyhedrosis virus (HNPV)

Helicoverpa nuclear polyhedrosis virus produced at ICRISAT-HNPV laboratory was used for these studies. The HNPV stock solution was prepared in such a way that 1 ml of HNPV equals to one larval equivalent. The spray was carried out in the evenings so as to protect the virions from the harmful ultraviolet rays. In order to protect from UV rays robin blue was used as a adjuvant in the spray solution @ 1.0 ml/litre of spray fluid. HNPV was used @ 500 LE/ha. The spraying was done by the power sprayer carefully when there was no wind thus avoiding the drift into adjacent plots. A polythene bag was held between the plots while spraying as an extra care to avoid spray drift to other plots. The spraying was done at 113, 132 and 152 days after sowing.

c) **Neem**

Neem 1500 ppm was used in the experiment. The dosage required was 500 ml/ac. The stock solution required for the spray was 6 ml for an area of 72 m^2 plot. The spray fluid required for the plot was 5 litres of water and was sprayed by the power sprayer at 113, 132 and 152 days after sowing.

d) **Shaking**

This is an indigenous technology in the management of the pod borer larvae which was practiced in the olden days. This is the mechanical disturbance by gentle shaking of the plants, the larvae found feeding on the flowers, pods dropped on a polythene sheet spread over the ground.The larvae collected in the polythene sheet were killed by crushing and dropping the debris far from the field. Shaking was done at 113, 130, 141 and 152 DAS in T_5 and at 130, 141 and 152 DAS in T_4

e) **Shaking+Chemical**

On this treatment endosulfan was sprayed at 113DAS and shaking was done at 130,141 and152DAS.

f) **Chemical**

Endosulfan 35 EC was sprayed @ 0.07%. The treatments were given three times at 113, 132 and 152 DAS.

g) **Control**

T_7 is control plot which was left unsprayed.

Experimental details:

Crop	:	Pigeonpea	Variety	:	ICPL 87119
Gross area	:	1512 m^2	Replications	:	3
Plot size	:	8 x 9 m	Treatments	:	7
Gross plot area	:	72 m^2	Design	:	RBD
Net plot area	:	36 m^2			

Treatments:

T_1 - IPM (HNPV + neem + chemical (endosulfan 35 EC 0.07%) + shaking + bird perches

T_2 - HNPV spraying - 500 LE/ha

T_3 - Neem spraying - 1500 ppm

T_4 - Endosulfan 0.07% + shaking

T_5 - Mechanical shaking of plants.

T6 - Endosulfan 0.07%

T7 - Control

METHOD OF RECORDING OBSERVATIONS

At ICRISAT Centre

a) **Insect pest population**

The predominant pest was *Helicoverpa armigera*. The activity of this pest started from the early flowering stage. Five plants were randomly selected

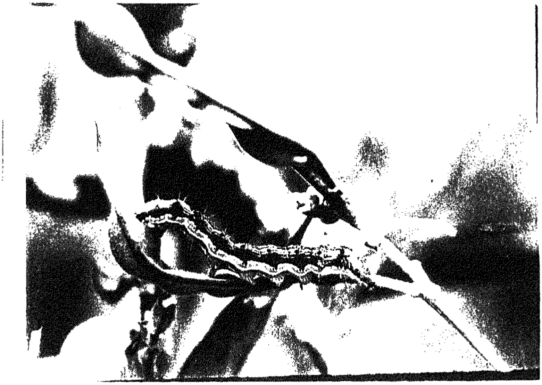


Plate 3: *Helicoverpa armigera* larvae feeding on the pod of pigeonpea

Plate 4: HNPV affected larvae of *Helicoverpa armigera*

from each plot and number of *Helicoverpa* eggs and larvae were counted. The population of *Maruca* and blister beetles were also recorded.

The observations were taken at 9 day intervals starting from 113 DAS upto crop maturity.

b) Monitoring of natural enemies

The population count of general predators like spiders and coccinellids was taken on 5 randomly selected plants from each plot. The initial natural enemy population was taken at 121 DAS and the other two observations were taken at 130 and 145 DAS.

c) Pod and seed damage

Pod damage was calculated by selecting 20 plants from the net plot and the pods were collected in a cover and labelled.

To avoid the effects of drift from the neighbouring treatments border rows were left one on either side and a one mt distance on either side of the row was left and the remaining part was considered as a net plot. The area was 36 m^2 (6 x 6 m).

In the laboratory the number of pods damaged by pod borer, pod fly and bugs were counted and the percentage pod damage was worked out for all treatments and replications.

$$\text{Per cent pod damage} = \frac{\text{No. of damaged pods}}{\text{Total no. of pods}} \times 100$$

Seed damage was estimated by pooling the pods and selecting 100 pods and counting the total locules and damaged locules by borer, pod fly and bug.

$$\text{Per cent seed damage} = \frac{\text{No. of damaged locules}}{\text{Total locules}} \times 100$$

Yield

The plants in the net plot were harvested separately and threshed. The threshed grains were cleaned, weighed and the net plot yields were obtained The pods collected from 5 plants for the damage assessment were also threshed, cleaned and weighed and these weights were added to the net plot yield.

Simple correlation regression analysis was carried out using yield as dependent variable (y) and pod damage as independent variable (x)

Weather data

The weather parameters viz., maximum, minimum temperatures (°C), total rainfall (mm) and relative humidity (%) were recorded daily at meteorological observatory at ICRISAT, which were obtained from agroclimatological division of ICRISAT. The mean weather data that prevailed in every standard week during cropping season (*kharif* 1999 June-December) were calculated.

Monitoring of *Helicoverpa armigera* moth activity using sex pheromone

The sex pheromone of *H. armigera* prepared at Natural Resources Institute, Chatham, UK was obtained through ICRISAT and was used in the experiment. The lures were impregnated in polythene vial septa with 97:3 blend of (Z) 11-hexadecenal and 2-9-hexadecenal.

The vials containing pheromone were kept in dry funnel trap and were changed once in 30 days. The trap was set up @ 1 trap/ha at two metres height and maintained through out the cropping season. The number of male moths caught was counted and removed daily. Total number of moths caught per standard week was worked out to monitor the peak moth emergence period.

STATISTICAL ANALYSIS

The observations of the laboratory data and field pest populations data i.e., egg and larvae were analysed by using the standard analysis of variance procedures. The data on percentage were transformed into arcsin values and the populations into square root values before analysis. The test of significance was assessed using the critical difference at 5% level (Gomez and Gomez, 1970). For the purpose of correlation and regression studies, since transformation was not required, the analysis were carried out as such with actual data.

Cost benefit ratio

To know the economics of different treatments, the quantity and cost of insecticide for all the three sprays was calculated and the cost incurred on labour charges for spraying and for shaking were taken into consideration. The income was calculated by considering the prevailing market price of the produce obtained in different treatments. The costs and benefits were tabulated and their ratio was calculated and compared.

ON FARM

1) Village: Gulladurthi; Kurnool district.

The egg count and the larval population on about 5 plants in each farmers field were taken.

In this village some farmers grew pigeonpea during the *rabi* season i.e., October sowing. All the farmers use ICPL 85063 (Laxmi) variety In these fields 5 fields each with IPM practices and non IPM practices were selected In each field observations were recorded on *Helicoverpa* eggs and larvae on 5 randomly selected plants. Observations were taken at 15 days interval

The treatments received by IPM farmers included neem, NPV,endosulfan, bird perches etc and non IPM farmers include endosulfan and other synthetic pyrethroids like Cypermethrin . In addition, observations were also taken on farmer's fields where shaking is a common practice and compared with other treatments.

The per cent pod damage by *Helicoverpa* and grain yield was recorded and tabulated.

The cost benefit ratio was calculated taking into consideration the costs of chemicals and income from the produce

RESULTS

CHAPTER IV

RESULTS

With a view to compare various components of integrated pest management strategies against *Helicoverpa armigera* (Hubner) on pigeonpea, investigations were carried out in field during rainy season (*kharif*) of 1999-2000 at International Crops Research Institute for the Semi Arid Tropics, Patancheru, Andhra Pradesh and the results have been presented in this chapter.

EFFICACY OF DIFFERENT TREATMENTS ON THE OVIPOSITION PREFERENCE OF *H. armigera*

The performance of various treatments on the ovipositional behaviour of *H.armigera*, is presented in table 1 and fig.1.

The pre treatment count taken at 112 DAS revealed uniform ovipositional behaviour of *H. armigera* moths throughout the experimental area with a mean number of 2.45 eggs/plant.

First spray

One day after first spray, neem and IPM plots recorded lowest egg population (1.33/plant and 1.26/plant respectively) as IPM plot also received neem as first spray. Endosulfan treated plots stood next in order of efficacy (1.40/plant) followed by the plots sprayed with NPV (1.53/plant). The manual shaking had minimum effect on the oviposition behaviour. So more (1.80/plant) egg population was recorded. The highest number of eggs was found in control plot (2 73/plant) where there was no disturbance.

Even at 9 days after treatment (DAT) neem was found to be superior as an oviposition deterrent recording the lowest number of eggs (1.26/plant). IPM and NPV plots were on par recording nearly equal population (1.66/plant). The egg population in endosulfan treated plots increased slightly, followed by shaking of plants (1.66/plant) and control with maximum number of eggs (2.93).

On 18 DAT, T_4 (chem + shaking) plot was significantly effective with reduced ovipositional preference (1.53/plant) which was on par with neem treated plot (1.53). IPM plots and endosulfan treated plots were on par (1.66/plant). In control plots egg laying was significantly higher (2.73/plant).

Second spray

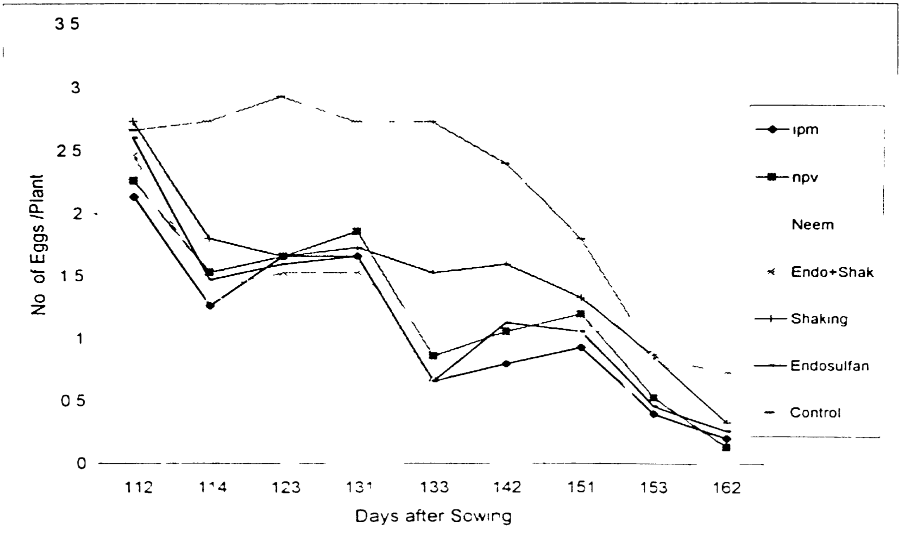
At first and ninth day after second spray also neem and IPM stood first in reducing the oviposition by registering the minimum number of eggs, (0.66 and 0.86 per plant) for neem and for IPM(0.66 and 0.80) which was closely followed by endosulfan (0.66 and 1.13). The egg population remained relatively higher 1.06 and 1.53 at 9 DAT and 1.0 and 1.60 at 18 DAT in T_4 and T_5. Control recorded the highest number of eggs with 2.73 and 2.4 at 1^{st} and ninth DAT. At 18 DAT the egg population in IPM plot was found to be least (0.93/plant). In all the remaining treatments the number of eggs showed slight increase whereas in endosulfan treated plot there was a slight decrease in the egg number (Table 1, Fig.1).

Table 1: Efficacy of different treatments on the oviposition preference of gram pod borer *Helicoverpa armigera* - ICRISAT center, Patancheru, rainy season 1999 – 2000.

Treatment	DAS	No. of eggs plant^{-1}									* Mean	% decrease over control
		112	114	123	131	133	142	151	153	162		
T_1 IPM		2.13	1.26	1.66	1.66	0.66	0.80	0.93	0 40	0.20	0 95	54 98
-		(1.62)	(1.32)	(1.47)	(1.47)	(1.07)	(1.13)	(1.19)	(0.94)	(0.83)		
T_2 NPV		2.26	1.53	1.66	1.86	0.86	1.06	1.20	0.53	0.13	1.10	47.87
		(1.66)	(1.42)	(1.46)	(1 53)	(1.16)	(1.25)	(1.30)	(1.01)	(0.79)		
T_3 Neem		2.33	1.33	1.26	1.60	0.66	0.86	1.06	0.33	0.00	0.89	57.82
		(1.67)	(1.35)	(1.32)	(1.44)	(1.07)	(1.16)	(1.25)	(0.91)	(0.70)		
T_4 Endosulfan + shaking		2.46	1.40	1.53	1.53	1 06	1.00	1.13	0.86	0.46	1.12	46.92
		(1.71)	(1.37)	(1.42)	(1.42)	(1.24)	(1.22)	(1.27)	(1.16)	(0.98)		
T_5 Shaking		2.73	1.80	1.66	1.73	1 53	1.60	1.33	0.86	0.33	1.33	36 96
		(1.79)	(1.50)	(1.47)	(1 49)	(1.42)	(1.44)	(1.35)	(1.16)	(0.90)		
T_6 Endosulfan		2.60	1.40	1.60	1.66	0 66	1.13	1.06	0.46	0.26	1.03	51 18
		(1.76)	(1.37)	(1 44)	(1.47)	(1.07)	(1.27)	(1.25)	(0.97)	(0.87)		
T_7 Control		2.66	2.73	2.93	2.73	2.73	2.4	1.80	0.86	0.73	2.11	
		(1 77)	(1.79)	(1.85)	(1 79)	(1.79)	(1.69)	(1.51)	(1.16)	(1.10)		
SEd		0.074	0.094	0 047	0.051	0 060	0.061	0.043	0.081	0.063		
C.D at 5%		0 149	0.189	0 095	0.104	0.121	0.124	0.086	0.163	0.127		

Figures in parenthesis are square root transformed
DAS Days after sowing
* mean . Pretreatment values not included
Sprays were given at 113, 132 and 152 DAS

Fig 1 Efficacy of Different Treatments On the Oviposition Preference of Gram podborer *Helicoverpa armigera* - ICRISAT center Patancheru rainy season 1999-2000



Third spray

At first day after the third spray neem was found to be highly effective by recording the lowest number of eggs (0.33) which was on par with IPM (0.40) which received endosulfan as a treatment at this stage. Plot treated with endosulfan (0.46) ranked next. Shaking plots registered 0.85 eggs per plant which was on par with control (0.86).

Nine days after third spray the egg population in all the treatments declined drastically.

In general, throughout the cropping period neem and IPM were found to be effective treatments in suppressing the oviposition, followed by endosulfan wherein its effect is seen only upto 9 DAT. The plots where shaking was done recorded more number of eggs, it was not upto the level of control. The ovipositional preference in different treatments was as follows.

$T_1 > T_3 > T_6 > T_2 > T_4 > T_5 > T_7$

EFFECT OF DIFFERENT TREATMENTS AGAINST THE LARVAL POPULATION OF GRAM POD BORER *H. armigera*

Studies conducted to assess the efficacy of different treatments against the larval population of gram pod borer *H. armigera* revealed the following results which are elucidated in table 2 and fig.2. Larval population was uniform throughout the experimental area before imposing the treatments (Table 2, Fig.2).

Perch in project pea field

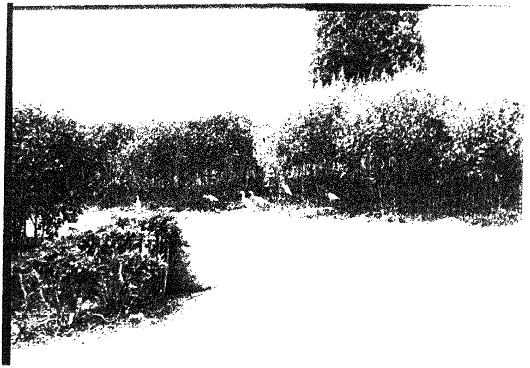


Plate 5: Birds feeding on *Helicoverpa armigera* larvae

First spray

One day after the first spray the shaking was found to be superior by recording 0 4 larvae/plant as against 2 4 larvae/plant in control (as shaking was a mechanical method of controlling larvae where they were dislodged from plants and destroyed), followed by endosulfan in T_4 and T_6 with 1 00 and 1 33 larva/plant respectively NPV and Neem were at par (1 26/plant), followed by IPM (1 40) which received neem as treatment At 9 DAT the lowest population was recorded in endosulfan, NPV and neem (1 53/plant) followed by IPM (1 6/plant) At ninth day after treatment the larval population increased in shaking plot to 2 26 larvae/plant however control recorded maximum number of larvae (2 6)

At 18 DAT shaking was done in treatments T_4 and T_5 wherein they were tested for mechanical control measure These treatments recorded the lowest number of eggs 0 33 and 0 40 in T_4 and T_5 respectively followed by NPV (1 80) endosulfan on par with IPM (1 86) and non neem (1 93) control with higher population of 2 86 larva/plant

Second spray

The day after second spray endosulfan was found to be highly effective in controlling the larvae (0 73 larva/plant) followed by IPM and NPV (0 80) and then neem (0 93) The shaking plots T_4 and T_5 where no spraying was applied larval population increased to 1 40 and 1 53 respectively The larvae in control plot remained the highest with 2 60 per plant Nine days after second spray with shaking in T_4 and T_5 The larval population was found to be least in shaking plots with 0 33 larvae/plant in T_4 and T_5 plots followed by NPV 1 13 larvae/plant IPM 1 20 larvae/plant and neem (1 26) Control plots had 2 46 larvae/plant

Eighteen days after second spray there was a slight increase in the larval population in almost all the treatments In the shaking plots (2 0) there was a sudden rise in the population but in control (2 06) there was a slight decrease in the population (Table 2, Fig 2)

Third spray

One day after the application of various treatments and shaking in T_4 and T_5 the least larval population was found in T_4 and T_5 (0 20 and 0 26 respectively)followed by IPM NPV, neem (0 53) endosulfan (0 73) and control (2 06) which has recording maximum larval population

Nine days after 3rd spray the crop was close to maturity and the larval population declined uniformly across the treatments

In general, the initial population was uniform throughout the experimental area After inducing various treatments the larval population had fluctuated during different days of crop growth Initially shaking treatment was found to be the most effective for early instar larvae and at the peak flowering stage, with 80 per cent larval reduction but this is effective upto 7 days

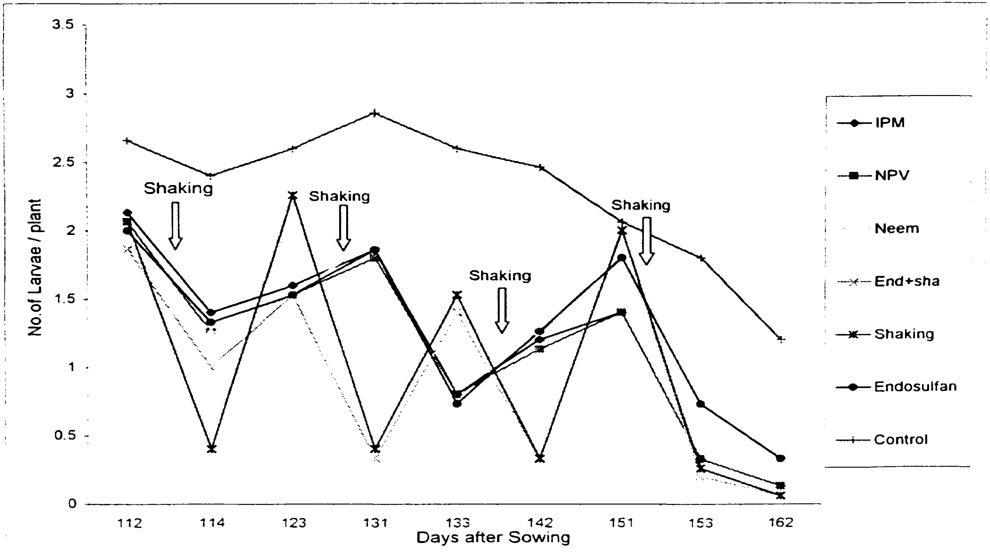
Endosulfan was effective on early instar larvae of *Helicoverpa* upto 9 DAT Eventhough NPV and neem were found to be reducing the larval population IPM was concluded as the best effective treatment followed by shaking and

Table 2 Efficacy of different treatments against the gram pod borer (*H armigera*) larvae - ICRISAT center, Patancheru, rainy season 1999 – 2000

Treatment		No of larvae plant^{-1}									Overall effect	% decrease over control
	DAS	112	114	123	131	133	142	151	153	162		
T_1 IPM		2 133 (1 622)	1 40 (1 37)	1 60 (1 44)	1 86 (1 53)	0 80 (1 13)	1 20 (1 30)	1 40 (1 37)	0 33 (0 91)	0 13 (0 79)	1 1	51 6
T_2 NPV		2 066 (1 600)	1 26 (1 32)	1 53 (1 42)	1 80 (1 51)	0 80 (1 14)	1 13 (1 27)	1 40 (1 37)	0 33 (0 91)	0 13 (0 79)	1 1	53 3
T_3 Neem		1 866 (1 53)	1 26 (1 32)	1 53 (1 42)	1 93 (1 55)	0 93 (1 19)	1 26 (1 32)	1 66 (1 47)	0 53 (1 01)	0 20 (0 83)	1 2	48 4
T_4 Endosulfan + shaking		1 866 (1 53)	1 00 (1 22)	1 53 (1 42)	0 33 (0 91)	1 40 (1 37)	0 33 (0 91)	2 00 (1 58)	0 20 (0 83)	0 06 (0 75)	0 9	62 2
T_5 Shaking		2 066 (1 60)	0 4 (0 94)	2 26 (1 65)	0 40 (0 94)	1 53 (1 42)	0 33 (0 91)	2 00 (1 64)	0 26 (0 86)	0 06 (0 75)	0 9	60 0
T_6 Endosulfan		2 00 (1 58)	1 33 (1 27)	1 53 (1 42)	1 86 (1 53)	0 73 (1 10)	1 26 (1 32)	1 8 (1 51)	0 73 (1 10)	0 33 (0 91)	1 2	46 7
T_7 Control		2 66 (1 77)	2 4 (1 7)	2 6 (1 76)	2 86 (1 83)	2 60 (1 75)	2 46 (1 72)	2 06 (1 60)	1 8 (1 51)	1 2 (1 30)	2 3	-
SEd		0 060	0 050	0 074	0 052	0 055	0 070	0 042	0 067	0 056		
C D at 5%		0 121	0 101	0 150	0 106	0 112	0 141	0 086	0 136	0 113		

Figures in parenthesis are square root transformed
DAS Days after sowing
Sprays were given at 113 132 and 152 DAS

Fig. 2: Efficacy of Different Treatments Against the Gram podborer *H. armigera* Larvae, ICRISAT center, Patancheru, rainy season, 1999-2000



endosulfan which maintained its supremacy in suppressing the population of *H armigera* until crop harvest The efficacy of various treatments was as follows

$T_4 > T_5 > T_1 > T_2 > T_6 > T_3 > T_7$

EFFICACY OF DIFFERENT TREATMENTS ON NATURAL ENEMIES IN PIGEONPEA

To assess the treatmental effects on natural enemies that live in pigeonpea canopy the population of spiders, coccinellids, chrysopids, ichneumonids, reduviid bugs, mud wasps were taken into consideration and the results are presented in Table 3 and Fig 3

At 130 DAS i e , eight DAT after first spray endosulfan recorded the lowest natural enemy (NE) population (1 6/plant) The IPM components like NPV and neem were found to be least harmful to NE with IPM (2 6/plant), NPV (2 8/plant), neem (2 2/plant) However the T_5 shaking and control had the highest NE population

At 145 DAS in all the treatments there was a general declining trend in NE population Endosulfan and neem (0 8) having least NE, followed by NPV (1 0) and IPM (1 2) The shaking plots recorded 1 0 and 2 2 NE in T_4 and T_5 respectively with control on the top of the chart (2 6)

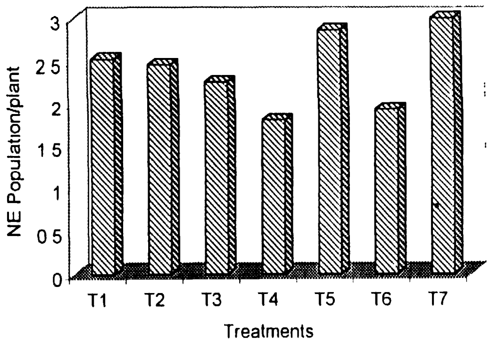
The overall effect showed that treatments left unsprayed i e , T_5, T_7 and IPM leaded its supremacy in maintaining the natural enemy population

Table 3 Effect of different treatments on natural enemies living in pigeonpea crop canopy

Treatment DAS	No of natural enemies (NE)/plant 121	130	145	Overall effect	% decrease over control
T_1 IPM	3 8 (11 22)	2 6 (9 24)	1 2 (6 19)	2 53	15 6
T_2 NPV	3 6 (10 93)	2 8 (9 6)	1 0 (5 72)	2 46	18 0
T_3 Neem	3 8 (11 23)	2 2 (8 47)	0 8 (5 1)	2 26	24 6
T_4 Endosulfan + shaking	2 8 (9 6)	1 6 (7 24)	1 0 (5 72)	1 8	40 0
T_5 Shaking	3 4 (10 61)	3 0 (9 96)	2 2 (8 49)	2 86	4 6
T_6 Endosulfan	3 2 (10 28)	1 8 (7 68)	0 8 (5 01)	1 93	35 6
T_7 Control	3 4 (10 62)	3 0 (9 96)	2 6 (9 24)	3 0	-
SEd	0 339	0 370	0 424		
C D at 5%	0 739	0 824	0 924		

Figures in parenthesis are square root transformed
NE = Spiders, coccinellids, lace wings
DAS = Days after sowing

Fig 3 Effect of different treatments on natural enemies living in pigeonpea crop canopy- ICRISAT centre Patancheru, rainy season 1999-2000



T1 = IPM
T2 = HNPV
T3 = Neem
T4 = Endosulfan + Shaking
T5 = Shaking
T6 = Endosulfan
T7 = Control

EFFECT OF VARIOUS PLANT PROTECTION STRATEGIES ON POD DAMAGE BY *H. armigera* ON PIGEONPEA

The effect of different treatments on the pod damage by *H armigera* in pigeonpea was assessed and the results are given in table 4 and fig 4 The results revealed that the maximum pod damage was observed in control (28 0%) Among various treatments, IPM was found to be the best treatment by recording the lowest pod damage (15 1%) which was about 46 16 per cent less than that in control Endosulfan stood next in order of efficacy with 17 5 per cent pod damage which was 32 43 per cent less than the control NPV and endosulfan + shaking were found to be on par by recording 18 7 per cent and 18 5 per cent pod damage respectively which was 33 1 and 34 1 per cent reduction over control Neem (20 1%) with 28 2 per cent reduction over control was on par with shaking (19 6%) with 30 0 per cent reduction over control Eventhough the shaking did not receive any spray it recorded significantly less pod damage compared to control (Table 4, Fig 4)

Besides pod damage by *Helicoverpa* observations on pod fly incidence at harvest indicated 5 6 per cent pod damage in control Though the incidence of pod fly was less the treatment with endosulfan resulted in lower damage with 2 1 per cent followed by IPM (2 8%), Endosulfan + shaking (3 0%), HNPV (3 7%), Neem (3 8%) and shaking alone (4 9%)

EFFECT OF DIFFERENT PLANT PROTECTION STRATEGIES ON THE GRAIN YIELD OF PIGEONPEA

The efficacy of different treatments on grain yield of pigeonpea studies are elucidated in table 5 and fig 5 The results revealed that IPM was found

Table 4 Effect of various IPM components on the pod damage caused by *H armigera* on pigeonpea - ICRISAT center, Patancheru, rainy season 1999 – 2000

Treatment	% pod damage	% decrease over control
T_1 IPM	15 1 (22 85)	46 2
T_2 NPV	18 8 (25 65)	33 1
T_3 Neem	20 1 (26 64)	28 3
T_4 Endosulfan + shaking	18 5 (25 47)	34 1
T_5 Shaking	19 6 (26 29)	30 0
T_6 Endosulfan	17 6 (24 76)	37 4
T_7 Control	28 1 (31 98)	
SEd	0 358	
C D at 5%	0 781	

Figures in parenthesis are arcsin transformed

Table 5 Effect of different plant protection strategies on grain yield of pigeonpea - ICRISAT center, Patancheru, rainy season 1999 – 2000

Treatment	Yield (kg/ha)	% increase over control
T_1 IPM	632	54 14
T_2 NPV	477	16 34
T_3 Neem	462	12 68
T_4 Endosulfan + shaking	574	40 00
T_5 Shaking	532	29 75
T_6 Endosulfan	607	48 04
T_7 Control	410	
SEd	5 981	
C D at 5%	13 03	

Fig.4: Effect of various IPM components on the pod damage caused by H. armigera on pigeonpea - ICRISAT centre Patancheru, rainy season 1999-2000

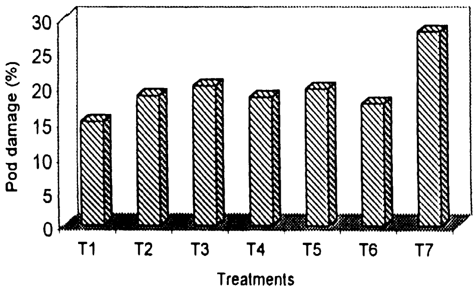


Fig.5: Effect of different plant protection strategies on grain yield of pigeonpea - ICRISAT center Patancheru, rainy season 1999-2000.

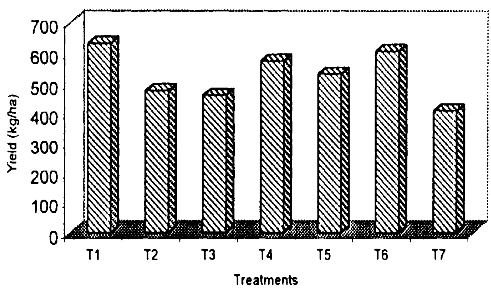


Plate 6: Bug feeding on *Helicoverpa armigera* larvae

to be the best effective treatment which recorded 632 kg/ha which resulted in 54.14 per cent increase over control, followed by endosulfan spray 607 kg/ha which recorded 48.04 per cent increase over control. Endo + shaking treatment gave 574 kg/ha which was over 40 per cent increase over control The shaking treatment (532 kg/ha) which showed 29.07 per cent increase over control comes next best after T_4. NPV (477 kg/ha) and neem (462 kg/ha) were on par and found to be significantly effective (410kg/ha)over control.

CORRELATION BETWEEN YIELD AND POD DAMAGE

It was found that there was significant negative correlation (r = -0.8421) between yield and pod damage both at 1 per cent and 5 per cent levels. So when pod damage decreases, yield will increase. Pod damage contributed to 65.1 per cent towards yield (R^2 = 0.6510288).

SEASONAL INCIDENCE OF *H. armigera* ON PIGEONPEA

Studies on seasonal incidence of *H. armigera* were carried out with a view to find out peak period of activity during kharif season and also the population fluctuations in relation to crop phenology.

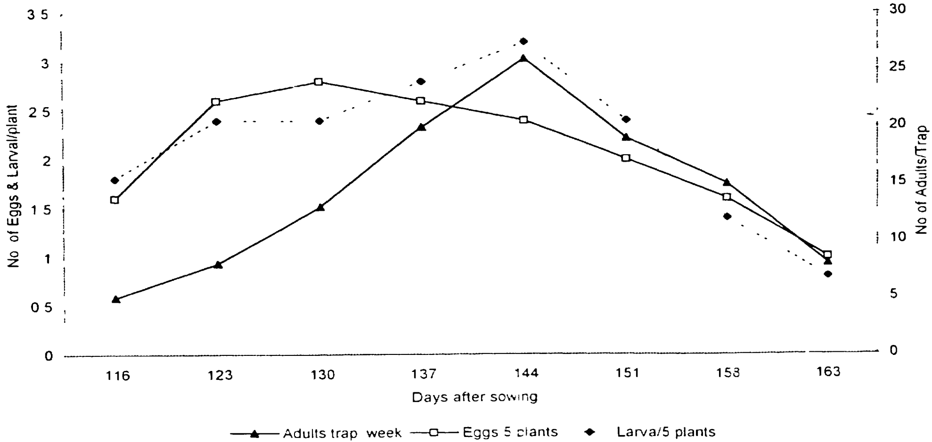
a) Monitoring of *H. armigera* adults using sex pheromone trap

To monitor peak emergence of *H. armigera* moth population using pheromone traps, daily observations were taken and total number of moths caught per standard week were calculated and presented in table 6 and fig.6. A perusal of the data in table 6 and fig.6 indicated that maximum moth was observed during 41st and 42nd standard weeks of 1999 with 20 and 26 adults per trap.

Table 6: Monitoring of *H. armigera* adults, eggs and larvae at different stages of pigeonpea crop - ICRISAT center, Patancheru, rainy season 1999 – 2000.

DAS	Eggs / plant	Larva / plant	Adults /trap/week
116	1.6	1.8	5
123	2.6	2.4	8
130	2.8	2.4	13
137	2.6	2.8	20
144	2.4	3.2	26
151	2.0	2.4	19
158	1.6	1.4	15
163	1.0	0.8	8

Fig 6 Monitoring of *H armigera* adults eggs and larvae at different stages of pigeonpea crop - ICRISAT centre Patancheru, rainy season 1999-2000



b) Oviposition in relation to age of crop

The number of eggs laid were recorded on 5 plants at 7 day interval starting from 116 DAS

The data in table 6 and fig 6 showed that the number of eggs laid was 1 6 per plant at 116 DAS and reached a peak of 2 6 per plant at 130 DAS The eggs started decreasing at 144 DAS So the egg laying was observed to be maximum at 130 DAS i e 40th standard week in 3rd fortnight of October

c) Larval population in relation to age of the crop

The larval population was recorded on 5 plants at weekly intervals from 120 DAS The pest incidence was started at early flowering stage A perusal of data in table 7 and fig 6 revealed that larval population was less at 120 DAS (1 8 per plant) A gradual increase in larval population was observed thereafter and attained the peak at 144 DAS (3 2larvae/ pl) The larvae started decreasing at 151 DAS (2 4 plant) The peak activity of pest was observed in 144 DAS when crop was at peak flowering to early podding stage

ECONOMICS OF DIFFERENT TREATMENTS IN DETERMINING THE EFFICACY OF VARIOUS IPM COMPONENTS

To know the economics of different treatments cost benefit ratios were worked out and presented in table 7 If we examine the table shaking treatment was found to be the best one with 1 7 1 followed by endosulfan + shaking (1 6 4) endosulfan (1 6 2) IPM (1 5 5) neem (1 4 6) and NPV (1 3 4) Eventhough the

Table 7 Cost benefit ratio of different treatments against *Helicoverpa armigera* in Pigeonpea – ICRISAT center, Patancheru, rainy season 1999 – 2000

Treatments		Grain yield (kg/ha) Gross	Extra yield over control	Total cost of insecticidal treatment Rs/ha	Additional income Rs/ha	Total income Rs/ha	C : B ratio
T_1	IPM	632	222	1700	3180	9480	1 : 5.57
T_2	NPV	477	67	2100	1005	7155	1 : 3.40
T_3	Neem	462	52	1500	780	6930	1 : 4.62
T_4	Endosulfan + shaking	574	164	1340	2460	8610	1 : 6.42
T_5	Shaking	532	122	1120	1830	7980	1 : 7.125
T_6	Endosulfan	607	197	1475	2955	9105	1 : 6.17
T_7	Control	410	-	-	-	6150	-

yield was not the highest (532 kg/ha) in this treatment the C:B ratio is high (1:7.1)because of very low inputs on plant protection.

ON FARM

1) Village Gulladurthi, Kurnool district

a) Oviposition of *H. armigera* in farmers fields under different plant protection practices:

Five farmers fields in each of the IPM and non IPM practicing locations were taken and 5 plants in each farmers field were selected for the egg count and results were tabulated in table 8a, fig.7a. In IPM plots the maximum count was observed (13.6) at 93 DAS and later it started declining to 8.2 at 107 DAS and 3.2 at 121 DAS. Similarly in non IPM plots initially it was low (2.2) at 76 DAS recorded a maximum of (7.4) at 93 DAS and started declining thus at 107 and 121 DAS with 4.2 and 2.2 respectively.

b) Larval population fluctuation in farmers fields under different plant protection regimes:

The average of larval population represented in table 8b, fig 7b showed that, in IPM plots the population was initially low at 76 DAS (2.6larva/plant). The maximum population was observed at 93 DAS (7.4 larvae/plant) after that there was a sudden decline in population by (1.2larvae/plant) at 107 DAS and it further declined to (0.5 larvae/plant) at 121 DAS.

Fig 7a Oviposition of *H armigera* in IPM & non IPM farmers fields at Gulladurthi village Kurnool dist

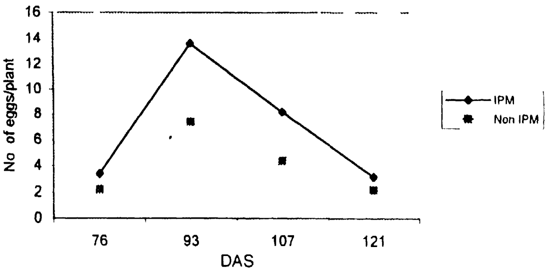


Fig 7b Larval population of *H armigera* in IPM and non IPM farmers fields at Gulladurthi village Kurnool dist

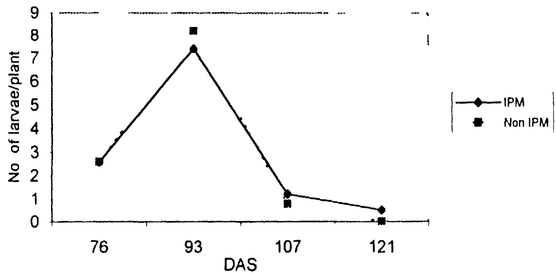


Fig 7c Yield & pod damage in IPM & non IPM fields at Gulladurthi village Kurnool dist

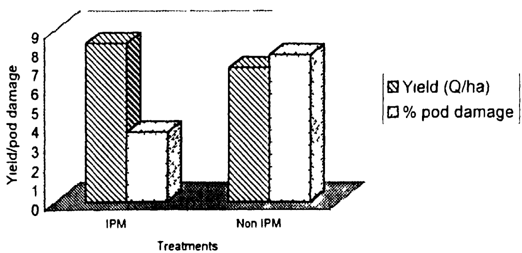


Fig 7d Larval population in different treatments in farmers fields at Gulladurthi villager, Kurnool dist

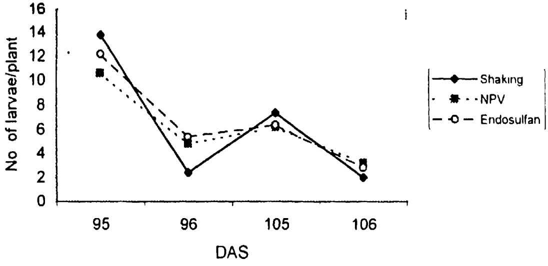
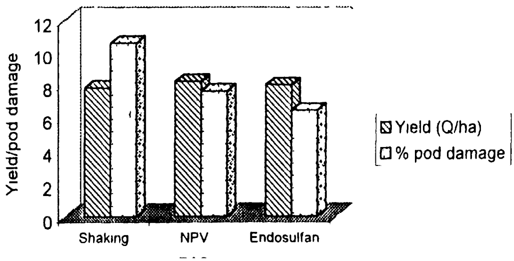


Fig 7e Yield & pod damage of shaking NPV & endosulfan treatments in farmers fields at Gulladurthi village, Kurnool dist



The similar trend was observed in non IPM plots also with maximum population at 93 DAS (8.2) and declined to 0.7 larvae/plant by 107 DAS.

c) Grain yield and pod damage by pod borer in different plant protection practices:

Data on pod damage and grain yield were presented in table 8c, fig.7c. It was clear from the data that IPM plots recorded 57percent less pod damage than the non-ipm plots. This has resulted in obtaining increased yield (830kg/ha)in ipm plots compared to non-ipm plots(700kg/ha).

The pod damage was in the inverse proportion with maximum damage in non IPM (7.7%) and minimum damage in IPM (3.6%).

Economics

The economics was looked into by calculating the cost benefit ratio. The results were represented in table 8d. The maximum C:B ratio is obtained for IPM (1:7.1) involving lower investment on chemicals and low C:B ratio in case of non IPM (1:4.6) involving more expenditure on chemicals.

d) Efficiency of shaking treatment in comparision with NPV and endosulfan against *H. armigera* larvae in the farmers field in Gulladurthi village:

The observations were made in three farmers fields who were practicing shaking, spraying HNPV and endosulfan on 5 randomly selected plants at 95 and 105 DAS in each treatment. The average values of results were represented in table 8e, fig. 7d.

Table 8a Oviposition of *H armigera* in IPM & non IPM farmers fields at Gulladurthi village, Kurnool Dist

DAS	76	93	107	121
IPM	3 4	13 6	8 2	3 2
Non IPM	2 2	7 4	4 4	2 2

Table 8b Larval population of *H armigera* in IPM and non IPM farmers fields at Gulladurthi village, Kurnool dist

DAS	76	93	107	121
IPM	2 6	7 4	1 2	0 5
Non IPM	2 6	8 2	0 76	0

Table 8c Yield & pod damage in IPM & non IPM fields at Gulladurthi village, Kurnool Dist

Treatment	Yield (kg/ha)	% pod damage
IPM	830	3 6
Non IPM	700	7 7

Table 8d Economics i e cost benefit ratio

Treatment	Grain yield (kg/ha)	Total cost of treatment (Rs)	Total income (Rs)	C B ratio
IPM	830	1750	12450	1 7 1
Non IPM	700	2250	10500	1 4 6

Table 8e Larval population in different treatments in farmers fields at Gulladurthi village, Kurnool Dist

DAS	95	96	105	106
Shaking	13 8	2 4	7 4	2 0
NPV	10 6	4 8	16 2	3 2
Endo 0 07%	12 2	5 4	6 4	2 8

Table 8f Yield & pod damage of shaking, NPV & endosulfan treatments in farmers fields at Gulladurthi village, Kurnool dist

Treatment	Yield (kg/ha)	% pod damage
Shaking	780	10 6
NPV	820	7 6
Endosulfan	800	6 4

Table 8g Economics i e cost of benefit ratio

Treatment	Grain yield (kg/ha)	Total cost of treatment (Rs)	Total income (Rs)	C B ratio
Shaking	780	1120	11700	1 10 4
NPV	820	2100	12300	1 5 8
Endosulfan	800	2000	12000	1 6

The maximum percentage reduction in larval population was observed in shaking 82.6 per cent at 95 DAS and 72.97 per cent at 105 DAS compared to NPV and endosulfan.

NPV recorded 54.71 per cent and 48.38 per cent reduction in larval number at 95 and 105 DAS respectively. Endosulfan 0.07 per cent recorded 55.73 per cent and 56.25 reduction in larval number at 95 and 105 DAS respectively.

d) Yield and pod damage of shaking, HNPV and endosulfan in farmers fields of Gulladurthi village, Kurnool district:

From the mean values of the results represented in table 8f, fig.7c. NPV recorded highest yield (820 kg/ha) followed by endosulfan (800 kg/ha) and then by shaking (780 kg/ha).

The pod damage recorded was highest in shaking (10.6%) followed by NPV (7.6%) and then endosulfan (6.4%).

Economics

The cost benefit ratios were calculated and represented in table 8g. Shaking was found to be the best with highest C:B ratio 1:10.4, followed by endosulfan 1:6 and then by NPV 1:5.8.

DISCUSSION

CHAPTER V

DISCUSSION

Helicoverpa armigera (Hubner) is a major pest on pigeonpea. This is because of its higher fecundity, multiple generations, polyphagy and migratory behaviour. With a view to compare the efficacy of various components of IPM against *H. armigera* in pigeonpea, studies were carried out during kharif season 1999-2000 at ICRISAT, Patancheru, A.P. The results of the experiments are discussed in this chapter.

Efficacy of different treatments on the ovipositional preference of *H.armigera*

The overall effect of all the sprays and shakings (Table 1 and Fig.1) revealed that neem was effective in reducing the ovipositional preference of *H armigera* by recording 57.8 per cent reduction over control followed by IPM in order of efficacy with 54 per cent reduction over control, since it received neem as first spray. Next comes endosulfan in the order with 51 per cent reduction over control, here the effect is upto 5 days after treatment.

Rao and Rao (1993) reported that application of 1.5 per cent Replin 1500ppm on pigeonpea against *H. armigera* was found to be effective in reducing the oviposition.

Rosaiah (1992) stated that Replin showed maximum ovipositional repellency of *H. armigera* on cotton. Anwar *et al.* (1993) observed 50 per cent reduction in oviposition by *H. armigera* treated with neem oil compared to untreated

Plate 7: Shaking technique adopted in pigeonpea crop

Good pigeonpea crop

crop. The present studies also showed the ovipositional deterrance of Neem against *H.armigera* with 58 percent reduction in oviposition against control plots.

Efficacy of various treatments on the larval population of *H. armigera*

Amongst the treatments T_4 (Endosulfan + shaking) was the superior treatment which recorded 62.2 per cent reduction in the larval population over control. In T_4 the first interception was with endosulfan as it was effective mostly on small sized larvae then the mechanical shaking wherein the larvae were collected and destroyed.

Effect of different treatments on natural enemies

The natural enemy population in all treatments declined with the age of crop. The overall effect showed that (Table 3 and Fig.3) among the treatments endosulfan (T6) and Endosulfan + Shaking (T4) showed the most suppressing effect on natural enemies with 35.6 – 40 per cent reduction over control. The percentage reduction of natural enemy population over control was the least in shaking treatment (4.6 per cent) as it received no chemicals. However Sanap *et al*(1990) reported that natural enemy population was not affected by endosulfan sprayed against *H.armigera* on pigeonpea in india.

Effect of various treatments on the pod damage caused by *H. armigera*

The overall effect showed that (Table 4 and Fig.4) among the treatments IPM was found to be best with lowest pod damage (15.1%) which was about 46.2 per cent less over control followed by endosulfan with 17.6 per cent pod damage which was 37.4 per cent less over control. HNPV spray and endosulfan +

shaking registered 33.1 per cent and 34.1 per cent reduction over control and were on par. The pod damage was more in neem and shaking treatments with 28.3 per cent and 30 per cent reduction over control.

The percentage pod damage was observed to be low in IPM which was concluded as the superior strategy in managing the gram pod borer, *H. armigera* in pigeonpea. Giraddi *et al.* (1994) reported that lowest pod damage was obtained in treatments receiving three rounds of spray of NPV and pyrethroids while NPV or insecticide alone failed to give appreciable control.

Neharkar *et al.* (1999) reported that in control of *Helicoverpa* on pigeonpea cv. BDN-2 HNPV treatment recorded lowest pod damage (26.51%).

Chaudhary *et al.* (1995) reported that endosulfan spray applied at the reproductive stage of the pigeonpea crop effectively reduced the pod damage by *H armigera* (18.5%).

Thakaur *et al.* (1989) reported that 21.6 per cent of pods and 12.1 per cent of grains of pigeonpeas were damaged by *H. armigera* in treated fields as compared with 43.7 and 37.2 per cent in pods and grains respectively in untreated fields (12.3%).

Rao and Rao (1993) reported that application of Replin 1.5 per cent thrice reduced the pod damage by *H. armigera* in pigeonpea.

Effect of different pest management strategies on grain yield of pigeonpea

The results (Table 5 and Fig 5) showed that IPM was adjudged as the superior strategy among all treatments by recording the highest yield of 632 kg/ha which was 54 1 per cent increase over control followed by endosulfan with 60 7 kg/ha which was 48 0 per cent increase over control, followed by endosulfan + shaking with about 40 per cent increase over control Shaking showed 29 5 per cent increase over control NPV and neem with 16 34 and 12 68 per cent increase over control

Das (1998) reported that 4 insecticides and NSKI alone or in combinations were tested against *H armigera* and *M obtusa* on pigeonpea Highest yields were obtained using dimethoate 0 15 per cent + NSKL at 5 per cent

Nehrarker *et al* (1999) reported that in control of Helicoverpa on pigeonpea cv BDN-2 HNPV treatment recorded highest yield 18 2 q/ha Sanap and Pawar (1998) revealed that IPM treatment comprising endosulfan 0 07 per cent, NSKE 5 per cent and NPV @ 250 LL/ha gave 27 per cent higher yield

The yield obtained showed negative relationship with pod damage (r = -0 8421) by *H armigera* on pigeonpea Rosaiah (1997) also reported similar relationship in cotton

Seasonal incidence

Monitoring of *H. armigera* using pheromone traps

The maximum moth catches was observed at 144 DAS (Table 6 and Fig 6)

A sound knowledge on the seasonal activity of pod borer *H armigera* and weather factors conducive for the build up of pest helps to evolve suitable pest management strategies against the pest. Maximum oviposition was observed at 123 DAS which coincided with maximum flowering and pod initiation stage of crop.

The larvae attained its peak from 123 to 133 DAS with maximum at 131 DAS which is supported from the results of Khaire *et al.*(1993) who found the seasonal abundance of *H. armigera* on pigeonpea ICPL-87 in Maharastra during third week of October. According to Chabra and Kooner (1993) the peak of *H. armigera* was observed during October in Punjab.

SUMMARY

CHAPTER VI

SUMMARY

A field experiment was conducted during rainy season 1999 at International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh to assess the comparative efficacy of various components of IPM like neem, HNPV, shaking and endosulfan individually and in different combinations against gram pod borer *Helicoverpa armigera* Hubner on pigeonpea In addition to on station trial at ICRISAT, the effect of IPM and non IPM practices against *H. armigera* in pigeonpea in farmers fields of villages Gottipadu in Guntur district during rainy season 1999 and in Gulladurthi, Kurnool district during *rabi* season 1999-2000 were also studied

The other aspects studied were

i) Evaluating the treatmental effects on natural enemies that live in pigeonpea canopy

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

iii) Studying the seasonal incidence of *H. armigera*

In the present studies all the treatments were found significantly superior to control in reducing oviposition of *H armigera* The maximum reduction in oviposition was observed in neem (57 8%) followed by IPM (54 9%) over control The treatment with the combination of endosulfan + shaking was adjudged as the best treatment in managing the larval population, followed by shaking alone HNPV stood next in the order of efficacy then IPM (51 5) Neem and endosulfan reduced the larval population to the tune of 48 per cent and 46 per cent respectively

Endosulfan was found effecting the natural enemy fauna that live in pigeonpea canopy Shaking was found to be safe to natural enemies as there was no involvement of toxic chemicals

The least pod damage was obtained with IPM (15 1%), followed by endosulfan (17 5%), endosulfan + shaking (18 5%) as against highest pod damage in control (28%)

Maximum yield of 632 kg/ha was obtained in IPM, followed by endosulfan (602 kg/ha) as against 410 kg/ha in control The cost benefit ratio of 1 7 1 for the shaking treatment was found to be best followed by the combination of endosulfan + shaking 1 6 4

The studies on seasonal incidence of *H. armigera* revealed that the peak moth catch at 137 to 144 DAS i e, at 41 and 42 standard weeks of 1999, followed by oviposition in second fortnight of October Larval population attained peak at 144 DAS

In Gulladurthi village higher yield was obtained in IPM treatment compared to non IPM plots in *rabi* pigeonpea

The observations on comparison of shaking with NPV and endosulfan revealed the maximum per cent reduction in larval population in shaking plots with higher yields and high C B ratio (1 10 9) in Gulladurthi village

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The pattern of Literature cited' presented above is in accordance with the Guidelines' for thesis presentation for Acharya N G Ranga Agricultural University, Hyderabad

Weather data for the year 1999 – 2000 - ICRISAT center, Patancheru, rainy season

Week	Rain	Evaporation	Temperature		Relative humidity		Wind velocity	Solar radiation	Sunshine
			Max	Min	7.00 hrs	14.00 hrs			
26	2.39	51.7	33.03	21.39	81.14	50.28	15.76	17.89	8.68
27	55.6	52.6	32.7	21.1	84.14	49.28	11.67	19.40	5.83
28	52.29	33.5	30.12	20.8	87.56	64.85	13.09	16.05	3.89
29	52.29	32.29	30.14	21.19	89	68.85	15.33	16.48	3.83
30	20.6	38	29.53	20.71	88.7	63.85	18.30	16.8	4.11
31	68.7	28.1	28.69	20.41	90.7	70.7	13.96	14.41	2.53
32	26.1	30.89	28.35	20.21	89	69.87	14.67	15.4	3.49
33	17.19	31.69	29.89	20.57	91.85	65.29	8.92	16.39	5.92
34	5.4	29.0	29.70	20.87	90.7	65	7.08	17.8	4.54
35	16.89	27.19	28.58	20.37	90.43	68.7	13.58	17.5	2.7
36	39.89	35.7	29.12	20.07	89	61.28	12.67	16.39	4.03
37	17.10	22.80	27.6	20.16	92.20	76	11.81	12.60	4.08
38	6	37	30.03	20.28	87.56	60.14	11.02	15.35	6.44
39	17	24	29.89	21.07	93.29	65	5.3	13.57	4.57
40	0.3	33.1	30.3	20.71	89.56	63.71	8.61	14.92	8.8
41	5.7	34.6	31.19	19.67	93.85	53.14	8.00	14.0	7.79
42	17.6	33.39	30.44	17.42	95.14	51.14	4.68	17.03	7.57
43	14.8	34.39	30.8	17.85	89	48.85	4.29	16.23	8.57
44	0	40.5	30.82	14.68	87.85	37.14	6.46	18.03	8.97
45	0	32.29	31.32	15.63	88.82	38.67	4.08	17.35	9.19
46	0	42.2	29.92	10.33	80.29	27.14	4.03	18.71	10.07
47	0	38.5	28.1	11.11	79.56	33.85	4.29	15.8	7.79
48	0	34.2	29.76	10.47	88.43	31.26	4.29	16.96	9.3
49	0	25.39	28.42	10.67	89.17	34	4.25	15.84	9.16
50	0	35.6	27.76	9.22	87.62	30.75	3.74	15.89	9.33

Fig 8 Whether data for the year 1999 - ICRISAT centre