

**EVALUATION OF MANAGEMENT PRACTICES
AGAINST BOLLWORMS AND THEIR EFFECT ON
SUCKING PESTS IN COTTON**

**BY
BHUPENDER SINGH**

(2003A27M)

*Thesis submitted to the Chaudhary Charan Singh
Haryana Agricultural University in the partial fulfillment
of the requirements for the degree of:*

Master of Science

In

Entomology



**COLLEGE OF AGRICULTURE
CCS Haryana Agricultural University
Hisar- 125 004 (Haryana)**

2005

Dedicated
To My
Beloved Parents

Acknowledgement

Nothing is impossible in the world. Impossible itself is possible i.e. 'I' 'm' 'possible'. No burden remains heavy if there are so many hands to lift it. These aphorisms have been amply substantiated in this present work. Vocabulary falls short in expressing my sense of indebtedness and profound gratitude, I owe to my major advisor, Dr. R.K. Saini, Senior Scientist, Department of Entomology, CCSHAU, Hisar, who inoculated in me the insurmountable enthusiasm, the constant help and the spirited inspiration not only limited to this work, but will take me a long way in my life. All the extra pains he took to get me feel satiated with fervour that I had been blessed with an able facilitator.

The supreme guidance, close supervision, constructive criticism, constant encouragement and everwilling help exhibited by my Co-advisor, Dr. Pala Ram, Entomologist, Department of Entomology in the pursuit of present study which boosted my moral in the successful completion of the present research is acknowledged with sincere and deep sense of gratitude.

It is my privilege to express immense pleasure, indebtedness and profound sense of gratitude to other members of my advisory committee Dr. Sher Singh, Professor & Head, Department of Plant Pathology, Dr. (Mrs.) Urmil Verma, Scientist, Department of Maths & Statistics, Dr. S.S. Siwach, Scientist, Department of Plant Breeding (Cotton Section), Dean Nominee for their everwilling help, valuable suggestions and guidance provided at various stages of this investigation.

I also express my sincere regards and gratitude to Dr. B.S. Chhillar, Professor & Head-cum-Director, Centre of Advanced Studies, Department of Entomology for his kind co-operation, facilities and timely help during degree programme.

I owe earnest thanks to Dr. S.S.Sharma, Sr. Scientist, Department of Entomology, for his prompt scrutiny during my research. I also take this opportunity to express my thanks to other teaching and non-teaching staff of Department of Entomology for their kind help during the investigations.

Feelings, which can not be moulded into words, from the core of my heart, I truly express my gratitude to my affectionate parents, brothers and sister-in-law for their love, sacrifices, encouragement and unflagging inspirations.

Even the best words of thanks fall short to express my intense feelings to my seniors and friends, Surender Singh, Rajesh Kathwal, Praveen Jakhar, B.P., V. Pal, Mukesh Sihmar, Rajesh Bodla, Mahesh Bhatia, Shyam Sunder, Rahul Chauhan, Sudhir Yadav, Govind Reddy, Ravinder, Salinder Danda, Malakari, Ravikumar, Mamata, Shashi, Mukesh, Amit, Davender P., Karmveer, Ravinder K., Manoj, Praveen, Rakesh, Davender B., Sachin for providing me all possible help during conduct of this investigation.

Dr. Sardana, Incharge, Computer Section, College of Agriculture is duly acknowledged with heartiest feelings for providing valuable help and all facilities for typing this manuscript.

Without blessing of the almighty god this effort would have remained a far-fetched dream and a sheath of note.

Hisar

(Bhupender Singh)

June, 2005

CERTIFICATE-I

This is to certify that this thesis entitled, “**Evaluation of management practices against bollworms and their effect on sucking pests in cotton**”, submitted for the degree of **Master of Science** in the subject of **Entomology** of the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by **Mr. Bhupender Singh, Admn. No. 2003A27M** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

(Dr. R.K. Saini)
MAJOR ADVISOR
Sr. scientist,
Department of Entomology,
CCS Haryana Agricultural University,
Hisar-125004,
INDIA

CERTIFICATE-II

This is to certify that this thesis entitled, **“Evaluation of management practices against bollworms and their effect on sucking pests in cotton”**, submitted by **Mr. Bhupender Singh, Admn. No. 2003A27M** to the Chaudhary Charan Singh Haryana Agricultural University, in the partial fulfillment of the requirements for the degree of **Master of Science** in the subject of **Entomology**, has been approved by the Student’s Advisory Committee after an oral examination on the same.

HEAD OF THE DEPARTMENT

MAJOR ADVISOR

DEAN, POST-GRADUATE STUDIES

CONTENTS

CHAPTER NO.	DESCRIPTION	PAGES
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-14
III	MATERIALS AND METHODS	15-25
IV	RESULTS AND DISCUSSION	26-49
V	SUMMARY AND CONCLUSION	50-52
	LITERATURE CITED	i-xiii
	ANNEXURE	I-VII

LIST OF TABLES

Table No.	Description	Page (s)
1.	Management practices tested against cotton bollworms under different sowing and spacing regimes	17
2.	Incidence of bollworms in green fruiting bodies of cotton during different months in different treatments	27
3.	Effect of different management practices on bollworms incidence in open bolls and yield of seed cotton	31
4.	Population of <i>Helicoverpa armigera</i> larvae in different treatment on different dates	36
5.	Effect of different management practices used against bollworms on population of leafhopper	38
6.	Effect of different management practices on population of whitefly adults	40
7.	Effect of different management practices on population of whitefly nymphs	43
8.	Effect of different management practices on population of aphid	44
9.	Effect of intercropping and <i>Trichogramma</i> release on parasitization of <i>H. armigera</i> eggs	47

LIST OF FIGURES

Figure	<i>Description</i>
No.	
1.	Effect of date of sowing and spacing on incidence of bollworms in green fruiting bodies
2.	Effect of date of sowing and spacing on population of <i>H.armigera</i> larvae
3.	Effect of date of sowing and spacing on population of leafhopper
4.	Effect of date of sowing and spacing on population of whitefly adults
5.	Effect of date of sowing and spacing on population of whitefly nymphs
6.	Effect of date of sowing and spacing on population of aphid

CHAPTER - I

Introduction

Cotton is an important cash crop of India. It plays an important role in national economy and is called as white gold. Though, India occupies the foremost position among the cotton growing countries of the world in respect of area, yet it contributes only about ten per cent towards the yield. Cotton is grown on an area of 9.09 million ha in India, which is the largest in the world (Anon., 2003). However, the country ranks third in the world, after USA and China, with respect to production. One of the major factors responsible for low yield in India is the damage caused by a vast array of insect pests at different stages of crop growth.

Nearly 130 species of insects and a few species of mites have been reported to cause considerable reduction in cotton yield in India. Among various important insect pests, sucking pests viz., whitefly (*Bemisia tabaci* Genn.), leafhopper (*Amrasca biguttula biguttula*) and bollworms viz., American bollworm (*Helicoverpa armigera* Hub.), pink bollworm (*Pectinophora gossypiella* Saund.) and spotted bollworms (*Earias insulana* Boisd. and *E. vittella* Fab.) cause considerable reduction in the yield in almost all cotton

growing areas. However, bollworms are the most important. They not only reduce the yield to the extent of 50-60 per cent but also adversely affect the quality of lint and seed (Sundramurthy, 1985).

In the past, control measures against bollworms have been mainly insecticide-intensive. The predominance of *H. armigera* on cotton, particularly during the last about a decade, has forced the farmers to go for frequent applications of insecticides and that too, at doses higher than the recommended one. More than 50 per cent of pesticides in India are used in cotton alone. Consequently, the susceptibility of bollworms in general and *H. armigera* in particular is gradually declining.

In most of the traditional cotton growing areas of Haryana, satisfactory control of bollworms is not being achieved. So, the margin of profit of cotton growers is narrowing down. The situation becomes worse in years when environmental conditions become favorable for bollworms build-up. There is an increasing awareness these days about the ill effects of pesticides, particularly in terms of pest resurgence, environmental pollution and toxic residues in food. Therefore, reduction of pesticides load on the crops is the need of hour. To achieve this objective it is imperative to encourage practices other than the use of chemicals.

A number of practices have been recommended by various workers to manage bollworms in cotton. However, several of these practices have been evaluated in an isolated manner. A review of literature indicates that, except

under certain conditions, no single non-chemical practice has offered satisfactory control of bollworms. Therefore, different practices need to be integrated keeping in mind the scope and limitations of each practice. In the present studies, it is proposed to evaluate promising pest management practices against bollworms of cotton alone and in suitable combinations with the following objectives:

1. To assess the role of different management practices alone and in suitable combinations against bollworms.
2. To study the effect of different bollworms management practices on population of sucking pests.

CHAPTER - II

Review of Literature

Various workers have suggested the use of different practices to manage bollworms in cotton. Work done on the effect of different management practices on pest incidence and seed cotton yield is reviewed briefly under following headings:

2.1 Sowing time

2.2 Spacing

2.3 Intercropping

2.4 Biopesticides

2.5 Natural enemies

2.6 Insecticides

2.7 Combination of different pest management practices

2.1 Sowing time

The mean percentage of damaged bolls and loculi due to bollworm attack increased as the sowing was delayed. (Simwat *et al.*, 1987; Nagargoje *et al.*, 2002). Prasad (1995) reported that the mean seed cotton yield was reduced up to 32.43 percent when the sowing was delayed from May first week to June first

week. In another study conducted by Dhoble *et al.* (1987), it was found that the infestation of bollworms in green bolls of early sown crop was lowest as compared to late sown but locule infestation was similar in all the sowing dates. Rosaiah and Reddy (1997) reported that the early sown crop had low infestation of bollworms in term of egg and larval population and damage in squares, flowers and bolls as compared to late sown.

Early sowing of cotton in the last week of April was better in increasing the seed cotton yield while subsequent delay of sowing reduced the yield considerably (Singh and Bishnoi, 2000; Prasad *et al.*, 2000). It was reported that sowing of cotton in the first week of May recorded the highest mean seed cotton yield as compared to third and last week (Nehra and Chandra 2001; Singh *et al.*, 2003).

2.2 Spacing

It was observed that the incidence of bollworms on locule basis was higher in crop sown at closer spacing of 75 x 15 cm as compared to crop sown at wider spacing of 75 x 30cm (Butter *et al.*, 1989). Prasad (1995) reported that cotton sown at closer spacing of 60cm x 20cm resulted in significant higher mean seed cotton yield as compared to the spacing of 60cm x 30cm and 67.5cm x 20cm.

Nehra and Chandra (2001) reported that cotton sown at a distance of 67.5cm x 30cm gave significantly higher mean seed cotton yield (1600 kg/ha) than wider spaced crop at 67.5cm x 45cm (1398 kg/ha) and was rated *on a par*

with 67.5cm x 15cm spacing. Similar results were reported by Prasad *et al.* (2000). Deol and Brar (2003) reported that crop sown at wider spacing of 100cm x 50cm produced maximum number of pickable bolls per plant while at closer spacing the pickable bolls per plant were less, but the seed cotton yield was lower at wider spacing than at closer spacing.

However, in another study Nehra and Kumawat (2003) reported that seed cotton yield was not significantly different due to different spacing.

2.3 Intercropping

Intercropping of cotton with cowpea, soybean, sesame etc has been reported to encourage the population of natural enemies. Intercropping of cotton with sesame was found to increase parasitization of *H. armigera* eggs on cotton by about 32 per cent (Ram *et al.*, 2002). Rajput and Daware (2002) studied the effect of intercrop on incidence of bollworm complex of cotton and found that plots with intercrop like soybean, black gram, cowpea, pigeonpea, sorghum and maize recorded low bollworm incidence in fruiting bodies, shed material, bolls and loculi at harvest.

2.4 Biopesticides

Biopesticides are known for their eco-friendly nature. Yield of seed cotton following treatment with 4 sprays of 150 ppm neem oil and insecticides was 8.5 ± 0.61 and 7.7 ± 0.63 'kantar', respectively in 1989 and 6.29 ± 0.53 and 5.83 ± 0.29 'kantar', respectively in 1990 (Salem, 1991). Neemrich 20 EC (extracted from *Azadirachta indica*) at a rate of 1.5 litre per hectare reduced the bollworm

damage to cotton significantly and was also effective in reducing the population of sucking pests and leaf eating larvae (Dhawan *et al.*, 1992).

It was reported that neem seed kernal extract (NSKE) 6% with HNPV (Heliothis Nuclear Polyhedrosis Virus) 500 LE per ha was the most effective treatment for the control of *Pectinophora gossypiella*, followed by half the concentration of NSKE (3%) + HNPV 500 LE per ha, NSKE 6% + half the concentration of HNPV (250 LE per ha), half the concentration of NSKE (3%) + half the concentration of HNPV (250 LE per ha), HNPV 500 LE per ha and NSKE 6% (Sarode *et al.*, 1995). Gupta *et al.* (1996) reported that the combination of neem, *Bacillus thuringiensis* and an 84 per cent reduced rate of synthetic pyrethroid resulted in satisfactory control of bollworm complex and increase in yield than conventional spray schedules. Also there was no resurgence of aleyrodids.

Alternate spray of Godrej Achook and alphamethrin on cotton proved as effective as the sprays of fenvelerate /alphamethrin alone in checking number of bollworms and increasing the seed cotton yield (Butter and Kular, 1997). Neem when used alternatively with *Bacillus thuringiensis* and at least one spray with synthetic pyrethroid, was effective in managing the bollworm complex (Gupta and Sharma, 1997).

Parthiban and Ananthan (1998) reported that the spraying of crop with alternate applications of a neem formulation and *B. thuringiensis* sub species kurstaki (1.01 l/ha) at 7, 10 and 14 days interval significantly reduced the

incidence of bollworms in cotton. Murugan and Babu (1998) reported that 0.2 to 2.0 per cent concentration of *Pongamia* oil inhibited the larval growth of *H. armigera* and *Earias* spp. and the larvae of *H. armigera* treated with 0.2 per cent *Pongamia* oil showed 93.3 per cent mortality.

Gupta *et al.* (1999) observed that neem in combination with one spray of synthetic pyrethroid gave significant control of bollworms as it resulted in minimum incidence of bollworms (10.8%) and maximum yield of the seed cotton (1970 kg/ha). Also, there was no build up of whitefly population in neem treated plots. Similarly, Gurusamy *et al.* (2000) reported that neem leaf extract was the most effective in reducing jassid (*Amrasca bigutulla bigutulla*) and American bollworm (*H. armigera*) population.

Need based spray of 0.5 per cent neem oil and 0.088 per cent Polytrin C 44 EC (cypermethrin 40g + profenofos 400g) effectively managed the bollworm populations and resulted in the highest seed cotton yield (Bharpoda *et al.*, 2000). A four-spray schedule system consisting of one spray of neem (5ml per litre of water), cypermethrin (60g a.i./ha) at 15 days interval effectively protected the crop from bollworm damage (Mohan and Katiyar, 2000).

It was found that a mixture of methanolic neem seed kernel extract (NSKE) and *Pongamia pinnata* seed extract (PPSE) increased feeding deterrence, mortality and decreased fecundity of *H. armigera* (Babu *et al.*, 2000). Singh *et al.* (2000) reported that the application of Bt and neem at alternate turns with the synthetic insecticides controlled the bollworms infestation and increased

the yield of seed cotton. Also this strategy reduced the use of synthetic pyrethroid upto 60-70 per cent, which reduced the environment hazard and the problem of whitefly resurgence.

Application of neem products alone and in combination with synthetic insecticides was found to give significantly better control of bollworms than the unsprayed plots (Sreenivas and Patil, 2001).

2.5 Natural enemies

Among different natural enemies, namely, *Trichogramma brasiliensis*, *Bracon kirkpatricki*, *Chelonus blackburni*, *Bracon hebitor* and *Bracon brericornis* tried against pink bollworm, it was observed that *B. kirkpatricki* accounted for 2-10 per cent and *T. brasiliensis* for 15 per cent parasitization (Pawar *et al.*, 1980). Similarly, parasitization of eggs of *Earias vittella*, *Helicoverpa armigera* and *Pectinophora gossypiella* by nine species of *Trichogramma* in the laboratory ranged from 89-97, 88-97 and 68-86 per cent, respectively (Hanumanna *et al.*, 1984). It was reported that *Trichogramma achaeae* and *T. chilonis* parasitized the eggs of *Earias* and *H. armigera* on cotton and okra; and the average parasitism of *Earias* on cotton and okra was 23.44 and 14.87 per cent and that of *H. armigera* 51.16 and 4.84 per cent, respectively (Naganagoud and Thontadarya, 1984).

Pawar and Prasad (1985) released three exotic parasitoids, *T. brasiliensis*, *Bracon* sp. and *Chelonus* sp. to control bollworms in cotton. As a result, about 3-20 percent less damage to bolls and to reproductive parts of cotton was noticed

in parasitoid released field as compared to control. Similarly, different parasitoids of the *Earias* spp. and *P. gossypiella* viz. *T. brasiliensis*, *T. pretiosum*, *T. achaeae* and the *Braconids*, *C. blackburni* and *B. kirkpatricki* caused significant reduction in bollworm damage to cotton (Prasad *et al.*, 1985).

Release of *T. brasiliensis* at the rate of 20,000 newly emerged adults per acre per week in combination with sprays of carbaryl, dimethoate and monocrotophos significantly reduced the damage caused to cotton by *Earias* spp. and *P. gossypiella* (Tuhan *et al.*, 1987). It was reported that the parasitism of cotton bollworms eggs increased from 1.92 to 37.9-44.3 (Nan *et al.*, 1987) and from 41.2 to 44.8 (Bilal *et al.*, 2002) per cent after release of *Trichogramma* spp.

In another study when *T. achaeae* was released alongwith the recommended insecticides for the control of cotton bollworms, it was found that there was 16.7-19.6 per cent parasitization in the parasitoid released field (Brar *et al.*, 1991). The yield was also high in parasitoid released field as compared to control and it was concluded that although the insecticide treatment was better than that involving parasitoid release in the field, yet the parasitoid release proved better than the control in reducing the population of bollworms and increasing the yield of seed cotton.

Dhandapani *et al.* (1993) suggested that in severe outbreak of *H. armigera*, the egg parasitoids *T. chilonis* might be released at the rate of 1 lakh per hectare so that the proportion of larvae hatching out could be reduced considerably to reduce pest load on the crop. In an experiment conducted by

Chao and Liu (1996), it was observed that a small release of *Trichogramma flavum* was sufficient under the conditions when the incidence of cotton bollworms was light or moderate. It was found less costly than chemical spray and safer to natural enemies and the environment.

Studies conducted to evaluate *Trichogramma chilonis* against bollworms in cotton indicated that the repeated release of the parasitoid at a rate of 1.5 lakh per hectare at 5-6 days interval along with need based application of recommended insecticides during the reproductive phase of the crop was the most effective in reducing bollworm infestation and increasing yield of seed cotton (Ram *et al.*, 1997).

Three sprays each for sucking pests and cotton bollworms + 8 releases of *Trichogramma chilonis* at the rate of 1.5 lakh per hectare weekly + one release of *Chrysoperla carnea* at the rate of 10,000 per hectare was found *on a par* with chemical control (Brar *et al.*, 2002). Further, it was also noticed that when *T. chilonis* was integrated with insecticides it reduced the damage by bollworms by 70.3 per cent and increased yield by 44.5 per cent over insecticide alone.

For the control of spotted bollworm and spiny bollworm (*Earias* spp.) indigenous parasitoid *Bracon greeni* gave satisfactory results in Karnal, Haryana but the same parasitoid gave only limited results in Gujarat. It was also reported that the release of *Trichogramma chilonis* @ 10,000 parasitoids/acre/week reduced the infestation of bolls by *Pectinophora gossypiella* effectively and

about 576 kg per acre increase in yield of seed cotton was obtained (Rabindra and Jalali, 2004).

Seven releases of *Trichogramma brasiliensis*, *A. angaleti* and *Chelonus blackburni* at the rate of 50,000 per hectare at an interval of ten days starting from 45 days after sowing reduced the infestation of bollworms to the extent of 56 per cent over control (Rabindra and Jalali, 2004).

Inundative release of *T. chilonis* Ishii was evaluated against bollworm complex in cotton. Egg parasitism of *H. armigera* ranged from 15.4 to 32.5 per cent in released plots against 5.0 to 18.5 per cent in control plots (Ram *et al.* 2004). Further, boll damage was 12.2 and 21.9 per cent on boll basis, and 6.0 and 10.4 per cent on locule basis in parasitoid released and control plots, respectively.

2.6 Insecticides

A number of insecticides have been found effective against bollworms. It was reported that three or four sprays of insecticides through the season caused a satisfactory decrease of infestation and loss of yield (Abdalla, 1992). It was found that pyraclophos and profenofos at a rate of 0.75kg a.i. per ha were significantly more effective than quinalphos for the control of bollworms and to increase the yield of seed cotton (Dhawan and Simwat, 1997).

Rosaiah *et al.* (1997) observed that deltapos, a combination product of deltamethrin and triazophos, was effective in reducing the *H. armigera* infestation in fruiting bodies and contributed maximum to yield. Rohilla and

Saini (2003) reported that readymix formulation of endosulfan + cypermethrin gave equally good control of bollworms as cypermethrin or fenvalerate and significantly better control than endosulfan in a dose dependent manner. Further, endosulfan + cypermethrin at higher doses proved significantly superior to its lower dose in checking bollworm incidence. In another study, Dhawan and Simwat (2000) reported that indoxacarb was more effective against spotted bollworm at a rate of 60 g a.i. and against American bollworm at a rate of 80 g a.i. per ha and increased the yield of seed cotton. They also observed that it did not cause resurgence of sucking pests; was safer to beneficial arthropods and was as effective as chlorpyrifos.

It was reported that synthetic pyrethroid Decis 2.8 EC at a rate of 12.5 g a.i. per ha was most effective to reduce the bollworm infestation up to 4.4-4.7 per cent in green bolls and 10.1-23.50 per cent in open bolls and also increased the yield up to 23.10 quintals per ha (Banerjee *et al.*, 2000). Chandramani *et al.* (2004) evaluated emamectin benzoate, omit+cypermethrin and spinosad in comparison with endosulfan and found that all were equally effective in reducing the *Earias* spp. damage. The population of pink bollworm was also low in treated plot as compared to control. BTK (Halt), spinosad and indoxacarb provided effective control of bollworms in term of squares, green bolls and locule damage and increased yield of seed cotton (Yadav *et al.*, 2004).

It was observed that profenofos (875g a.i.), fipronil (200g a.i.), thiodicarb (375g a.i.), indoxacarb (150g a.i.) and carbaryl (1250g a.i.) were as effective as

quinalphos (560g a.i.) while deltamethrin, thiodicarb (at higher dose) and cypermethrin reduced the incidence of bollworms significantly as compared to quinalphos (Saini *et al.*, 2004). Further, yield of seed cotton was higher in the case of deltamethrin, followed by profenofos and indoxacarb. Bhosle *et al.* (2004) reported that spinosad and combination of CHP + spinosad were comparatively better treatment as compared to chlorpyrifos, Spark and Polytrin-C in reducing the bollworm incidence and increasing the seed cotton yield.

2.7 Combination of two or more practices

It was reported that cotton crop sown in second fortnight of April at a plant spacing of 67.5cm x 30cm and 7 to 8 times sprayed in integration with 13 release of *T. chilonis* at weekly interval at a rate of 1,50,000 per ha gave the higher yield. Sorghum can be used as trap crop to increase the parasitization efficacy of *T. chilonis* (Singh, 2003). Similarly, Virk *et al.* (2003) reported that sowing of cotton between April 10th and April 30th at moderate spacing resulted in less damage by bollworms and higher yield of seed cotton.

CHAPTER - III

Materials and Methods

The present investigations "Evaluation of management practices against bollworms and their effect on sucking pests in cotton" were conducted in the experimental area of Department of Entomology, CCS Haryana Agricultural University, Hisar during 2004. The materials and methods used in investigations are described as below:

3.1 Sowing of crop

The cotton variety H-1117 was sown on three different dates i.e. 12th April (early sown), 29th April (normal sown) and 27th May (late sown). The sowing was done with hand plough by pora method, keeping a spacing of 67.5 cm between the rows. A treatment having late sown crop with wider spacing of one meter between the rows was also kept. After one month of sowing thinning was done to keep plant to plant distance of 30 cm. In all, there were nine rows of cotton in each plot. However, in the case of crop sown with wider spacing, the number of rows were six. In the plots where intercropping was kept as a treatment, the central row (i.e. 5th row from sides) was left unsown. In this space two rows of sesame were sown on July 29th, 2004. All agronomic practices

were followed as per the recommendations for raising the crop under irrigated condition in northern India (Anonymous, 2003).

3.2 Evaluation of management practices

Different pest management practices advocated by various workers were evaluated in plots of 48m² (7.8 x 6.1m) size in randomized block design keeping three replications for each treatment. A gap of 1.2 meter was maintained between the plots to avoid the influence of neighbouring treatments. The following pest management practices were evaluated:

- i. *Trichogramma* release
- ii. Neem spray (Azadirachtin 0.15%)
- iii. Insecticides spray
- iv. Intercropping with sesame
- v. Spacing:
 - a) 67.5cm x 30cm
 - b) 1.0m x 30cm
- vi. Date of sowing:
 - a) Early sown
 - b) Normal sown
 - c) Late sown

The different management practices were applied alone and in suitable combinations of two or more to the normal sown crop. Since farmers in Haryana were, sometimes, compelled to go for sowing of cotton either earlier or later than the recommended period of sowing depending upon the availability of irrigation

water. Treatment having need based insecticide application was evaluated under early sowing as well as late sowing conditions also. Further, a combination of various management practices was also tested under late sown conditions. Since late sowing was reported to increase the bollworms incidence, effect of wider spacing in reducing of bollworms incidence was evaluated under such a situation. All the treatments, except intercropping, were initiated when the bollworms incidence reached economic threshold (i.e. at 5% incidence in fruiting bodies). To check the incidence of thrips, one spray of imidacloprid @ 100ml/ha was applied during late July in all the plots including control.

Different treatments applied are listed in Table 1 below:

Table 1. Management practices tested against cotton bollworms under different sowing and spacing regimes

Treatment	Description
Early sown crop	
T1	Need based insecticides application (NBIA)
T2	Control
Normal sown crop	
T3	<i>Trichogramma chilonis</i> release @ 1.5 lakh at weekly interval
T4	Neem spray at weekly interval
T5	<i>Trichogramma</i> release and neem spray on alternate week
T6	Need based insecticides application (NBIA)
T7	Intercropping with sesame
T8	Intercropping + NBIA
T9	Intercropping + <i>Trichogramma</i> release and neem spray on alternate week
T10	Intercropping + first two weekly spray of neem + NBIA + <i>Trichogramma</i> release after 10 days of spray
T11	Control
Late sown crop	
T12	NBIA
T13	Intercropping + first two weekly spray of neem + NBIA + <i>Trichogramma</i> release after 10 days of spray
T14	Control
Late sown with	

Wider spacing

T15

NBIA

T16

Control

Detail of each treatment is as under

Treatments T1 and T2 relate to early sown crop; T3, T4, T5, T6, T7, T8, T9, T10, and T11 to normal sown crop; T12, T13 and T14 to late sown crop and T15 and T16 to late sown with wider row to row spacing (i.e. 1 m).

T1: Need based insecticides application (NBIA)

Under this treatment as and when bollworms incidence in green fruiting bodies reached 5 per cent, the recommended insecticide was applied to suppress the incidence. A total of seven sprays of various insecticides were done with the help of manually operated knapsack sprayer, starting from middle of August to early October. The following insecticides were sprayed on different dates:

Spray number	Insecticide	Dose (litre/ha)	Date of spray
1	Deltamethrin (Decis 2.8 EC)	0.5	20.08.04
2	Triazophos (Trikon 40 EC)	1.5	26.08.04
3	Profenofos (Profex 50 EC)	2.0	02.09.04
4	Carbaryl (Sevin 50 WP)	2.0	10.09.04
5	Triazophos (Trikon 40 EC)	1.5	17.09.04
6	Profenofos (Profex 50 EC)	2.0	27.09.04
7	Triazophos (Trikon 40 EC)	1.5	06.10.04

T2: Control

It served as control for early sown crop wherein no insecticides were applied against bollworms.

T3: *Trichogramma chilonis* release @ 1.5 lakh/ha at weekly interval

Treatment T3 consisted of release of egg parasitoid, *Trichogramma chilonis*, @ 1.5 lakh/ha at weekly intervals. Paper card having *Corcyra cephalonica* eggs parasitized by *T. chilonis*, henceforth termed as 'Tricho cards', were taken from Biological Control Laboratory, Department of Entomology, CCS Haryana Agricultural University, Hisar. These cards were cut into pieces in such a way that about 750 parasitized eggs were available on each piece. On the backside of each card piece, a small drop of honey was placed so that the emerging adults of *T. chilonis* could feed upon it. Such pieces were kept in glass tubes, which were plugged with a cotton plug (cotton swab wrapped in muslin cloth) so that the emerging adults of the parasitoid could not escape. When 2/3rd of the adults emerged, these were released in the field. The cards having the remaining parasitized eggs (i.e. from which adults did not still emerge) were stapled on the lower surface of the leaves in the field. A total of eight releases of the parasitoid were made from middle of August to early October, i.e., on 15th Aug, 22nd Aug, 31st Aug, 7th Sept, 14th Sept, 21st Sept, 28th Sept and 5th Oct.

T4: Neem spray at weekly interval

Eight sprays of neem (Azadirachtin 0.15%) were done at weekly interval at recommended dose (500ml/ha) from middle of August to early October.

T5: *Trichogramma* release and neem spray on alternate week

The releases of *T. chilonis* and sprays of neem were done on alternate weeks. A total of four releases of *T. chilonis* and four sprays of neem were done during the season.

T6: Need based insecticides application (NBIA)

Seven sprays of four different insecticides were done starting from middle of August to early October as in the case of T1.

T7: Intercropping with sesame

Sesame was sown as an intercrop in cotton during the last week of July. Since *Trichogramma chilonis* is reported to parasitize heavily the eggs of til halk moth (*Achrontia styx*), a pest of sesame, and that the eggs of this pest are quit big from which more than 20 *Trichogramma* adults could emerge from a single egg (Ram *et al.*, 2002). Intercropping with sesame was included to indirectly augment the population of *Trichogramma* in the cotton ecosystem. Two rows of sesame were sown after every four rows of cotton. No insecticides were sprayed against bollworms.

T8: Intercropping + NBIA

Sesame was sown as an intercrop during the last week of July as in T7 and six sprays of four different insecticides were done at recommended dose. The schedule of spraying was similar to that followed in the case of T1 and T4.

T9: Intercropping + *Trichogramma* release and neem spray on alternate week

Intercropping of sesame was done as under T7. Release of *T. chilonis* and spray of neem were done on alternate week.

T10: Intercropping + first two weekly sprays of neem + NBIA + *Trichogramma* release after 10 days of spray

Cotton was intercropped with sesame as under T7. First two sprays of neem at weekly interval were applied on 20th Aug and 27th Aug after which three sprays of insecticides were done at an interval of 15 days. During this period *T. chilonis* was released after ten days of each spray when insecticidal residue was supposed to be considerably low so that the parasitoid could be safe from the toxic effect of the insecticides.

T11: Control

Treatment T11 served as control for normal sown crop wherein no insecticides were applied against bollworms.

T12: Need based insecticides application (NBIA)

Treatment T12 comprised of need based application of insecticides under late sown condition. Five sprays of four different insecticides were done starting from middle of August to early October. The sequence of spraying of different insecticides was similar to that followed for the first five sprays under T1. Different dates of sprayings were: Aug 31st, Sept 10th, Sept 17th, Sept 27th and Oct 6th.

T13: Intercropping + first two weekly spray of neem + NBIA + *Trichogramma* release after 10 days of spray

Same as under T10 but in this case the number of insecticides spray was reduced to two due to late sowing of crop.

T14: Control

Treatment T14 served as control for the late sown crop and no insecticides were applied against bollworms.

T15: Need based insecticides application (NBIA)

Same as under T12 and five sprays of different insecticides were applied to the crop under late sown condition with wider spacing.

T16: Control

Treatment T16 served as control under late sown conditions with wider spacing. No insecticides were applied against bollworms.

3.3 Observations on incidence of insect pests

For recording the bollworms incidence and population of sucking pests (leafhopper, whitefly and aphid) the following standard procedure was followed:

3.3.1 Bollworms incidence in green fruiting bodies

To record incidence of bollworms in green fruiting bodies of cotton, 100 intact green fruiting bodies (squares, flowers and bolls) per plot in each treatment were examined randomly for bollworms damage at weekly interval starting from end of July to middle of October. Presence of entry/exit hole along with excreta or larvae, if any, was considered as criterion of damage by bollworms. Further, flared up squares and damage to reproductive parts of flowers also gave an indication of bollworms damage. On the basis of damaged fruiting bodies, the per cent incidence of bollworms was calculated.

3.3.2 Leafhopper and whitefly population

The nymphal population of leafhopper and adult population of whitefly was recorded on different dates on under surface of 3 fully expanded leaves in the upper crop canopy from each of the 10 random plants in a plot. One time observation on nymphal population of whitefly was also recorded. For this, 10 cotton leaves from each plot were detached from the plants and brought to the laboratory for examination under dissecting microscope. Whitefly nymphs were counted in different treatments and mean population per leaf was calculated.

3.3.3 Aphid population

The population of aphid was recorded on 10 random plants by observing three leaves on each plant. For this, 4-cm² area of a leaf was selected for counting the aphid. The area was selected as follow:

Four windows of 1cm² area were cut out in a thick paper card at different places and this card was placed over the lower leaf surface. Aphids visible through these windows were counted. The observations were initiated from middle of September and were followed at fortnightly interval.

3.3.4 Larval population of *H. armigera*

The population of *H. armigera* larvae was observed from 10 randomly selected plants from each plot. For this, the whole plant was thoroughly searched for the larvae. The larval counts were made at fortnightly interval starting from end of July.

3.3.5 Incidence of bollworms in open bolls at harvest

The incidence of bollworms at the time of harvest was also recorded. For this purpose, ten plants in the middle five rows (four in case of intercropping and wider spacing each) of a plot were tagged randomly in each plot and all the open bolls of such plants were collected in polyethylene bags. Lint and seed of all the bolls were examined carefully for bollworms damage and for daipausing larvae of pink bollworm. The per cent incidence on boll as well as locule basis was calculated by using following formula: -

$$\% \text{ Incidence on boll basis} = \frac{\text{No. of damaged bolls}}{\text{Total no. of bolls observed}} \times 100$$

$$\% \text{ Incidence on locule basis} = \frac{\text{No. of damaged locules}}{\text{Total no. of locules observed}} \times 100$$

Population of pink bollworm larvae in the seed was computed for number of larvae per hundred bolls in each plot.

3.4 Parasitization of *H. armigera* eggs by *Trichogramma chilonis*

In order to assess the role of sesame as intercrop in enhancing the parasitization of *H. armigera* eggs by *T. chilonis*, observation on egg parasitization were made with respect to the three treatments, namely, *Trichogramma* release, intercropping with sesame, and the control. *H. armigera* eggs were collected from the field in glass vials at 10-12 days interval. For this, the part of leaf bearing egg (s) was removed from the plant and brought to the laboratory. Leaf portion along with the egg (s) was placed on a paper strip and kept in a glass tube to record parasitization, if any. Daily observations were taken until the emergence of parasitoid or hatching of the egg. The eggs which shrank were considered as infertile. Per cent parasitization was calculated by using the following formula:

$$\% \text{ Parasitization} = \frac{\text{No. of parasitized eggs}}{\text{Total no. of eggs collected}} \times 100$$

3.5 Yield of seed cotton

The yield of seed cotton was recorded from a net plot comprising of five middle rows (four in the case of intercropping and wider spacing each) in each treatment. Yield from two rows from each side of a plot was not considered to

avoid border effect as well as the effect of other treatments, if any. In plots intercropped with sesame, yield of two rows of sesame in such plots was also recorded. The yield obtained from the net plots was converted into yield in quintals per hectare.

3.6 Meteorological data

Data on temperature, relative humidity, rainfall etc. were obtained from the Department of Agricultural Meteorology of the University and correlations of these parameters with pest population in the field were worked out.

3.7 Statistical analysis of data

The data obtained during the studies were tabulated and subjected to the analysis of variance using Randomized Block Design (RBD) wherever applicable. The differences were compared at 5% level of significance. Wherever necessary, the data were subjected to angular transformation also.

CHAPTER - IV

Results and Discussion

Results of the studies conducted on “Evaluation of management practices against bollworms and their effect on sucking pests in cotton” during April to November, 2004 are presented in this chapter as under:

4.1 Incidence of bollworms in green fruiting bodies

Both under early sown and normal sown conditions, the bollworms incidence in green fruiting bodies in the control plots started from early August and continued to increase reaching its peak during end of September (Table 2). As high as 30.33 to 34.33 per cent fruiting bodies were found damaged by different bollworms during the peak period of incidence. The incidence gradually declined afterwards but still remained above 28 per cent by mid October. The incidence of bollworms in green fruiting bodies remained relatively low in the late sown crop as compared to the early sown and normal sown crop. The peak incidence also appeared late i.e. during mid October in the late sown crop. Pooled mean bollworms incidence was 19.06, 14.65, 9.61 and 9.25 per cent in early sown, normal sown, late sown and late sown with wider spacing crop, respectively. Comparative bollworms incidence in control plots under different sowing conditions is also depicted in Fig. 1. Similar observations

Table 2: Incidence* of bollworms in green fruiting bodies of cotton during different months in different treatments

Treatment	No. of insecticidal sprays	% Green fruiting bodies damaged by bollworms on different dates											Pooled mean incidence (%)
		August					September			October			
		3/8	10/8	17/8	24/8	31/8	7/9	14/9	21/9	28/9	5/10	12/10	
Early sown crop													
T ₁ (NBIA)	7	2.83	4.17	7.83	4.67	6.00	5.33	10.33	8.67	7.33	5.33	4.00	5.50 ^{c**}
T ₂ (Control)	0	2.17	4.50	10.17	14.67	18.00	19.67	32.67	33.00	34.33	32.33	28.67	19.06 ⁱ
Normal sown crop													
T ₃ (<i>Tricho.</i>)	0	1.17	2.83	3.83	6.67	6.00	7.00	8.33	12.00	12.33	14.33	15.00	7.35 ^e
T ₄ (Neem)	0	2.17	2.17	4.50	5.67	4.33	7.00	7.67	9.67	10.00	12.33	14.67	6.56 ^d
T ₅ (Nm.+ <i>Tricho.</i>)	0	1.50	2.17	5.17	6.33	6.00	6.67	7.00	8.67	10.33	11.67	14.00	6.74 ^d
T ₆ (NBIA)	7	1.83	2.17	4.17	6.33	4.33	4.67	7.00	7.00	6.00	8.00	4.67	4.55 ^b
T ₇ (Intercropping)	0	2.17	2.83	4.50	5.67	6.33	8.00	8.00	18.33	15.00	18.33	16.33	8.67 ^f
T ₈ (Inter.+NBIA)	6	1.50	2.50	4.50	4.00	3.33	5.67	5.67	5.00	7.67	8.33	5.67	4.36 ^b
T ₉ (Inter.+Nm. + <i>Tricho.</i>)	0	1.17	2.17	4.17	3.67	5.00	5.67	7.00	9.67	10.33	10.00	8.00	5.46 ^c
T ₁₀ (Inter. +Nm.+ NBIA+ <i>Tricho.</i>)	3	1.50	1.50	3.50	4.00	2.67	5.00	5.00	7.33	8.00	7.33	5.33	4.14 ^b
T ₁₁ (Control)	0	1.67	2.50	4.83	8.33	15.00	16.33	16.33	27.33	30.33	26.33	28.67	14.65 ^h
Late sown crop													
T ₁₂ (NBIA)	5	0.83	0.83	1.83	2.00	4.33	5.33	3.00	5.00	6.33	7.00	5.33	3.42 ^a
T ₁₃ (Inter.+Nm.+ NBIA+ <i>Tricho.</i>)	2	0.83	0.83	1.50	3.00	4.33	5.00	8.33	8.67	7.00	7.00	6.67	4.37 ^b
T ₁₄ (Control)	0	1.17	1.17	2.17	2.67	4.33	9.33	16.00	17.33	17.33	16.33	28.67	9.61 ^g
L.S.+W.S. crop													
T ₁₅ (NBIA)	5	0.50	0.83	1.50	4.00	4.33	6.67	6.67	6.67	8.00	6.33	5.00	4.16 ^b

T ₁₆ (Control)	0	0.50	0.83	1.67	2.67	5.00	9.67	16.00	16.33	16.33	14.33	28.00	9.25 ^{fg}
C.D. (p=0.05)		1.10	1.28	1.88	1.88	2.44	2.22	3.23	2.09	1.99	1.63	2.73	0.60

* Based on 100 fruiting bodies from each replication

** DMRT (Duncan's multiple range test): Figures with the same letter(s) do not differ significantly

were made by Virk *et al.* (2003) who reported that green boll infestation was lowest in late sown cotton. However, the present findings are at variance with those of Rosaiah and Reddy (1997) who reported that the bollworms incidence in green fruiting bodies of early sown crop was lower as compared to that in the late sown crop. Similarly, Dhoble *et al.* (1987) also found lower bollworms incidence in green bolls of early sown crop than the late sown crop but the locule infestation was similar in all the sowing dates. The possible reason for higher bollworms incidence in early sown crop may be due to the fact that the year 2004 was an unusual year in which there were no rains during July (Annexure I). Thus, the semi drought conditions encouraged stress flowering in early and normal sown crops, which attracted spotted bollworms, particularly *E. insulana* for which such conditions are more favourable as reported by Singh and Chaudhary (1988). But under late sown conditions, the crop was small and the vegetative growth of the plants lasted for a longer period and escaped the earlier attack of spotted bollworms. Taneja and Dhindwal (1982) also reported that the incidence of spotted bollworms was higher in early sown crop as compared to late sown crop. As the late sown crop bore few green bolls upto August, which is the peak period of spotted bollworm and hence escaped attack.

No differences in bollworms incidence in green fruiting bodies were observed between the plots having a row to row spacing of 67.5 cm and those with a wider spacing of one meter under late sown conditions.

Comparison of bollworms incidence among different treatments in normal sown crop showed that in green fruiting bodies, all treatments recorded significantly lower incidence of bollworms than the control. Treatments with weekly spray of neem recorded significantly lower (6.86%) incidence of bollworms than weekly release of *Trichogramma* (7.35%). However, both these treatments were significantly superior to intercropping alone which recorded 8.67 per cent incidence. The treatment having intercropping, followed by use of neem spray and *Trichogramma* on alternate week recorded significantly lower incidence (5.46%) of bollworms than those having either *Trichogramma* or neem spray alone without intercropping. This showed the additive effect of various non-insecticidal practices. Several workers have also reported the suppression of cotton bollworms through the use of *Trichogramma* (Ram *et al.*, 1997; Brar *et al.*, 1999; Ram *et al.*, 2000) and neem (Dhawan *et al.*, 1992; Butter and Kular, 1997; Singh, *et al.*, 2000; Bharpoda *et al.*, 2000; Sreenivas and Patil, 2001; Gupta and Sharma, 1997). Gajmer *et al.* (2003) also reported that neem adversely affected survival and development of *Earias vittella*. However, this treatment (i.e. intercropping + neem + *Trichogramma*) was inferior to those having NB1A either alone or in combination with different management practices. Therefore, treatments without the involvement of insecticides seemed to have certain limitations in checking bollworms. Ashraf *et al.* (1999) also expressed similar views that unilateral applications of non-insecticide management strategies may have limited success for cotton bollworms.

The treatment where all management practices including NBIA were combined proved to be as effective as that with NBIA alone. However, the number of sprays required was reduced by about 57 per cent in the former treatment. Nan *et al.* (1987) also reported the reduction in number of sprays of insecticides required where other management practices were integrated in the experiments. On the other hand, under late sown conditions, treatment involving all management practices recorded significantly higher bollworms incidence (4.37%) than NBIA (3.42%), although there was 60 per cent reduction in the number of insecticide spray required in the former treatment. This suggested that there was a need to accommodate some more number of insecticide spray(s) in the former treatment to obtain comparable level of bollworms control to that with NBIA.

4.2 Incidence of bollworms in open bolls at harvest

Data on bollworms incidence in open bolls at harvest are presented in Table 3. No significant differences in incidence of bollworms on boll basis were observed in control plots of early sown, normal sown and late sown crops. But in case of late sown crop with wider spacing, the incidence was significantly higher as compared to that with normal spacing. All treatments proved significantly better than the control in reducing bollworms incidence. The plots treated with neem recorded significantly lower bollworms incidence (58%) as compared to the plots intercropped with sesame (70.4%) and control (75.8%). The incidence of bollworms in T3 (i.e. *Trichogramma* release), T5 (*Trichogramma* release and

neem spray on alternate week) and T9 (intercropping + neem + *Trichogramma*) was found *on a par* with each other but significantly lower than T4 (neem spray), T7 (intercropping) and T11 (control). The per cent incidence of bollworm on boll basis was significantly lower in treatments involving

Table 3. Effect of different management practices on bollworms incidence in open bolls and yield of seed cotton

Treatment	Mean % incidence in open bolls		No. of pink bollworm larvae /100 bolls	Yield (q/ha)	Total income (Rs)	Cost of inputs (Rs)	Net income (Rs)	Net increase over control (Rs)
	Boll basis	Locule basis						
<i>Early sown crop</i>								
T ₁ (NBIA)	32.8 (34.8)bc*	13.2 (21.2)b	2.0ab	34.5a	62100	6162	55938	24978
T ₂ (Control)	73.6 (59.1)f	41.0 (39.8)ef	4.3b	17.2c	30960	0	30960	0
<i>Normal sown crop</i>								
T ₃ (<i>Tricho.</i>)	47.2 (43.4)d	18.5 (25.5)c	2.6ab	16.3c	29340	0	29340	5580
T ₄ (Neem)	58.0 (49.6)e	26.9 (31.2)d	4.9b	16.0c	28800	2660	26140	2380
T ₅ (Nm.+ <i>Tricho.</i>)	44.9 (42.1)cd	18.6 (25.6)c	2.3ab	19.3bc	34740	1520	33220	9460
T ₆ (NBIA)	23.1 (28.7)a	9.6 (18.0)ab	2.7ab	33.3a	59940	6162	53778	30018
T ₇ (Intercropping)	70.4 (57.0)f	36.2 (37.0)e	2.8ab	12.6c	24815	0	24815	1055
T ₈ (Inter.+NBIA)	24.7 (29.7)ab	8.7 (17.1)ab	2.1ab	25.7b	48536	5353	43183	19423
T ₉ (Inter.+Nm. + <i>Tricho.</i>)	45.7 (42.5)cd	17.6 (24.8)c	4.0b	17.3c	33202	1538	31664	7904
T ₁₀ (Inter. +Nm.+ NBIA+ <i>Tricho.</i>)	30.7 (33.6)b	11.9 (20.1)b	5.7b	25.6b	48428	3205	45233	21473
T ₁₁ (Control)	75.8 (60.5)fg	46.6 (43.0)fg	5.7b	13.2c	23760	0	23760	0
<i>Late sown crop</i>								
T ₁₂ (NBIA)	24.1 (29.3)ab	8.2 (16.6)a	1.3a	24.9b	44820	4205	40615	19555
T ₁₃ (Inter.+Nm.+ NBIA+ <i>Tricho.</i>)	39.1 (38.6)c	13.4 (21.2)b	3.6ab	20.7bc	39395	2075	37320	16260
T ₁₄ (Control)	76.4 (61.0)fg	42.4 (40.6)f	6.0b	11.7c	21060	0	21060	0
<i>L.S.+W.S. crop</i>								
T ₁₅ (NBIA)	30.4 (33.4)b	11.5 (19.8)b	2.8ab	23.9bc	43020	4205	38815	17395
T ₁₆ (Control)	80.4 (63.9)g	49.6 (44.8)g	9.0c	11.9c	21420	0	21420	0

C.D. (p=0.05)	(4.42)	(3.0)	2.5	6.6
----------------------	--------	-------	-----	-----

*DMRT (Duncan's multiple range test): Figures with the same letter(s) do not differ significantly
Values in parentheses are angular transformed figures

insecticides as compared to control and other treatments under normal sown conditions. Significantly lower incidence (23.1%) was observed in T6 (NB1A) as compared to control (75.8%) and it was *on a par* with T8 (inter + NB1A). The management strategy involving all the practices (intercropping + neem + NB1A + *Trichogramma*) recorded significantly lower incidence (30.7%) as compared to other treatments, except T6 and T8. Better management of bollworms through integration of two or more management practices including insecticides has been advocated by several workers (Gupta and Sharma, 1996; Bharpoda *et al.*, 2000; Singh, 2003; Virk *et al.*, 2003)

Under late sown conditions, the incidence was significantly lower (24.1%) in T12 (NB1A) as compared T13 (39.1%) where all management practices were combined.

The incidence of bollworm on locule basis followed similar trend as that on boll basis. The bollworms incidence at different dates of sowing did not differ significantly. Similarly, Dhoble *et al.* (1987) reported that the locule infestation of bollworms was similar in all sowing dates. The wider spacing did not help in reducing bollworms incidence in late sown crop. All treatments recorded significantly lower incidence of bollworms than the control.

In normal sown crop, significantly lower incidence (36.2%) was recorded in plots intercropped with sesame as compared to control plots (46.6%). The incidence in *Trichogramma* release plots was significantly lower (18.5%) as compared to neem (26.9%) but it was found statistically *on a par* with the plots

where neem spray was followed by release of *Trichogramma* on alternate week (18.6%), and where intercropping was followed by spray of neem and *Trichogramma* release on alternate week (17.6%). The incidence of bollworms in treatment T6 (NB1A) was found *on a par* with T8 (intercropping + NB1A) and T10 (intercropping + neem + NB1A + *Trichogramma*).

In the late sown crop, incidence of bollworms was higher in open bolls, which was probably due to greater infestation of pink bollworms in late stages of crop growth. Earlier studies also show greater incidence of pink bollworm in the late sown cotton (Jayaswal *et al.*, 1981; Taneja and Dhindwal, 1982; Vennila *et al.*, 2003; Nagargoje *et al.*, 2002).

4.3 Pink bollworms larvae

The number of daipassing larvae of pink bollworm (PBW) per 100 bolls was higher in the late sown crop as compared to early and normal sown crop (Table 3). Under late sown conditions, significantly higher number of pink bollworm larvae was observed in crop sown with wider spacing (9.0 larvae) than that with normal spacing (6.0). Other workers have also reported that incidence of pink bollworm was greater in the late sown crop (Jayaswal *et al.*, 1981; Taneja and Dhindwal, 1982; Vennila *et al.*, 2003; Nagargoje *et al.*, 2002). Minimum number of PBW larvae was observed in NB1A (1.3-2.8) which was *on a par* with treatments having *Trichogramma* (T3), neem + *Trichogramma* (T5), intercropping (T7), intercropping + NB1A (T8), and intercropping + neem + NB1A + *Trichogramma* (T13). However, under normal sown crop, intercropping

+ NBIA (T8) proved significantly better than neem (T4) and intercropping + neem + NBIA + *Trichogramma* (T10).

4.4 Yield of seed cotton

As compared to other treatments, significantly higher yield of seed cotton was recorded in treatment having NBIA, being 34.5 and 33.3 q/ha under early and normal sown conditions, respectively (Table 3). The yield was significantly low (23.9 q/ha) under NBIA in late sown crop as compared to other sowing dates. These results are in line with the earlier findings reporting early sowing of cotton to be better in increasing the seed cotton yield and that delayed sowing reduced the yield considerably (Dhoble *et al.*, 1987; Singh and Bishnoi, 2000; Prasad *et al.*, 2000).

There were no significant differences in the yield of seed cotton observed in crops sown with different spacings. Similar results were reported by Nehra and Kumawat (2003) who stated that seed cotton yield did not differ significantly due to different spacings. Generally, the treatments which were without NBIA did not give significantly higher yield than the control. Thus, there were no significant differences in yield of seed cotton in treatment T3 (*Trichogramma* release), T4 (neem spray), T5 (neem + *Trichogramma*), T7 (intercropping), T9 (intercropping + neem + *Trichogramma*) and T11 (control). The yield in the plots with intercropping followed by NBIA (T8) was found to be *on a par* with that where all the management practices were adopted (T10) but the number of

insecticidal sprays was reduced by 50 per cent in the latter. The above treatments were also *on a par* with neem spray + *Trichogramma* (T5).

Under late sown conditions, the treatment having the insecticides application alone recorded significantly higher (24.9 q/ha) yield as compared to control (11.7 q/ha) but it was found statistically *on a par* with treatment T13 which included all management practices (20.7 q/ha).

Higher income per hectare was recorded under NBIA at all the sowing dates, being maximum in the early sown crop (Rs 62100), followed by normal sown crop (Rs 59940). However, a maximum increase in net income per hectare was observed in the case of normal sown crop (Rs 30018), followed by early sown crop (Rs 24978).

c).5 Population of *Helicoverpa armigera* larvae

Population of *H. armigera* larvae on cotton during the period of study remained below economic threshold of 0.5 larvae/plant (Table 4). No larvae of *H. armigera* were observed in the field upto the first fortnight of August. During the second fortnight of August, the population in the control plots remained less than 2 larvae/10 plants. It gradually increased and reached its peak (i.e. 3.83 larvae/10 plants) during second fortnight of September in the late sown crop. The major reason behind the low population of the pest was probably the high temperature and low rainfall prevailing during the season. Saini *et al.* (2004) concluded that *H. armigera* population on cotton was higher in years having high rainfall and relative humidity than in years with low rainfall. Data on effect of

different sowing dates and spacing on *H. armigera* population are depicted in Fig. 2. Though, different dates of sowing and spacing did not affect the population of *H. armigera* larvae significantly, yet the population seemed to be higher in the late sown crop. Studies by Sekhar *et al.* (1996) also indicated that late sown crop was conducive for *H. armigera* population build-up.

Table 4. Population of *Helicoverpa armigera* larvae in different treatments on different dates

Treatment	Mean number of larvae/10plants on different dates				Pooled mean
	28.08.04	09.09.04	24.09.04	09.10.04	
<i>Early sown crop</i>					
T ₁ (NBIA)	0.50	0.83	1.17	0.83	0.87a*
T ₂ (Control)	0.83	1.50	2.83	2.83	2.03cd
<i>Normal sown crop</i>					
T ₃ (<i>Tricho.</i>)	1.50	1.50	2.83	2.50	2.10cd
T ₄ (Neem)	1.50	2.17	2.17	2.17	2.03cd
T ₅ (Nm.+ <i>Tricho.</i>)	0.83	2.17	2.17	2.50	1.93bc
T ₆ (NBIA)	0.50	0.83	1.50	1.17	1.03ab
T ₇ (Intercropping)	1.17	1.50	1.83	1.50	1.50b
T ₈ (Inter.+NBIA)	0.50	0.83	1.17	1.50	1.03ab
T ₉ (Inter.+Nm. + <i>Tricho.</i>)	1.17	1.17	1.50	1.50	1.37ab
T ₁₀ (Inter. +Nm.+ NBIA+ <i>Tricho.</i>)	0.50	0.83	1.17	0.83	0.87a
T ₁₁ (Control)	1.83	2.33	3.17	2.83	2.57d
<i>Late sown crop</i>					
T ₁₂ (NBIA)	0.50	0.83	1.83	1.50	1.20ab
T ₁₃ (Inter.+Nm.+ NBIA+ <i>Tricho.</i>)	0.50	1.50	2.50	2.83	1.87bc
T ₁₄ (Control)	0.50	2.00	3.83	3.83	2.67d
<i>L.S.+W.S. crop</i>					
T ₁₅ (NBIA)	0.50	0.83	1.83	1.50	1.27ab
T ₁₆ (Control)	0.50	1.67	2.50	3.17	2.13cd
C.D. (p=0.05)	0.88	1.06	1.21	1.19	0.51

* DMRT (Duncan's multiple range test): Figures with the same letter(s) do not differ significantly

Comparison of larval population of *H. armigera* among different treatments on the basis of pooled mean indicated that under normal sown conditions, significantly lower population of *H. armigera* larvae was recorded in plots intercropped with sesame as compared to control, *Trichogramma* release and neem spray. It was found *on a par* with the plots where neem spray and *Trichogramma* release were done on alternate week. Minimum population was observed in treatments where NBIA was there either alone or in combination with other management practices. However, treatment having intercropping + neem + *Trichogramma* (T9) was as effective as NBIA in reducing larval population of *H. armigera*. Treatment with *Trichogramma* or neem used alone did not prove better than the control while the remaining treatments were significantly better than the control in checking the pest's population.

Under late sown conditions, the population of *H. armigera* larvae was significantly lower (1.2 larvae/10 plants) in NBIA alone as compared to control (2.67 larvae) but it was found statistically *on a par* with the treatment where all the management practices were included (intercropping + neem + NBIA + *Trichogramma*).

4.6 Nymphal population of leafhopper (*Amrasca biguttula biguttula*)

The data pertaining to nymphal population of cotton leafhopper is presented in Table 5. It was observed that the population of leafhopper was low throughout the season and it did not reach economic threshold, except under late sown conditions, where it reached so in the middle of October. It was probably

due to high temperature (Av. 39.2°C) and less relative humidity (Av. 69%) prevailing July while the optimum ranges of temperature and relative humidity

Table 5. Effect of different management practices used against bollworms on population of leafhopper

Treatment	Mean no. of leafhopper nymphs/leaf on different dates							Pooled mean
	03.08.04	10.08.04	17.08.04	31.08.04	14.09.04	28.09.04	12.10.04	
<i>Early sown crop</i>								
T ₁ (NBIA)	0.60	0.51	0.50	1.08	1.64	1.35	0.72	0.91 ^{bc*}
T ₂ (Control)	0.52	0.52	0.51	0.92	1.44	1.08	0.76	0.82 ^a
<i>Normal sown crop</i>								
T ₃ (<i>Tricho.</i>)	0.57	0.50	0.50	0.72	1.02	0.83	0.65	0.66 ^a
T ₄ (Neem)	0.57	0.50	0.52	0.78	0.95	0.78	0.59	0.67 ^a
T ₅ (Nm.+ <i>Tricho.</i>)	0.64	0.52	0.50	0.87	1.30	0.98	0.55	0.76 ^{ab}
T ₆ (NBIA)	1.23	0.52	0.50	0.94	1.31	0.97	0.64	0.86 ^b
T ₇ (Intercropping)	0.66	0.53	0.54	0.74	0.94	0.79	0.56	0.68 ^a
T ₈ (Inter.+NBIA)	0.94	0.51	0.52	0.93	1.38	1.03	0.60	0.81 ^{ab}
T ₉ (Inter.+Nm. + <i>Tricho.</i>)	0.57	0.52	0.50	0.78	1.07	0.88	0.56	0.69 ^{ab}
T ₁₀ (Inter. +Nm.+ NBIA+ <i>Tricho.</i>)	0.62	0.51	0.50	0.80	1.11	0.88	0.57	0.71 ^{ab}
T ₁₁ (Control)	0.66	0.50	0.51	0.79	1.07	0.87	0.59	0.71 ^{ab}
<i>Late sown crop</i>	0.54	0.50	0.52	1.01	1.56	1.54	1.86	1.08 ^c
T ₁₂ (NBIA)								
T ₁₃ (Inter.+Nm.+ NBIA+ <i>Tricho.</i>)	0.55	0.53	0.50	0.95	1.14	1.70	2.45	1.11 ^c
T ₁₄ (Control)	0.87	0.52	0.50	1.04	1.37	1.57	1.80	1.11 ^c
<i>L.S.+W.S. crop</i>	0.53	0.54	0.51	1.12	1.34	1.47	1.55	1.01 ^{bc}
T ₁₅ (NBIA)								
T ₁₆ (Control)	0.90	0.50	0.51	0.88	1.19	1.29	1.61	0.97 ^{bc}

C.D. (p=0.05)	0.20	NS	0.02	NS	NS	0.35	0.46	0.17
----------------------	------	----	------	----	----	------	------	------

* DMRT (Duncan's multiple range test): Figures with the same letter(s) do not differ significantly

for leafhopper population build up have been reported to be 32-34°C and 81-92%, respectively (Singh *et al.*, 2004).

The overall population of leafhopper was higher in late sown crop, followed by early sown and normal sown crop (Fig. 3). Butter *et al.* (1992) also reported that population of leafhopper was higher in the late sown crop as compared to early sown crop. Under normal sown conditions, the pooled mean of leafhopper population indicated that it was significantly higher (0.86 nymphs/leaf) in treatment T6 (NBIA) as compared to T3 (0.66 nymph), T4 (0.67 nymphs) and T7 (0.68 nymphs/leaf) whereas it was found statistically *on a par* with other treatments including control. These results are in confirmation with those reported by Srinivasan and Sundara Babu (2000) wherein neem product gave effective control of leafhopper nymphs. Brar *et al.* (1994) also reported the reduction in population of *A. biguttula biguttula* after sprays with neem oil. Rajendran *et al.* (1996) reported that neem oil (3%) and neem seed kernel extract (5%) suppressed the leafhopper incidence considerably. They also reported that cotton intercropped with clusterbean reduced the population of leafhopper as compared to the sole crop. Similarly, Singh *et al.* (1993) suggested okra and sunflower as an intercrop to manage leafhopper. Under late sown conditions, there were no significant differences in population of leafhopper in all the treatments.

4.7 Population of whitefly adults and nymphs

The data related to adult population of whitefly are presented in Table 6. The whitefly population was also very low and it did not reach economic threshold (6-8 adults/leaf) throughout the season due to unfavourable

environmental conditions. As reported by Singh *et al.* (2004), the optimum range

Table 6. Effect of different management practices on population of whitefly adults

Treatment	Mean number of whitefly adults/leaf on different dates							Pooled mean
	03.08.04	10.08.04	17.08.04	31.08.04	14.09.04	28.09.04	12.10.04	
<i>Early sown crop</i>								
T ₁ (NBIA)	0.30	0.39	0.42	1.52	3.17	2.77	3.10	1.55de*
T ₂ (Control)	0.33	0.33	0.39	1.63	2.40	3.07	3.00	1.70de
<i>Normal sown crop</i>								
T ₃ (<i>Tricho.</i>)	0.94	0.30	0.43	1.21	2.00	2.06	1.25	1.09b
T ₄ (Neem)	0.49	0.31	0.42	0.75	1.18	1.36	1.03	0.85a
T ₅ (Nm.+ <i>Tricho.</i>)	0.94	0.34	0.39	1.14	1.77	1.44	1.45	1.01ab
T ₆ (NBIA)	0.76	0.37	0.35	1.97	3.86	3.30	2.77	1.91e
T ₇ (Intercropping)	0.58	0.32	0.40	1.39	2.15	1.79	1.30	1.14bc
T ₈ (Inter.+NBIA)	0.96	0.37	0.42	1.44	2.48	2.20	2.47	1.37cd
T ₉ (Inter.+Nm. + <i>Tricho.</i>)	0.45	0.26	0.44	1.45	2.57	1.55	1.20	1.13bc
T ₁₀ (Inter. +Nm.+ NBIA+ <i>Tricho.</i>)	0.57	0.34	0.41	1.52	2.39	2.53	1.83	1.47cd
T ₁₁ (Control)	0.65	0.38	0.44	1.15	1.51	1.43	1.21	0.97ab
<i>Late sown crop</i>								
T ₁₂ (NBIA)	0.60	0.41	0.34	1.73	2.72	3.19	3.32	1.73e
T ₁₃ (Inter.+Nm.+ NBIA+ <i>Tricho.</i>)	0.46	0.42	0.40	1.29	1.76	2.59	3.13	1.46cd
T ₁₄ (Control)	0.46	0.37	0.32	1.54	2.90	2.49	2.36	1.49d
<i>L.S.+W.S. crop</i>								
T ₁₅ (NBIA)	0.41	0.43	0.29	1.18	1.64	2.34	2.57	1.27c
T ₁₆ (Control)	0.41	0.37	0.33	1.51	2.36	2.57	2.47	1.43cd
C.D. (p=0.05)	0.18	NS	NS	0.30	0.28	0.53	0.76	0.21

* DMRT (Duncan's multiple range test): Figures with the same letter(s) do not differ significantly

of temperature and relative humidity for whitefly population build up were 25-29°C and 68-75%, respectively. However, as evident from the meteorological data (Annexure I), the average temperature was higher than the optimum range for whitefly upto the month of September. Similarly, Ramamurthy *et al.* (2000) reported that whitefly incidence was negatively correlated with maximum temperature and positively correlated with relative humidity.

Whitefly population was higher in early sown and late sown crop as compared to normal sown crop. (Fig. 4). The population did not differ significantly due to different spacing. Under normal sown conditions,

significantly lower population (0.85 adults/leaf) was recorded in neem treated plots (T4) as compared to other treatments, except T5 (neem + *Trichogramma*) and control where it was found *on a par*. The population was higher (1.91 adults/leaf) in treatment T6 where insecticides were sprayed alone as compared to control. Earlier studies also indicated higher whitefly population in plots sprayed with certain insecticides than the control plots (Anonymous, 2004; Singh and Gupta, 1993). Mohan and Katyar (2000) also stated that relatively less population of whitefly was recorded in neem treated plots whereas continuous use of insecticides increased the population. Likewise, Gupta *et al.* (1999) noted that there was no build up of whitefly population in neem. In treatment T10 (intercropping + neem + NB1A + *Trichogramma*), the population of whitefly was significantly higher (1.47 adults/leaf) as compared to control (0.97 adults) but it was found *on a par* with T7 (intercropping), T8 (intercropping + NB1A) and T9 (intercropping + neem + *Trichogramma*).

Under late sown conditions, the population of whitefly adults was significantly higher (1.73 adults/leaf) in insecticide treated plots as compared to control (1.49 adults) and the plots where all the management practices were included (1.46 adults). Higher whitefly population in insecticide treated plots could probably be due to killing of natural enemies of whitefly.

Almost similar trend was observed in the case of nymphal population of whitefly as in case of adult population (Table 7). The lower population was recorded in early sown crop as compared to normal and late sown crop (Fig. 5). Under late sown conditions, the population of whitefly nymphs was significantly

lower in crop sown with wider spacing as compared to that sown with normal spacing. The pooled mean of whitefly nymphs over the different dates indicated that the plots intercropped with sesame recorded significantly lower population (5.11 nymphs/10 leaves) as compared to other treatments, including control. The treatment T5 (neem + *Trichogramma*) recorded significantly lower population as compared to T3 (*Trichogramma* release) T4 (neem spray), T9 (intercropping + neem + *Trichogramma*) and T10 where all the management practices were adopted (i.e. intercropping + neem + NB1A + *Trichogramma*). The population was found significantly higher in T6 (32.89) as compared to control (12.11 nymph/10 leaves) and other treatments. Under late sown conditions, significantly higher population (57 nymphs/leaves) was recorded in T12 (as compared to T13 (25.6 nymphs) where all the management practices were included and the control T14 (11.33 nymphs/10 leaves).

4.8 Population of aphid (*Aphis gossypii*)

The population of aphid was low upto the middle of September. It started increasing and reached its peak (18.5 aphids/ 4 cm² leaf area) in second fortnight of October under late sown conditions (Table 8). The population of aphid was

Table 7. Effect of different management practices on population of whitefly nymphs

Treatment	Number of whitefly nymphs /10 leaves			Pooled mean
	18.09.04	01.10.04	20.10.04	
<i>Early sown crop</i>				
T ₁ (NBIA)	155.00	25.67	2.00	60.89k*
T ₂ (Control)	3.33	4.00	3.00	3.44a
<i>Normal sown crop</i>				
T ₃ (<i>Tricho.</i>)	24.33	49.33	1.33	25.00fg
T ₄ (Neem)	7.00	20.33	2.67	10.00d
T ₅ (Nm.+ <i>Tricho.</i>)	20.33	4.00	3.00	9.11c
T ₆ (NBIA)	64.33	26.33	8.00	32.89i
T ₇ (Intercropping)	11.00	3.00	1.33	5.11b
T ₈ (Inter.+NBIA)	56.00	14.67	1.00	23.89f
T ₉ (Inter.+Nm. + <i>Tricho.</i>)	65.67	6.33	2.00	24.67fg
T ₁₀ (Inter. +Nm.+ NBIA+ <i>Tricho.</i>)	70.67	21.00	1.00	30.89h
T ₁₁ (Control)	23.67	11.33	1.33	12.11e
<i>Late sown crop</i>				
T ₁₂ (NBIA)	24.33	121.00	25.67	57.00j
T ₁₃ (Inter.+Nm.+ NBIA+ <i>Tricho.</i>)	24.33	49.33	3.33	25.66g
T ₁₄ (Control)	18.33	10.33	5.33	11.33de
<i>L.S.+W.S. crop</i>				
T ₁₅ (NBIA)	118.00	84.33	2.33	68.22l

T ₁₆ (Control)	18.00	4.33	1.67	8.00 ^c
C.D. (p=0.05)	2.03	3.13	1.56	1.36

* DMRT (Duncan's multiple range test): Figures with the same letter(s) do not differ significantly

Table 8. Effect of different management practices on population of aphid

Treatment	Mean number of aphid/4cm ² leaf area on different dates			Pooled mean
	12.09.04	26.09.04	11.10.04	
<i>Early sown crop</i>				
T ₁ (NBIA)	4.8	5.5	6.6	5.65a*
T ₂ (Control)	7.8	11.7	13.0	10.84d
<i>Normal sown crop</i>				
T ₃ (<i>Tricho.</i>)	12.1	14.5	17.8	14.79fg
T ₄ (Neem)	13.1	17.3	18.3	16.23h
T ₅ (Nm.+ <i>Tricho.</i>)	12.7	13.8	16.4	14.23f
T ₆ (NBIA)	10.1	13.7	12.5	12.09e
T ₇ (Intercropping)	11.0	17.3	14.9	14.42fg
T ₈ (Inter.+NBIA)	9.5	7.5	12.0	9.67c
T ₉ (Inter.+Nm. + <i>Tricho.</i>)	9.1	13.7	13.0	11.95e
T ₁₀ (Inter. +Nm.+ NBIA+ <i>Tricho.</i>)	8.0	7.6	9.2	8.30b
T ₁₁ (Control)	12.7	16.0	17.1	15.25g
<i>Late sown crop</i>				
T ₁₂ (NBIA)	13.3	13.4	18.5	15.01g
T ₁₃ (Inter.+Nm.+ NBIA+ <i>Tricho.</i>)	7.2	8.0	11.6	8.93bc
T ₁₄ (Control)	16.5	17.1	22.0	18.53i
<i>L.S.+W.S. crop</i>				
T ₁₅ (NBIA)	4.8	6.4	7.1	6.07a
T ₁₆ (Control)	13.4	13.6	17.5	14.81fg

C.D. (p=0.05)	0.8	1.7	1.3	0.74
----------------------	-----	-----	-----	------

* DMRT (Duncan's multiple range test): Figures with the same letter(s) do not differ significantly

higher in late sown crop, followed by normal sown and early sown crops. The population was higher in crop soon with normal spacing as compared to that with wider spacing (Fig. 6).

The pooled mean of the data indicated that under normal sown conditions, the population of aphid did not differ significantly in treatments T3 (*Trichogramma*), T5 (neem + *Trichogramma*) and T7 (intercropping). But the plots in which intercropping was followed by neem spray and release of *Trichogramma* on alternate week, recorded significantly lower population of aphid than in plots where these practices were used alone. This showed an additive effect of various non-insecticidal management practices on population. Treatments T8 (where intercropping was followed by application of insecticides) recorded significantly lower population (9.67 aphids) than the other treatments, except T10 (8.30 aphids /4 cm²/leaf/area). It was observed that the population of aphid was significantly lower (8.3 aphid/ 4 cm² leaf area) in plots where all the management practices adopted as compared to other practices. The treatments involving the application of insecticides recorded lower population as compared to other treatments including control.

Under late sown conditions, the treatment in which all the management practices were included recorded significantly lower population of aphid as compared to control NBIA.

4.9 Parasitization of *H. armigera* egg by *T. chilonis*

The data on parasitization of *H. armigera* eggs by *T. chilonis* on different dates indicated that maximum parasitization was observed in the end of September (Table 9). Parasitization of *H. armigera* eggs in *Trichogramma* released plots increased to 21.5 per cent as compared to the control (4.1%). Nan *et al.* (1987) also reported an increased parasitization of bollworms eggs after release of *Trichogramma*. However, intercropping with sesame proved even better than *Trichogramma* release in parasitizing *H. armigera* eggs. Pooled mean of parasitization over different dates showed that the maximum percentage of eggs were parasitized in plots intercropped with sesame (31.8) as compared to *Trichogramma* released plots (21.5) and control (4.1). These findings are in conformity with the earlier findings wherein intercropping of cotton with sesame was found to increase parasitization of *H. armigera* eggs on cotton by about 32 per cent (Ram *et al.*, 2002).

It is concluded from the present studies that by integration of various pest management practices, the management of cotton pests could be made cheaper, cost effective and environment friendly. Each of the management practices contributed positively towards reduction in bollworms incidence and their combined use had additive effect.

Combination of various practices other than chemical insecticides, for example, *Trichogramma* release, neem spray and intercropping with sesame though significantly reduced bollworms incidence over the control, yet the control achieved was far from satisfactory. The above practices could not

compete insecticides in controlling bollworms. Nevertheless, their integration with insecticides not only helped in achieving good control of bollworms, but resulted in as high as 57 per cent reduction in the number of sprays also. But

Table 9. Effect of intercropping and *Trichogramma* release on parasitization of *Helicoverpa armigera* eggs

Treatment	Parasitization of <i>H. armigera</i> eggs on different dates						Pooled mean parasitization (%)
	18.09.04		29.09.04		08.10.04		
	No. of eggs collected	Parasitization (%)	No. of eggs collected	Parasitization (%)	No. of eggs collected	Parasitization (%)	
<i>Trichogramma</i> release	40	20	30	23.3	37	21.6	21.5
Intercropping	25	32	30	33.3	33	30.3	31.8
Control	36	2.7	32	6.25	29	3.4	4.1

such an integration of both chemical and non-chemical practices could not give comparable yield to that achieved by chemical control alone. This was partly due to the fact that area covered under intercropping was too large to compensate the corresponding expected benefit had cotton been sown in that area. Secondly, *Trichogramma* release were made after 10 days of insecticide application and the parasitoid was allowed another 4-5 days to work before the next insecticidal spraying was done. During this period, bollworms population overtook the control afforded by the parasitoid. It was also reflected in the form of higher bollworms incidence in green fruiting bodies as well as open bolls and reduced seed cotton yield. Nevertheless, it could be inferred from the studies that the interval between the two sprays needs to be reduced. It could possibly be achieved by releasing *Trichogramma* after 6-7 days instead of after 10 days of insecticidal spray. Though, this may result in the increase in the number of sprays but this number will definitely be lower than that under insecticides alone. A reduction in the number of sprays so achieved would not only help in conserving the natural enemies population, delaying the development of insecticide resistance in cotton pests, reducing the chance of pest resurgence, but also help in improving the environmental quality.

Intercropping of cotton with sesame though increased parasitization of *H. armigera* (and possibly of other bollworms as well), yet it could not off set the losses in yield caused by various bollworms, as returns from sesame could not match the expected returns from cotton, from the area occupied by sesame.

Therefore, it needs to be standardized that after how many rows of cotton one or two rows of sesame may be grown as intercrop without sacrificing gross returns. Similarly, unlike in insecticide sprayed plots, there was no increase in whitefly and leafhopper population in neem sprayed plots. Therefore, integration of neem with other pest management practices may help in checking population of these sucking pests. Thus, the present studies may help in further modifying the management strategy to achieve effective, cheaper and safer management of cotton pests.

CHAPTER - V

Summary and Conclusion

The research work entitled “Evaluation of management practices against bollworms and their effect on sucking pests in cotton” was carried out during 2004 at Research Farm of the Department of Entomology, CC Haryana Agricultural University, Hisar. For this purpose, cotton variety H-1117 was sown on three different dates i.e. 12th April, 29th April and 27th May and different treatments were evaluated in plot size of 48m² keeping three replications for each. Different management practices, namely, *Trichogramma chilonis* Ishii release, neem spray, intercropping with sesame, need based insecticides application (NBIA), sowing dates (early, normal and late) and spacing (67.5cm x 30cm and 1.0m x 30cm) were evaluated for their effectiveness against bollworms of cotton.

Bollworms incidence in green fruiting bodies (i.e. squares, flowers and young bolls) was recorded by examining 100 fruiting bodies randomly in each plot for damage by bollworms; while incidence in open bolls at harvest was recorded by examining all the open bolls from 10 random plants from each plot.

Population of diapausing pink bollworm larvae was also recorded in the open bolls. The yield of seed cotton was recorded from a net plot comprising of five rows (four in the case of intercropping and wider spacing each) in each treatment. In treatments having intercropping, the yield of sesame was also recorded. The population of sucking pests (leafhopper, whitefly and aphid) was recorded from three fully expanded leaves of 10 random plants in each plot. The parasitization of *H. armigera* eggs by *T. chilonis* was also recorded in *Trichogramma* released intercropping and control plots.

The results indicated that bollworms damage in green fruiting bodies in the control plots reached its peak (30.33 to 34.33%) during end of September. Overall pooled mean incidence of bollworms in green fruiting bodies was highest (19.6%) in early sown crop, followed by that in normal sown crop (14.65%) and late sown crop (9.61%) in the control plots. The incidence of bollworms in open bolls (on locule basis) was lesser (41.1%) in early sown crop as compared to late sown crop (49.6%) in the control plots.

All management practices gave significantly better control of bollworms than the control, both on green fruiting bodies and open bolls basis. Minimum bollworms incidence in green fruiting bodies and open bolls was observed in treatments where insecticides were used either alone or in combination with other management practices.

Combination of different management practices resulted in reduction in insecticides application by about 57 per cent, but yield of seed cotton was

significantly higher in treatments involving insecticides alone as compared to other treatments. Wider row to row spacing of one meter did not help in reducing bollworms incidence in open bolls in the late sown crop.

Intercropping + neem + *Trichogramma* release proved better than either neem or neem + *Trichogramma* release in reducing bollworms incidence in green fruiting bodies as well as in open bolls. Population of diapausing larvae of pink bollworm as well as bollworms damage was higher in the late sown crop as compared to early sown and normal sown crop. Intercropping of cotton with sesame resulted in greater parasitization (31.8%) of *H. armigera* eggs by *Trichogramma chilonis* and, thus, lower population of *H. armigera* larvae as compared to weekly *Trichogramma* release (21.5%) and control (4.1%) during mid September to early October.

Combination of various pest management practices other than chemical insecticides though could not compete insecticides in controlling bollworms and increasing the yield of seed cotton, yet the bollworms control achieved through them was quite significant. Their integration with insecticides not only caused substantial reduction in insecticides use but also provided good control of bollworms and increased seed cotton yield also.

Neem sprayed plots recorded significantly lower population of leafhopper and whitefly than those sprayed with chemical insecticides. But the population of aphid was lower in treatments involving NBIA as compared to other treatments.

Literature Cited

- Abdalla, E.F. 1992. Effect of sowing date and certain chemical control programme against the cotton bollworms *Pectinophora gossypiella* Saund. and *Earias insulana* Boisd. *Bull. ent. Soc. Egypt. Eco. Series.* **19**: 157-165.
- Anonymous, 2003. *Stat. Abst. Haryana.* **12**: 223-276.
- Anonymous, 2004. Annual report (Research) 2003-2004. Department of Entomology, CCS Haryana Agricultural University, Hisar. p. 17.
- Ashraf, M.; Ahmad, N. and Fatima, B. 1999. Strategy to control cotton bollworms through ecofriendly techniques. *Pakistan J. Zool.* **31**(4): 339-341.
- Babu, R.; Mrugan, K.; Kavita, R. and Sivaramakrishnan, S. 2000. Synergistic effect of extract from *Azadirachta indica* and *Pongamia pinnata* on feeding, survival and fecundity of *H. armigera*. *Indian J. Environ. Toxicol.* **10**(1): 42-44.

Banerjee, S.K.; Turkar, K.S. and Ram Ratan, 2000. Efficacy of newer insecticides against bollworms of cotton. *Pestology* **24**(7): 12-14.

Bharpoda, T.M.; Patel, G.P.; Patel, H.P.; Patel, J.J. and Patel, J.R. 2000. Need based control of cotton bollworms with mixtures of synthetic and botanical insecticides. *Indian J. Pl. Prot.* **28**(10): 74-77.

Bhosle, B.B.; Ratod, K.S.; Patange, N.R. and More, A.W. 2004. Bio-efficacy of new insecticides against cotton bollworms in field conditions. *National symposium on Changing World Order- Cotton Research, Development and Policy in context* held from August 10-12, 2004 at Acharya N.G. Ranga Agricultural University, Rajendernagar, Hyderabad. p. 109.

Bilal-Rasod; Jalal-Arif; Mohammed-Hamed; Bajid-Nadeem, 2002. Field performance of *Trichogramma chilonis* against *Helicoverpa armigera* under varying sowing time and varieties of cotton *Int. J. Agri. Bio.* **4**(1): 113-114.

Brar, K.S.; Arora, S.K. and Ghai, T.R. 1994. Efficacy of neem oil, Dipel and insecticides for the control of cotton jassid and fruit borer on okra. *Pestology* **18**: 14-16.

Brar, K.S.; Sekhon, B.S.; Singh, J.; Shenhmar, M. and Singh, J. 2002. Biocontrol based management of cotton bollworms in the Punjab. *J. Bio. Cont.* **16**(2): 121-124.

- Brar, K.S.; Varma, G.C.; Sekhon, B.S. and Shenmar, M. 1999. Comparative efficacy of *Trichogramma achaeae* Nagarkatti and insecticides for control of cotton bollworms. *J. Res. Punjab agric. Univ.* **28** (4): 511-514.
- Butter, N.S. and Kular, J.S. 1997. Efficacy of Godrej Achook containing azadirachtin against cotton bollworms. *J. Insect Sci.* **10**(2): 198-199.
- Butter, N.S.; Brar, A.S.; Kular, J.S. and Singh, T.H. 1992. Effect of agronomic practices on incidence of key pests of cotton under unsprayed conditions. *Indian J. Ent.* **54**(2): 115-123.
- Butter, N.S.; Kular, J.S.; Brar, A.S. and Singh, T.H. 1989. Effects of nitrogen, intra row spacing and varieties on the incidence of cotton bollworms under unsprayed conditions. *J. Cotton Res. Dev.* **3**(1): 27-31.
- Chandramani, P.; Murugesan, N. and Sivasamy, N. 2004. Evaluation of newer insecticide molecules against *Earias spp.* and *Pectinophora gossypiella* in rice fallow *hirsutum* cotton. *National symposium on Changing World Order- Cotton Research, Development and Policy in context* held from August 10-12, 2004 at Acharya N.G. Ranga Agricultural University, Rajendernagar, Hyderabad. p. 87.
- Chao, Y.Z. and Liu, J.H. 1996. The induction of adversity resistant *Trichogramma flava* and its use in the experimental control of bollworms. *China Cottons* **23**:10-26.

- Deol, J.S. and Brar, Z.S. 2003. Effect of different spacing and mepiquat chloride on cotton (*Gossypium hirsutum* L.) productivity. *J. Cotton Res. Dev.* **17** (2): 247-248.
- Dhandapani, N.; Kalyanasundaram, M.; Swamiappan, M. Sundara babu, P.C. and Jayaraj, S. 1993. Experiment on management of major pests of cotton with biocontrol agent in India. *J. appl. Ent.* **114**:52-56.
- Dhawan, A.K. and Simwat, G.S. 1997. Evaluation of some new insecticides against bollworms and sucking pests on Asiatic cotton. *J. Cotton Res. Dev.* **11**(1): 105-108.
- Dhawan, A.K. and Simwat, G.S. 2000. Evaluation of indoxacarb for the control of bollworm complex and its impact on population of sucking pests and beneficial arthropods in cotton ecosystem. *Pestology* **24** (7): 15-20.
- Dhawan, A.K.; Simwat, G.S.; Tauro, P. (ed.) and Narwal, S.S. (ed). 1992. Field evaluation of Neemrich 20EC for management of insect pests on cotton during reproductive phase. *Proc. first national symposium: Allelopathy in Agro-ecosystems (Agri. and Forestry)*. Feb. 12-14, 1992 held at CCS, Haryana Agricultural University, Hisar-125004, India. p. 152-153.
- Dhoble, M.V.; Pawar, B.R.; Patil, V.D. and Daware, D.G. 1987. Studies on sowing date and infestation of bollworms on yield of different cotton genotypes. *J. Cotton Res. Dev.* **1**(1): 86-87.

- Gajmer, T.; Singh, R.; Saini, R. K. and Kalidhar, S.B. 2003. Growth and development inhibitory effects of *Azadirachta indica* and *Melia azedarach* on *Earias vittella* larvae. *J. Medicinal Aromatic Pl. Sci.* **25**: 108-112.
- Gupta, G.H. and Sharma, K. 1997. Neem based strategy in cotton system. *J. Pest. Res.* **9**(2): 190-197.
- Gupta, G.P. and Sharma, K. 1996. Utilization of biopesticides in managing the cotton pest complex in India. *Proc. Beltwide Cotton Conf.* Mashvilla, T.N., USA, Jan. 9-12, 1996. **2**: 1135-1140.
- Gupta, G.P.; Katiyar, K.N.; Sharma, K.; Singh, R.P. (ed.) and Saxena, R.C. 1999. Neem in the management strategies of insect pest of cotton. *Azadirachta indica A. Juss.* p. 177-189.
- Gurusamy, A.; Ganesarya, V.; Rajaram, V. and Raveendran, M. 2000. Management of biotic stresses in dry land cotton through bioextracts. *J. physiol. Res.* **13**(1): 105-106.
- Hanumanna, M.; Thuntadarya, T.S. and Rao, K.J. 1984. A note on the acceptance of the eggs of cotton bollworms by different *Trichogramma* parasitoids. *Current Research*, University of Agricultural Sciences, Bangalore. **13**:4-6, 27.

- Jayaswal, A.P.; Saini, R.K. and Kairon, M.S. 1981. Incidence of pink bollworm in some promising varieties of upland cotton in Haryana. *Indian J. agric. Sci.* **51**(8): 577-578.
- Mohan, M. and Katiyar, K.N. 2000. Impact of different insecticides used for bollworm control on the population of jassid and whitefly in cotton. *J. Pest. Res.* **12**(1): 99-102.
- Murugan, K. and Babu, R. 1998. Impact of certain plant products and *Bacillus thuringiensis* Berliner *sp. kurstaki* on the growth and feeding physiology of *H. armigera*. *J. Sci. Indust. Res.* **57**: 757-765.
- Naganagoud, A. and Thuntadarya, T.S. 1984. Incidence of natural enemies of *Heliothis armigera* (Hubner) and *Earias spp.* on okra used as a trap crop in the management of cotton bollworms. *Current research*, University of Agricultural Sciences, Bangalore. **13**: 7-9, 56-57.
- Nagargoje, D.C.; Mehetre, S.S and Patil, S.D. 2002. Effect of different sowing dates and irrigation methods on insect pests in cotton. *J. Cotton Res. Dev.* **16**(2): 227-229.
- Nan, L.Z.; Wang, D.A.; Sun, X.Z.; Li, X.Z.; Tian, X.G.; Zhang, W.H.; Wang, G.X.; Han, Y.J. and Zhang, J.Q. 1987. Study of protection and application of natural enemies of insect pests. *Nat. Enemies Ins.* **9**(3): 125-129.

- Nehra, P.L. and Chandra, M. 2001. Performance of *hirsutum* cotton under different sowing dates and spacing. *J. Cotton Res. Dev.* **15**(2): 147-150.
- Nehra, P.L. and Kumawat, P.D. 2003. Response of cotton varieties to spacing and nitrogen levels. *J. Cotton Res. Dev.* **17**(1): 41-42.
- Parthiban, M. and Ananthan, G. 1998. Alternate application of neem and biopesticide in cotton pest management. *Insect Environ.* **3**(4): 97-98.
- Pawar, A.D. and Prasad, J. 1985. Evaluation of some exotic parasites in biocontrol of cotton bollworms in Haryana. *Indian J. Pl. Prot.* **13**:21-24.
- Pawar, A.D.; Prasad, J. and Gupta, M. 1980. Biological control of cotton bollworm *Pectinophora gossypiella*. *Andhra agric. J.* **27**(1&2): 33-54.
- Prasad, H. 1995. Effect of sowing dates and spacing on seed cotton yield of early maturing genotypes of *hirsutum* cotton. *J. Cotton Res. Dev.* **9**(1): 28-31.
- Prasad, H.; Nehra, P.L.; Gothwal, D.K. and Singh, H. 2000. Effect of date of sowing and spacing on seed cotton yield. *J. Cotton Res. Dev.* **14**(2): 232-234.
- Prasad, J.; Pawar, A.D. and Singh, P. 1985. Role of exotic and indigenous parasites, *Trichogramma brasiliensis*, Ashmead, *T. pretiosum*, Riley, *T. acheae*, Nagaraja and Nagarkati, *Chelonus blackburni*, Cameron and *Bracon kirkpatricki*, (Wilkinson) for the control of cotton bollworms in

Hisar (Haryana) India. *Proc. national symposium on Pesticide Residue and Environmental Pollution*, Muzaffarnagar, India. 2-4 Oct. 1985. 190-194.

Rabindra, R. J. and Jalali, S.K. 2004. Role of biocontrol agents in integrated pest management in cotton. *National symposium on Changing World Order- Cotton Research, Development and Policy in context* held from August 10-12, 2004 at Acharya N.G. Ranga Agricultural University, Rajendernagar, Hyderabad-500030. p. 163-172.

Rajendran, M.; Nalini, R.; and Muthusankaranarayanan, A.1996. Evaluation of the influence of intercropping and plant products on the incidence of leafhopper on rainfed cotton. *J. Cotton Res. Dev.* **10**(1): 76-80.

Rajput, K.P. and Daware, D.G. 2002. Effect of different intercrops on incidence of bollworm complex of cotton. *J. Cotton Res. Dev.* **16**(2): 217-220.

Ram, P.; Ombir and Chhillar, B.S. 2004. Role of inundative release of *Trichogramma chilonis* Ishii in reducing bollworms incidence in cotton. *National symposium on Changing World Order- Cotton Research, Development and Policy in context* held from August 10-12, 2004 at Acharya N.G. Ranga Agricultural University, Rajendernagar, Hyderabad-500030. p. 107.

- Ram, P.; Sharma, P.D. and Chaudhary, S.D. 1997. Evaluation of inundative release of *Trichogramma chilonis* Ishii against bollworm pests of cotton. *J. Cotton Res. Dev.* **11**(1): 116-119.
- Ram, P.; Sharma, S.S. and Saini, R.K. 2002. Role of egg parasitism by *Trichogramma chilonis* Ishii to control *Helicoverpa armigera* (Hubner) in cotton-sesame intercropping. *J. Cotton Res. Dev.* **16**(1): 109.
- Ramamurthy, R.; Raja Ram, V.; Rajendran, M. and Krishnadoss, D. 2000. Impact of weather parameters on cotton pests. *J. Cotton Res. Dev.* **14**(2): 193-195.
- Rohilla, H.R. and Saini, R.K. 2003. Efficacy of newer formulation of insecticides against bollworms of cotton. *J. Cotton Res. Dev.* **17**(2): 191-193.
- Rosaiah, B. and Reddy, A.S. 1997. Effect of sowing time on incidence of *Helicoverpa armigera* (Hubner) on MCU-5 cotton in Andhra Pradesh. *J. Cotton Res. Dev.* **11**(1): 74-83.
- Rosaiah, B.; Reddy, A.S. and Mukundan, S. 1997. Evaluation of different insecticides of recent origin against *Helicoverpa armigera* (Hubner) on cotton. *J. Cotton Res. Dev.* **11**(1): 65-73
- Saini, R.K.; Rohilla, H.R.; Ram, P. and Chhillar, B.S. 2004. Effect of some newer insecticides on bollworms incidence and yield of seed cotton in Haryana. *National symposium on Changing World Order- Cotton*

Research, Development and Policy in context held from August 10-12, 2004 at Acharya N.G. Ranga Agricultural University, Rajendernagar, Hyderabad-500030. p. 90.

Saini, R.K.; Jaglan, R.S. and Naresh, J.S. 2004. Status of American bollworm, *Helicoverpa armigera* (Hubner), on cotton in Haryana. *J. Cotton Res. Dev.* **18**(1): 78-80.

Salem, S.A. 1991. Response of cotton bollworm, *Pectinophora gossypiella* Saund. and *Earias insulana* Boisd. to neem kernel pure oil. *Ann. agric. Sci. Moshtohor.* **29**(1): 597-607.

Sarode, S.V.; Patil, P.P. and Borkar, S.L. 1995. Evaluation of neem seed kernel extract in combination with *Heliothis* nuclear polyhedrosis virus against cotton bollworms. *J. ent. Res.* **19**(3) 219-222.

Sekhar, P.R.; Venkantaiah, M.; Venugopal Roa, N. and Ramarao, B. 1996. Population studies of *Helicoverpa armigera* (Hubner) on early and late sown cotton crop in NSP area of Andhra Pradesh. *J. Cotton Res. Dev.* **10**(2): 225-231.

Simwat, G.S.; Dhawan, A.K. and Sindhu, A.S.1987. Effect of delayed sowing, higher nitrogen level and plant population on incidence of bollworms and yield of seed cotton in F-414 *hirsutum* cotton. *J. Res. Punjab agric. Univ.* **24**(2): 247-254.

- Singh, J. 2003. Integration of *Trichogramma chilonis* Ishii in the management of cotton bollworms. *Ph.D. Dissertation, Punjab Agricultural University, Ludhiana*
- Singh, J. and Bishnoi, L.K. 2000. Effect of sowing dates on yield and fibre characteristics of different cotton varieties of Haryana. *J. Cotton Res. Dev.* **14(1)**: 73-77.
- Singh, J.P. and Gupta, G.P. 1993. Impact of various insecticide on intermittent population of jassid and whitefly infesting American cotton during different spray scheduled followed for the control of bollworm complex. *J. ent. Res.* **17**: 297-303.
- Singh, J.P. and Gupta, G.P. 1993. Impact of various insecticides on intermittent population of jassid and whitefly infesting American cotton during different spray schedules followed for the control of bollworm complex. *J. ent. Res.* **17(4)**: 297-303.
- Singh, R. and Chaudhary, J.P. 1986. Incidence and relative abundance of *Earias spp.* on some host plants in Hisar, Haryana. *Proc. Nat. Symp. Integrated Pest Control-Progress and Perspective*, Oct. 15-17, 1987, 123-
- Singh, R. Singh, D. and Garg, H.R. 2000. Efficacy of biopesticide (Nimbecidine) on bollworm complex incidence in upland cotton in Punjab. *J. Cotton Res. Dev.* **14(1)**: 73-77.

Singh, S., Ram Niwas, Saini, R.K. and Khichar, M.L. 2004. Relationship of micro climatic parameters with population dynamics of leafhopper and whitefly in cotton. *National symposium on Changing World Order-Cotton Research, Development and Policy in context* held from August 10-12, 2004 at Acharya N.G. Ranga Agricultural University, Rajendernagar, Hyderabad-500030. p. 104.

Singh, T.; Brar, Z.S.; Parkash, R. and Hassan, H. 2003. Effect of dates of planting and defoliant on yield and quality of cotton (*Gossypium hirsutum*). *J. Cotton Res. Dev.* **17**(2): 146-149.

Sreenivas, A.G. and Patil, B.V. 2001. Role of commercial neem products in cotton insect pest management. *J. Cotton Res. Dev.* **15**(1): 58-62.

Srinivasan, G. and Sundara Babu, P.C. 2000. Comparative efficacy of neem products against brinjal leafhopper, *Amrasca biguttula biguttula*. *Indian J. Ent.* **62**(1): 18-23.

Sunderamurthy, V.T. 1985. Integrated insects management system for cotton. *Training-cum-workshop on Integrated Cotton Production Technology* held at CICR, Nagpur, Nov. 20-Dec. 10, 1985, 220-229.

Taneja, S.L. and Dhindwal, A.S. 1982. Bollworm incidence as affected by sowing date, nitrogen application and plant population in upland cotton. *Indian J. Plant Prot.* **10**: 1-6.

- Tuhan, N.C.; Pawar, A.D. and Arora, R.S. 1987. Use of *Trichogramma brasiliensis* Ashmad against cotton bollworms in Sriganganagar, Rajasthan, India. *J. Adv. Zool.* **8**(2): 131-134.
- Vennila, S.; Panchbhai, P.R.; Ramteke, M.S. and Biradar, V.K. 2003. Crop phenology, pink bollworm (*Pectinophora gossypiella*, Saunders) damage and yield of cotton hybrids in relation to sowing dates. *J. Cotton Res. Dev.* **17**(1): 65-70.
- Virk, J.S.; Brar, K.S.; Tandon, P.L. (ed.); Ballal, C.R. (ed.); Jalali, S.K. (ed.) and Rabindra, R.J. 2003. Effect of cultural practices on the efficacy of *Trichogramma chilonis* Ishii for the management of cotton bollworms. *Proc. Symp. Bio. Control of Lepidopteran Pests*, Jul. 2003, 341-346.
- Yadav, A.S.; Shrivastava, V.K. and Tomar, S.P.S. 2004. Efficacy of newer insecticides against bollworms of cotton. *National symposium on Changing World Order- Cotton Research, Development and Policy in context* held from August 10-12, 2004 at Acharya N.G. Ranga Agricultural University, Rajendernagar, Hyderabad-500030. p. 107.

ANNEXURE – I

Daily Meteorological Data of Hisar

June , 2004													
Day	Temperature O C		GMIN	Avp mm		RH, %		WD-CODE		WS	SS	EVAP	Rain
	Max	Min		M	E	M	E	M	E	km/hr	hrs	mm	mm
1	43.2	25.7	-	18.8	12.7	60	21	20	32	6.6	10.4	10.8	0
2	41.7	25.7	-	19.2	15.6	63	30	20	34	7.7	7.8	9.7	0
3	39.7	23.7	-	17.4	13.2	58	23	23	20	8.9	4.6	8.3	0
4	41.4	25.5	-	17.5	12.1	53	19	25	32	3.8	5.7	8.3	0
5	42.9	26.0	-	19.3	17.2	70	30	14	29	9.1	6.7	7.6	2
6	41.0	26.6	-	19.9	16.6	70	30	16	16	10.9	9.2	11.1	0
7	40.4	23.7	-	16.7	19.1	66	54	14	14	16	9.7	12.7	0
8	36.0	22.5	-	18.5	14.8	58	45	14	5	12.2	2.9	9.6	0
9	33.4	23.0	-	18.1	14.9	74	40	14	14	14.3	3.7	5.8	0
10	33.4	23.0	-	20.6	14.3	72	30	14	34	3.8	0.5	6.6	0
11	38.2	26.3	-	19.3	20.3	64	42	7	7	6.7	10.9	11.5	0
12	38.4	26.4	-	18.5	16.4	58	31	11	14	9	10.9	9.9	0
13	39.5	27.3	-	20.3	18.7	67	38	11	11	10.5	9	11.3	0
14	38.6	28.5	-	21.5	19.3	68	40	14	11	12.3	10.7	10.1	0
15	38.4	28.6	-	20.7	18.4	60	36	11	14	12	10.7	10.3	0
16	39.1	28.6	-	22.4	21.7	63	42	9	11	8.7	9.1	9.6	0
17	39.5	26.5	-	20.9	22.1	68	43	14	14	9	6.6	10.9	0
18	39.2	27.0	-	22.4	22.8	80	48	14	14	10.7	10.6	11.8	1
19	38.0	28.0	-	21.3	22.4	67	43	14	20	8.5	1.5	9.7	0
20	39.5	23.0	-	23.5	22.9	79	49	20	23	13.3	0	13	28.4
21	37.3	22.0	-	20.2	20.6	88	47	14	25	10.7	2.1	7.3	2
22	36.1	22.1	-	22.0	19.9	72	52	16	2	8.3	5.2	7.6	0
23	33.8	23.0	-	20.7	20.4	65	52	27	27	10.4	0	5.2	0
24	34.8	22.1	-	20.4	22.4	63	70	25	23	12.1	0	10.1	0
25	32.0	20.3	-	22.0	21.3	100	59	25	25	9.7	2.4	3.1	26.3
26	33.8	20.5	-	21.7	22.8	92	80	23	11	5	4.8	2.2	1
27	31.1	23.0	-	20.9	21.9	91	63	5	5	4.1	4.7	3.2	1
28	33.0	22.0	-	22.0	19.7	87	45	0	14	2.7	3.9	5.4	0
29	36.6	24.0	-	22.3	19.5	79	43	27	29	2.7	11.8	5	0
30	38.0	24.3	-	19.7	20.4	56	41	27	29	7.1	10.7	10.8	0
Total	1128.0	738.9	-	608.7	564.4	2111	1286	-	-	266.8	186.8	258.5	61.7
Avg.	37.6	24.6	-	20.3	18.8	70	43	-	-	8.9	6.2	8.6	-

Annexure-I Contd.....

Daily Meteorological Data of Hisar

July , 2004													
Day	Temperature O C			Avp mm		RH, %		WD-CODE		WS	SS	EVAP	Rain
	Max	Min	GMIN	M	E	M	E	M	E	km/hr	hrs	mm	mm
1	40.8	28.5	-	20.9	22.9	62	41	23	23	8.6	8.1	10	0
2	41.5	26.8	-	20.6	20.9	59	39	23	23	7.8	10.5	11.6	0
3	40.9	27	-	23.2	21.6	67	41	0	29	6.9	9.3	12.7	0
4	40.2	27.3	-	21.1	22	66	40	11	14	12.3	10.1	11.5	0
5	40.2	27.5	-	24.5	22.8	77	45	20	7	7	8.1	10.1	0
6	39.1	26.5	-	22.3	23.9	73	47	18	16	6.4	8.5	7.4	0
7	39.2	29.1	-	23.9	23.6	71	43	23	29	8.9	9.6	10.5	0
8	40	30.5	-	21.5	19	61	40	25	25	16.1	3.3	11.4	0
9	38.3	29.1	-	22	21.3	67	47	27	25	20.8	0	15.4	0
10	37.2	27.7	-	21.7	22.7	65	50	25	25	9.9	0	7.9	0
11	37.3	28.3	-	21.5	20.3	61	40	25	27	14.2	0	13.4	0
12	39.2	29.5	-	22.1	21.2	66	42	25	23	14.3	0	14.6	0
13	39.4	26.7	-	19.7	19.5	58	37	25	25	8.6	1	10.3	0
14	39	27	-	18.9	18.5	56	37	25	29	9.6	3.2	11.7	0
15	38.9	26.8	-	21.2	19.9	65	38	27	2	8.3	6.1	11	0
16	39.9	27	-	22.3	20.8	75	42	14	14	9.8	8.6	12.8	0
17	38.6	28.5	-	24.9	20.8	78	42	11	14	6.8	8.4	8.5	0
18	38.5	26.3	-	20.2	19.9	63	42	25	29	6.2	6.7	8.2	0
19	38	27	-	21.3	20.3	67	47	23	27	10.2	7.6	13.1	0
20	37.3	26	-	20.1	16.2	62	33	25	25	10.8	7.4	8.1	0
21	38.3	25	-	21.1	16.8	74	36	34	25	10.6	0	10.8	0
22	38.5	26	-	20.1	17.4	67	37	25	27	7.8	2.1	8.4	0
23	38.6	27.6	-	16.2	20.6	51	40	29	27	8.9	6.3	13.3	0
24	39.7	27.8	-	24.1	21.3	73	42	11	32	6.7	9.5	9	0
25	39.8	27.3	-	23.3	19.5	72	37	14	14	7.7	10.2	10.6	0
26	40.2	27.5	-	24.3	17.8	72	33	11	29	8.7	9.5	9	0
27	41.1	26.9	-	21.9	20.3	68	37	14	29	10.5	8.1	11.6	0
28	40.3	26.5	-	25.2	21.9	81	42	14	99	9.5	5.2	10.7	0
29	39.3	27.5	-	25.7	21.5	86	40	14	14	9.7	9	7.2	0
30	39.8	26.9	-	25.5	22.1	85	52	14	9	13.1	9.7	10.2	0
31	36.9	27.4	-	24.2	19.8	77	53	11	7	9.7	8.7	9	0
Total	1216.0	849.1	-	686.3	637.1	2125	1282	-	-	306.8	194.8	330.0	0.0

Avg.	39.2	27.4	-	22.1	20.6	69	41	-	-	9.9	6.3	10.6	-
-------------	-------------	-------------	----------	-------------	-------------	-----------	-----------	----------	----------	------------	------------	-------------	----------

Annexure – I contd.....

Daily Meteorological Data of Hisar

August, 2004													
Day	Temperature O _C		GMIN	Avp mm		RH, %		WD-COD E		WS	SS	EVAP	Rain
	Max	Min		M	E	M	E	M	E	km/hr	hrs	mm	mm
1	35.1	26.6	-	24.9	20.7	82	49	14	5	7.1	7.9	6.7	0
2	36	24.9	-	24.3	23.1	92	90	34	9	6.8	8.6	5.4	1.5
3	29	24	-	24.2	25.5	98	97	5	2	5.7	0.6	2.8	8.9
4	30.1	24	-	25.2	24.1	89	57	9	9	6.6	1.1	1.2	1.7
5	35.3	27.3	-	25.5	24.2	82	56	11	9	6.6	10.6	5.6	0
6	35.7	27.6	-	24.6	23.8	78	56	11	11	10.6	12.2	8.3	0
7	35.2	27.8	-	25.2	23.8	85	56	14	14	9.6	10.1	10	0
8	35.6	26.9	-	25.2	23.8	85	56	9	14	8	7.8	83	0
9	35.2	25.1	-	24.8	24.1	93	62	14	14	4.8	5.2	4.1	0
10	34.4	24.9	-	23.2	23.6	92	63	0	14	3.5	2.6	3.8	4
11	33.4	25.2	-	26.3	23.2	94	65	5	9	5.7	6.7	6.4	0
12	33	25	-	24.1	25.2	85	69	9	11	6.5	1.1	5.1	0
13	33.5	25.3	-	26.4	26.4	97	72	2	29	3.9	1.5	3.6	11
14	34.3	25	-	24.6	27.2	92	67	0	14	3.7	4.3	3.7	3.1
15	34.8	25.1	-	26.1	26.9	92	67	14	14	4.1	8.5	5.7	0
16	34.3	26	-	25.5	24.9	81	59	14	14	3.7	8.3	5.4	0
17	35.2	25.2	-	25.1	24.1	87	57	18	23	6.7	8.6	7.6	0
18	35.2	23.9	-	23.5	28.5	92	83	20	36	6.2	7.3	7.3	3.5
19	33.4	25.9	-	23.5	22.5	82	57	25	34	5.7	8.4	6.4	3.9
20	34.7	24.6	-	23.2	24.8	82	49	27	27	10.2	6.7	7.3	0
21	36.5	26.1	-	22.9	24.2	79	56	27	29	7.8	7.1	6.3	0
22	36	26.3	-	25.2	25.1	82	65	11	14	4.9	8.2	5.7	0
23	34.1	23.9	-	23.9	25.1	98	93	5	9	7	5.5	3.6	5
24	28.9	23.9	-	23.3	22.8	98	90	7	5	8.9	1	2	3
25	26.5	22.1	-	23.5	23.1	97	98	2	7	8.2	0	2.5	1
26	27.9	22.8	-	23.3	23.6	95	61	0	27	2.7	1.3	1.7	40
27	33.6	25	-	22.5	23.5	84	55	25	27	4.7	10.3	4.7	0
28	35.4	24	-	22.8	22.4	87	52	25	29	7.8	9.2	6.8	0
29	35.9	24.6	-	22.7	22.4	83	51	25	25	6.2	9.1	5.7	0
30	36.4	24	-	20.6	21.7	77	51	25	29	6.3	8.8	7	0
31	36	23.5	-	19.9	19.7	77	43	23	25	6.5	8.9	7.2	0
Total	1050.6	776.5	-	746	744	2717	2002	-	-	196.7	197.5	167.9	86.6
Avg.	33.9	25	-	24.1	24	88	65	-	-	6.3	6.4	5.4	-

Annexure – I contd.....

Daily Meteorological Data of Hisar

September, 2004													
Day	Temperature OC		GMIN	Avp mm		RH, %		WD-COD E		WS	SS	EVAP	Rain
	Max	Min		M	E	M	E	M	E	km/hr	hrs	Mm	mm
1	36.9	23.1	-	19.6	19.6	75	43	23	23	9.0	8.6	8.1	0.0
2	36.5	22.5	-	20.3	19.2	77	46	20	32	7.0	9.4	7.4	0.0
3	35.6	23.0	-	23.2	15.1	92	34	27	29	6.0	9.5	6.7	0.0
4	35.9	22.0	-	16.9	15.3	71	33	29	29	5.9	9.7	7.6	0.0
5	37.2	21.6	-	16.9	17.0	71	38	25	27	5.5	9.4	7.6	0.0
6	36.4	22.0	-	18.2	16.8	73	37	27	32	6.2	10.0	7.0	0.0
7	37.0	21.6	-	19.2	15.6	76	34	27	25	5.1	10.3	7.6	0.0
8	37.0	21.3	-	17.4	13.1	74	26	27	29	4.3	10.8	7.8	0.0
9	39.0	24.1	-	15.0	12.9	56	25	25	34	6.4	9.0	6.9	0.0
10	39.2	23.5	-	18.7	22.5	72	48	20	20	6.4	9.8	8.6	0.0
11	37.2	22.7	-	18.4	19.8	73	45	20	23	4.7	10.1	8.0	0.0
12	36.6	23.7	-	19.7	20.1	73	44	23	23	5.1	9.5	7.7	0.0
13	37.0	23.6	-	20.3	17.9	72	39	25	29	3.3	8.9	6.3	0.0
14	36.9	24.7	-	19.2	17.9	71	39	27	5	4.6	7.8	6.4	0.0
15	36.9	24.1	-	19.6	20.4	74	54	9	11	5.5	9.0	7.8	0.0
16	33.6	21.9	-	20.4	22.0	91	77	5	11	10.4	6.5	o.f	38.0
17	29.0	22.4	-	21.1	22.1	83	59	0	34	1.5	0.3	1.6	0.0
18	33.2	24.1	-	18.2	22.0	95	57	0	2	2.7	9.5	4.5	0.0
19	34.7	24.3	-	23.6	22.4	83	56	0	0	2.2	8.6	4.1	0.0
20	34.6	24.1	-	23.6	20.1	83	51	16	9	2.8	9.3	5.4	0.0
21	34.2	24.1	-	20.3	22.0	84	60	7	7	5.2	9.4	5.9	0.0
22	33.4	21.4	-	21.1	19.8	93	53	0	34	6.4	10.4	5.3	0.0
23	32.9	21.0	-	19.5	16.7	88	44	11	5	4.5	9.9	5.7	0.0
24	33.4	21.4	-	19.9	16.4	88	41	25	36	3.0	9.6	4.1	0.0
25	34.0	19.7	-	19.5	15.8	82	38	0	7	3.5	10.0	5.5	0.0
26	35.2	19.9	-	20.4	13.5	91	32	0	5	2.2	7.9	4.1	0.0
27	35.1	21.6	-	18.3	15.1	77	34	0	2	2.6	10.1	6.7	0.0
28	36.0	20.8	-	17.9	13.6	65	30	0	5	2.5	10.1	4.8	0.0
29	36.6	23.5	-	18.9	18.0	74	63	5	11	3.3	8.1	7.0	0.0
30	29.9	20.5	-	21.5	14.7	90	37	0	5	6.0	6.2	4.5	3.0
Total	1061.1	674.2	-	586.8	537.4	2367	1317			143.8	267.7	180.7	41.0
Avg.	35.4	22.5	-	19.6	17.9	79	44			4.8	8.9	6.2	-

Annexure – I contd.....

Daily Meteorological Data of Hisar

October, 2004													
Day	Temperature			Avp mm		RH, %		WD-COD		WS Km/hr	SS hrs	EVAP. mm	Rain mm
	O C		GMIN	M	E	M	E	E					
	Max	Min						M	E	M	E		
1	34.5	21.6	-	19.8	18.3	84	46	0	18	2.9	7.6	3.9	0.0
2	34.1	23.8	-	22.3	21.9	84	54	0	16	2.3	5.2	4.4	0.0
3	34.7	21.7	-	20.8	18.4	93	63	9	7	7.3	4.9	O.F.	28.4
4	29.2	22.0	-	20.3	21.3	84	67	5	7	4.2	4.5	4.3	0.0
5	31.6	20.0	-	19.3	19.5	93	56	0	5	1.9	8.9	3.1	0.0
6	32.5	19.5	-	18.2	21.9	89	60	0	20	1.3	9.9	3.8	0.0
7	33.0	19.8	-	18.5	19.2	88	59	0	34	1.0	9.2	4.6	0.0
8	34.4	19.2	-	22.4	11.2	75	26	0	32	1.7	10.3	4.2	0.0
9	35.7	20.4	-	16.4	15.4	70	37	0	18	3.6	8.8	5.6	0.0
10	35.3	21.1	-	19.5	14.2	98	43	14	14	7.3	8.2	4.3	8.0
11	31.7	19.1	-	19.5	19.3	98	73	7	11	12.6	4.7	2.5	0.0
12	28.2	16.5	-	16.3	16.7	94	71	5	7	3.6	4.6	3.9	0.0
13	26.0	15.6	-	14.8	13.6	87	51	7	16	3.7	6.3	3.7	0.0
14	27.6	15.4	-	15.0	13.0	96	47	0	32	1.8	8.0	5.2	0.0
15	27.9	13.0	-	12.9	13.4	90	49	0	16	2.0	7.9	5.5	0.0
16	28.2	12.6	-	12.3	8.9	85	27	0	11	2.1	8.6	5.6	0.0
17	31.5	14.5	-	13.0	15.1	80	45	0	9	1.1	8.5	5.3	0.0
18	33.0	15.1	-	15.0	11.8	92	33	0	11	1.5	8.5	5.8	0.0
19	33.2	18.5	-	15.4	11.3	83	31	11	36	4.6	8.5	5.0	0.0
20	32.6	18.1	-	14.7	13.1	72	36	11	11	3.2	8.1	3.9	0.0
21	33.0	18.5	-	14.9	11.2	74	33	9	2	6.0	8.7	3.5	0.0
22	32.5	15.1	-	14.1	8.9	90	26	0	2	3.0	8.2	7.2	0.0
23	32.2	11.6	-	11.2	8.1	87	25	0	32	2.3	8.4	4.9	0.0
24	30.5	10.6	-	11.5	9.0	93	31	0	5	2.6	9.1	4.6	0.0
25	28.9	11.0	-	11.9	7.7	93	23	0	5	1.3	2.9	2.1	0.0
26	31.0	11.6	-	11.2	12.0	91	42	0	36	1.9	8.0	3.2	0.0
27	28.5	15.3	-	13.0	10.4	74	33	0	5	2.8	2.5	4.6	0.0
28	30.0	12.5	-	12.7	10.0	98	33	9	16	2.7	5.9	3.6	0.0
29	29.2	12.5	-	15.3	11.2	100	45	9	11	6.3	4.3	3.0	0.0
30	26.3	12.0	-	12.2	9.2	89	33	0	11	2.5	6.9	2.4	0.0
31	28.0	9.9	-	11.1	9.7	98	34	0	34	1.0	7.2	4.2	0.0
Total	965.0	508.1	-	485.5	424.9	2722	1332	-	-	102.1	223.3	127.9	36.4
Avg.	31.1	16.4	-	15.7	13.7	88	43	-	-	3.3	7.2	4.3	-

Annexure – I contd.....

Daily Meteorological Data of Hisar

November, 2004

Day	Temperature		GMIN	Avp mm		RH, %		WD-COD		WS km/hr	SS hrs	EVAP mm	Rain mm
	O C			M	E	M	E	M	E				
	Max	Min											
1	28.6	8.5	-	10.1	7.4	84	24	0	25	1.3	8.1	2.7	0.0
2	29.2	9.0	-	9.5	6.7	80	24	0	32	1.3	8.6	3.1	0.0
3	28.2	9.0	-	9.0	11.7	83	41	0	34	1.6	8.7	2.8	0.0
4	28.5	8.0	-	8.9	8.9	88	33	0	32	2.5	8.9	2.1	0.0
5	29.4	7.0	-	8.3	6.1	90	20	0	32	3.1	8.9	3.3	0.0
6	30.0	7.0	-	9.3	7.6	93	25	0	34	1.3	9.0	5.5	0.0
7	29.4	8.5	-	8.9	10.9	88	38	0	32	1.9	8.7	3.8	0.0
8	28.8	7.5	-	8.5	7.1	90	25	0	29	1.9	8.4	2.7	0.0
9	28.6	7.3	-	8.5	8.6	92	29	0	34	1.2	8.4	2.8	0.0
10	29.0	6.5	-	8.4	9.5	94	29	0	29	2.1	8.7	2.6	0.0
11	30.6	7.5	-	9.3	8.7	95	29	0	7	1.0	8.7	2.8	0.0
12	30.5	7.5	-	9.1	9.5	92	29	0	2	1.3	8.6	4.0	0.0
13	30.5	8.0	-	10.1	6.1	84	18	0	32	1.0	8.7	4.6	0.0
14	31.0	8.1	-	9.0	7.4	86	24	0	27	1.8	8.5	3.6	0.0
15	29.7	8.5	-	9.5	10.0	93	33	0	29	2.1	8.0	4.3	0.0
16	29.0	8.5	-	9.5	8.8	90	28	0	32	2.3	6.0	2.9	0.0
17	30.0	12.1	-	10.7	7.3	81	24	0	32	1.1	8.3	3.8	0.0
18	29.2	11.6	-	11.5	9.8	93	31	0	34	1.0	1.0	2.5	0.0
19	30.1	8.2	-	9.0	9.1	83	32	0	32	2.3	7.0	5.3	0.0
20	28.9	8.5	-	9.3	9.1	93	30	0	32	1.5	6.9	2.0	0.0
21	30.0	10.4	-	12.2	8.9	93	26	0	29	1.3	7.3	2.5	0.0
22	32.0	10.7	-	10.6	10.1	93	29	0	27	1.4	8.1	2.5	0.0
23	32.0	11.0	-	12.2	8.7	93	26	11	29	2.1	8.8	2.5	0.0
24	31.3	10.5	-	10.9	13.2	89	50	0	0	2.0	8.7	2.6	0.0
25	27.0	15.3	-	15.0	16.3	98	82	11	5	5.3	6.1	2.8	0.0
26	22.6	15.3	-	14.1	15.9	98	67	9	5	3.2	0.0	2.2	0.0
27	25.4	12.9	-	11.8	15.7	98	69	0	5	2.5	4.0	1.4	0.0
28	24.5	8.6	-	9.8	10.9	97	46	0	36	5.0	4.8	1.6	0.0
29	25.2	7.9	-	12.0	11.5	100	49	0	25	2.0	6.7	2.7	0.0
30	25.2	10.6	-	10.0	9.3	78	38	18	11	1.2	3.6	1.9	0.0
Total	864.4	280.0	-	305.0	290.8	2709	1048	-	-	59.6	216.2	89.9	0.0

Avg.	28.8	9.3	-	10.2	9.7	90	35	-	-	2.0	7.2	3.0	-
------	------	-----	---	------	-----	----	----	---	---	-----	-----	-----	---

Annexure – I contd.....

Daily Meteorological Data of Hisar

December, 2004

Day	Temperature °C		Avp mm			RH, %		WD-COD E		WS	SS	EVAP	Rain
	Max	Min	GMIN	M	E	M	E	M	E	Km/hr	hrs	mm	mm
1	26.2	14.1	11.7	12.4	12.9	89	66	9	9	5.3	7.1	2.0	0.0
2	23.0	10.3	7.7	11.2	10.4	93	47	0	9	8.4	2.2	2.9	0.0
3	24.1	9.4	6.4	10.3	11.1	95	46	0	34	4.0	6.7	3.7	0.0
4	25.5	7.8	3.2	8.5	11.2	92	51	0	32	1.5	7.2	2.2	0.0
5	24.0	8.0	2.7	8.3	5.8	92	26	0	34	2.6	6.7	2.4	0.0
6	24.4	4.0	-0.8	6.5	9.0	91	39	0	29	3.2	8.3	3.1	0.0
7	25.0	5.2	1.2	6.8	9.4	89	47	0	5	2.5	8.6	2.5	0.0
8	23.7	4.2	-0.3	6.8	7.9	94	38	0	7	1.0	4.4	1.4	0.0
9	23.8	3.4	-0.2	6.9	7.2	91	35	0	32	1.3	7.8	2.4	0.0
10	23.0	3.1	-0.4	7.1	7.5	91	35	0	34	2.0	7.1	2.5	0.0
11	23.8	3.5	0.1	7.9	9.3	94	45	0	7	1.1	7.3	1.4	0.0
12	23.5	3.8	1.1	7.5	8.9	97	45	0	0	1.0	7.0	1.7	0.0
13	23.2	3.9	0.8	8.1	9.8	100	46	27	29	1.0	5.5	1.6	0.0
14	23.4	4.5	0.3	7.1	8.1	89	36	0	34	2.0	5.1	1.4	0.0
15	24.5	4.6	0.6	7.5	8.7	89	38	0	32	3.1	7.8	2.1	0.0
16	25.1	5.4	0.8	7.3	7.9	94	31	0	32	2.4	8.3	1.4	0.0
17	26.6	5.5	1.7	7.3	9.6	94	39	0	32	2.4	8.2	1.8	0.0
18	26.0	5.7	3.3	7.7	9.8	92	41	0	36	0.6	6.8	1.6	0.0
19	26.4	9.9	5.3	9.4	8.1	86	31	14	16	3.1	7.8	1.5	0.0
20	27.0	5.0	0.7	9.1	9.6	100	55	36	36	5.6	7.1	2.2	0.0
21	20.2	7.5	0.6	9.3	10.6	100	74	34	25	3.7	0.0	2.2	0.0
22	17.9	9.0	5.3	9.5	10.7	90	95	0	25	1.5	0.0	2.1	0.0
23	14.2	10.1	5.2	10.1	10.0	100	73	11	32	2.8	0.0	1.0	0.0
24	17.0	4.5	2.7	7.5	10.7	100	77	0	34	1.2	0.0	1.2	0.0
25	16.6	9.1	4.8	9.2	9.3	93	66	34	32	2.5	0.5	1.4	0.0
26	17.2	4.8	-0.8	7.0	6.0	100	39	29	32	4.9	3.6	1.6	0.0
27	18.5	1.3	-2.2	5.9	5.9	97	35	25	34	4.6	6.2	1.9	0.0
28	20.4	3.1	-1.0	7.8	6.0	94	34	9	14	2.7	7.9	1.5	0.0
29	20.8	3.6	1.5	6.7	8.0	100	50	0	5	3.3	8.1	1.3	0.0
30	19.8	7.3	4.9	9.0	9.8	97	56	32	32	1.3	2.9	1.4	0.0
31	20.2	12.0	11.1	10.7	11.2	89	89	9	14	2.6	0.4	0.5	2.0
Total	695.0	193.6	78.0	256.4	281.0	2912	1525	-	-	85.2	166.6	57.9	2.0
Avg.	22.4	6.2	2.5	8.3	9.1	941	49	-	-	2.7	5.4	1.9	-

ABSTRACT

Title of thesis : “Evaluation of management practices against bollworms and their effect on sucking pests in cotton”

Name of degree holder : Bhupender Singh, (2003A27M)

Title of degree : Master of Science (Agriculture) in Entomology

Name and address of Major Advisor : Dr. R.K. Saini,
Sr. Scientist, Department of Entomology,
CCS Haryana Agricultural University,
Hisar-125004, India

Degree awarding University/Institute : CCS Haryana Agricultural University, Hisar

Year of award of degree : 2005

Major Subject : Entomology

Total number of pages in thesis : 52+i-xiii+I-VII

Number of words in the abstract : Approximately 300

Key words: Management practices, bollworms, cotton, intercropping, neem, *Trichogramma*

Different pest management practices, namely, date of sowing, *Trichogramma chilonis* release, intercropping with sesame, use of botanical pesticides like neem, and chemical insecticides, were evaluated alone and in combinations against bollworms of cotton during *Kharif*, 2004 at the Research Farm of Department of Entomology, CCS Haryana Agricultural University, Hisar. These practices were tested on cotton variety H-1117 in plot size of 48m² keeping three replications and their impact on population of sucking insect pests (i.e. leafhopper, whitefly and aphid) was also assessed. The studies indicated that

all management practices, either alone or in combinations, provided significantly better control of bollworms than the control both on the basis of damage in green fruiting bodies as well as open bolls. Minimum bollworms incidence was recorded in treatments where insecticides were used either alone or in combination with other management practices. Combined use of different management practices other than chemical insecticides did not prove as effective as chemical insecticides in controlling bollworms and increasing the yield of seed cotton. However, these practices offered significantly greater reduction in bollworms damage over the control. Further, their integration with insecticides resulted in about 57 per cent reduction in insecticides sprays. Combined use of different practices, i.e. intercropping of cotton with sesame + neem + *Trichogramma* release significantly reduced bollworms damage than when these practices were used alone.

There was 31.8, 21.5 and 4.1 per cent parasitization of *Helicoverpa armigera* eggs by *Trichogramma* in treatments having intercropping with sesame, weekly release of *Trichogramma* and control, respectively. Overall bollworms damage in green fruiting bodies was highest (19.6%) in early sown, followed by that in normal sown (14.65%) and late sown (9.61%) crop. On the other hand, bollworms incidence in open bolls (on locule basis) was lower (41.1%) in early sown than the late sown (49.6%) crop. Wider row to row spacing of one meter was no better than 67.5 cm spacing in reducing bollworms damage under late sown conditions.

MAJOR ADVISOR

SIGNATURE OF THE STUDENT

HEAD OF THE DEPARTMENT

