EVALUATION OF CARBOSULFAN (MARSHAL®25 EC) AGAINST COTTON AND BRINJAL SUCKING PESTS AND BRINJAL SHOOT AND FRUIT BORER

Thesis submitted in part fulfilment of the requirements for the degree of
MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL ENTOMOLOGY
to the Tamil Nadu Agricultural University, Coimbatore-3

By

R. SHEEBA JASMINE
I.D. No. 00-602-015)

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
CENTRE FOR PLANT PROTECTION STUDIES
TAMIL NADU AGRICULTURAL UNIVERSITY
COIMBATORE-641 003

2002

CERTIFICATE

This is to certify that the thesis entitled **"Evaluation of carbosulfan(Marshal®25 EC) against cotton and brinjal sucking pests and brinjal shoot and fruit borer"** submitted in part fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Miss. R.SHEEBA JASMINE** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles, prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

Place : Coimbatore
Date : 8.11.02

(Dr. S.CHANDRASEKARAN)
Chairman

Approved by:

Chairman : 27.12.02
(Dr. S.CHANDRASEKARAN)

Members :
27/12/2002
(Dr. S. KUTTALAM)

(Dr. R.JAYAKUMAR)

(Dr. T.MANOHARAN)

(External Examiner) 27/12/02
Dr. J. Ramesh Babu

Date : 27.12.2002

ACKNOWLEDGEMENT

ACKNOWLEDGEMENT

"God doeth great things and unsearchable;
Marvelous things without number"

I bow my head to Almighty, as he is "All in all" in providing me with the unconstant energy, untiring determination and fruitful wisdom to successfully complete my work.

I feel privileged and elated to keep on record the deep sense of gratitude and heartfelt thanks to my beloved Chairman of the advisory committee who had been instrumental in his venture **Dr. S. Chandrasekaran**, Associate Professor of Agricultural Entomology, for the incessant and steadfast inspiration, laudable counseling, surpassing guidance, who conceived, detailed and shaped the problem and provided insightful and indomitable lead with much care and affection throughout the study without which this thesis would not have seen the beacon light in this path of research.

My utmost reverence tinged with awe is registered with courteous and gracious faithfulness to the members of the advisory committee, **Dr. S. Kuttalam**, Professor of Agricultural Entomology, **Dr. R. Jayakumar**, Professor of Soil Science and Agricultural Chemistry and **Dr. T. Manoharan**, Professor of Agricultural Entomology, HC & RI, Periyakulam for their valuable suggestions during the study.

Immense is gratitude and heart felt thanks to **Dr. M. R. Srinivasan**, Assistant Professor of Agricultural Entomology, **Dr. J. S. Kennedy**, Associate Professor of Agricultural Entomology and **Dr. A. Regupathy**, Professor of Agricultural Entomology, for the candid suggestions, adroit and dexterous guidance, warm and willing help in executing the study.

I wish to place on record my gratitude to **Dr. S. Palanisamy**, Professor and Head Department of Agricultural Entomology and all other staff members of the department for their timely help and guidance.

I find a dearth of words to express my deepest gratitude to **Dr. S. Paneerselvam**, Manager, Eastern Block and **Mr. Palanisamy,** Farmer of Thopputhottam village (Coimbatore) who had granted fields for conducting my research works.

The help rendered by the lab technicians, **Mr. Rangasamy,** Mr. Jayabalan and Mrs. Jayalakshmi is gratefully acknowledged.

I am overwhelmed to deliberate heartfelt gratitude to my friends Balasubramanian, Sathya, Sheeba and Mr. Srinivasan and all my classmates for their love and thumping support at the adversities. It is a great pleasure to acknowledge the unfailing help I received in different contexts from Ph.D. Scholars namely, Mr. Senthilkumar, Mrs. Suganthy, Mr. Praveen, Mr.Murugan, Mr.Djanaguiraman, Mr. Ramasubramanian, Mr. Rajabaskar and other Senior and Junior friends.

On a personal note, words fail to acknowledge the love and affection showered by my parents, my lovable ***sis*** **Prisca Flavia,** Vinitha, Charles, brother in law, sister in law and my beloved Dennis, **Viji** and **Bala** for their prayers, boundless affection and encouragement all through my career.

I express my deep sense of gratitude to prayer friends, brothers and sisters for their prayers and immense encouragement all throughout by career.

I assert the expertise of **Vignesh Computers, TAUTA Illam, TNAU** for the neat and excellent execution of this thesis in a record time.

I thank FMC India Ltd.for having sponsored Junior Research Fellowship to undergo my postgraduate degree programme.

I express my commitment to the Tamil Nadu Agricultural University, Coimbatore for letting my dreams-come-true.

R. Sheeba J

(R.SHEEBA JASMINE)

ABSTRACT

ABSTRACT

EVALUATION OF CARBOSULFAN (MARSHAL®25 EC) AGAINST COTTON AND BRINJAL SUCKING PESTS AND BRINJAL SHOOT AND FRUIT BORER

By

R. SHEEBA JASMINE

Degree : Master of Science in Agricultural Entomology

Chairman : **Dr. S.Chandrasekaran,**
Associate Professor,
Department of Agricultural Entomology,
Tamil Nadu Agricultural University,
Coimbatore - 641 003.

2002

Field experiments were conducted to evaluate the bioefficacy of carbosulfan 25 EC as foliar application against pests of cotton and brinjal, toxicity to natural enemies, phytotoxicity to plants and to determine the terminal residues.

The results of the experiments on cotton elicited that carbosulfan sprayed at 300g a.i.ha^{-1} effectively reduced the leaf hopper population (83.2%) but stands second to methyldemeton sprayed at 250g a.i.ha^{-1} with the highest per cent reduction of population (86.9%) on 3 DAT. Cent percent reduction of aphids on cotton was observed irrespective of the doses of carbosulfan at 1 DAT and it was followed by methyl demeton 250 g a.i.ha^{-1}.Among the three doses, carbosulfan 300 ga.i./ha was the most effective against cotton thrips with 96.2 per cent reduction followed by methyl demeton at 250g a.i.ha^{-1} with 95.9 per cent.

With regard to the sucking pests of brinjal, significant reduction of leafhopper (89.1%) was achieved with the endosulfan 350g a.i.ha^{-1} followed by carbosulfan 300g a.i. ha^{-1} (86.1%).Significant reduction of whiteflies and aphids

were observed with the application of carbosulfan at 300g a.i.ha^{-1} followed by endosulfan 350g a.i.ha^{-1}. The per cent damage caused by brinjal fruit borer on number and weight basis was minimum (1.3-2.8) in carbosulfan 300 g a.i.ha^{-1}followed by 250g a.i.ha^{-1} (1.8-3.3).

Studies on the toxicity of carbosulfan to the natural enemies of cotton and brinjal ecosystem revealed that carbosulfan at 200, 250 and 300g a.i.ha^{-1} exhibited toxicity to the tune of 5.6 to 41.0 per cent to spiders. Foliar application of carbosulfan at 1000g a.i./ha (over and above the recommended level of 300g a.i./ha) did not show any phytotoxic symptoms both for cotton and brinjal.

Three rounds of carbosulfan spray at 14 days interval on cotton left residues at first harvest in the seed for 500 and 1000g a.i.ha^{-1} to the tune of 0.042-0.099 and 0.054-0.121µg/g respectively. There was no detectable level of residues on lint samples. Similarly, for the same doses the residue analysis in the brinjal fruits at first and third harvests revealed that none of them recorded residues at detectable levels.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

CHAPTER I

INTRODUCTION

Cotton, the most important natural textile fibre of the world, occupies a prominent place in the Indian economy, providing livelyhood to millions of people as well as serving as the basic raw material for the huge domestic textile industry. (Gupta, 2001). The area and production of cotton in India is 8.53 million hectares with total production of 2.84 million tonnes (CSIW, 2000). It is one of the principal commercial crops of Tamil Nadu occupying 1.848 lakh hectares which remain unchanged over decades (Kumar *et al.*, 1999). Equally important native commercial vegetable crop brinjal (*Solanum melongena* L.) is widely grown in Tamil Nadu occupying 7,189 hectares. Both crops harboured many insect pests including leafhopper, *Amrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Genn.), aphid, *Aphis gossypii* (Glover) and thrips, *Thrips tabaci* (Lind.) and bollworm complex (*Pectinophora gossypiella* Saund., *Earias insulana*, *Earias vittella* Boisd., *Helicoverpa armigera* Hubner.) in cotton and shoot and fruit borer, *Leucinodes orbonalis* (Guen.) in brinjal.

Cotton crop is damaged by more than 40 insect pests (Nair, 1995) coupled with a yield loss of 30-40 per cent. Simultaneously brinjal suffered the ravages from 36 insect pests since nursery stage (Regupathy *et al.*, 1997) coupled with a yield loss of 70-92 per cent.

The right choice of chemical insecticides in pest control strategy for cotton and brinjal is not governed by its toxicity alone but depends more on their safety to natural enemies in the ecosystem and the environment. Many insecticides like monocrotophos, endosulfan, carbaryl, quinalphos and many formulations of synthetic pyrethroids were recommended for the management of pests.

Nonetheless, the pyrethroides have been withdrawn in our state or restricted from use because they caused secondary outbreak of spider mites *Tetranychus cinnabarinus* Boisduval and resurgence of coccids and pseudococcids (Regupathy *et al.*, 1997). Even the newer molecule like lambda cyhalothrin is found to cause resurgence of cotton aphid *A. gossypii* (Kidd and Rummel, 1997). This probably might have paved the way for the advent of newer insecticide molecule, alternate to existing formulation for the effective management of pests.

The invention and evaluation of newer molecules may always have superiority over the existing insecticides in controlling the pest without much environmental pollution and over come the ecological constraints like resurgence, resistance and residues. The carbamate groups of insecticides *viz.*, carbofuran, aldicarb, carbaryl etc., were always favoured for ecological, economical and sociological adaptability against cotton and brinjal pests (Krishnaiah *et al.*, 1976; Reddy and Joshi, 1990; Mishra, 1993; Walunj and Dethe, 1996).

Carbosulfan 25 EC (Marshal®) is one of the carbamate of broad spectrum insecticides developed by Farm Machinery and Chemicals (FMC) for the management of sucking and chewing insect pests in agriculture and public health. Carbosulfan both 25 EC and 25 DS formulations were proved effective as foliar spray and seed dresser respectively against many insect pests on okra, chillies, rice, beans, maize, apple, cotton, brinjal, citrus and cauliflower (Mote and Shah, 1993; Chandrasekaran *et al.*, 1994; Rao and Panwar, 1995; Asaf Ali and Chinniah, 1999; Ahmed *et al.*, 2000; Karthikeyan and Purushothaman, 2000; Lei Hui De *et al.*, 2000; Singh *et al.*, 2000; Sontakke and Dash, 2000; Srinivasan and Rabindra, 2001). But the effect of Marshal® on sucking pests of cotton and brinjal are lacking. Keeping this in view the present study was taken up to evaluate the usefulness of carbosulfan against cotton and brinjal pests with the following objectives.

- To assess the bio-efficacy of carbosulfan against sucking pests of cotton and brinjal along with shoot and fruit borer of brinjal.
- To study the effect of carbosulfan on natural enemies in cotton and brinjal ecosystem.
- To study the phytotoxic effect of carbosulfan on cotton and brinjal.
- To determine the terminal residues of carbosulfan in cotton seed and lint as well as in brinjal fruits for the harvested produce.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1. Effectiveness of insecticides against cotton pests

Cotton is one of the versatile crops whose pesticide consumption is steadily increasing (54%) year by year (Anonymous, 1997), despite, its area under cultivation remaining unchanged (8 million hectares) over decades (Kumar *et al.*, 1999). Cotton crop is damaged by more than 40 insect pests (Nair, 1995) coupled with a yield loss of 30-40 per cent annually at different growth stages (Mustafee, 1996). During the early stage, the crop is highly vulnerable to sucking insect pests like jassid (*Amrasca biguttula biguttula* Ishida.), Whitefly (*Bemisia tabaci* Genn.), aphid (*Aphis gossypii* Glover), thrips (*Thrips tabaci* Lind.). Dhawan *et al.* (1988) reported an avoidable loss of 1.10 q /ha seed cotton due to jassid alone. Reddy (1987) stated that whitefly is causing economic loss of 10 to 45 per cent.

Several carbamate insecticides such as carbofuran, aldicarb and carbosulfan (Surulivelu and Kumarasamy, 1990; Regupathy, 1981; Chinniah and Asaf Ali, 1999) have been tested and found to be effective against these pests.

2.1.1. Leafhopper (*A.biguttula biguttula*)

Gupta *et al.* (1999) evaluated the efficacy of different insecticidal schedules and reported that foliar sprays of dimethoate (0.05%) methyl demeton (0.04%) and phosphamidon (0.04%) were effective against leafhoppers, whiteflies and aphids.

Bhamburkar (1986) proved that phosphamidon @ 0.34 kg a.i./ha and methamidophos @ 0.8 kg a.i/ha were effective against leafhoppers under dryland condit. ions and the yield was also higher. Patil *et al.* (1991) reported that better control of leafhoppers was achieved with monocrotophos @ 360 g a.i/ha and dimethoate @ 555 g a.i/ha.

Several others have reported that monocrotophos 36WSC @ 500 g a.i./ha was effective in controlling leafhoppers (Karuppuchamy *et al.*, 1986; Dhandapani *et al.*, 1988; Dhawan *et al.*, 1988; Patel and Bhalani, 1988; Surulivelu and Kumaraswamy, 1989; Shahawy *et al.*, 1991; Banbote *et al.*, 1995; Patel and Yadav, 1995; Javaid Iqbal *et al.*, 1997; Patel, 1999).

Senapati and Behera (1989) reported that methyl demeton at 0.5 kg a.i./ha at 20 days interval provided good control of leafhoppers. Similarly methyl demeton was recommended by Santhini and Uthamasamy (1997).

Spraying schedule consisting of monocrotophos (500 g a.i./ha), deltamethrin (12.5 g a.i./ha), endosulfan (750 g a.i/ha), cypermethrin (60 g a.i./ha) and triazophos (600 g a.i/ha) has proved their effectiveness against jassids (Roshan Lal and Gupta, 1998).

Foliar application of carbosulfan 25 EC at 0.075 per cent was found to be effective in controlling jassids (Asaf Ali and Chinniah, 1999). Patil *et al.* (1999) conducted studies with imidacloprid 70 WS at 10 g/kg of seed treatment which revealed that the leafhopper population could be kept below the ETL up to 35 days on DCH - 32 and up to 40 days on NHH-44 cotton hybrids.

Chinniah and Asaf Ali (1999) found that seed treatment with carbosulfan 25 DS @ 50 g/kg of delinted cotton seed at the time of sowing was found to control leaf hopper very effectively up to 40 days after sowing compared to two rounds of foliar spray with systemic insecticides viz., dimethoate, acephate and monocrotophos.

2.1.2. Whitefly (*B. tabaci*)

Dahiya and Ram Singh (1982) observed that monocrotophos, dimethoate and methyl demeton were effective in the control of whiteflies. Gupta *et al.* (1999) conducted experiment on the insecticidal spray schedules and reported that phosphamidon (0.04%), methyl demeton (0.04%) and dimethoate (0.05%) were effective in controlling whiteflies.

Spraying organophosphorus insecticides like chlorpyriphos, monocrotophos and methyl demeton at 250, 175 and 300 g a.i/ha respectively were effective in the control of whiteflies (Nagia *et al.*, 1992). Banbote *et al.* (1995) reported the efficacy of monocrotophos (0.6%) against pupae and adults of whiteflies.

Spraying schedule consisting of monocrotophos (500 g a.i/ha), deltamethrin (12.5 g a.i./ha), endosulfan (750 g a.i/ha), cypermethrin (60 g a.i/ha) and triazophos (600 g a.i/ha) was proved to be the most effective against whiteflies (Roshan Lal and Gupta, 1998). Imidacloprid 70 WS at 10 g/kg of seed treatment recorded whitefly population below ETL level up to 35 and 45 days on DCH and NHH-44 cotton hybrids respectively (Patil *et al.*, 1999).

2.1.3. Aphid (*A. gossypii*)

Gupta *et al.* (1999) reported that three rounds of foliar sprays including dimethoate (0.05%), methyl demeton (0.04%) and phosphomidon (0.04%) were effective against aphids. Manisegarane and Kumarasamy (1994) proved the superiority of methyl demeton over methomyl for the control of aphids.

The efficacy of monocrotophos in controlling aphids was reported by several authors (Karuppuchamy *et al.*, 1986; Surulivelu and Kumarasamy, 1989; Banbote *et al.*, 1995; Pawar and Mali, 1997). The studies conducted by Chinniah and Asaf Ali (1999) revealed that seed treatment with carbosulfan 25 DS (50 g/kg) was effectively controlled the incidence of aphids.

Among the seven insecticides tested, carbosulfan 25 EC at 0.075 per cent concentration given as two rounds at 15 days interval significantly reduced the population of aphids in field condition (Asaf Ali and Chinniah, 1999).

Surulivelu and Kumrasamy (1990) reported that soil application of aldicarb (1.0 kg a.i./ha) reduced the aphid population significantly over all other treatments.

2.1.4. Thrips (*T. tabaci*)

Regupathy (1981) reported that seed treatment with aldicarb sulfone (75 WP)and carbofuran (50 SP) were equally effective in bringing significant reduction in thrips population. The studies conducted by Pawar and Mali (1997) revealed that monocrotophos (300 g a.i./ha) was found to be the most effective against thrips. Imidacloprid 70 WS (10 g/kg) seed treatment recorded thrips population below ETL up to 40 and 35 days on NHH-44 and DCH-32 cotton hybrids respectively (Patil *et al.*, 1999).

2.2. Effectiveness of insecticides against brinjal pests

Brinjal is an important vegetable crop grown all over the country. It forms one of the important requirements of Indian diet with considerable nutritional values. This cash earning crop is damaged by more than 36 insect pests, even from nursery stage (Regupathy *et al.*, 1997). It is prone to the attack by a complex of pests like jassids (*A.biguttula biguttula*), whiteflies (*B. tabaci.*) and shoot and fruit borer (*Leucinodes orbonalis* Guen.) which cause about 70-92 per cent loss in the fruit yields. The yield loss of fruits by shoot and fruit borer was reported to be up to 70 per cent in case of severe incidence.

Several carbamate insecticides have been evaluated for the control of these pests (Krishnaiah *et al.*, 1976, Ramzan *et al.*, 1976; Choudhary, 1982; Singh and Kavadia, 1989; Mishra, 1993; Walunj and Dethe, 1996).

2.2.1. Leafhopper (*A. biguttula biguttula*)

Brinjal jassid (*A. biguttula biguttula*) is an important pest causing considerable damage. In the early stage of the crop, jassids cause heavy loss by sucking the cell sap from the leaves and ultimately reduce the yield. Butani and Varma (1976) reported that phosphamidon, monocrotophos or dimethoate at 0.03 per cent reduced the population of leafhoppers on brinjal. Similarly Mall *et al.* (1997) reported that monocrotophos and phosphamidon showed better control of jassids and aphids etc.

Ramzan *et al.* (1976) concluded that endosulfan 0.05 per cent was effective in the control of brinjal leafhopper and it was followed by fenthion 0.07 per cent and quinalphos 0.1 per cent. Foliar application of carbosulfan 0.44 per cent, endosulfan 0.07 per cent or dimethoate 0.03 per cent was effective in controlling the leafhoppers (Mohan, 1988).

Monocrotophos was recommended at 0.05 per cent for effective control of leafhoppers by several workers (Bhandarkar and Borle, 1980; Mote, 1981; Dhandapani and Kumaraswamy, 1982). Shah *et al.* (1990) found that application of monocrotophos 0.036 per cent if it was follwed by malathion 0.05 per cent and endosulfan 0.07 per cent was effective. Combination of monocrotophos with mancozeb or carbendazim controlled the leafhopper infestations on brinjal (Naria *et al.*, 1993).

On contrary, Rosaiah (2001) reported that application of monocrotophos 0.05 per cent followed by Neemazal (0.25%) and NSKE (3%) was the most effective. Monocrotophos 36 WSC @ 500 g a.i/ha was the most effective treatment in maintaining jassid population at a low level followed by quinalphos 25 EC @ 500 g a.i/ha. (Ghongale *et al.*, 2002).

Several authors have reported about the effectiveness of dimethoate against leafhoppers (Prakash *et al.*, 1981; Prakash and Verma, 1985; Singh and Kavadia, 1989). Singh *et al.* (1996) reported that application of cypermethrin 0.007 per cent was the most effective in suppressing the population of leafhopper followed by chlorpyriphos 0.03 per cent and quinalphos 0.03 per cent.

The soil application of disulfoton and aldicarb each @ 1.5 kg a.i./ha was found to be significantly superior over foliar sprays in controlling jassids at 30 days after transplanting (Singh and Kavadia, 1989).

Sushilkumar *et al.* (1990) reported that quinalphos 25 EC proved to be the most effective insecticide followed by carbaryl 50 WP and sevisulph (40:50 WP). Sudhakar *et al.* (1998) reported that bifenthrin at 0.01 per cent recorded the highest per cent reduction of jassids followed by malathion at 0.1 per cent.

2.2.2. Whitefly (*B. tabaci*)

Foliar sprays with disulfoton and dimethoate reduced infestations of whiteflies on brinjal (Prakash *et al.*, 1981; Prakash and Verma, 1985). Sudhakar *et al.* (1998) found that application of bifenthrin 0.01 per cent was the most effective in controlling whitefly followed by malathion 0.1 per cent.

Singh and Kavadia (1989) reported that carbaryl 50 WP, endosulfan 35 EC and malathion 50 EC in combination either with disulfoton or aldicarb each @ 1.5 kg a.i./ha were found to be effective against whiteflies during the fruiting stage. Litainger and Apostol (1994) reported that carbofuran (1 kg a.i/ha) provided

provided the best control of whiteflies. Application of Neemazal (0.5%) was significantly superior in reducing the whitefly population (Rosaiah, 2001).

2.2.3. Aphid (*A. gossypii*)

The efficacy of phosphamidon and dimethoate in controlling aphids was reported by Patel *et al.* (1980). Where as the superiority of the monocrotophos in controlling aphids was reported by several authors (Bhandarkar and Borle, 1980; Bodhade *et al.*, 1992; Mishra, 1996; Mall *et al.*, 1997). Dhamdhere and Mathur (1994) reported that methyl demeton (0.05%) was found to be effective against aphids.

Reghunath *et al.* (1989) reported that application of phorate or carbofuran along with seed followed by the need based spraying of carbaryl 0.2 per cent, malathion 0.1 per cent or quinalphos 0.05 per cent were effective in controlling aphids. Ghongale *et al.* (2002) found that Nurelle® D 505 (chlorpyriphos + cypermethrin 50:5) @ 550 g a.i/ha was being the most effective followed by quinalphos 25 EC @ 500 g a.i/ha; chlorpyriphos 20 EC @ 500 g a.i./ha and monocrotophos 36 WSC @ 500 g a.i/ha against aphids.

Among all plant products tested by Chitra *et al* (1993) against aphids, petroleum ether extract of *Argemone mexicana* L. at (0.1%) was superior in controlling aphids (76.19%) comparable to monocrotophos (78.82%) and endosulfan (75.46%). Litainger and Apostol (1994) reported that high dosage of disulfoton (2 kg a.i/ha), mephosfolan (2 kg a.i/ha) and carbofuran (2 kg a.i/ha) either as a split or single application were found to be excellent against aphids.

2.2.4. Shoot and fruit borer (*L. orbonalis*)

Krishnaiah *et al.* (1976) observed that application of carbaryl at 0.1 per cent was effective against fruit borer infestation on brinjal. Yazdani *et al.* (1981) found that carbofuran when applied in split doses, proved to be effective against brinjal shoot and fruit borer. Singh *et al.* (1996) reported that spraying of endosulfaln @ 0.5 kg a.i/ha was significantly superior in reducing the shoot and fruit infestation by brinjal borer.

Ramzan *et al.* (1976) tested endosulfan, quinalphos, fenthion and methomyl against brinjal fruit borer and concluded that all were effective but quinalphos was the least effective. Spraying of 0.07 per cent endosulfan resulted in the lowest percentage of fruit infestation as compared to 0.04 and 0.05 per cent endosulfan, 0.15 per cent carbaryl and 0.05 per cent phosalone (Shah, 1979).

Similarly, Choudhary (1982) evaluated seven insecticides viz.,carbaryl (1.0 kg a.i./ha), endosulfan (0.7 kg a.i./ha), quinalphos, fenitrothion, chlorpyriphos, phenthoate and methomyl (each @ 0.5 kg a.i/ha). Among these, carbaryl and endosulfan were the most effective against shoot and fruit borer of brinjal. Sontakke *et al.* (1990) found that percentage of shoot and fruit borer infestation was 4.2-7.7 per cent in quinalphos, deltamethrin, fenvalerate, monocrotophos and endosulfan treatments and thereby increasing the yield of brinjal and also recorded higher cost benefit ratios. Bothara and Dethe (1991) tested the bioefficacy of different formulations of endosulfan namely 35 EC, 50 EC and 25 ULV against brinjal shoot and fruit borer and found that the treatment with ULV formulation was the best of all.

Spraying of thiodicarb (Larvin® 75 WP) and methomyl (Lannate®40 SP) were effective against *L. orbonalis* when they were applied along with carbaryl 50 WP and monocrotophos 36 WSC (Walunj and Dethe, 1996). Anilkumar *et al.* (2000) found that the insecticide mixture Spark® (deltamethrin + triazophos) 0.1per cent was the most effective and significantly superior over other treatments in controlling shoot and fruit borer of brinjal.

Srinivas and Peter (1993) evaluated nine insecticides and found that pyraclofos, deltaphos and cartap hydrochloride were significantly superior to the other insecticides in controlling the shoot and fruit borer. Choudhary and Saraf (1995) reported that soil application of phorate combined with endosulfan was more effective against fruit and shoot borer. Radhika *et al.* (1997) reported that application of 0.1 per cent triazophos on need basis (ie. when > 20% of the fruits were infested by the pest) produced the highest fruit yield and returns.

Chinniah and Asaf Ali (1999) found that quinalphos 25 EC @ 2ml/l and carbosulfan 25 EC @ 2ml/l were on par and significantly superior to all other treatments, in terms of the least shoot damage and average fruit yield/ha. Srinivasan and Rabindra (2001) reported that carbosulfan 25 EC when applied individually at 2.0 or 2.5 ml/l, as foliar spray was very effective in checking the damage caused by shoot and fruit borer to brinjal.

Spraying of 2 per cent carbaryl (or) endosulfan 0.07 per cent in combination with plant growth regulator (Planofix® (NAA), 1000 ppm) gave higher yields of brinjal and the combination was the most economical as reported by Reddy and Joshi (1990). Soil application of carbofuran 3 G @ 0.5 kg a.i/ha during earthing up followed up spraying of fenvalerate @ 0.1 or cypermethrin @ 0.5 or deltamethrin @ 0.007 kg a.i./ha were found to be the most effective insecticides for the control of *L. orbonalis* (Mishra, 1993).

Spraying of fenvalerate and permethrin @ 0.25, decamethrin @ 0.05 and endosulfan @ 0.75 kg a.i. /ha were affective against the fruit borer (Yien, 1985). Spraying of fenvalerate @ 50 g a.i/ha at 15 days interval for five times, proved significantly better than dusting endosulfan 4 per cent @ 525 and carbaryl 1000 g a.i/ha in recording less fruit damage and higher number of fruits per plant (Brar *et al.*, 1992).

Seedling dipping and spraying of cypermethrin 0.01 per cent greatly reduced the incidence of fruit borer (Sinha *et al.*, 1986). Roy and Pande (1994) reported that fenvalerate applied at the rate of 280 g a.i/.ha was the most effective against *L. orbonalis* followed by deltamethrin (280 g a.i/ha) and endosulfan (1400 g a.i.ha).

Azeez Basha *et al.* (1982) reported that spraying decamethrin at 0.05 per cent recorded the least fruit borer infestation of 9.3 and 7.76 per cent on number and weight basis respectively. Deltamethrin (20g a.i/ha) and endosulfan (750 g a.i/ha) were equally effective against shoot and fruit borer (Sharma and Chhibber, 1999).

Similarly, Paul and Ghosh (1990) reported that deltamethrin 225 ml/ha was found to be the best treatment recording 21.3 per cent fruit borer damage as compared with 58.7 per cent in the untreated check. Among the insecticides tested by Ghongale *et al.*,(2002) against brinjal fruit borer, application of Nurulle® D 505 @ 550 g a.i/ha was observed to be the most effective and was significantly superior to the remaining insecticidal treatments.

Chitra *et al.* (1993) reported that petroleum extract of *A. mexicana* (0.01%) was superior among all plant products tested against shoot and fruit borer. Rosaiah (2001) observed that Neemazal (0.5%) was significantly superior in reducing shoot and fruit damage and contributed to maximum yield.

2.3. Toxicity to natural enemies

Selective use of insecticides to control pests without adversely affecting natural enemies is important for pest management programmes. Among the various entomophage, the coccinellids, spiders, green lacewing and *Geocoris* sp. are very important in cotton and brinjal ecosystem. The use of insecticides for the control of insect pests may cause harmful effects to these natural enemies. Several workers had studied selective toxicity of insecticides for these natural enemies.

Gerling *et al.* (1997) proved that populations of *Chrysoperla carnea* Stephens were unaffected by applying monocrotophos. Ramalho and Jesus (1988) reported less toxicity of methyl demeton to the predators of cotton ecosystem. Dimethoate and methyl demeton were non toxic to the natural enemy population (Ali and Karim,1990). The toxicity of monocrotophos at 0.04 per cent to *Chrysopa scelestes* (Banks) in cotton ecosystem was proved by Patel and Yadav (1995).

Raman and Uthamasamy (1983) reported that carbosulfan was found to be the least toxic to spiders in cotton ecosystem. Fenvalerate 10 EC at 0.3 lit/ha recorded 57 per cent mortality of *Pardosa* in cotton ecosystem (Mansour *et al.*, 1992). Restabilization of spider population was noticed after 4-5 weeks of spraying of deltamethrin and methamidophos was reported by Volkumar and Wetzel (1993).

Cole *et al.* (1997) observed that lambda-cyhalothrin recorded little impact on ground spiders. Diazinon, fenobucarb, carbaryl, dichlorvos and imidacloprid were found to be toxic to spiders in cotton ecosystem (Nagata *et al.*, 1997). Vandenberg *et al.* (1998) found that monocrotophos @ 108 g a.i/ha adversely affected the population of *Pardosa* Boes.et str. in cotton ecosystem.

Azadirachtin was found to be sensitive to spiderlings (Punzo, 1997). Tiwari and Khan (2002) reported that fenobucarb and chlorpyriphos methyl adversely affected the per cent parasitization by *Trichogramma chilonis* Ishii, at all the tested concentrations. Among several insecticides tested, none of the insecticides were safer to the adults of *Geocoris orchropterus* Fieber, however neemarin 1500 ppm was found safer to the nymphs of the predator. Quinalphos (0.05%) was found comparatively safe to the predator (Anand Jha *et al.*, 2001).

Manisegarane and Kumarasamy (1988) reported that endosulfan (700 g a.i.ha) was relatively safer to *Chelonus blackburni* Cam.

Beevi and Balasubramanian (1992) reported that buprofezin (0.05%) and diflubenzuron (0.1%) were safe to the adult parasitoids (*Encarsia shafeei* Hayat). The studies conducted by Hegde and Patil (1994) revealed that endosulfan 35 EC, cotton seed oil and carbaryl 42 SL produced more than 50 per cent mortality of *Amblyseius longipinosus* Evans on cotton.

Neem oil and fish oil rosin soap were found to be less harmful to the natural enemies of whitefly (Natarajan, 1990). Venugopal Rao *et al.* (1990) found that endosulfan and phorate were the least harmful to the early stage predators of whitefly where as carbaryl was the least harmful to late stage predators (Phytoseiid mites).

Among the insecticides tested for toxicity to eggs of *C. scelestes,* methyl parathion was found to be the safest insecticide having only 23.46 per cent mortality of the predator followed by dimethoate (27.78%) (Shukla *et al.*, 1995). Sreelatha *et al.* (1995) found that endosulfan was found to be the least toxic to the adults of *Bracon habetor* Say.

Maleque *et al.*, (1999) reported that cypermethrin 10 EC applied at weekly intervals caused population reduction of ladybird beetles and spiders in brinjal. Imidacloprid 70 WS at 7 g/kg was found to be safer to natural enemies in cotton ecosystem (Kumar *et al.*, 1999). Srinivasan and Sundarababu (2000) observed that endosulfan (0.07%) and abamectin (0.003%) are the least toxic to *C. carnea* Stephens.

Neemazal (0.5%) and NSKE (5%) were safer to natural enemies like syrphids and spiders in brinjal ecosystem as reported by Rosaiah (2001). Srinivasan (2000) reported that phosphamidon 40 SL @ 300 g a.i./ha recorded lower levels of toxicity to spiders in brinjal and cotton eco system.

2.4. Phytotoxicity studies

Quinalphos (AF, CS, and EC) formulations did not show any phytotoxic effect on cotton (Valarmathi, 1997). Borle *et al.* (1980) found that granular formulations of insecticides *viz.*, phorate (10%), disulfoton (5%) and dimethoate (5%) exhibited phytotoxic effect on cotton. Lambda-cyhalothrin applied in the three doses, *viz.*, 7.5, 15 and 30 g a.i./ha did not have any phytotoxic effect on brinjal (Mathirajan, 1998).

Gupta *et al.* (1998) reported that foliar application of imidacloprid 17.8 SL at 0.005 and 0.02 per cent did not produce any phytotoxic symptoms on cotton. Beta-cyfluthrin @ 12.5, 18.75, 25, 37.50 and 75 g a.i/ha and lambda-cyhalothrin @ 35 g a.i./ha did not exhibit any phytotoxicity and any other adverse effects on brinjal (Dikshit *et al.*, 2001).

Srinivasan (2000) revealed that foliar application of phosphomidon 40 SL at four times the normal dosage did not cause any phytotoxic symptoms on cotton and brinjal.

2.5. Insecticide residues

2.5.1. Cotton

Gupta *et al.* (1998) investigated the residue of imidacloprid in cotton at harvest in samples of lint, seed and soil collected from plots with seed treatments. The analysis revealed that no detectable residue of imidacloprid was present in any samples of lint or seed.

Mukherjee and Gopal (2001) reported that the residues of imidacloprid were not detected in cotton lint and seeds or even soil. The residues were invariably below detectable level (<0.05 mg/kg).

The level of quinalphos (25 EC and 20 AF) residues detected in lint samples varied from BDL to 0.06 ppm at first picking and 0.01 to 0.09 at third picking. In seeds, the residues were below detectable level except one sample that had 0.01 ppm (Kumar, 1995).

Valarmathi (1997) noticed that the harvest time residues of quinalphos in lint samples of first picking were in detectable level, but less than the maximum allowable residual limit (MRL) of 0.05 ppm. During third picking, the harvest time residues were at below detectable limit (BDL) in both lint and seed samples.

Manimegalai *et al.* (1994) found that the residues of pyraclofos in cottonseed, oil, lint and soil were quite low.

2.4.2. Brinjal

Dewan and Beri (1965) reported that average deposits of 3.9 ppm due to 0.1 per cent DDT emulsion spray, which was reduced to 2.2 ppm in three days, 1.7 ppm in seven days and 0.3 ppm in two weeks. Similar reduction in the deposits due to 0.1 per cent gamma-HCH emulsion spray was also observed.

Rajukannu *et al.* (1980) reported that the half-life period of quinalphos applied at the rate of 0.50 kg a.i./ha was 2.38 days, while Verma (1984) found that half-life of quinalphos (0.03, 0.05 per cent) was 3 days in brinjal.

In contrast, the half-life of quinalphos (0.3125 kg a.i./ha) was 2 days in brinjal (Kishore and Raj, 1985), but Ramsubbarao *et al.* (1987) reported that 0.05 per cent quinalphos application to brinjal resulted half-life of 1.951 days.

Patel *et al.* (1994) suggested a safe waiting period of 2.1 days for quinalphos (0.05%) in / on brinjal for safe harvest with half - life of 0.9 days.

The cumulative residues of the insecticides in / on marketable fruits sampled 1 h after the last spray with quinalphos (0.05%) ranged from 1.26 to 1.79 mg/kg and half-life values were 2.1 to 2.2 days (Barooah and Yein, 1996).

Agnihotri *et al.* (1992) found that residues of fluvalinate (0.05 %) persisted for 7 days on brinjal with a half-life of 1.2 - 1.8 days. Dethe *et al.* (1995) found detectable levels of residues in 73.3 per cent of farm gate samples.

Dikshit *et al.* (2001) reported that the half-life of beta-cyfluthrin and lambda-cyhalothrin on brinjal were found to be 1.43 - 2.60 days and 1.45-2.54 days respectively. Residues of beta-cyfluthrin in brinjal fruits declined progressively with time and become non-detectable after seven days.

The residues of lambda - cyhalothrin on brinjal ranged from 1.98 to 2.15 ppm, 3.64 to 4.70 ppm and 5.82 to 7.12 ppm for the corresponding doses of lambda – cyhalothrin at 7.5, 15 and 30 g a.i/ha. The analysis revealed that no detectable residue of lambda - cyhalothrin was present in soil samples (Mathirajan, 1998).

Litainger and Apostol (1994) revealed that the residues in the brinjal fruit under Philippine conditions do not vary much for carbofuran from 1to 8 kg a.i/ha but are below the 100 ppb tolerance limits set in edible commodities.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Experiments were conducted to evaluate the bioefficacy of carbosulfan (Marshal ®25EC) against pests, toxicity to natural enemies, phytotoxicity and determination of terminal residues in cotton and brinjal. The details of the experiments carried out are described in this chapter.

3.1. Cotton

Two randomised and replicated trails were conducted at Eastern block, Tamil Nadu Agricultural University Coimbatore during January - May 2002 and June - October 2002 with the cotton cultivar, MCU-7 to evaluate the bioefficacy of carbosulfan against pests, toxicity to natural enemies, phytotoxicity and determination of terminal residues in cotton.

3.1.1. Evaluation of bioefficacy against sucking pests

Bioefficacy of carbosulfan 25 EC was evaluated against sucking pests of cotton. Methyldemeton(Metasystox®25 EC) was included for comparison.

Properties of carbosulfan

Chemical name	:	2,3-dihydro-2,2-dimethyl benzofuran-7yl (dibutylamino thio) methyl-carbamate.
Common name	:	Carbosulfan
Trade name	:	Marshal ®
Mode of action	:	Systemic insecticide with contact and stomach poison. Cholinesterase inhibitor.
Empirical formula	:	$C_{20}H_{32}N_2O_3S$
Formulation	:	25 EC/GR/DS
Source	:	FMC India Ltd, Bangalore.

3.1.1.1. Experimental details

The insecticides used in the present investigation and their dosages are given below.

T_1 – Carbosulfan 25EC @ 200 g a.i./ha

T_2 – Carbosulfan 25 EC @ 250 g a.i./ha

T_3 – Carbosulfan 25EC @ 300 g a.i. / ha

T_4 – Methyl demeton 25 EC @ 250 g a.i./ha

T_5 – Untreated check

Three rounds of sprayings were given in the first and second trials at 14 days interval commencing from 25th day after sowing with pneumatic knapsack sprayer using 500 litres of spray fluid per hectare. The plot size was 20 m^2 and replicated four times.

3.1.1.2. Method of assessment

The populations of sucking pests *viz.,* leafhopper (*Amrasca biguttula biguttula* Ishida.), whitefly (*Bemisia tabaci* Genn.), aphid (*Aphis gossypii* Glover.) and thrips (*Thrips tabaci* Lind.) were recorded on top, middle and bottom leaves of ten randomly tagged plants per plot prior to spraying and 1, 3, 7 and 14 days after spraying.

Cotton yield per plot was recorded separately and it was computed to quintal/hectare and the same is subjected to statistical analysis.

3.1.2. Evaluation of toxicity to natural enemies

In both the field trails, toxicity of carbosulfan 25 EC was evaluated to natural fauna of cotton eco system particularly to spiders and coccinellid complex. In the present investigation, the occurrence of coccinellids is in very low numbers in both the field trials and hence, it could not be taken up. So the spiders are taken

Plate 1. Field view of cotton field experiment at Eastern Block, TNAU, Coimbatore.

Plate 2. Field view of brinjal field experiment at Thopputhottam, Coimbatore.

into account for evaluating the toxicity of the insecticides tried in the field experiment.

a. Method of assessment

The numbers of spiders were recorded to assess the toxicity of chemicals prior to third application and 1, 3, 7 and 14 days after spraying on ten randomly tagged plants per plot.

3.1.3. Evaluation of phytotoxicity

Phytotoxicity of carbosulfan 25 EC was evaluated on cotton using the following five treatments.

T_1 – Carbosulfan 25 EC @ 250 g a.i./ha

T_2 - Carbosulfan 25 EC @ 500 g a.i./ha

T_3 – Carbosulfan 25 EC @ 1000 g a.i./ha

T_4 – Methyl demeton 25 EC @ 250 g a.i./ha

T_5 – Untreated check

Symptoms of phytotoxicity *viz.,* leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty were observed from ten randomly tagged plants per plot at 1, 3, 7 and 14 days after each spraying as per Central Insecticide Board Registration Committee (C.I.B-RC) protocol. Leaf injury was assessed on visual rating from 1-10 such as (0-10% = 1, 11-20% = 2, 21-30% = 3, 31-40%=4, 41-50% =5, 51=60%=6, 61-70%=7, 71-80%=8, 81-90%=9 and 91-100%=10).

The percent leaf injury was calculated using the formula,

$$\text{Per cent leaf injury} = \frac{\text{Total grade points}}{\text{Max. grade X No. of leaves observed}} \text{ X } 100$$

Plate 3. Study on phytotoxicity of carbosulfan on cotton @ 500 g a.i./ha

Plate 4. Study on phytotoxicity of carbosulfan on cotton @ 1000 g a.i./ha

3.1.4. Terminal Residue Analysis

3.1.4.1. Sampling

Cotton was sprayed with carbosulfan (Marshal® 25 EC) at the rate of 250, 500 and 1000 g a.i/ha with the help of pneumatic knapsack sprayer. Each treatment was replicated four times in randomized block design. Cotton lint and seed samples were collected from each replicate of three treatments at first and third harvests. Control samples were collected similarly from untreated plots.

The samples collected from four replications for each treatment were pooled together and they were made into two replicates for residue analysis.

3.1.4.2. Extraction

a. Lint

Weighed samples of first and third harvests (10g) were soaked overnight in methonol. Then, the samples were filtered through buchner funnel with repeated washings and the extract was filtered through Whatman No 1 filter paper and it was dried by passing through anhydrous sodium sulphate. The methonol extract was then condensed in the rotary vaccum flash evaporator (Buchi Rotovapor R-14®).

Derivatisation

The condensed methanol extract was dissolved in 1 ml of the reactant solution (Holden, 1973) (1.0 g of 1- fluoro 2, 4-dinitrobenzene in 100 ml of acetone) and transferred quantitatively to stoppered 25x190 mm test tubes. With this, 15 ml of the phosphate buffer solution (phosphate buffer of pH 11-25.0 g of Na_2HPO_4 was dissolved in 2480 ml of distilled water and 20 ml of 1 M NaOH solution was added and mixed well) was added, mixed well and kept in the water bath and the temperature was maintained at 50°C for 30 minutes. After 30 minutes, the test tubes were removed from the water bath, cooled and transferred to a 60 ml separatory funnel. The content was extracted twice with exactly two 25 ml portions of n-hexane and the organic layer was collected and the hexane extracts was condensed and retained for final determination.

b. Seed

Ten gram of seed samples collected at first and third harvests were blended with the help of a homogenizer and was extracted with diethyl ether in soxhlet apparatus at 60°C for 6 h.

3.1.4.3. Clean up

The condensed seed extract was transferred to a separating funnel, mixed with 250 ml of saturated sodium chloride solution and extracted thrice with 50 ml of dichloromethane. The dichloromethane extract was combined and evaporated to near dryness through rotary vaccum flash evaporator (Buchi Rotovapor R-14®).

For column chromatograph, 50 cm x 1.5 cm (I.D) glass columns were used. The tip of the chromatographic column was plugged with cotton wool. Anhydrous sodium sulphate was filled to a height of 2 cm followed by 8 cm of Florisil: charcoal mixture (8g of deactivated Florisil + 1.5 g of acid washed charcoal) and overlaid with 2 cm layer of anhydrous sodium sulphate. The Florisil was activated at 135°C for six hours and cooled in desiccator. The cooled Florisil was deactivated by adding 4 per cent water and mixed well. The deactivated Florisil was used as fresh.

The condensed dichloromethane extract was loaded on to the column and eluted with a mixture of 9:1 hexane and ethyl acetate. About 100 ml of elutant was collected, condensed to near dryness and re dissolved in 1 ml of derivatizing agent and derivatisation was done as detailed in 3.1.4.2.a.and ~~extracted~~ with n-hexane for final determination.

3.2. Brinjal

Two randomized and replicated trials were conducted *viz.* one at Eastern block, Tamil Nadu Agricultural University, Coimbatore during January – May 2002 and the other at Thopputhottam Village during March – July 2002 with the variety CO 2 to evaluate the bioefficacy of carbosulfan 25 EC, toxicity to natural enemies, phytotoxicity and determination of terminal residues in brinjal.

3.2.1. Evaluation of bioefficacy of carbosulfan

Bioefficacy of carbosulfan 25 EC was evaluated against the sucking pests and shoot and fruit borer of brinjal. Endosulfan (Thiodan® 35 EC) was included for comparison (Standard).

3.2.1.1.Experimental details

The insecticides used in the present study and their dosages were given below.

T_1 – Carbosulfan 25 EC @ 200 g a.i./ha

T_2 – Carbosulfan 25 EC @ 250 g a.i./ha

T_3 – Carbosulfan 25 EC @ 300 g a.i./ha

T_4 – Endosulfan 35 EC @ 350 g a.i./ha

T_5 – Untreated control

Three rounds of sprayings were given in the first and second trials at 14 days interval commencing from 70th day after sowing with pneumatic knapsack sprayer, using 500 litres of spray fluid per hectare. The plot size was 20 m^2 and replicated four times.

3.2.1.2. Method of assessing pest population and damage

The population of sucking pests *viz.,* leafhopper, whitefly and aphid was recorded on top, middle and bottom leaves of ten randomly tagged plants per plot prior to spraying and 1, 3, 7 and 14 days after spraying.

The fruits showing exit holes or entry points of larvae in the form of minute plugged holes surrounded by small discolored patches were counted as damaged fruits.

The total number of shoots and infested shoots in ten randomly selected plants per plot were counted before and after spraying and the percentage was worked out. The number and weight of damaged and healthy fruits per plot were recorded after each picking during the spray schedule. During each picking, the fruit yield was recorded in each plot and the yield of healthy fruits for each treatment from all the pickings was pooled and worked out on hectare basis.

3.2.2. Evaluation of toxicity to natural enemies

Toxicity against the natural enemies of the brinjal pests especially spiders were evaluated in the field experiment as per the treatment details and spray schedule given under section 3.2.1.1 and method of assessment given under section 3.1.2.1.

3.2.3. Evaluation of phytotoxicity

Phytotoxicity of carbosulfan 25 EC was evaluated on brinjal with the following five treatments replicated four times.

T_1 – Carbosulfan 25 EC @ 250 g a.i./ha

T_2 – Carbosulfan 25 EC @ 500 g a.i./ha

T_3 – Carbosulfan 25 EC @ 1000 g a.i./ha

T_4 – Endosulfan 35 EC @ 350 g a.i./ha

T_5 – Untreated control

Method of assessment is similar to that of given under section 3.1.3.

3.2.4. Residue Analysis

3.2.4.1. Sampling

Brinjal fruit samples were collected at first and third harvests from each replicate of three treatments sprayed with carbosulfan (Marshal ®25 EC) at the rate of 250, 500 and 1000 g a.i./ha. Control samples were collected similarly from the untreated plots. The samples collected from four replications for each treatment were pooled together and they were made into two replicates for residue analysis.

3.2.4.2. Extraction

A representative sample of 50 g fruit was taken for analysis of carbosulfan with 9:1 methanol: pH 8 buffer (100 ml) in a warring laboratory blender. Then the sample was filtered through Buchner funnel and the extract was condensed through rotary vaccum flash evaporator (Buchi Rotovapor R-14®).

3.2.4.3. Cleanup

The condensed extract was transferred to a separating funnel, mixed with 250 ml of saturated sodium chloride solution and extracted thrice with 50 ml of dichloromethane. The dichloromethane extract was combined and evaporated to near dryness through rotary vaccum flash evaporator (Buchi Rotovapor R-14®).

For column chromatograph, 50 cm x 1.5 cm (I.D) glass columns were used. The tip of the chromatographic column was plugged with cotton wool. Anhydrous sodium sulphate was filled to a height of 2 cm followed by 8 cm of Florisil: charcoal mixture (8g of deactivated Florisil + 1.5 g of acid washed charcoal) and overlaid with 2 cm layer of anhydrous sodium sulphate. The Florisil was activated at 135°C for six hours and cooled in desiccator. The cooled Florisil was deactivated by adding 4 per cent water and mixed well. The deactivated Florisil was used as fresh. The condensed dichloromethane extract was loaded on to the column and eluted with a mixture of 9:1 hexane and ethyl acetate. About 100 ml of elutant was collected, condensed to near dryness and re dissolved in 1 ml of derivatizing agent and derivatisation was done as detailed in 3.1.4.2.a.and extracted with n-hexane for final determination.

3.3. End analysis

3.3.1. Standards

The reference standard carbosulfan received from FMC India Ltd. was used for the preparation of stock solution, spiking and quantification of residue in the sample matrices.

3.3.1.1. Concentrated stock solution

From the technical standard of 93.3 per cent purity, 110 mg was weighed and transferred to a 100 ml volumetric flask with distilled hexane and the volume was made up. Then the flask was shaken well to get a homogenous solution of 1000 ppm and was stored in refrigerator at 4°C.

3.3.1.2. Intermediate stock solutions

The concentrated stock solution was brought to room temperature and one ml from the concentrated stock solution was transferred to a 100 ml volumetric flask. The volume was made up and the flask was shaken well to obtain a homogenous solution of 10-ppm standard solution. This was utilized for spiking the samples for recovery studies.

3.3.1.3. Working standard

From the intermediate stock solution, working standards of 0.1-1 ppm were prepared by diluting one ml of 10 ppm solution to 10-100 times. These working standards were derivatised with of derivatising agent as in 3.1.4.2.a for standardization of operating parameters in GC to find out the retention time and for quantitative determination of residues in samples.

3.3.2. Fortification

The cotton lint, seed and brinjal fruits were fortified at 1-10 µg / g by adding required quantity of 10-ppm standard stock solution.

3.3.3. Final determination

Carbosulfan residues in samples were determined with Gas Chromatography (GC) Chemito model 2865 equipped with ^{63}Ni electron capture detector (ECD). The following are the operating parameters of the GC.

Column	-	3% OV 17(Glass column packed with1.8m X 2.00mm.I.D) Chw.100-120µ.
Temperature (°C)		
Oven	-	220
Injector	-	240
Detector	-	260
Source	-	300
Flow rate		
Nitrogen	-	20 ml/min

The final quantification was worked out using the following formula.

$$\text{Residues} = \frac{Hs}{Hstd} \times \frac{Wstd}{Ws} \times \frac{Vs}{Asj}$$

Where,

Hs - Peak height of the sample

Hstd - Peak height of the standard

Wstd - Weight of the standard in ng

Ws - Weight of the sample in g

Vs - Volume of the sample (final extract in ml)

Asj - Aliquot of the sample injected

RF - Recovery factor

3.4. Statistical analysis

The corrected percent reduction in field population was worked out by using the formula of Henderson and Tilton (1955).

$$\text{Corrected per cent reduction} = 1 - \frac{Ta \times Cb}{Tb \times Ca} \times 100$$

Where

Ta – Number of insects in the treatment after spraying

Tb – Number of insects in the treatment before spraying

Cb – Number of insects in the untreated check before spraying

Ca – Number of insects in the untreated check after spraying

The field level population was subjected to statistical analysis adopting randomized block design. The percentage values were converted to arc sin (angular) $\sqrt{\text{percentage}}$ transformed values for shoot and fruit borer while the data on sucking pests and natural enemies were transformed into $\sqrt{x+0.5}$ .The mean values of treatments were then compared by using Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

EXPERIMENTAL RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

The results of field experiments conducted to assess the bioefficacy against sucking pests of cotton and brinjal and shoot and fruit borer of brinjal, toxicity of insecticides against natural enemies, phytotoxicity and terminal residues of carbosulfan 25 EC in/on cotton and brinjal are presented in this chapter.

4.1. Bioassay evaluation of carbosulfan 25 EC

4.1.1. Cotton

4.1.1.1. Experiment I

a. Leafhopper

The results of the observations on the leafhopper population in the field experiment conducted during 2002, are presented in the Table .1. The pre - treatment count of cotton leafhopper ranged from 41.5 to 44.0 per 10 plants before first round of spray. Carbosulfan 300g a.i/ha recorded the lowest population (9.0/10 plants)on 1 DAT, followed by methyl demeton 250g a.i/ha (11.0/10 plants) as against 44.3 per 10 plants in untreated check, whereas, methyl demeton on 3 DAT recorded maximum per cent reduction (86.9 %)followed by carbosulfan at higher concentration (83.2%). Fig.1.Similar trend was observed on 7 DAT and continued the superiority over the other in second and third sprayings also. Carbosulfan at 300g a.i./ha effectively controlled the leafhopper till 14 DAT and it was found to be superior to other carbosulfan treatments.

b. Whitefly

The population of whiteflies was in all the treatments, which varied from 0.3 to 9.0/10 plants during experimental period. Hence, the bioefficacy of the treatments could not be differed significantly between the treatments (Table. 2).

Table 1. Effect of carbosulfan 25 EC on cotton leafhopper- Field experiment I

(Mean of four observations)

Treatments	Number of leafhoppers per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	44.0	21.5^{d} (4.7)	19.5^{d} (4.5)	24.5^{d} (5.0)	39.8^{d} (6.3)	32.0^{d} (5.7)	24.8^{c} (5.0)	33.0^{d} (5.8)	35.0^{d} (6.0)	23.8^{d} (4.9)	16.8^{d} (4.2)	21.0^{d} (4.6)	25.0^{d} (5.1)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	42.5	14.5^{c} (3.8)	11.5^{c} (3.5)	17.8^{c} (4.3)	37.0^{c} (6.1)	21.5^{c} (4.7)	23.0^{c} (4.9)	26.0^{c} (5.2)	25.5^{c} (5.1)	11.0^{c} (3.4)	7.8^{c} (2.9)	10.0^{c} (3.2)	13.3^{c} (3.7)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	42.0	9.0^{a} (3.1)	6.5^{b} (2.6)	15.3^{b} (4.0)	34.8^{b} (5.9)	11.5^{b} (3.5)	7.3^{b} (2.8)	18.0^{b} (4.3)	21.0^{b} (4.6)	7.0^{b} (2.7)	3.8^{b} (2.0)	6.3^{b} (2.6)	10.3^{b} (3.3)
T4- Methyl demeton 25 EC @ 250 g a.i./ha	41.5	11.0^{b} (3.4)	5.0^{a} (2.3)	14.0^{a} (3.8)	33.5^{a} (5.8)	10.5^{a} (3.3)	6.0^{a} (2.6)	16.0^{a} (4.1)	18.0^{a} (4.3)	5.0^{a} (2.3)	2.5^{a} (1.7)	5.0^{a} (2.3)	8.3^{a} (3.0)
T5- Untreated Check	43.5	44.3^{e} (6.7)	40.0^{e} (6.4)	47.0^{e} (6.9)	58.0^{e} (7.7)	69.0^{e} (8.3)	76.0^{d} (8.8)	77.0^{e} (8.8)	68.0^{e} (8.3)	67.5^{e} (8.3)	69.5^{e} (8.4)	70.8^{e} (8.4)	71.3^{e} (8.5)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p = 0.05$)

Fig. 1. Effect of carbosulfan 25 EC on cotton leafhopper

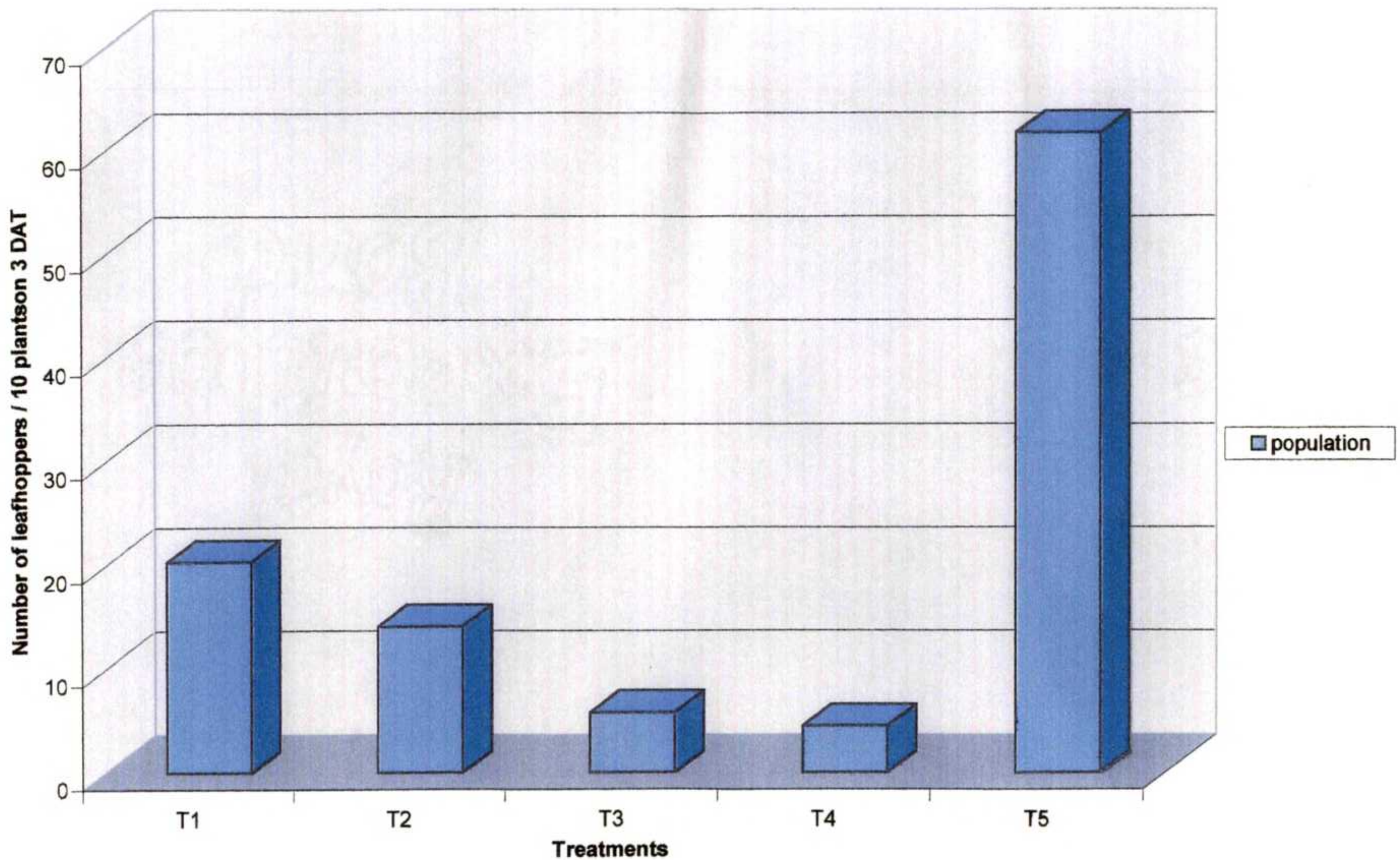

Table 2. Effect of carbosulfan 25 EC on cotton whiteflies -Field experiment I

(Mean of four observations)

Treatments	Number of whiteflies per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	0.0	0.0	0.5	3.0	4.0	0.8	1.5	0.3	0.3	1.3	1.5	2.3	7.0
T2- Carbosulfan 25 EC @ 250 g a.i./ha	0.0	0.0	1.3	3.0	2.5	0.8	0.3	0.5	0.5	1.0	0.5	3.0	8.0
T3- Carbosulfan 25 EC @ 300 g a.i./ha	0.0	0.0	1.0	2.3	1.0	2.3	1.0	0.8	0.8	0.3	0.5	1.8	7.5
T4- Methyl demeton 25 EC @ 250 g a.i/ha	0.0	0.0	0.8	3.0	1.8	2.8	1.3	0.8	0.5	0.0	0.8	1.5	7.5
T5- Untreated Check	0.0	0.0	1.3	2.0	2.5	1.5	1.5	1.0	1.0	1.3	1.5	2.5	9.0

DAT- Days after treatment; PTC – Pre treatment count

c. Aphid

The pre-treatment population before the first round of spray ranged from 318.5 to 343.5 per 10 plants (Table .3). On 1 DAT, a reduction of cent per cent was achieved in carbosulfan sprayed plots, whereas, methyl demeton reduced the aphids to 99.1 per cent. After that, the difference in per cent reduction brought out by various treatments was significant.

Similar trend in reduction of aphid was observed in all the treatments except in control at second round of spraying. On 3 DAT, the population of aphid was observed for the lower dose of carbosulfan (200g a.i./ha) and methyl demeton sprayed plots (4.0 and 2.0/10 plants), whereas, in the third round of spraying, carbosulfan at higher concentration of 300g a.i/ha achieved cent per cent reduction of aphid population upto 3 DAT.

d. Thrips

The population level of thrips varied from 0.5 – 9.0 per 10 plants during the period of observation in all the three rounds of sprays, hence, a suitable conclusion could not be drawn (Table .4)

4.1.1.2. Experiment II

a. Leafhopper

The pre treatment count ranged from 30.0 to 33.8 per 10 plants (Table.5). Carbosulfan 300 g a.i/ha recorded maximum per cent reduction (78.7%) at one DAT and it was on par with methyl demeton 250 g a.i/ha (71.9%). Afterwards, methyl demeton achieved better control of leafhopper and it was on par with carbosulfan at higher dose. Similar trend was found on 7 DAT and 14 DAT.

Table 3. Effect of carbosulfan 25 EC on cotton aphids -Field experiment I

(Mean of four observations)

Treatments	Number of aphids per 10 plants												
		I Application				II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	322.5	0.0^{a} (0.7)	15.0^{d} (3.9)	58.5^{d} (7.7)	165.0^{d} (12.9)	0.0^{a} (0.7)	4.0^{c} (2.1)	45.5^{d} (6.78)	110.8^{d} (10.6)	3.0^{b} (1.9)	7.0^{d} (2.7)	29.8^{c} (5.5)	63.8^{d} (8.0)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	318.5	0.0^{a} (0.7)	7.5^{b} (2.8)	42.8^{b} (6.6)	151.0^{b} (12.3)	0.0^{a} (0.7)	0.0^{a} (0.7)	22.0^{b} (4.7)	93.0^{b} (9.7)	0.0^{a} (0.7)	3.0^{b} (1.9)	15.5^{b} (4.0)	44.0^{b} (6.7)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	343.5	0.0^{a} (0.7)	3.8^{a} (2.0)	15.3^{a} (4.0)	130.8^{a} (11.5)	0.0^{a} (0.7)	0.0^{a} (0.7)	9.0^{a} (3.1)	60.0^{a} (7.8)	0.0^{a} (0.7)	0.0^{a} (0.7)	5.0^{a} (2.3)	25.5^{a} (5.1)
T4- Methyl demeton 25 EC @ 250 g a.i/ha	337.8	3.0^{b} (1.9)	10.0^{c} (3.2)	45.5^{c} (6.8)	158.3^{c} (12.6)	0.0^{a} (0.7)	2.0^{b} (1.6)	24.5^{c} (5.0)	95.5^{c} (9.8)	0.0^{a} (0.7)	4.0^{c} (2.1)	16.0^{b} (4.1)	45.3^{c} (6.8)
T5- Untreated Check	343.3	340.0^{c} (18. 5)	342.0^{e} (18.5)	334.5^{e} (18.3)	280.5^{e} (16.8)	282.0 (16.8)	278.5^{d} (16.7)	286.0^{e} (16.9)	312.5^{e} (17.7)	310.0^{c} (17.6)	311.0^{e} (17.7)	280.0^{d} (16.8)	302.0^{e} (17.4)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p= 0.05$)

Table 4. Effect of carbosulfan 25 EC on cotton thrips- Field experiment I

(Mean of four observations)

Treatments	Number of thrips per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	0.0	0.0	0.0	2.8	3.3	1.3	3.5	6.5	2.5	3.5	3.0	1.5	4.5
T2- Carbosulfan 25 EC @ 250 g a.i./ha	0.0	0.0	0.0	3.0	2.5	0.5	2.5	4.5	3.5	4.0	2.5	1.0	5.5
T3- Carbosulfan 25 EC @ 300 g a.i./ha	0.0	0.0	0.0	2.5	0.8	0.8	3.0	4.0	5.0	3.0	2.0	1.5	4.5
T4- Methyl demeton 25 EC @ 250 g a.i/ha	0.0	0.0	0.0	2.3	1.0	0.3	3.5	4.5	5.5	4.0	2.5	1.0	5.0
T5- Untreated Check	0.0	0.0	0.0	2.5	2.3	3.0	5.0	8.0	7.0	8.5	7.0	6.5	9.0

DAT- Days after treatment; PTC – Pre treatment count

Table 5. Effect of carbosulfan 25 EC on cotton leafhopper- Field experiment II

(Mean of four observations)

Treatments	Number of leafhoppers per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	32.5	16.0^c (4.1)	16.0^c (4.1)	20.0^c (4.5)	32.5^b (5.7)	26.5^c (5.2)	20.5^c (4.6)	27.3^d (5.3)	37.3^d (6.1)	25.3^d (5.1)	18.0^d (4.3)	24.0^d (5.0)	30.0^d (5.5)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	33.3	11.5^b (3.5)	9.5^b (3.2)	14.8^b (3.9)	31.0^{ab} (5.6)	17.8^b (4.3)	20.0^c (4.5)	23.0^c (4.9)	33.0^c (5.8)	15.5^c (4.0)	11.0^c (3.4)	16.0^c (4.1)	23.5^c (4.9)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	33.8	7.3^a (2.8)	5.3^a (2.4)	12.5^{ab} (3.6)	28.5^{ab} (5.4)	9.5^a (3.2)	6.0^b (2.6)	15.0^b (3.9)	28.3^b (5.4)	10.0^b (3.2)	5.5^b (2.4)	9.5^b (3.2)	17.5^b (4.2)
T4- Methyl demeton 25 EC @ 250 g a.i/ha	30.0	8.5^a (3.0)	4.0^a (2.1)	11.3^a (3.4)	27.0^a (5.2)	8.8^a (3.0)	5.0^a (2.3)	13.8^a (3.8)	26.0^a (5.2)	7.5^a (2.8)	4.0^a (2.1)	8.0^a (2.9)	15.5^a (4.0)
T5- Untreated Check	32.5	32.8^d (5.8)	29.5^d (5.5)	34.3^d (5.9)	42.3^c (6.5)	50.5^d (7.1)	55.4^d (7.5)	55.5^e (7.5)	60.5^e (7.8)	60.0^e (7.8)	62.0^e (7.9)	63.3^c (8.0)	64.0^e (8.0)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p = 0.05$)

In second and third round of sprayings as a whole, methyl demeton 250g a.i./ha was found to be superior than other treatments followed by carbosulfan 300g a.i/ha.

b. Whitefly

The population of whiteflies observed in all the treatments varied from 0.3 to 6.0 per 10 plants during the experimental period, hence, there was no significant difference between the treatments on the bioefficacy (Table .6).

c. Aphid

The observations recorded before spraying revealed that, the population was ranging from 61.0 to 64.5 per 10 plants (Table .7). The results obtained from 1 and 3 DAT indicated that, cent per cent control of aphid was achieved in all the treatments. Results from the subsequent observations (7 and 14 DAT) revealed that, the population of aphid was minimum (6.3 - 15.0/10 plants) in carbosulfan at higher concentration followed by carbosulfan 250 g a.i/ha, which was on par with methyl demeton 250 g a.i/ha. In third round of spraying, carbosulfan 250 and 300 g a.i/ha recorded cent per cent reduction till 7 DAT, which were on par with methyl demeton 250g a.i/ha.

d. Thrips

The pre-treatment population of thrips before the first round of spraying ranged from 21.5 to 23.5 per 10 plants (Table .8). On 1 DAT, the results showed that, carbosulfan at higher concentration recorded maximum per cent reduction of 96.2 and it was on par with other treatments. Though all the treatments were found to be superior to untreated control at 7 and 14 DAT, carbosulfan 300 g a.i/ha recorded minimum aphid population (7.5 - 12.5/10 plants) followed by methyl demeton 250 g a.i/ha (10.5 - 14.5). Similar trend was observed in second and third sprayings also.

Table 6. Effect of carbosulfan 25 EC on cotton whiteflies-Field experiment II

(Mean of four observations)

Treatments	Number of whiteflies per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	2.5	2.0	2.8	2.3	5.3	2.3	0.5	1.3	0.8	0.0	0.5	1.8	2.0
T2- Carbosulfan 25 EC @ 250 g a.i./ha	3.5	1.5	1.8	1.8	4.3	2.0	1.0	2.5	0.5	0.0	0.5	1.8	3.0
T3- Carbosulfan 25 EC @ 300 g a.i./ha	3.0	1.0	1.3	1.8	4.0	2.0	2.0	1.5	0.3	0.3	0.8	1.0	3.5
T4- Methyl demeton 25 EC @ 250 g a.i/ha	3.3	1.5	1.8	1.5	4.3	3.0	1.0	3.5	0.5	0.0	0.5	1.3	3.5
T5- Untreated Check	2.8	4.3	2.5	3.0	4.5	5.0	5.5	6.0	2.0	2.5	2.5	3.0	6.0

DAT- Days after treatment; PTC – Pre treatment count

Table 7. Effect of carbosulfan 25 EC on cotton aphids -Field experiment II

(Mean of four observations)

Treatments	Number of aphids per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	61.0	0.0^{a} (0.7)	0.0^{a} (0.7)	14.5^{b} (3.9)	26.3^{c} (5.2)	0.0^{a} (0.7)	0.0^{a} (0.7)	9.8^{b} (3.2)	13.0 (3.7)	0.0^{a} (0.7)	0.0^{a} (0.7)	2.3^{b} (1.6)	7.5^{c} (2.8)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	64.5	0.0^{a} (0.7)	0.0^{a} (0.7)	12.0^{b} (3.5)	22.5^{b} (4.8)	0.0^{a} (0.7)	0.0^{a} (0.7)	6.0^{ab} (2.5)	9.0^{b} (3.1)	0.0^{a} (0.7)	0.0^{a} 0.7)	0.0^{a} (0.7)	3.3^{b} (1.9)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	63.0	0.0^{a} (0.7)	0.0^{a} (0.7)	6.3^{a} (2.6)	15.0^{a} (3.9)	0.0^{a} (0.7)	0.0^{a} (0.7)	1.8^{a} (1.4)	4.5^{a} (2.2)	0.0^{a} (0.7)	0.0^{a} (0.7)	0.0^{a} (0.7)	1.3^{a} (1.3)
T4- Methyl demeton 25 EC @ 250 g a.i/ha	63.5	0.0^{a} (0.7)	0.0^{a} (0.7)	12.3^{b} (3.6)	23.0^{b} (4.9)	0.0^{a} (0.7)	0.0^{a} (0.7)	6.3^{ab} (2.6)	10.0^{b} (3.2)	0.0^{a} (0.7)	0.0^{a} (0.7)	0.5^{a} (1.0)	3.8^{b} (2.0)
T5- Untreated Check	62.0	65.3^{b} (8.1)	52.5^{b} (7.3)	49.8^{c} (7.1)	58.0^{d} (7.7)	58.0^{b} (7.7)	58.3^{b} (7.6)	60.3^{c} (7.7)	64.5^{d} (8.1)	68.0^{b} (8.3)	69.5^{b} (8.4)	64.5^{c} (8.1)	67.0^{d} (8.2)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT (p= 0.05)

Table 8. Effect of carbosulfan 25 EC on cotton thrips. Field experiment -II

(Mean of four observations)

Treatments	Number of thrips per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	23.0	2.0^{a} (1.6)	7.5^{a} (2.8)	17.3^{c} (4.2)	38.3^{c} (6.2)	14.0^{c} (3.80	18.0^{c} (4.3)	34.0^{c} (5.9)	43.8^{c} (6.6)	15.0^{c} (3.9)	18.0^{c} (4.3)	24.0^{c} (5.0)	31.0^{d} (5.6)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	22.5	1.5^{a} (1.4)	6.8^{a} (2.6)	11.8^{b} (3.5)	24.3^{b} (5.0)	5.0^{b} (2.3)	11.5^{b} (3.5)	14.0^{b} (3.8)	21.0^{b} (4.6)	4.0^{b} (2.1)	6.0^{b} (2.6)	8.0^{b} (2.9)	11.0^{c} (3.4)
T3- Carbosulfan 25 EC @ 300 g ai./ha	23.5	1.0^{a} (1.2)	4.3^{a} (2.2)	7.5^{a} (2.8)	12.5^{a} (3.6)	0.0^{a} (0.7)	1.5^{a} (1.4)	4.0^{a} (2.1)	7.5^{a} (2.8)	0.3^{a} (0.8)	0.8^{a} (1.1)	1.5^{a} (1.4)	2.3^{a} (1.6)
T4- Methyl demeton 25 EC @ 250 g a.i/ha	21.5	1.0^{a} (1.2)	6.0^{a} (2.5)	10.5^{ab} (3.3)	14.5^{a} (3.9)	0.0^{a} (0.7)	2.3^{a} (1.7)	6.0^{a} (2.6)	9.0^{a} (3.1)	0.5^{a} (1.0)	1.0^{a} (1.2)	2.0^{a} (1.6)	3.0^{b} (1.9)
T5- Untreated Check	23.0	26.0^{b} (5.1)	31.0^{b} (5.6)	46.3^{d} (6.8)	52.5^{d} (7.3)	65.3^{d} (8.1)	68.0^{d} (8.3)	77.5^{d} (8.8)	96.0^{d} (9.8)	98.0^{d} (9.9)	104.3^{d} (10.2)	96.5^{d} (9.9)	107.5^{e} (10.4)

DAT- Days after treatment; PTC – Pre treatment count

Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.

Means followed by a common letter in a column are not significantly different by DMRT ($p = 0.05$)

e. Seed cotton yield

The seed cotton yield in untreated check was 1.8 and 1.9 kg/20 m^2 in first and second field experiments, respectively. The maximum yield of 2.8 and 2.9 kg/20 m^2 (13.8 and14.3 q/ha) was recorded in plots treated with carbosulfan at 300g a.i./ha. Methyl demeton 250g a.i./ha and carbosulfan 250 a.i./ha recorded 2.7 - 2.8 and 2.5 - 2.6 kg/20 m^2 in first and second field experiments, respectively. All the treatments are on par with each other and superior over control (Table .9).

4.1.2. Brinjal

4.1.2.1. Experiment I

a. Leafhopper

The pre-treatment population of leafhopper varied from 63.5 to 65.0 numbers per 10 plants (Table .10). Endosulfan 35 EC at 350g a.i/ha was found to be superior to other treatments till third round of spraying followed by carbosulfan at higher dose (300 g a.i./ha). The difference in per cent reduction brought by various treatments was significant.

b. Whitefly

The pre-treatment population of whitefly varied from 53.0 to 55.0/10 plants. Carbosulfan at higher concentration was found to be the best among the treatments which resulted reduction ranging from 65.1 to 96.6 per cent followed by endosulfan 350 g a.i/ha (63.4 to 96.2%) during the first round of spraying. In second round, prior to spraying, population of whiteflies ranged from 37.5 to 108.5 per 10 plants. The efficacy trend in second and third round of spraying was as that of first round (Table .11).

Table 9. Effect of carbosulfan 25 EC on the yield of seed cotton.

(Mean of four observations)

S.No.	Treatments	Dose (g a.i./ha)	Yield			
			Experiment I		Experiment II	
			Kg/plot	Qtl/ha	Kg/plot	Qtl/ha
1	Carbosulfan 25 EC	200	2.3^a	11.5^a	2.3^a	11.5^a
2	Carbosulfan 25 EC	250	2.5^a	12.5^a	2.6^a	13.0^a
3	Carbosulfan 25 EC	300	2.8^a	14.0^a	2.9^a	14.5^a
4	Methyl demeton 25 EC	250	2.7^a	13.5^a	2.8^a	14.0^a
5	Untreated check	-	1.8^b	9.0^b	1.9^b	9.5^b

Means followed by a common letter in a column are not significantly different by DMRT ($p= 0.05$)

Table 10. Effect of carbosulfan 25 EC on brinjal leafhopper- Field experiment I

(Mean of four observations)

Treatments	Number of leafhoppers per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	65.0	22.3^d (4.8)	28.8^d (5.4)	38.8^d (6.3)	58.3^d (7.7)	17.0^d (4.2)	22.3^d (4.8)	32.0^d (5.7)	44.0^d (6.7)	12.5^d (3.6)	16.3^d (4.1)	21.0^d (4.6)	26.5^d (5.2)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	63.5	17.5^c (4.2)	21.5^c (4.7)	32.5^c (5.7)	47.8^c (7.0)	12.5^c (3.6)	16.5^c (4.1)	21.0^c (4.6)	29.3^c (5.5)	6.5^c (2.6)	9.0^c (3.1)	12.5^c (3.6)	16.0^c (4.1)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	65.5	5.3^b (2.4)	7.5^b (2.8)	22.8^b (4.8)	37.0^b (6.1)	4.3^b (2.2)	7.0^b (2.7)	11.5^b (3.5)	18.5^b (4.4)	2.0^b (1.6)	3.5^b (2.0)	5.0^b (2.3)	7.0^b (2.7)
T4- Endosulfan 35 EC @350 g a.i./ha	65.0	4.5^a (2.2)	6.0^a (2.6)	20.3^a (4.6)	34.3^a (5.9)	3.0^a (1.9)	5.0^a (2.3)	8.3^a (3.0)	16.0^a (4.1)	1.0^a (1.2)	2.0^a (1.6)	4.0^a (2.1)	5.3^a (2.4)
T5- Untreated Check	64.5	68.0^e (8.3)	69.5^e (8.4)	88.0^e (9.4)	105.5^e (10.3)	108.0^e (10.4)	110.5^e (10.5)	120.0^e (11.0)	132.5^e (11.5)	134.0^e (11.6)	134.0^e (11.6)	132.0^e (11.5)	133.5^e (11.6)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p = 0.05$)

Table 11. Effect of carbosulfan 25 EC on brinjal whiteflies -Field experiment I

(Mean of four observations)

Treatments	Number of whiteflies per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	55.0	6.3^{c} (2.6)	10.5^{c} (3.3)	34.8^{d} (5.9)	52.0^{d} (7.3)	5.3^{c} (2.4)	8.0^{c} (2.9)	19.0^{d} (4.4)	28.0^{d} (5.3)	1.0^{a} (1.2)	5.5^{b} (2.4)	12.3^{d} (3.6)	15.0^{c} (3.9)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	54.0	4.5^{b} (2.2)	6.0^{b} (2.6)	26.5^{c} (5.2)	43.8^{c} (6.7)	3.0^{b} (1.9)	5.0^{b} (2.3)	14.5^{c} (3.9)	19.0^{c} (4.4)	0.5^{a} (1.0)	4.0^{b} (2.1)	6.5^{c} (2.6)	8.3^{b} (3.0)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	53.5	2.0^{a} (1.6)	4.0^{a} (2.1)	19.8^{a} (4.5)	37.5^{a} (6.2)	1.0^{a} (1.2)	3.0^{a} (1.9)	9.3^{a} (3.1)	14.0^{a} (3.8)	0.0^{a} (0.7)	0.8^{a} (1.1)	2.5^{a} (1.7)	4.0^{a} (2.1)
T4- Endosulfan 35 EC @350 g a.i./ha	53.0	2.3^{a} (1.6)	4.3^{a} (2.2)	20.5^{b} (4.6)	38.8^{b} (6.3)	1.0^{a} (1.2)	3.0^{a} (1.9)	10.0^{b} (3.2)	15.0^{b} (3.9)	0.0^{a} (0.7)	1.0^{a} (1.2)	3.3^{b} (1.9)	4.3^{a} (2.2)
T5- Untreated Check	54.0	60.0^{d} (7.8)	63.5^{d} (8.0)	85.8^{e} (9.3)	108.5^{d} (10.4)	109.0^{d} (10.5)	109.5^{d} (10.5)	113.0^{e} (10.7)	114.0^{e} (10.7)	113.0^{b} (10.7)	113.5^{c} (10.7)	107.0^{e} (10.4)	109.0^{d} (10.5)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p= 0.05$)

c. Aphid

The population level of aphids before insecticide application on brinjal varied from 44.0 to 45.5 per 10 plants. On 1 DAT, a reduction of cent per cent was achieved in all the treatments till the second round of spraying. In the third round, cent per cent reduction was till 3 DAT except for carbosulfan at lower dose (200 g a.i./ha) with 98.6 per cent reduction. The per cent reduction increased with increase in doses of carbosulfan and carbosulfan 300g a.i/ha was found to be more effective than standard check (Endosulfan 350g a.i./ha) (Table .12).

d. Shoot and fruit borer

Shoot damage by the borer was not found throughout the cropping period. The incidence of fruit borer based on fruit weight was significantly less in the treated plots ranging from 1.3 to 3.5 per cent after first application, 2.0 to 4.5 per cent after second application and 4.3 to 7.0 per cent after third application (Fig.2) (Table. 13). While on number basis the fruit damage was 2.8-5.3, 4.3-8.0 and 7.0-11.5 per cent, respectively. In untreated control, the fruit borer incidence ranged from 14.5 to 34.3 per cent. Carbosulfan 300 g a.i/ha and 250 g a.i/ha were found to be more effective than the endosulfan 350g a.i/ha in all the three rounds of spraying.

4.1.2.2. Experiment II

a. Leafhopper

The population of leafhopper ranged from 99.3 to 105.3 per 10 plants before the treatment. The per cent reduction of leafhopper was maximum in endosulfan 350g a.i./ha sprayed plants followed by carbosulfan 300g a.i./ha in all the three rounds of spray (Table.14). Endosulfan 350g a.i/ha registered 90.3 per cent reduction of leafhopper followed by carbosulfan 300g a.i./ha (87.2%). Afterwards, the reduction was in a decreasing trend with 87.8 per cent in endosulfan and 83.9 per cent in carbosulfan 300g a.i./ha. Similarly,

Table 12. Effect of carbosulfan 25 EC on brinjal aphids -Field experiment I

(Mean of four observations)

Treatments	Number of aphids per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	45.5	0.0^{a} (0.7)	1.0^{a} (1.2)	8.0^{c} (2.9)	23.5^{d} (4.9)	0.0^{a} (0.7)	0.5^{a} (1.0)	6.0^{d} (2.6)	17.0^{d} (4.2)	0.0^{a} (0.7)	0.3^{a} (0.8)	6.0^{c} (2.6)	11.0^{d} (3.4)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	44.5	0.0^{a} (0.7)	0.5^{a} (1.0)	4.5^{b} (2.2)	18.8^{c} (4.4)	0.0^{a} (0.7)	0.0^{a} (0.7)	2.0^{c} (1.6)	8.5^{c} (3.0)	0.0^{a} (0.7)	0.0^{a} (0.7)	2.0^{b} (1.6)	5.8^{c} (2.5)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	45.0	0.0^{a} (0.7)	0.0^{a} (0.7)	1.5^{a} (1.4)	14.0^{a} (3.8)	0.0^{a} (0.7)	0.0^{a} (0.7)	0.5^{a} (1.0)	4.0^{a} (2.1)	0.0^{a} (0.7)	0.0^{a} (0.7)	0.5^{a} (1.0)	1.5^{a} (1.4)
T4- Endosulfan 35 EC @350 g a.i./ha	44.0	0.0^{a} (0.7)	0.3^{a} (0.8)	2.8^{a} (1.8)	16.5^{b} (4.1)	0.0^{a} (0.7)	0.3^{a} (0.8)	1.3^{b} (1.3)	7.0^{b} (2.7)	0.0^{a} (0.7)	0.0^{a} (0.7)	1.5^{b} (1.4)	3.5^{b} (2.0)
T5- Untreated Check	45.5	47.0^{b} (6.9)	49.5^{b} (7.1)	51.0^{d} (7.2)	53.5^{e} (7.4)	54.5^{b} (7.4)	54.0^{b} (7.4)	56.0^{e} (7.5)	65.0^{e} (8.1)	66.0^{b} (8.2)	66.5^{b} (8.2)	72.0^{d} (8.5)	75.5^{e} (8.7)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x+0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT (p= 0.05)

Table 13. Effect of carbosulfan 25 EC on brinjal fruit borer- Field experiment I

(Mean of four plots)

Treatments	Per cent fruit damage						Total Yield Kg/plot	Fruit Yield tonnes/ha
	I Application		II Application		III Application			
	Number basis	Weight Basis	Number basis	Weight Basis	Number basis	Weight basis		
T1-Carbosulfan 25 EC @ 200 g a.i./ha	5.3^{b} (13.2)	3.5^{b} (10.8)	8.0^{c} (16.4)	4.5^{b} (12.2)	11.5^{c} (19.8)	7.0^{c} (15.3)	47.5^{c}	23.8^{c}
T2- Carbosulfan 25 EC @ 250 g a.i./ha	3.3^{a} (10.3)	1.8^{a} (6.4)	5.0^{b} (12.9)	2.5^{a} (8.9)	8.3^{b} (16.7)	5.0^{b} (12.9)	53.3^{b}	26.6^{b}
T3- Carbosulfan 25 EC @ 300 g a.i./ha	2.8^{a} (9.2)	1.3^{a} (5.5)	4.3^{a} (11.8)	2.0^{a} (8.0)	7.0^{a} (15.3)	4.3^{a} (11.8)	55.0^{a}	27.5^{a}
T4- Endosulfan 35 EC @350 g a.i./ha	3.3^{a} (10.3)	2.0^{ab} (8.0)	5.3^{b} (13.2)	2.8^{a} (9.2)	8.5^{b} (16.9)	5.0^{b} (12.9)	53.0^{b}	26.5^{b}
T5- Untreated Check	20.5^{c} (26.9)	14.5^{c} (22.4)	35.8^{d} (36.72)	31.0^{c} (33.8)	48.0^{d} (43.9)	34.3^{d} (35.8)	32.3^{d}	16.1^{d}

Figures in parentheses are arc sin $\sqrt{\text{per cent}}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT (p= 0.05)

Fig.2. Per cent reduction in fruit damage due to carbosulfan 25 EC

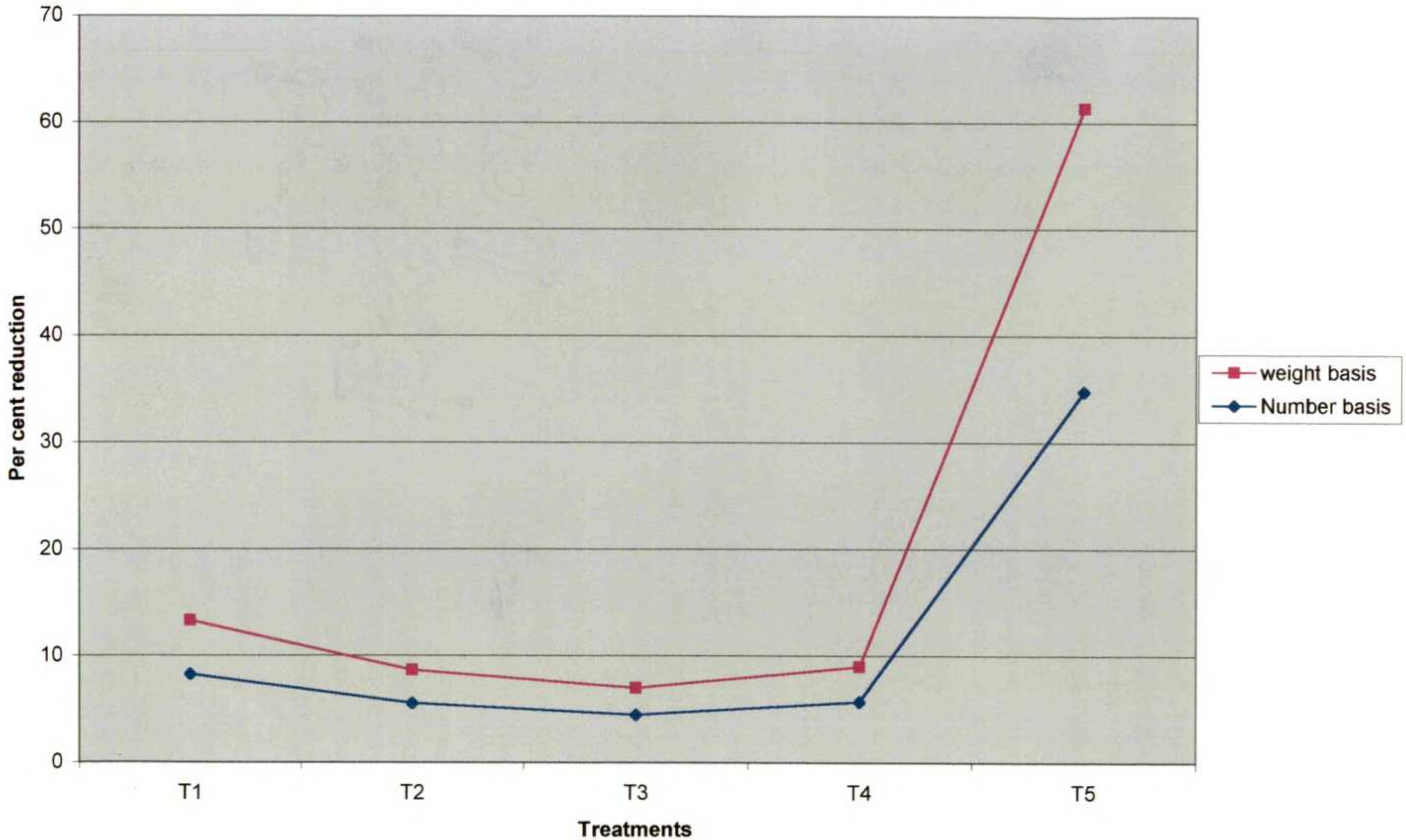

Table 14. Effect of carbosulfan 25 EC on brinjal leafhopper- Field experiment II

(Mean of four observations)

Treatments	Number of leafhoppers per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	105.3	50.3d (7.1)	57.5d (7.6)	126.0d (11.25)	158.3d (12.6)	62.0d (7.9)	72.0d (8.5)	105.0d (10.3)	138.3d (11.8)	60.0d (7.8)	67.5d (8.3)	83.5d (9.2)	110.0d (10.5)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	101.5	41.8c (6.5)	49.3c (7.1)	110.5c (10.5)	126.3c (11.3)	42.5c (6.5)	51.5c (7.2)	75.3c (8.7)	94.5c (9.8)	35.8c (6.0)	40.0c (6.4)	51.0c (7.2)	64.0c (8.0)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	99.3	16.0b (4.1)	22.5b (4.8)	85.5b (9.3)	106.0b (10.3)	19.8b (4.5)	23.0b (4.9)	55.0b (7.5)	65.0b (8.1)	13.0b (3.7)	16.0b (4.1)	27.0b (5.2)	37.8b (6.2)
T4- Endosulfan 35 EC @350 g a.i./ha	100.5	12.3a (3.6)	17.3a (4.2)	67.0a (8.2)	94.0a (9.7)	14.5a (3.9)	18.0a (4.3)	34.5a (5.9)	51.8a (7.2)	9.0a (3.1)	11.3a (3.4)	16.3a (4.1)	25.0a (5.1)
T5- Untreated Check	99.3	125.0e (11.2)	139.5e (11.8)	171.3e (13.1)	183.8e (13.6)	162.0e (12.8)	173.5e (13.2)	182.5e (13.5)	201.5e (14.2)	205.0e (14.3)	195.3e (14.0)	190.5e (13.8)	202.8e (14.3)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p = 0.05$)

on 14 DAT, endosulfan 350g a.i./ha reduced leafhopper population to 49.5 per cent followed by carbosulfan 300g a.i./ha (42.3%). Efficacy status of the different chemicals remained as same till third spray.

b. Whitefly

The pre treatment population of whitefly on brinjal was varied from 60.0 to 62.5 /10 plants. The population after treatment ranged from 1.3 to 63.0, 3.3 to 64.3, and 18.5 to 82.0 and 32.3 to 98.5/10 plants on 1, 3, 7 and 14 DAT, respectively. Carbosulfan 300g a.i./ha was found to be superior to other treatments in all the three rounds of spraying followed by standard endosulfan. During the third round of spraying, carbosulfan at higher concentration recorded cent per cent reduction on 1 DAT and it was found to be on par with endosulfan 350g a.i/ha (98.1%) and carbosulfan 250g a.i./ha (94.6%). At 14 DAT, both endosulfan and carbosulfan registered the lowest population of each 4.5 whiteflies /10 plants against 99.5 in untreated control (Table .15).

c. Aphid

Prior to spraying, the aphid population on brinjal varied from 36.0 to 38.0 per 10 plants. A reduction of cent per cent was achieved in all the chemical sprayed plots in 1 and 3 DAT. After that, the difference in per cent reduction brought by various treatments was found to be significant (Table .16). At 7 DAT, carbosulfan 300g a.i./ha registered the maximum per cent reduction of 97.5 followed by endosulfan (95.2%), carbosulfan 250g a.i./ha (90.1%) and carbosulfan 200g a.i/ha (81.8%). The per cent reduction was ranging from 53.6 to 73.5 at 14 DAT in various treatments. Similar trend on the efficacy was continued in the second spray, however, in the third spray, carbosulfan 300g a.i/ha recorded a remarkable cent per cent reduction till 7 DAT, but it was on par with endosulfan 350 and carbosulfan 250g a.i./ha.

Table 15. Effect of carbosulfan 25 EC on brinjal whiteflies- Field experiment II

(Mean of four observations)

Treatments	Number of whiteflies per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC@ 200 g a.i./ha	60.0	5.5^c (2.4)	9.8^c (3.2)	33.5^d (5.8)	48.3^d (7.0)	4.5^b (2.2)	8.8^c (3.0)	18.0^d (4.3)	27.0^c (5.2)	3.3^b (1.9)	5.8^c (2.5)	12.0^c (3.5)	14.3^c (3.8)
T2- Carbosulfan 25 EC@ 250 g a.i./ha	62.3	3.0^b (1.9)	5.3^b (2.4)	25.3^c (5.1)	39.8^c (6.3)	2.8^b (1.8)	5.0^b (2.3)	14.3^c (3.8)	18.8^b (4.4)	1.0^a (1.2)	4.0^b (2.1)	6.8^b (2.7)	8.0^b (2.9)
T3- Carbosulfan 25 EC@ 300 g a.i./ha	61.5	1.3^a (1.3)	3.3^a (1.9)	18.5^a (4.4)	32.3^a (5.7)	0.5^a (1.0)	3.0^a (1.9)	9.0^a (3.1)	13.0^a (3.7)	0.0^a (0.7)	1.0^a (1.2)	3.0^a (1.9)	4.5^a (2.2)
T4- Endosulfan 35 EC @350 g a.i./ha	61.0	1.5^a (1.4)	3.5^a (2.0)	19.8^b (4.5)	33.5^b (5.8)	0.8^a (1.1)	3.3^a (1.9)	10.3^b (3.3)	13.5^a (3.7)	0.3^a (0.8)	1.0^a (1.2)	3.5^a (2.0)	4.5^a (2.2)
T5- Untreated Check	62.5	63.0^d (8.0)	64.3^d (8.1)	82.0^e (9.1)	98.5^e (10.0)	101.0^c (10.1)	101.5^d (10.1)	106.0^e (10.3)	106.0^d (10.3)	105.0^c (10.3)	105.5^d (10.3)	98.0^d (9.9)	99.5^d (10.0)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p= 0.05$)

Table 16. Effect of carbosulfan 25 EC on brinjal aphids-Field experiment II

(Mean of four observations)

Treatments	Number of aphids per 10 plants												
	I Application					II Application				III Application			
	PTC	1 DAT	3 DAT	7 DAT	14 DAT	I DAT	3 DAT	7 DAT	14 DAT	1 DAT	3 DAT	7 DAT	14 DAT
T1-Carbosulfan 25 EC @ 200 g a.i./ha	36.5	0.0^{a} (0.7)	0.0^{a} (0.7)	7.5^{d} (2.8)	21.8^{d} (4.7)	0.0^{a} (0.7)	0.0^{a} (0.7)	4.8^{c} (2.3)	15.0^{d} (3.9)	0.0^{a} (0.7)	0.5^{a} (1.0)	3.5^{b} (2.0)	9.0^{d} (3.1)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	38.0	0.0^{a} (0.7)	0.0^{a} (0.7)	4.3^{c} (2.2)	17.0^{c} (4.2)	0.0^{a} (0.7)	0.0^{a} (0.7)	2.8^{b} (1.8)	9.0^{c} (3.1)	0.0^{a} (0.7)	0.0^{a} (0.7)	1.0^{a} (1.2)	4.3^{c} (2.2)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	36.0	0.0^{a} (0.7)	0.0^{a} (0.7)	1.0^{a} (1.2)	12.3^{a} (3.6)	0.0^{a} (0.7)	0.0^{a} (0.7)	1.0^{a} (1.2)	5.0^{a} (2.3)	0.0^{a} (0.7)	0.0^{a} (0.7)	0.0^{a} (0.7)	1.5^{a} (1.4)
T4- Endosulfan 35 EC @350 g a.i./ha	37.0	0.0^{a} (0.7)	0.0^{a} (0.7)	2.0^{b} (1.6)	14.5^{b} (3.9)	0.0^{a} (0.7)	0.0^{a} (0.7)	1.5^{a} (1.4)	6.5^{b} (2.6)	0.0^{a} (0.7)	0.0^{a} (0.7)	0.5^{a} (1.0)	2.8^{b} (1.8)
T5- Untreated Check	37.8	38.3^{b} (6.2)	39.0^{b} (6.3)	42.5^{e} (6.6)	48.5^{e} (7.0)	48.0^{b} (7.0)	49.8^{b} (7.1)	53.0^{d} (7.3)	67.5^{e} (8.3)	66.0^{b} (8.2)	66.5^{c} (8.2)	63.3^{c} (8.0)	69.0^{e} (8.3)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT (p= 0.05)

d. Shoot and fruit borer

There was no shoot borer incidence noticed throughout the cropping period. The fruit borer incidence on both number and weight basis was significantly less in treated plots (Table.17). The incidence was 1.5 to 3.8 per cent in insecticide treated plots when, compared to untreated check (17.5%) on weight basis after first application, 2.8-4.8 per cent, after second application and 4.5 to 8.3 per cent, after third application. Carbosulfan 300g a.i./ha was found to be superior over the other treatments followed by carbosulfan 250g a.i./ha in all the three rounds of spraying and it was found to be on par with standard endosulfan 350g a.i./ha.

e. Brinjal fruit yield

The statistical analysis of the yield data revealed that, the healthy brinjal fruit yield was maximum (27.5 and 29.0 t/ha) in carbosulfan (300g a.i./ha) treated plots followed by carbosulfan at 250 g a.i./ha (26.6 and 28.1 t/ha), which was on par with endosulfan 350g a.i./ha (26.5 and 27.9 t/ha) and carbosulfan at 200g a.i./ha (23.8 and 26.8 t/ha) as against untreated control which recorded the lowest (16.1 and 19.1 t/ha) yield in the first and second experiments, respectively (Table 13&17).

4.2. Toxicity of carbosulfan 25 EC to natural enemies

Experiments were conducted to assess the toxicity of carbosulfan 25 EC to natural enemies in cotton and brinjal ecosystem.

4.2.1. Cotton

4.2.1.1. Spiders

The population of spiders ranged from 6.00 to 7.00 from the 10 observed plants. Carbosulfan at higher dose recorded minimum number of spiders (5.0 and 4.5/10 plants) on 1 and 3 DAT (Table .18). At 7 and 14 DAT, all the insecticides tried were not toxic to spiders.

Table 17. Effect of carbosulfan 25 EC on brinjal fruit borer - Field experiment II

(Mean of four plots)

Treatments	Per cent fruit damage						Total Yield Kg/plot	Fruit Yield tonnes/ha
	I Application		II Application		III Application			
	Number basis	Weight basis	Number basis	Weight basis	Number basis	Weight Basis		
T1-Carbosulfan 25 EC @ 200 g a.i./ha	5.5^{c} (13.5)	3.8^{b} (11.0)	8.3^{c} (16.7)	4.8^{b} (12.0)	12.8^{c} (20.9)	8.3^{b} (16.6)	53.5^{d}	26.8^{d}
T2- Carbosulfan 25 EC @ 250 g a.i./ha	3.8^{ab} (11.0)	1.8^{a} (6.4)	5.0^{a} (12.9)	3.0^{a} (9.9)	9.5^{b} (17.9)	5.3^{a} (13.2)	56.2^{b}	28.1^{b}
T3- Carbosulfan 25 EC @ 300 g a.i./ha	3.3^{a} (10.3)	1.5^{a} (6.0)	4.5^{a} (12.2)	2.8^{a} (9.2)	8.5^{a} (16.9)	4.5^{a} (12.2)	58.1^{a}	29.0^{a}
T4- Endosulfan 35 EC @ 350 g a.i./ha	4.3^{b} (11.8)	2.0^{a} (8.0)	5.5^{b} (13.6)	3.3^{a} (10.4)	10.0^{b} (18.4)	5.8^{a} (13.8)	55.8^{c}	27.9^{c}
T5- Untreated Check	22.8^{d} (28.5)	17.5^{c} (24.7)	38.3^{d} (38.2)	31.5^{b} (34.1)	46.5^{d} (43.0)	38.5^{c} (38.4)	38.3^{e}	19.1^{e}

Figures in parentheses are arc sin $\sqrt{\text{per cent}}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p = 0.05$)

Table 18. Toxicity of carbosulfan 25 EC to spiders of cotton ecosystem-Third Application

(Mean of four observations)

Treatments	Number of spiders per 10 plants				
	PTC	1DAT	3 DAT	7 DAT*	14 DAT*
T1-Carbosulfan 25 EC @ 200 g a.i./ha	6.5	6.0^{a} (2.6)	6.0^{ab} (2.6)	6.8^{a} (2.7)	7.8^{a} (2.9)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	6.5	5.5^{ab} (2.4)	5.0^{cd} (2.3)	6.5^{a} (2.6)	7.5^{a} (2.8)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	7.0	5.0^{b} (2.3)	4.5^{d} (2.2)	6.3^{a} (2.6)	7.3^{a} (2.8)
T4- - Methyl demeton 25 EC @ 250 g a.i/ha	7.0	6.0^{a} (2.6)	5.5^{bc} (2.4)	6.5^{a} (2.6)	7.8^{a} (2.9)
T5- Untreated Check	6.0	6.0^{a} (2.6)	6.5^{a} (2.6)	7.0^{a} (2.7)	8.0^{a} (2.9)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT ($p = 0.05$)
* Not significant

4.2.2. Brinjal

4.2.2.1. Spiders

The pre-treatment population of spiders varied from 8.5 to 9.5 per 10 plants before spraying (Table .19). Carbosulfan 300g a.i./ha exhibited 23.5 per cent reduction in spider population over control followed by carbosulfan 250g a.i./ha (15.8%). At 3 DAT, carbosulfan at higher concentration registered maximum reduction over other treatments. However, at 7 and 14 DAT, none of the treatments were considerably toxic to spiders and the population in all the treatments was on par with control.

4.3. Phytotoxicity of carbosulfan 25 EC on cotton and brinjal

The results of the investigations on the phytotoxicity effect of carbosulfan 25 EC as foliar application to cotton and brinjal are furnished in the Table 20 and 21. It was observed that, the plants were normal in all the doses of carbosulfan 25 EC, methyl demeton 25 EC and endosulfan 35 EC treated plots and were not differed symptomatically with the control. During the entire period of observations, the mean grade of "1" was graded for all the treatments imposed plants. Hence, it was concluded that all the treatments irrespective of the doses given did not inflict any phytotoxicity effect on cotton and brinjal.

4.4. Residues of carbosulfan 25 EC

4.4.1. Determinability

The minimum detectable level or sensitivity of the Gas Chromatography (GC) was 0.1 µg for carbosulfan. The lower quantitative limit of the GC for cotton lint and seeds considering 10g weight was 0.02 µg and 0.004 µg for brinjal of 50 g respectively with a final volume of the extract (2ml). Values below this level are reported as below detectable level (BDL).

Table 19. Toxicity of carbosulfan 25 EC to spiders of brinjal ecosystem – Third Application

(Mean of four observations)

Treatments	Number of spiders per 10 plants				
	PTC	1DAT	3 DAT	7 DAT*	14 DAT*
T1-Carbosulfan 25 EC @ 200 g a.i./ha	9.0	8.5^{ab} (3.0)	8.0^{b} (2.9)	9.3^{a} (3.1)	10.3^{a} (3.3)
T2- Carbosulfan 25 EC @ 250 g a.i./ha	9.5	8.0^{b} (2.9)	7.5^{b} (2.8)	9.0^{a} (3.1)	10.0^{a} (3.2)
T3- Carbosulfan 25 EC @ 300 g a.i./ha	8.5	6.5^{c} (2.6)	5.5^{c} (2.4)	8.8^{a} (3.0)	9.5^{a} (3.2)
T4- Endosulfan 35 EC @350 g a.i./ha	8.5	8.0^{b} (2.9)	7.5^{b} (2.8)	9.0^{a} (3.1)	10.0^{a} (3.2)
T5- Untreated Check	9.0	9.0^{a} (3.1)	9.5^{a} (3.2)	9.5^{a} (3.2)	10.5^{a} (3.3)

DAT- Days after treatment; PTC – Pre treatment count
Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by a common letter in a column are not significantly different by DMRT (p= 0.05)
* Not significant

Table 20. Phytotoxicity of carbosulfan 25 EC to cotton

(Mean of four observations)

Treatments	1 DAT						3 DAT						7 DAT						14 DAT					
	L	W	V	N	E	H	L	W	V	N	E	H	L	W	V	N	E	H	L	W	V	N	E	H
T1-CS 25 EC @ 200 g a.i./ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T2- CS 25 EC @ 250 g a.i./ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T3- CS 25 EC @ 300 g a.i./ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T4- MD 25 EC @ 250 g a.i/ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T5- Untreated Check	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1

L-Leaf injury, W-Wilting, V-Vein clearing, N-Necrosis, E-Epinasty and H-Hyponasty
CS-Carbosulfan; MD-Methyl demeton

Table 21. Phytotoxicity of carbosulfan 25 EC to brinjal

(Mean of four observations)

Treatments	1 DAT						3 DAT						7 DAT						14 DAT					
	L	W	V	N	E	H	L	W	V	N	E	H	L	W	V	N	E	H	L	W	V	N	E	H
T1-CS 25 EC @ 200 g a.i./ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T2- CS 25 EC @ 250 g a.i./ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T3- CS 25 EC @ 300 g a.i./ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T4- ES 35 EC @ 350 g a.i/ha	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1
T5-Untreated Check	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1	L1	W1	V1	N1	E1	H1

L-Leaf injury, W-Wilting, V-Vein clearing, N-Necrosis, E-Epinasty and H-Hyponasty
CS-Carbosulfan; ES-Endosulfan

4.4.2. Recovery

The mean recovery of carbosulfan was 81.5, 87.0 and 84.5 per cent from cotton seed, lint and brinjal fruit spiked samples respectively.

4.4.3.1. Cotton

The residues of carbosulfan at 250g a.i./ha were at below detectable levels in cotton lint and seed in both the experiments. Application of carbosulfan (Marshal 25 EC) at 500 and 1000 g a.i/ha left residues of 0.042 and 0.054 and 0.099 and 0.121 µg/g in the cotton seeds sampled at first harvest from first and second field experiments respectively, while, the residues in lint samples were at below detectable level (Table .22).

4.4.3.2. Brinjal

No detectable residue levels were determined in brinjal fruit samples collected at first and third harvests of first and second field trials. (Table.23)

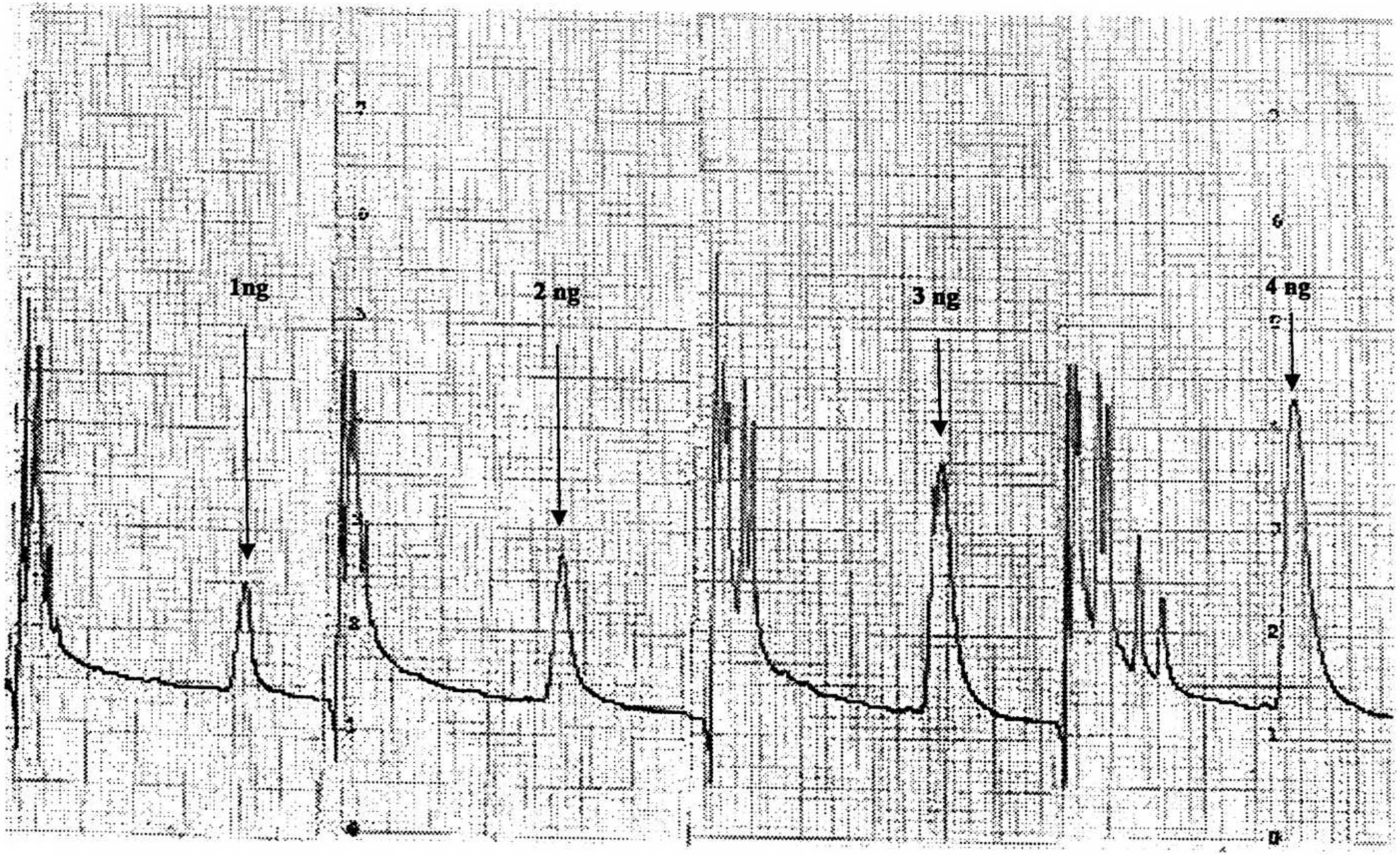

Plate 5. Standard Chromatogram of carbosulfan

Table 22. Harvest time residues of carbosulfan 25 EC on cotton lint and seed (µg/g).

(Mean of two replications)

S.No	Treatments	Dose g a.i./ha	Experiment I				Experiment II			
			First Harvest		Third Harvest		First Harvest		Third Harvest	
			Lint	Seed	Lint	Seed	Lint	Seed	Lint	Seed
1	Carbosulfan 25 EC	250	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
2	Carbosulfan 25 EC	500	BDL	0.042	BDL	BDL	BDL	0.099	BDL	BDL
3	Carbosulfan 25 EC	1000	BDL	0.054	BDL	BDL	BDL	0.121	BDL	BDL
4	Untreated check	-	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL – Below Detectable Level;

Table 23. Harvest time residues of carbosulfan 25 EC on brinjal fruits (µg/g).

(Mean of two replications)

S.No	Treatment	Dose (g a.i./ha)	First and Third Harvests	
			Experiment I	Experiment II
1.	Carbosulfan 25 EC	250	BDL	BDL
2.	Carbosulfan 25 EC	500	BDL	BDL
3.	Carbosulfan 25 EC	1000	BDL	BDL
4.	Untreated check	-	BDL	BDL

BDL – Below Detectable Level;

DISCUSSION

CHAPTER V

DISCUSSION

The results obtained from the field experiments conducted to evaluate the bioefficacy of carbosulfan 25 EC against sucking pests of cotton and brinjal and shoot and fruit borer of brinjal, toxicity against natural enemies, phytotoxicity effect and on terminal residues are discussed in this chapter.

5.1. Bioefficacy

Carbosulfan 25 EC @ 300 g a.i./ha spray registered 83.2 per cent reduction in leafhopper population on third day after the treatment was imposed. The other two doses of the carbosulfan (250 and 200 g a.i./ha) were also found in reducing the hopper population significantly from the number of 42.5 to 11.5 and from 44.0 to 19.5 respectively. Similar findings were also reported by Asaf Ali and Chinniah (1999) that carbosulfan 25 EC @ 0.075 per cent has resulted the highest mortality (84.5% and 85.6%) of leafhopper respectively on 7^{th} day after first and second spray. Chinniah and Asaf Ali (1999) also suggested that, cotton seeds coated with carbosulfan 25 DS @ 50 g/kg effectively controlled (66.6%) the leafhopper population on 7 DAT. The insecticides evaluated against the leafhopper remarkably reducing the population when compared to the untreated plots where an increase in the number of hoppers form 43.5 to 71.3 at the end of third round of spray. The findings of the two field experiments elicited that, methyl demeton 25 EC sprayed @ 250 g a.i/ha reduced the leafhopper population to the maximum level of 86.9 per cent on third day after the spray. Senapati and Behera (1989) also investigated concordant results that methyl demeton at 0.5 kg a.i./ha at 20 days interval resulted in good control of leafhoppers and again supported by

Gupta *et al.*, (1999); Manisegarane and Kumaraswami (1994) and Santhini and Uthamasamy (1997).

The population level of whitefly varied from 0.3 to 9.0 and 0.3 to 6.0 per 10 plants in the first and second field experiments respectively. Since the population was very low.

Cent per cent reduction of cotton aphid was observed for the three doses of (200, 250 and 300 g a.i/ha) carbosulfan sprayed plants even after a day of spray. But on 3 DAT, the carbosulfan 300 and 250 g a.i./ha were effected cent per cent reduction. In the present field experiment, results showed that carbosulfan 300 and 250 g a.i./ha brought down the aphid population to the zero level in all the three rounds of spray and the findings were in agreement with the results obtained for carbosulfan 25 EC @ 0.075 per cent which registered a higher mortality (95.6 and 97.5%) of aphids on 7th day after first and second spraying by Asaf Ali and Chinniah (1999) and 86.3 per cent reduction was obtained with carbosulfan 25 DS @ 50 g /kg seed treatment by Chinniah and Asaf Ali (1999). Similar findings were reported by Drishpon *et al.* (1989) that carbosulfan, methyldemeton, pirimicarb were highly effective against all stages of the cotton aphid.

The studies on population level of thrips were ranged from 0.3 to 9.0 in the first experiment. The carbosulfan 300 g a.i./ha effected 96.2 per cent reduction on 1 DAT, which was on par with methyl demeton (95.9%), carbosulfan 250 g a.i./ha (94.1%) and carbosulfan 200 g a.i./ha (92.3%). The highest dose of carbosulfan 25 EC (300 g a.i./ha) was maintained its superiority over the other treatments in the second and third round of spray too. These results were in accordance with the findings of Patil *et al.* (2002) who reported that carbosulfan at 300 g a.i./ha effected 80.5 per cent reduction of thrips on 3rd day after the treatment was imposed. Similarly Regupathy (1981) proved the efficacy of carbofuran @ 7.5 and 10 per cent w/w (96%) for the control of thrips.

The bioefficacy of carbosulfan against the brinjal leafhopper evaluated in two field experiments revealed that carbosulfan 300 g a.i./ha recorded the higher reduction of 92.4 per cent of leafhoppers in the first, 88.7 per cent in the second and 89.3 per cent in the third round of spray on the first day observations after the each round of spray. This is in confirmation with the earlier report of Mohan (1988) with 0.44 per cent treatment of carbosulfan. Sushilkumar *et al.* (1990) found that carbaryl (50 WP @ 0.15%) effected 80.32 per cent reduction of leafhopper population after 7 DAT. Endosulfan 350 g a.i./ha reduced the leafhopper population to 93.4 per cent on 1 DAT and the efficacy was persisted for the subsequent observation also (77.1% - 7 DAT). This findings were similar to the observation made by Singh and Kavadia (1989) who proved that endosulfan 35 EC and aldicarb 10 g @ 1.5 kg a.i./ha resulted 80.4 per cent reduction of leafhopper even after 7 DAT and also in agreement with the findings of Ramzan *et al.* (1976), Mohan (1988) and Shah *et al.* (1990).

Effective percentage reduction of 96.6 and 96.1 of brinjal whitefly was achieved by the spray of carbosulfan 300 and endosulfan 350 g a.i./ha respectively in the first round of spray. But cent per cent reduction in the 3rd round of spray which were on par with carbosulfan 250 and 200 g a.i./ha. The findings are agreeable with Singh and Kavadia (1989) who reported that aldicarb 10 G @ 1.5 kg a.i./ha in combination either with carbaryl or endosulfan resulted in 82.9 and 84.3 per cent reduction respectively. Similarly Litainger and Apostol (1994) obtained 100 per cent control of whiteflies when carbofuran applied @ 1 kg a.i./ha.

Though all the doses of carbosulfan controlled the brinjal aphid population effectively, the highest dose of carbosulfan (300 g a.i./ha) showed the persistence control over other treatments. Cent per cent reduction was achieved in all the treatments after one day of spraying and continued till 3 DAT for carbosulfan 300, 250 and endosulfan 350 g a.i./ha in 3rd round of spray as against 66.5 aphids recorded in untreated check. Concordant results were also reported by Litainger and Apostol (1994) that carbofuran 1 kg a.i./ha registered 99-100 per cent control (0 – 2.7 aphids /30 leaves) against 1034 aphids /30 leaves in untreated checks on 49 DAT which coincide with the findings of Reghunath *et al.* (1989) who reported that carbofuran @ 0.5 kg a.i./ha along with seed followed by need based spraying of carbaryl 0.2 per cent were effective in controlling aphid. Chitra *et al.* (1993) reported that endosulfan (0.07%) gave 75.5 per cent reduction of aphid population.

In the present investigation, the damage on the shoot by *Leucinodes orbonalis* (Guen.) was not observed throughout the cropping period. The per cent damage caused by brinjal fruit borer on fruits were calculated both in number and weight bases to evaluate the efficacy of the insecticides. Among the treatments, carbosulfan 300 g a.i./ha recorded a minimum of 2.8 to 7.0 and 1.3 to 4.3 per cent damage of fruits on number and weight basis respectively and this was followed by next lower dose of carbosulfan 250 g a.i./ha (3.3 to 8.3 and 1.8 to 5.0%) which was on par with endosulfan 350 g a.i./ha (3.3 to 8.5 and 2.0 to 5.0%) as against 20.5 to 48.0 and 14.5 to 34.3 per cent in untreated check. Such an observation has been reported earlier by Chinniah and Asaf Ali (1999) when carbosulfan applied @ 2 ml/l and carbosulfan + quinalphos @ 1 ml of each/l registered 14.6 and 12.1 per cent fruit damage respectively as against 21.8 per cent damage in untreated check. This is again agreed in conformity with the findings of Srinivasan and Rabindra(2001) who found that carbosulfan 2 ml/l recorded a per cent damage of 0.7 to 4.3 and 1.5 to 7.6 on weight and number basis respectively. Though the endosulfan efficacy was next to the carbosulfan 250 g a.i./ha in reducing the fruit damage, the effectiveness was significant and was in agreement for an alternate insecticide because Sharma and Chhibber (1999) reported that endosulfan 750 g a.i./ha recorded 8.4 and 10.9 per cent of shoot and fruit damage respectively and also coincide with findings of Sontakke *et al.* (1990) who recorded 7.7 per cent and Bothara and Dethe (1991) who reported 9.9 per cent fruit damage with 25 ULV @ 3.50 kg a.i./ha.

Yield

Cotton

The seed cotton yield was found be the maximum in the carbosulfan 300 g a.i./ha imposed plots, which yielded 13.8 q/ha, followed by methyl demeton (13.5 q/ha). Similarly, in the other experiment also carbosulfan 300g a.i./ha registered the highest yield of 14.3 q/ha followed by methyl demeton (13.8 q/ha) as against 9.3 q/ha in untreated check. Such an observation had been reported by Patil *et al.* (2002) that carbosulfan 25 EC @ 300 g a.i./ha recorded an yield of 14.7 q/ha and Surulivelu and Kumaraswamy (1990) found that seed treatment with carbosulfan 25 SD at 1 g a.i./100 g seeds effected an yield of 19.4 q/ha as against untreated check yielded only 11.0 q/ha.

Brinjal

The harvest of healthy fruits was found maximum from the carbosulfan 300 g a.i./ha sprayed plots, which had a substantial increase over the other two doses of carbosulfan at 250 and 200 g a.i./ha and endosulfan at 350 g a.i./ha^{-1} with a recorded yield of 27.5 and 29.0 tonnes/ha in first and second field experiments respectively. This is in confirmation with the reports of Srinivasan and Rabindra (2001) who recorded a fruit yield of 27.02 tonnes/ha from the carbosulfan sprayed

@ 2.5 ml/lit. In the present investigation, endosulfan 350 g a.i./ha registered 26.5 and 27.9 tonnes/ha in the first and second field experiment. It is in concordance with the findings of Sharma and Chhibber (1999) who registered 23.6 tonnes/ha fruit yield for the spray dose of 750 g a.i./ha.

5.2. Toxicity to natural enemies

All the insecticides *viz.*, carbosulfan at three doses 300, 250 and 200 methyl demeton 250 and endosulfan 350 g a.i./ha evaluated against insect pests were not too toxic to the natural enemies particularly spiders after 7 and 14 DAT. The toxicity level noticed for the carbosulfan 300, 250,200 and methyl demeton (250) were with a reduction per cent of 28.6 and 41.0, 15.4 and 29.0 and 7.7 and 14.8 and 14.3 and 27.5 in cotton ecosystem on 1 and 3 DAT respectively. All the insecticides irrespective of the doses were safe to the spiders based on the report that till 50 per cent reduction in population is considered to be safe as reported by Dhawan(2000).Similarly, these findings were in accordance with Raman and Uthamasamy (1983) who found carbosulfan was the least toxic to spiders in cotton ecosystem and Srinivasan (2000) who observed for phosphamidon 85 WSC where he recorded a maximum of 42.02 per cent reduction of spider population at 5 DAT, in cotton ecosystem.

In brinjal, no insecticide is toxic to spiders after 7 and 14 DAT. However, considerable levels of toxicity were observed in the 1 and 3 DAT with carbosulfan 300, 250, 200 and endosulfan 350 g a.i./ha treated plots with a decrease in decrement per cent of 23.5 and 38.7, 15.8 and 25.2, 5.6 and 15.8 and 5.9 and 16.4 respectively.

This implies that the carbosulfan at 200 g a.i./ha was safer to the natural enemies especially to spiders which was in concordance with the other plant derived insecticides like Neemazal® (0.25% and 0.5%), NSKE (3.0% and 5.0%)

Jatropa leaf extract (0.5%), Calotropis (0.5%) and Anona (0.5%) recorded 1.87 spiders / 5 plants in all botanical treatments with brinjal plants. (Rosaiah, 2001)

The results of the toxicity of carbosulfan 25 EC to beneficial organisms on cotton and brinjal eco-system had indicated that carbosulfan 25 EC @ 300 and 250 g a.i./ha exhibited certain amount of toxicity to the natural enemy population. Such an observation has been reported earlier by Patil *et al.* (2002) in cotton

5.3. Phytotoxicity

Carbosulfan 25 EC applied at 250, 500 and 1000 g a.i./ha to cotton and brinjal did not develop any deleterious effects on the plants. This elicit that the chemicals even at the three and half times higher doses than the carbosulfan 300 g a.i./ha does not harm the plants and registered the phytotoxicity grade of 1 (0 – 10%) and therefore, it is considered as safest level for the phytotoxicity. The same effect was observed also by Mathirajan (1998) for lambda-cyhalothrin applied in three doses viz., 7.5, 15 and 30 g a.i./ha, Dikshit *et al.* (2001) with 12.5, 18.75, 25, 37.50 and 75 g a.i./ha, Srinivasan (2000) with phosphamidon (40 SL) as foliar application of 1200 g a.i./ha and Valarmathi (1997) who also found with quinalphos (AF, CS and EC) formulations @ 500, 1000 and 500 g a.i./ha on cotton. On the contrary to the present investigation Mote and Shah (1993) reported that carbosulfan @ 6, 7 and 5 per cent as seed treatment and carbofuran 3 G @ 1 kg a.i/ha showed phytotoxicity symptoms with leaf tip burning up to 7th day after germination on soybean and therefore, it might be due to the higher dose than the recommended one of 1 g/kg of seed and 1 kg a.i./ha as soil application respectively. The second reason might be due to the tenderness of the soybean seedling, which is considered to be prone for phytotoxicity at the germination as compared to the grown up leaves of brinjal and cotton plants sprayed with the insecticides.

5.4. Residues

Carbosulfan applied to cotton @ 500 and 1000g a.i./ha left residues in the seeds at first harvest to the level of 0.042 and 0.054 µg/g in the first experiment and 0.099 and 0.121 ppm in the second experiment respectively. Such an observation had been reported earlier for carbofuran by Rangathilakam(1990) that application of granules resulted in harvest time residues of 0.019 to 0.229 ppm in sorghum grains and 0.036 to 0.123 ppm in fodder on dry basis. Similarly, Manimegalai *et al.* (1995) reported for the other pesticide that pyraclofos @ 750 g a.i./ha left 0.1079 and 0.0894 ppm residues in cotton seed and lint respectively. While, Mukherjee and Gopal (2001) who reported that imidacloprid @ 6, 9, 12, 18 and 24 ml/kg seed treatment left residues of below detectable level (<0.05 mg/kg) in cotton seed at harvest. On contrast to seed, the residues were below detectable level in lint samples. It is concordance with the findings of Manimegalai *et al.* (1995) and Mukherjee and Gopal (2001) who reported that residues were at BDL for cotton lint samples after pyraclofos and imidacloprid application.

The carbosulfan residues were below detectable level in the brinjal fruits sampled for residues at first and third harvests. This is in accordance with the findings of Eswara Reddy and Srinivasa (2001) who determined the residues at below detectable level in the brinjal fruits after 12 days of application of carbosulfan. Though, Dikshit *et al.* (2001) reported that the initial residues of 0.98 mg/kg of lambda cyhalothrin for 35 g a.i./ha on brinjal fruits but subsequently seen that it was declined to 0.76 mg/kg on 1 day and dissipated to an extent of 0.14 mg/kg on 7 days after second spray. Litainger and Apostol (1994) reported that there were 2 residue peaks for 1 kg a.i. /ha as a single application and 2 kg a.i. /ha as split application of carbofuran ranged from 58 – 60 ppb (first) and 50 – 60 ppb (second) respectively on brinjal fruits.

SUMMARY

CHAPTER VI

SUMMARY

The results of the investigation carried out on the bio efficacy of carbosulfan 25 EC against the sucking pests of cotton and brinjal, toxicity of the chemicals to spiders, phytotoxicity and residues of carbosulfan are summarized here.

(i) The maximum reduction of cotton leafhopper population (86.9%) was recorded by methyl demeton 25 EC @ 250 g a.i/ha followed by carbosulfan 25 EC @ 300g a.i/ha (83.2%)at 3 DAT. The results were similar in both the field experiments after the second and third round of spray.

(ii) Cent per cent reduction of cotton aphid was in all the doses of carbosulfan treated plots at 1 DAT, whereas in the second round, carbosulfan 300 and 250g a.i/ha effected cent per cent reduction at 3 DAT too. Carbosulfan 300 and 250g a.i./ha were found to be superior to methyl demeton and especially carbosulfan 300g a.i./ha showed a remarkable reduction of the aphid (100%) till 7 DAT at third round of spray.

(iii) Carbosulfan 300g a.i/ha effected 96.2 per cent reduction of thrips at 1 DAT, which was on par with methyl demeton (95.9%), carbosulfan 250g a.i./ha (94.1%) and carbosulfan 200g a.i/ha (92.3%). The highest dose of carbosulfan 25 EC was maintaining its superiority in efficacy over the other treatments in the second and third round of spray.

(iv) In brinjal, endosulfan at 350g a.i/ha was found to be the superior than carbosulfan 300 g a.i/ha (86.1%) in reducing leafhopper to the mean percentage of 89.1 per cent at 1 DAT in the second and third round spray of both the field experiments.

(v) Effective reduction of brinjal whitefly to the tune of 96.6 and 96.2 per cent was achieved by the spray of carbosulfan 300 g a.i./ha and endosulfan 350g a.i/ha respectively in first round of spray, but cent per cent reduction was achieved in the third round of spray, but were on par with the carbosulfan 250g a.i./ha.

(vi) Though all the doses controlled the brinjal aphid population effectively, the highest dose carbosulfan 25 EC @300 g a.i./ha maintaining its superiority over other treatments. Cent per cent reduction was achieved in all treatments at 1DAT and continued till 3 DAT for carbosulfan 300 and 250g a.i/ha and endosulfan 350g a.i/ha in third round of spray.

(vii) Damage on the shoot by fruit borer was not observed throughout the cropping period. The per cent damage caused by brinjal fruit borer on fruits both on number and weight basis was minimum (2.8 and 1.2) in carbosulfan 300 g a.i/ha and it was followed by carbosulfan 250g a.i/ha (3.3 and 1.8) which was on par with endosulfan 350 g a.i/ha (3.3 and 2.0). Carbosulfan 300g a.i/ha was found to be superior followed by carbosulfan 250g a.i/ha, which was on par with the standard check endosulfan 350 g a.i/ha.

(viii) All the insecticides tried for the evaluation of the insect pests of cotton were found to be non toxic to natural enemies after 7 and 14 DAT, however moderate levels of toxicity were noticed for carbosulfan 300 g a.i/ha (28.6 to 41.0%), carbosulfan 250 g a.i/ha (15.4 to 29.0%) and methyl demeton (14.3 to 27.5%) in cotton ecosystem.

(ix) In brinjal, no insecticide is toxic to spiders after 7 and 14 DAT. However, considerable levels of toxicity were observed in the 1 and 3 DAT with carbosulfan 300, 250, 200 and endosulfan 350 g a.i./ha treated plots with a decrease in decrement per cent of 23.5 and 38.7, 15.8 and 25.2, 5.6 and 15.8 and 5.9 and 16.4 respectively.

(x) Carbosulfan 25 EC applied at 250, 500 and 1000 g a.i/ha to cotton and brinjal did not show any phytotoxicity effect on the crops tested.

(xi) Carbosulfan applied to cotton at the rate of 500 and 1000g a.i/ha left residue in the seeds at first harvest to the level of 0.042 and 0.054 μg/g in the first trial and 0.099 and 0.121 μg/g in the second trial respectively. Carbosulfan at 250g a.i./ha samples had the residues at below detectable level.

(xii) The harvest time residues of carbosulfan 25 EC applied at 250, 500 and 1000 g a.i/ha were found below detectable level in lint samples of both the field experiments.

(xiii) Carbosulfan residues detected for the different doses *viz*, 250,500 and 1000g a.i./ha were below detectable level in the brinjal fruits sampled for residues at first and third harvests in both the field experiments.

REFERENCES

REFERENCES

Agnihotri, N.P., V.T. Gajbhiye, Samarjit Raj and K.P. Saivaraj. 1992. Persistence and safe waiting period of fluvalinate on some vegetables. **Indian J. Entomol., 54**(3): 239-306.

Ahmed, K., P. P. C. Rao and N.H.P. Rao. 2000. Evaluation of new insecticides against yellow mite *Polyphago tarsonemus latus* (Banks) on chillies. **Pestology, 24**(1): 54-57.

*Ali, M.I. and M.A. Karim. 1990. Threshold sprays insecticides: its advantages on conservation of arthropod predators and parasites in cotton ecosystem in Bangladesh. **Bangladesh J. Zool., 18**(1): 17-22.

Anand Jha, D.N. Yadav and P. Komala Devi. 2001. Evaluation of toxicity of some insecticides against *Geocoris ochropterus* Fieber (Hemiptera: Lygaeidae). **Pestology, 25**(7): 17-18.

Anilkumar, B., B. Narasimha Rao and M. Sriramulu. 2000. Studies on the efficacy of certain insecticides and their mixtures against shoot and fruit borer, *Leucinodes orbonalis* Guen. on brinjal. **Indian J. Plant Prot., 28**(1): 25-28.

Anonymous, 1997. Pesticides production - Current status. **Pesticides Information, 22**(4): 36-38.

Asaf Ali, K. and C. Chinniah. 1999. Bio-efficacy of carbosulfan (Marshal 25 EC) against sucking pests of cotton, *Gossypium hirsutum*. **Pestology, 23**(3): 62-64.

Azeez Basha, A., S. Chellaiah and M. Gopalan. 1982. Effect of synthetic pyrethroids in control of brinjal fruit borer (*Leucinodes orbonalis* Guen.). **Pesticides, 16**: 10-11.

*Banbote, B.G., R.B. Gawande and S.U. Satpute. 1995. Efficacy of different synthetic and herbal insecticides against the pests of cotton. **PKV Res. J., 19**(2): 104-106.

Barooah, A.K. and B.R. Yein. 1996. Residues of quinalphos in/on brinjal (*Solanum melongena*) fruits. **Pestic. Res. J.,** **8**(1): 43-48.

Beevi, S.P. and M. Balasubramanian. 1992. Relative safety of buprofezin and insecticides to *Encarsia shafeei* a parasite of cotton whitefly *Bemisia tabaci* Genn. **J. Biol. Control,** **6**(2): 59-63.

Bhamburkar, M.W. 1986. Role of systemic insecticides on the control of sucking pests in relation to cotton yield under dryland conditions. **Pesticides, 20(3)**: 24-25.

*Bhandarkar, R.K. and M.N. Borle. 1980. Efficacy of some organosynthetic insecticides against the pests of brinjal (*Solanum melongena* L.). **PKV Res. J.,** **4**(1): 1-4.

Bodhade, S., P.W. Narkhedo, and M.N. Borle. 1992. Residual toxicity of different synthetic insecticides against aphids on bhindi, *Abelmoschus esculentus* Moench. **Indian J. Entomol., 54**(1): 20-26.

Borle, M.N., B. Ramarao and S.D. Deshmukh. 1980. Residual toxicity of some granular systemic insecticides as soil application in the control of cotton aphid, *Aphis gossypii* Glover. **Indian J. Entomol., 42(1)**: **142-147.**

Bothara, P.A. and M.D. Dethe. 1991. Bioefficacy of different endosulfan formulations against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. **J. Insect., Sci.,** 4(1): 103-104.

Brar, J.S., J.S. Bhalla and H. Singh. 1992. Chemical control of *Leucinodes orbonalis*. Guen. in brinjal. **J. Insect Sci., 5**(2): 225-226.

Butani, D.K. and S. Varma. 1976. Pests of vegetables and their control : brinjal. **Pesticides, 10**: 32-35.

Chandrasekaran, J., A. Regupathy, K. Bhuvaneswari and V. Balasubramani. 1994. Biological evaluation of carbosulfan and biobit (B.T.K.) for the control of diamond back moth *Plutella xylostella* (L.) on cabbage and cauliflower. **Pestology, 18**(5): 5-12.

Chinniah, C. and K. Asaf Ali. 1999. Field evaluation of certain new insecticides against the shoot and fruit borer *Leucinodes orbonalis*. Guen. of brinjal. **Pestology, 23**(6): 10-14.

Chinniah, C. and K. Asaf Ali. 1999. Seed treatment with carbosulfan (Marshal 25 DS) for effective control of sucking pests in cotton. **Pestology, 23**(5): 19-23.

Chitra, K.C., S. Janardhan Rao, P. Kameshwara Rao and K. Nagaiah. 1993. Field evaluation of certain plant products in the control of brinjal pest complex. **Indian J. Entomol., 55**(3) : 237-240.

*Choudhary, P.K. and R.K. Saraf. 1995. Influence of growth regulators and insecticides on growth and yield of brinjal. **Punjab Vegetable Grower, 30**: 30-34.

Choudhary, R.S. 1982. Control of brinjal shoot and fruit borer. *Leucinodes orbonalis* Guen (Pyralidae : Lepidoptera). **Entomon, 7**: 257-259.

*Cole, J.F., E.D. Pilling, R. Boykin and J.R. Ruberson. 1997. Effects of Karate insecticide on beneficial arthropods in Bollgourd® cotton. **Proc. Beltwide Cotton Conf.**, New Orleans, LA, USA, January 6-10, **2**: 1118-1120.

CSIW, 2000. **Project Coordinator's Report of Cotton Scenario in India and World** 1999-2000,Central Institute of Cotton Research, Regional Station, Coimbatore, India. pp. 5-7.

Dahiya, A.S. and Ram Singh. 1982. Bioefficacy of some systemic insecticides against jassids, thrips and whiteflies attacking cotton. **Pesticides, 16**(12): 13-14.

*Dethe, M.D., V.D. Kale and S.D. Rane. 1995. Pesticide residues in / on farm gate samples of vegetables. **Pest Mgmt. Hort. Ecosys., 1**(1): 49-53.

Dewan, R.S. and Y.P. Beri. 1965. Persistence of DDT and BHC residues on brinjal, *Solanum melongena* L. (var. Pusa purple long) fruits. **Indian J. Entomol., 27**(2): 202-203.

Dhamdhere, S. and R. Mathur. 1994. Efficacy of some foliar insecticides against *Aphis gossypii* Glover infesting brinjal. **J. Entomol. Res., 18**(3): 283-285.

Dhandapani, N. and T. Kumaraswami. 1982. Effect of egg plant seedling root dip for the control of sucking pests. **Entomon,** 7(2): 229-231.

Dhandapani, N., T. Kumaraswami and R. Janarthanan. 1988. Effect of combined use of diammonium phosphate and insecticides as foliar spray against sucking pests of cotton. **Indian J. Agric. Res., 22**(3): 155-158.

Dhawan, A.K. 2000. Impact of some new insecticides on natural enemy complex of cotton ecosystem. **Pestology, 24**(5): 8-14.

Dhawan, A.K., G.S. Simwat and A.S. Sidhu. 1988. Field evaluation of monocrotophos for the control of sucking pests on cotton. **Pesticides, 22**(6): 25-28.

Dikshit, A.K., Y.N. Srivastava and O.P. Lal. 2001. Residue studies and bioefficacy of beta - cyfluthrin and lambda - cyhalothrin in brinjal (*Solanum melongena* L.) fruits. **Pestology, 25**(10): 27-31.

*Drishpon, Y., N. Bilizer, Y. Karni. 1989. Chemical control of cotton aphid *Aphis gossypii* (Glover.) on cotton early in the season. **Hassadeh, 69**(3): 1397-1398.

Eswara Reddy, S.G. and N. Srinivasa. 2001. Persistence of deltamethrin and carbosulfan in / on brinjal. **Proceeding of the Second National Symposium on Integrated Pest Management in horticultural crops: New Molecules, Biopesticides and Environment**, IIHR, Bangalore, October17-19, pp. 179-180.

Gerling, D., V. Krarchenko and M. Lazare. 1997. Dynamics of common green lacewing (Neuroptera : Chrysopidae) in Israel cotton fields in relation to whitefly (Homoptera : Aleyrodidae) populations. **Environ. Entomol., 26**(4): 815-827.

Ghongale, P.R., N.S. Satpute, S.N. Tikar and N.R. Naitam. 2002. Field evaluation of ready - mix insecticides against the shoot and fruit borer of brinjal *Leucinodes orbonalis* Guen. **Pestology, 26**(3): 26-28.

Gomez, K.A. and A.A. Gomez. 1984. **Statistical procedures for agricultural research**. A Wiley International Science Publication, John Wiley and Sons, New Delhi.

Gupta, G.P. 2001. Alternate strategies for insect pest management in cotton. **Summer School on Alternate strategies for insect pest management in major crops,** ICAR - IARI, New Delhi, June 11 - July 2, pp. 232-236.

Gupta, G.P., N.P. Agnihotri, K.Sharma and V.T. Gajbhiye. 1998. Bio efficacy and residue of imidacloprid in cotton. **Pestic. Res. J., 10**(2): 149-154.

Gupta, M.P., D.P. Gupta, K.K. Shrivastava and B.S. Thakur. 1999. Field evaluation of insecticidal spray schedules against insect pests of hybrid cotton in Madhya Pradesh. **Indian J. Agric. Res., 33(2)**: **103-112**.

Hegde, M. and B.V. Patil. 1994. Toxicity of pesticides to the red spider mite, *Tetranychus macfarlanei* Baker and Pritchard and the predatory mite, *Amblyseius longispinosus* (Evans) on cotton. **J. Biol. Control, 8**(2): 126-128.

Henderson, C.F. and E.N. Tilton. 1955. Tests with acaricides against the brown wheat mite. **J. Econ. Entomol., 48**(2): 157-161.

*Holden,E.R. 1973. Gas chromatographic determination of residues of methyl carbamate insecticides in crops as their 2-4,dinitrophenyl ether derivatives.**JAOAC, 56**:713-717.

*Javaid Iqbal, Mahmood Ul Hassan and I.A. Khan. 1997. Relative efficacy of some organophosphate insecticides against jassids (Cicadallide : Homoptera) in cotton crop. **Sarhad J. Agric., 13**(1): 83-85.

Karthikeyan, K. and S.M. Purushothaman. 2000. Efficacy of carbosulfan against rice yellow stem borer, *Scirpophaga incertulas* Walker. (Pyralidae : Lepidoptera). **Indian J. Plant Prot., 28**(2): 212-214.

Karuppuchamy, P., S. Uthamasamy and M.G. Kumar. 1986. Chemical control of pests in rice fallow cotton in Cauvery Deltaic Region. **Madras Agric. J., 73**(3): 178-180.

*Kidd, P.W. and P.R. Rummel. 1997. Effect of insect predators and a pyrethroid on cotton aphid *Aphis gossypii* Glov. population density. **South Western Entomologist, 22**(4): 381-393.

Kishore, R. and L. Raj. 1985. Estimation of quinalphos residues in / on fruit of brinjal *Solanum melongena* L. **Indian J. Entomol., 47**: 278-282.

Krishnaiah, K., P.L. Tondon and N. Jaganmohan. 1976. Control of shoot and fruit borer of brinjal (*Leucinodes orbonalis* Guen.) with new insecticides. **Pesticides, 10** (6): 41-42.

Kumar, K. 1995. **Biological evaluation and determination of residues of quinalphos (Ekalux) 20 AF in cotton.** M.Sc., (Ag.) Thesis,Tamil Nadu Agric. Univ., Coimbatore. 53p.

Kumar, K., G. Santharam and A. Regupathy. 1999. Low cost and eco-friendly protection of cotton against aphids, thrips and leafhoppers. **Fourteenth International Plant Protection Congress (IPPC). Plant protection towards the third Millenium - where chemistry meets ecology,** Jerusalem, Israel, July 25-30, p. 67.

*Lei Hui De., Lin Bang Mao, Li Hong Yun, Ran Chun, Zhang Quan Bin, Qian Ke Ming and Tian Wenhua. 2000. Experiment on the control of citrus aphid and leaf miner by carbosulfan insecticide. **South China Fruits, 29**(5): 15.

Litainger, J.A. and R.F. Apostol. 1994. Control of foliar insect pests on egg plant with systemic granular insecticides. **Philipp. Entomol., 9**(3): 286-301.

Maleque, M.A., M.N. Islam, R. Kundu and M.S. Islam. 1999. Impact of chemical insecticides on the natural enemies of brinjal shoot and fruit borer. **Bangladesh J. Entomol.,** 9(1/2): 53-60.

Mall, N.P., R.S. Pandey, S.V. Singh and S.K. Sngh. 1997. Evaluation of insecticidal emulsion and dust formulation for sucking and leaf feeding pests on brinjal. **Indian J. Entomol., 59**(2): 130-134.

Manimegalai, N., G. Logiswaran and M.S. Venugopal. 1994. Residues of pyraclofos on cotton seed, oil, lint and soil. **Indian J. Plant Prot., 22**(1): 91-92.

Manisegarane, S. and T. Kumarasamy. 1988. Assessment of contact toxicity of insecticides to *Chelonus blackburni* Cam. (Hymenoptera : Braconidae). **J. Biol. Control, 2**(2): 126-127.

Manisegarane, S. and T. Kumarasamy. 1994. Evaluation of methomyl and EPN for the control of sucking insects of cotton. **Indian J. Entomol., 56**(2): 205-208.

Mansour, F., U. Heimbach and A. Wehling. 1992. Effect of pesticide residues on ground dwelling lycosid and micryphantid in laboratory tests. **Phytoparasitica, 20**(3): 195-202.

Mathirajan, V.G. 1998. **Bioefficacy and determination of lambda - cyhalothrin (Karate 5 EC) residues on brinjal, tomato and chillies.** M.Sc.(Ag.) Thesis, Tamil Nadu Agric. Univ., Coimbatore. 99p.

Mishra, D.N. 1996. Bioefficacy of some insecticides and acaro - insecticides for the control of *Aphis gossypii* Glover infesting *Solanum melongena* L. at West Bengal conditions. **Environ. Ecol., 14**(2): 279-281.

Mishra, H.P. 1993. Chemical control of brinjal fruit and shoot borer *Leucinodes orbonalis* (Guen.). **Indian J. Entomol., 55**(1): 89-90.

Mohan, K. 1988. **Studies on the use of botanicals for the management of insect and nematode pests of brinjal.** M.Sc.(Ag.) Thesis,Tamil Nadu Agric. Univ., Coimbatore. 137p.

Mote, U.N. 1981. Control of brinjal pests. **Indian J. Entomol., 43**(2): 229-232.

Mote, V.N. and J.M. Shah. 1993. Effect of carbosulfan as a seed dresser on initial plant growth characters of french bean under glass house condition. **Pestology, 17**(7):17-19.

Mukherjee,I. and M.Gopal. 2001. Residue estimation of imidacloprid on using its new liquid formulation as seed dressing in cotton. **Pestology, 25**(12): 25-29.

Mustafee, T.P. 1996. Increasing Agricultural Production. **Pestology,** Annual, 1995-96, pp. 12-17.

*Nagata, K., G. Shinjo, H., Okuda and M. Yoshida. 1997. Efficacy of several insecticides to red back widow spiders *Latrodecuts hasseltii*. Collected in Osaka and Mie Pre Fectures, Japan, **Medical Ento. and Zool., 48**(2): 135-139.

*Nagia, D.K., S. Kumar, S.P. Sharma, M.L. Saini, H. Prasad and A.K. Dikshit. 1992. Field studies on effectiveness and residues of some organophosphorus insecticides against pest complex of cotton. **Plant Prot, Bull., (Faridabad)** 44(1-2): 18-20.

Nair, M.R.G.K. 1995. **Insects and mites of crops in India**. ICAR, New Delhi, 408p.

Naria, D.K., F. Mallik, S. Kumar, M.D. Saleem, M.L. Saini and A. Kumar. 1993. Compatibility of insecticides and fungicides for the control of leafhopper and leaf blight of brinjal. **Plant Prot. Bull., (Faridabad) 45(2/3)**: 16-18.

Natarajan, K. 1990. Natural enemies of *Bemisia tabaci* Gennadius and effect of insecticides on their activity. **J. Biol. Control., 4(2): 86-88.**

Patel, B.K., P.G. Shah, J.A. Patel, M.F. Raj and J.S. Patel. 1994. Quinalphos residues in / on brinjal and cabbage. **Pestic. Res. J., 6(2)**: 167-170.

*Patel, I.S. 1999. Field efficacy of insecticides against cotton jassid, *Amrasca biguttula biguttula* Ishida. **Insect Environ., 5(1): 28-29.**

Patel, I.S. and D.N. Yadav. 1995. Susceptibility of *Amrasca biguttula biguttula* Ishida and *Chrysopa scelestes* Banks in cotton (*Gossypium* species) to three systemic insecticides. **Indian J. Agric. Sci., 65(4)**: 308-309.

Patel,J.R., R.C.Patel and P.R.Amin.1980. Field evaluation of some insecticides for the control of *Amrasca biguttula biguttula* Ishida and *Aphis gossypii* Glover on okra. **Indian J. Entomol.,42(4)**: 776-779.

Patel,V.N. and P.A.Bhalani.1988. Evaluation of insecticidal spray schedules against major pests of cotton(GAU-Cot-10)under rainfed conditions.**Pesticides,22(8)**: 31-33.

Patil, B.V., A.G. Sreenivas, S. Mujibur Rahaman and M. Bheemanna. 1999. Imidacloprid 70 WS seed treatment against early cotton sucking pests. **Pestology, 23(4)**: 35-39.

Patil, B.V., M. Bheemanna and A. Hosamani. 2002. Bioefficacy of carbosulfan (Marshal) 25% EC against cotton early sucking insect pests. **Report submitted to FMC- Rallis India Ltd,** Bangalore – 560 052, pp-11.

*Patil,C.S., S.A.Pawar,V.M.Khaire and U.N.Mote. 1991.Evaluation of isoprocarb against bollworms of cotton. **Annals Appl.Biol.,118(supplement)**:12-13.

Paul, S.K. and M.R. Ghosh. 1990. Comparative efficacy of some synthetic pyrethroids to reduce damage to brinjal by *Leucinodes orbonalis* Guen. (Pyraustidae: Lepidoptera). **Environ. Ecol., 8**(4): 1293-1295.

Pawar, S.A. and A.R. Mali. 1997. Performance of readymix pesticide formulations against cotton pests. **Pestology, 21**(2): 22-26.

Prakash, O. and A.N. Verma. 1985. Effect of different granular insecticides applied by different methods against jassid, *Amrasca devatans* (Dist.) and whitefly *Bemisia tabaci* (Genn.) on brinjal during prefruiting crop stage. **Indian J. Entomol., 47**(1): 66-70.

*Prakash, O., M.L. Pandita and Y.S. Malik. 1981. Effect of fertilizer and irrigation applications on the efficacy of granular insecticides against insect pests of brinjal (*Solanum melongena* L.). **Haryana J. Hort. Sci., 8**(3/4) : 143-146.

*Punzo, F. 1997. Effects of azadirachtin on mortality, growth and immunological function in the wolf spider *Schizocosa episima* (Araneae: Lycosidae) **Bull. Environ. Contam. Toxicol., 58**(3): 415-421.

*Radhika, S., K.D. Reddy and G.V. Subbarattnam. 1997. Management of brinjal shoot and fruit borer *Leucinodes orbonalis* (Guen.) with insecticides. **J. Res. ANGRAU., 25**(3): 10-14.

Rajukannu, K., K. Saivaraj, P. Vasudevan and M. Balasubramanian. 1980. Residues of certain newer insecticides in brinjal. **Pesticides, 14(11)**: 15-17.

*Ramalho,F.S. and F.M.M.Jesus.1988.Abamectin efficiency in the control of cotton aphid and effect on *Cicloneds sanguinea* and *Pseudodorus clavatus*.**Pesquisa Agropecuaria Brasileira,23**(12):1339-1342.

Raman, K. and S. Uthamasamy. 1983. Insecticide toxicity to natural enemies of brown plant hopper. **IRRN, 8** (4): 20.

Ramsubbarao,V., K.Sarkar,M.M.Krishnamurthy,V.V.L.Mayuravalli,G.P.V.Reddy and K.Ramasubbaiah.1987.Studies on residues of quinalphos and dichlorvos in brinjal.**Pesticides,20**(7):31-33.

Ramzan, M., D. Singh and D.S. Bindra. 1976. Field evaluation of some new insecticides against the insect pests of brinjal. **Indian J. Hort., 35**: 168-170.

Rangathilakam, M. 1990.Evaluation of encapsulated carbofuran formulations applied to sorghum with reference to bioefficacy and occupational exposure. **M.Sc.(Ag.) Thesis,** Tamil Nadu Agric. Univ., Coimbatore. 69p.

Rao, K.R. and V.P.S. Panwar. 1995. Efficacy of seed treatment with carbosulfan against shoot fly species (*Atherigona soccata* and *A. naqvii*) in spring sown maize. **Pestic.Res.J.,** 7(1): 42-48.

*Reddy, A.S. 1987. Management of whitefly in cotton .**All India Coordinated Cotton Improvement Project Eleventh All India workshop (Lead paper),** APAU, Hyderbad ,January 21-24, pp. 1-13.

*Reddy, K. and G.C. Joshi. 1990. Effect of insecticides and plant growth regulators on plant growth incidence and yield in brinjal *(Solanum melongena* L.). **J. Res. APAU, 18**(2): 141-145.

Reghunath, P., C. Nandakumar and N. Mohandas. 1989. Insecticidal control of the insect pest complex of brinjal *Solanum melongena* L. **Indian J. Entomol., 51**(3): 242-245.

Regupathy, A. 1981. Seed treatment with aldicarb sulfone and carbofuran against cotton jassid, *Amrasca devastans* (Dist.) and thrips thrips tabaci (Lind.). **Cotton Dev., 1**: 10-12.

Regupathy, A., S. Palanisamy, N. Chandramohan and K. Gunathilagaraj. 1997. **A guide on crop pests,**Sooriya Desktop Publishers, Coimbatore. 264p.

Rosaiah, B. 2001. Evaluation of different botanicals against the pest complex of brinjal. **Pestology, 25**(4): 14-16.

Roshan Lal and G.P. Gupta. 1998. Impact of spraying schedules on sucking pests in cotton system. **Indian J. Entomol., 60**(3): 305-310.

Roy, D.C. and Y.D. Pande. 1994. Damage to brinjal by shoot and fruit borer (Lep : Pyraustidae) and economics of its insecticidal control . **Indian J. Agric. Res., 28**(2): 110-120.

Santhini, S. and S. Uthamasamy. 1997. Susceptibility of cotton leaf hopper (*Amrasca devastans*) to insecticides in Tamil Nadu. **Indian J. Agric. Sci., 67**(8): 330-331.

*Senapati, B. and P.K. Behera. 1989. Studies on insecticidal control of cotton pests in Orissa. **Orissa J. Agric. Res., 2**(2): 102-106.

Shah, A.H. 1979. Field evaluation of some new insecticides against brinjal fruit and shoot borer *Leucinodes orbonalis* Guen. **Indian. J. Entomol., 41**(2): 195-196.

Shah, B.K., P.K. Borad, J.R. Patel, D.M. Mehta and J.I. Patel. 1990. Bioefficacy of various insecticides against brinjal jassid, *Amrasca biguttula bigutulla* Ishida. **Indian J. Plant. Prot., 8**(2): 261-263.

Shahawy, M.D. I. EL., J.P. Chaudhary and P.D. Sharma. 1991. Effect of different insecticides and spray intervals on the population of major sucking insect pests of cotton. **J. Insect Sci., 4**(2): 148-150.

Sharma, A.K. and R.C. Chhibber. 1999. Effect of exposure periods and insecticides on *Leucinodes orbonalis* Guen.in brinjal. **Indian J. Entomol., 61**(3) : 242-251.

Shukla, R.N., A. Kumar and G. Chand. 1995. Effect of some recommended insecticides on eggs of the green lace wing *Chrysopa scelestes* Banks. **Plant Prot. Bull., 47**(1-4):3-4.

Singh, B., S.V. Singh and V. Kumar. 1996. Evaluation of some insecticides against jassids and flea beetles on brinjal. **Ann. Pl. Prot. Sci., 4**(1): 38-41.

*Singh, I.P., R.K. Prasad and V. Mukherjee. 1996. Efficacy and relative toxicity of some insecticides against *Leucinodes orbonalis* Guen. **J. Res. Birsa Agric. Univ.**, **8**(1): 71-75.

Singh, S.S., H.C. Tiwari and K.M. Rai. 2001. Evaluation of some modern insecticides against San Jose Scale, *Quadraspidiotus perniciosus* (Comstock) on apple. **J. Entomol.Res.**, **25**(1): 69-71.

Singh, S.V. and V.S. Kavadia. 1989. Insecticidal schedule against the pest attacking brinjal. II during the fruiting stage. **Indian J. Entomol.**, **51**(1): 69-75.

Singh,O.P.,K.G.Singh and K.K.Nema.2000. Efficacy of some seed dressing and granular insecticides against major insect pests of soybean. **Pestology**,**24**(1):8-11.

Sinha, S.N., N.P. Agnihotri, A.K. Chakrabarti, H.K. Jain and H.C. Meher. 1986. Field evaluation of some chemical control schedules against insect pests of brinjal crop and their residues on fruit. **Pestology**, **10**(5): 5-9.

Sontakke, B.K. and A.N. Dash. 2000. Field efficacy of some new granular insecticides against major pests of rice. **Indian J. Entomol.**, **62**(4): 353-357.

Sontakke, B.K., A.N. Dash and H. Mohapatra. 1990. Bioefficacy of insecticides against brinjal pests in Western Orissa. **Indian J. Plant Prot.**, **18**: 101-103.

Sreelatha, K., V. Swamy and B.J. Divakar. 1995. Effect of six insecticides on the adult emergence of *Bracon hebetor* Say. **Plant Prot. Bull.**, **47**(1-4):22-23.

Srinivas, S.V. and C. Peter. 1993. Efficacy of certain new insecticides to the brinjal shoot and fruit borer - *Leucinodes orbonalis* Guen. **Pestology**,**17**: 36-38.

Srinivasan, G. and P.C. Sundarababu. 2000. Toxicity of certain insecticides to predatory green lacewing, *Chrysoperla carnea* Stephens (Neuroptera : Chrysopidae). **J. Biol. Control**, **14**(1): 5-7.

Srinivasan, M.R. and R.J. Rabindra. 2001. Bio-efficacy of a new molecule against brinjal shoot and fruit borer. **Proceeding of the Second National Symposium on Integrated Pest Management in horticultural crops: New Molecules, Biopesticides and Environment,** IIHR, Bangalore, October 17-19, pp. 249-250.

Srinivasan, T. 2000. **Bioefficacy of phosphamidon 40 SL against sucking pests of rice, cotton and brinjal.** M.Sc.(Ag.) Thesis, Tamil Nadu Agric. Univ., Coimbatore. 104p.

Sudhakar, K., K.C. Punnaiah and P.V. Krishnayya. 1998. Efficacy of certain selected insecticides on the sucking pest complex of brinjal (*Solanum melongena*). **Indian J. Entomol., 60**(3): 241-244.

Surulivelu, T. and T. Kumarasami. 1989. Effect of skip row coverage of insecticide application on some sucking pests and their predators in cotton. **J. Biol. Control, 3**(1): 17-19.

Surulivelu, T. and T. Kumarasami. 1990. Effect of different formulations and methods of application of insecticides on some sucking pests and their predator in cotton. **J. Biol. Control., 4**(1): 25-30.

Sushilkumar, P.C. Jain and C.P.S. Yadava. 1990. Relative efficacy of different insecticides against jassid (*Amrasca biguttula biguttula* Ishida) infesting brinjal crop in Rajasthan. **Pestology, 14**(10): 24-27.

Tiwari, S. and M.A. Khan. 2002. Effect of fenobucarb and chlorpyrifos - methyl on the parasitization by *Trichogramma chilonis* Ishii. **Pestology, 26**(3): 40-42.

Valarmathi, S. 1997. **Bioefficacy and residues of quinalphos applied as ecofriendly formulations aquaflow (AF) and colloidal suspension (CS) on cardamom and cotton.** Ph.D Thesis, Tamil Nadu Agric. Univ., Coimbatore. 161p.

*Vandenberg, H., K. Hassan and M. Marzuki. 1998. Evaluation of pesticide effects on arthropod predator populations in soybean in farmers fields. **Biocont. Sci. and Tech., 8**(1): 125-137.

Venugopal Rao, N., A.S. Reddy and D.D.R. Reddy. 1990. Effect of some insecticides on the parasitoids and predators of the cotton whitefly, ***Bemisia** tabaci* Genn. **J. Biol. Control, 4**(1): 4-7.

Verma, S. 1984. Persistence of carbaryl and quinalphos on brinjal *Solanum melongena*. **Indian J. Pl. Prot., 12**: 87-91.

*Volkumar, C. and T.Wetzel. 1993. Occurrence of insect pests and predatory spiders (Araneae) in cereal fields and the side effects on them of chemical pesticides. **Nachrichtenblatt – des Deutschen Pflanzensehu zdicnsts., 45**: 233-239.

Walunj, A.R. and M.D. Dethe. 1996. Efficacy of thiodicarb 75 WP (Larvin®) and methomyl 40 SP (Lannate®) against shoot and fruit borer of brinjal. **Pestology, 20**: 28-30.

Yazdani,S.S ., D.M.Mehto, R.Singh and K.Kumar.1981. Control of brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) with granules alone and in combination with spray formulation. **Indian J. Entomol., 43**: 297-301.

Yien, B.R. 1985. Field efficacy of some insecticides against shoot and fruit borer (*Leucinodes orbonalis* Guen.) in brinjal. **J. Res. Assam Agric.Univ., 6**(1): 31-34.

* Originals not seen