

**STUDIES ON BIOEFFICACY EVALUATION OF THIAACLOPRID
(CALYPSO 240 SC[®]) AGAINST SUCKING PESTS OF COTTON,
COCCIDS OF ORNAMENTAL PLANTS AND
DETERMINATION OF RESIDUES IN COTTON**

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. PREMALATHA

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

2001

CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON BIOEFFICACY EVALUATION OF THIACTOPRID (CALYPSO 240 SC®) AGAINST SUCKING PESTS OF COTTON, COCCIDS OF ORNAMENTAL PLANTS AND DETERMINATION OF RESIDUES IN COTTON" 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 Ms. R. PREMALATHA 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 or prizes and that the work has not been published in part or full in any scientific or popular journal or magazines.

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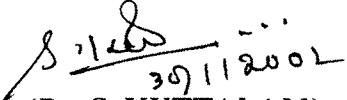
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EXTERNAL EXAMINER

ABSTRACT

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STUDIES ON BIOEFFICACY EVALUATION OF THIACTOPRID (CALYPSO 240 SC[®]) AGAINST SUCKING PESTS OF COTTON, COCCIDS OF ORNAMENTAL PLANTS AND DETERMINATION OF RESIDUES IN COTTON

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2001

Studies were carried out to evaluate the bioefficacy of thiacloprid (Calypso 240 SC[®]) as foliar application against sucking pests of cotton viz., *Thrips tabaci* (Lind.), *Aphis gossypii* (Glov.) and *Amrasca biguttula biguttula* (Ishida), also against *Ferrisia virgata* (Ckll.) and *Saissetia oleae* (Oliv.) in ornamental plants. Studies were also conducted to determine the safety of thiacloprid 240 SC to predators, parasitoids and pollinators, its phytotoxic effect and harvest time residues in cotton seed, lint and oil.

The acute toxicity of thiacloprid indicated that, *A. gossypii* was sensitive to thiacloprid at a low concentration and fifty per cent (LC₅₀) mortality was obtained at 0.119 ppm. The toxicity of thiacloprid 240 SC foliar spray persisted for 29 and 25 DAT against *A. gossypii* and the toxicity persisted for 33 and 31 DAT against *A. biguttula biguttula* at 125 and 100 ml/ha respectively.

The results of two field experiments conducted during November, 2000 - May, 2001 and January - June, 2001 revealed that thiacloprid 240 SC at 125 and 100 ml/ha were effective than imidacloprid 200 SL at 100 ml/ha and oxydemeton methyl 25 EC at 500 ml/ha in reducing *T. tabaci*, *A. gossypii* and *A. biguttula biguttula* and protected the

crop upto four weeks after application. The plots treated with thiacloprid 240 SC at 125 and 100 ml/ha recorded higher seed cotton yield.

No phytotoxic symptoms were observed even at a higher dose of thiacloprid 240 SC at 2000 ml/ha when applied as foliar treatment on cotton in both the field and greenhouse experiments.

The results on safety of thiacloprid 240 SC to parasitoids and predators showed that thiacloprid 240 SC was found to be totally innocuous to *Trichogramma chilonis* (Ishii), considering its adult emergence and parasitization. Though thiacloprid 240 SC had no deleterious effects on the egg hatchability of *Chrysoperla carnea* (Stephens), it caused grub mortality to the maximum of 60 per cent and reduced the adult longevity (52%) and fecundity (56.8%). This treatment also produced adverse effects on the development of grubs of *Menochilus sexmaculatus* (Fab.) and enhanced adult mortality to the tune of 74.8 per cent. Thiacloprid was least toxic to *Apis cerana indica* F. and the LC₅₀ obtained was 7.65 ppm, which was comparable with endosulfan (9.02 ppm).

The results of the residue analysis revealed that the residues of thiacloprid 240 SC when applied at 125 ml/ha were at below detectable limit in lint, seed and oil samples collected from both the field trials. But detectable amounts of residues were determined at the higher doses of 500 and 1000 ml/ha on 52nd and 55th days after last spraying in all the matrices.

The results of the field experiment conducted to determine the bioefficacy of thiacloprid 240 SC foliar treatments against *S. oleae* revealed that thiacloprid 240 SC at 100 and 125 ml/ha were superior to the standard oxydemeton methyl in controlling the black scale population. Interestingly, under laboratory conditions, thiacloprid 240 SC at 125 ml/ha inflicted cent per cent mortality of crawlers within 12 hours after treatment against *F. virgata*.

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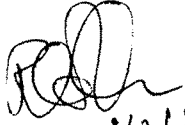
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INTRODUCTION

CHAPTER I

INTRODUCTION

In India, cotton, known as king of fibres, sustains the country's foremost organized industry-textiles and also accounts for about 73 per cent of the fibre consumption. Cotton based products dominate our exports which accounts for almost 35 per cent. Besides, seven lakh farmers are solely engaged in cotton cultivation in the states of Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Maharashtra, Madhya Pradesh, Punjab, Haryana and Rajasthan. The world cotton trade is estimated at six million tonnes of which India's share is only 0.23 million tonnes (Vikassinghal, 1999). Though India has the largest area under cotton in the world (8 million ha), it ranks third in production because of its poor yield of about 302 kg lint/ha, against the world average of 650 kg lint/ha while productivity in Australia and Israel is more than 1,600 kg lint (Lal, 2001).

The unquestionable fact is, however, that all over the world, cotton plants are suffering from attack by a large number of very aggressive pests, which are the major determinants of yield. Out of 162 species of insects that are associated with cotton in India (Sundaramurthy, 1985), 12 species are of major importance accounting an annual loss of 50 to 60 per cent of total production (AICCIP, 1989). In the early vegetative stage, sucking pests like cotton aphids, *Aphis gossypii* (Glov.), leafhoppers, *Amrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Genn.) and thrips, *Thrips tabaci* (Lind.) cause severe damage and during reproductive stage bollworm complex inflict significant damage to the crop.

To control these pests, insecticides are widely used. However, widespread use of structurally similar preparations, which have the same mechanism of action, carries the danger of resistance development, so that there is a growing interest in the discovery of novel groups with different biochemical targets. On this ground, the insecticidal properties of nitromethylene compounds were first discovered by Soloway *et al.* (1978) and after that, Nihon Bayer Agrochem K.K., synthesized highly active substances, using chloropyridyl-substituted heterocyclic compounds which led to the development of imidacloprid in 1985 (Elbert *et al.*, 1990 and 1991). This formed the baseline for the

synthesis of another chloronicotinyl compound YRC 2894, commonly called thiacloprid, which acts on the nicotinic acetylcholine receptor in the post-synaptic membrane. Thiacloprid has a broad spectrum of activity, particularly against sucking insects such as aphids, thrips, leafhoppers and whiteflies. It is also active against various species of beetles and leaf miners in apple and citrus (Ru, 1999).

The action of thiacloprid on insects is based on an interference with the transmission of impulses in the nervous system. Similar to the naturally occurring signal-transmitting acetylcholine, thiacloprid acts by exciting certain nerve cells by acting on a receptor protein. In contrast to acetylcholine esterase, thiacloprid cannot or only slowly be inactivated. The lasting effect of the product results in a disorder of the nervous system of the insect and resulting in its death. Thiacloprid acts like imidacloprid as an acute contact and stomach poison and has excellent systemic activity combined with required relatively low rates of application. It shows good plant compatibility in all relevant crops. It has a favourable environmental profile with a short half-life in soil and good margins of safety for birds, fish species and many beneficial arthropods. Due to its low acute toxicity to mammals (836 mg/kg of body weight for male rat and 444 mg/kg of BW for female rat), the product is safe for operators and consumers (Elbert *et al.*, 2000).

There is no group of insects, which is of greater interest to the agriculturalists and horticulturalists than Coccidae (Homoptera) (Ramakrishnaayyar, 1923). Members of the superfamily Coccoidea occur in abundance and no plant species is spared from their infestation. Since no detailed study has been taken on chemical control of coccids in ornamentals, particularly in recent years, this combination study was done. With this background, studies with thiacloprid were undertaken with the following objectives:

- * To evaluate the bioefficacy of thiacloprid (Calypso 240 SC[®]) as foliar application against sucking pests of cotton.
- * To assess the phytotoxicity of thiacloprid to cotton.
- * To assess the effect of thiacloprid 240 SC on yield of cotton.
- * To study the safety of thiacloprid to parasitoids, predators and pollinators.
- * To determine the residues of thiacloprid in cotton seed, lint and oil and
- * To evaluate the bioefficacy of thiacloprid (Calypso 240 SC[®]) as foliar spray against coccids of important ornamental plants.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Cotton, wherever grown, receives more insecticides than any other crop. In fact, 54 per cent of the insecticides produced in India are used for cotton (Anon, 1997). Synthetic pyrethroids, though brought the desired results in the control of pests, have also resulted in the resurgence of less important insect species (Natarajan *et al.*, 1986). Therefore, there is a need to develop appropriate strategies for managing the sucking pests of cotton based on better understanding of both the pest and the host.

Unlike the insecticides in common use today, chloronicotinyl compounds exert their action in a new way and is therefore particularly suitable for controlling resistant pests, apart from susceptible ones. They bind only the Ach R (Acetylcholine receptor) of insects and have no effect on Ach R of mammals. It is anticipated that chloronicotinyls may be as important as the pyrethroids by the end of this decade. Various studies conducted on the biological evaluation of chloronicotinyls in comparison with other insecticides are reviewed in this chapter.

2.1. Acute toxicity of chloronicotinyl compounds against aphids

Nauen and Elbert (1994) reported that the LC₅₀ value of imidacloprid was 0.30 and 0.38 ppm for *Aphis gossypii* (Glov.) and *Myzus persicae* (Sulz.) respectively from the assay with sachet test under laboratory condition. Rameshbabu (1999) determined the acute toxicity of imidacloprid to *Aphis craccivora* Koch. to be 0.329 ppm. Kumar (1998) reported that the LC₅₀ value for the imidacloprid against *A. gossypii* was 0.309 ppm and Sivaveerapandian (2000) reported it to be 0.316 ppm against the same species on bhendi.

2.2. Persistent toxicity of chloronicotinyls against aphids and leafhoppers

Shantappanavar *et al.* (1995) evaluated the persistent toxicity of imidacloprid against aphids on tobacco. The results revealed that the persistent toxicity of imidacloprid 70 WS at 75 and 100 g a.i./ha lasted for 30 and 31 days respectively. Kumar and Santharam (1999) observed that seed treatment of imidacloprid at 5 and 7 g/kg of seeds persisted upto 42 days against aphids and for leafhoppers, it was 44 and 46 days at 5 and

7 g/kg of seeds respectively. In case of foliar treatment, they observed that imidacloprid 200 SL at 100 ml/ha persisted for 30 and 22 days against leafhoppers and aphids respectively.

Rameshbabu and Santharam (2000) studied the persistent toxicity of imidacloprid 200 SL foliar spray against aphids and leafhoppers on groundnut in comparison with oxydemeton methyl and reported that imidacloprid 200 SL foliar spray at 100 and 150 ml/ha persisted for 23 days against aphids and for leafhoppers, it was 29 and 31 days at 100 and 150 ml/ha respectively, while oxydemeton methyl at 500 ml/ha persisted for 15 days against aphids and 17 days against leafhoppers. Sivaveerapandian (2000) found that persistent toxicity of imidacloprid 600 FS as seed treatment at 12 and 9 ml/kg of okra seeds were 48 and 46 days respectively, while imidacloprid 70 WS at 10 and 7 g/kg were 46 and 44 days respectively against *A. gossypii* on bhendi plants. Similarly, the order of relative efficacy of imidacloprid against *Amrasca biguttula biguttula* (Ishida) was found to be imidacloprid 600 FS @ 12 ml/kg (32 DAS) > imidacloprid 70 WS @ 10 g/kg (28 DAS) > imidacloprid 600 FS @ 9 ml/kg (28 DAS) > imidacloprid 70 WS @ 7 g/kg (26 DAS). He also observed imidacloprid 200 SL foliar application persisted for 23 and 25 DAT at 100 and 200 ml/ha respectively, against *A. gossypii*, while for *A. biguttula biguttula* the persistence lasted for 29 and 33 DAT.

2.3. Bioefficacy of chloronicotinyls against sucking pests

2.3.1. Thrips

Cotton is vulnerable to the thrips, *Thrips tabaci* (Lind.) and *Scirtothrips dorsalis* (Hood) which are small, slender insects causing shriveling of leaves by scrapping the epidermis and desapping, leading to silvery sheen on the under surface of leaves (Regupathy *et al.*, 1989).

2.3.1.1. Seed treatment

Walunj and Mote (1995) reported that imidacloprid 70WS 10 g/kg seed treatment plus 0.04 per cent root dip of seedlings gave the highest protection in tomato from thrips.

Phipps *et al.* (1996) reported that imidacloprid as seed treatment in cotton was proved to be an effective chemical against thrips. Furr *et al.* (1998) evaluated the efficacy of insecticides against thrips population in cotton and concluded that seed treatment with imidacloprid as Gaucho was effective and produced yield that is not significantly different from the highest yield. Santos and Santos (1999) examined newer insecticides for the control of *Frankliniella schultzei* on cotton and reported that thiamethoxam at 2.1 and 1.4 g a.i./kg of seeds and imidacloprid at 3.0 and 1.8 g a.i./kg of seeds gave the most consistent control of thrips.

The control of *F. schultzei* and *A. gossypii* using thiamethoxam, diafenthiuron, imidacloprid and carbosulfan was studied on cotton in Sao Paulo, Brazil (Scarpellini and Nakamura, 1999). The treatments, thiamethoxam at 25 and 50 g a.i./ha; imidacloprid at 50 g a.i./ha, diafenthiuron at 250 g a.i./ha and carbosulfan at 120 g a.i./ha, after two days gave 85, 85, 84, 75 and 68 per cent control respectively and after 14 days the control was 79, 86, 77, 76 and 66 per cent respectively.

El-Hamady and Sholoa (1999) examined the insecticidal activity of imidacloprid applied as seed treatment against *T. tabaci* on cotton under field conditions in Egypt at the rate of 280 g/40 kg seeds. Results revealed that the compound was rather efficient in suppressing the population of thrips on cotton seedlings. The residual effect lasted seven weeks after application.

2.3.1.2. Foliar application

Albuquerque *et al.* (1999) studied the effectiveness of different insecticides as foliar sprays for the control of thrips, *F. schultzei* on cotton and concluded that imidacloprid at 50 g a.i./ha and thiacloprid at 34 and 48 g a.i./ha were the most effective treatments, controlling the pest upto seven days after treatment. Imidacloprid at 0.25 l/ha and thiacloprid at 0.07 and 0.1 l/ha gave greater than 80 per cent control of thrips on Hirsutum cotton, with a residual effect upto 20 days (Calafiori *et al.*, 1999). Cook *et al.* (1999) concluded that treatment of imidacloprid at planting provided good control of thrips in cotton and allowed earlier harvest.

2.3.2. Aphids

In cotton, *A. gossypii* inflicts appreciable damage. In the recent years, synthetic pyrethroids are being extensively used in cotton ecosystem for the control of major pests and this aggravates the problem of aphid attack further (Surulivelu and Sundaramurthy, 1986; Ravindran and Xavier, 1996).

2.3.2.1. Seed treatment

Woodford (1992) tested two formulations of imidacloprid on potato against the resistant clones of *M. persicae* under greenhouse conditions. The results showed that only few aphids were found to feed on imidacloprid 350 FS painted potatoes at 0.25 or 0.125 mg a.i./g of tuber (fresh weight). In the experiments conducted with imidacloprid as Gaucho at 7 g/kg (seed treatment) aldicarb as Temik at 3 g/kg, oxamyl as Vydate at 10 g/kg and ethephon as Ethrel at 2 ml/kg of cotton seeds, the average number of *A. gossypii* per seedling was 0.33, 1.84, 2.27 and 6.43 respectively for each chemical above mentioned, compared to 19.96 in control. (Selim and Emam, 1993).

Westhuizen *et al.* (1994) evaluated the cost and effectiveness of imidacloprid as seed dresser against Russian wheat aphid *Diuraphis hoxia* (Kurdjmov) on wheat. He finally concluded that optimum dosage of 117 or 167 g a.i. provided good control of the pest and was economically feasible. Jarande and Dethé (1994) evaluated the bioefficiency of imidacloprid 70 WS against sucking pests of brinjal in nursery and in field by seed dressing and root dip and found that seed dressing of imidacloprid 70 WS at 15 g/kg followed by seedling root dip with 0.03 per cent was the most promising in keeping down the population of aphids, jassids and whiteflies during pre- and post-transplanting period of the crop.

Cisneros and Godfrey (1998) evaluated the agronomic and environmental factors influencing control of cotton aphids with insecticides in California. He reported that dark aphids were less susceptible to imidacloprid 1.6 F including three other insecticides namely bifenthrin, chlorpyrifos and carbofuran than the light morphs and they also reported that aphids from late-sown cotton were less susceptible to all insecticides than the aphids from early sown crop.

Lucas *et al.* (1999) studied the efficacy of imidacloprid as seed treatment for the control of sucking pests of cotton and concluded that imidacloprid as seed treatment and aldicarb applied in furrows at sowing, significantly reduced the incidence of *A. gossypii* upto 20 days after plant emergence. Thiamethoxam at 2.1 and 1.4 g a.i./kg of seeds and imidacloprid at 3.0 and 1.8 g a.i./kg of seeds gave the most consistent control of *A. gossypii* on cotton (Santos and Santos, 1999). According to Scarpellini and Nakamura (1999), treating the cotton seeds with imidacloprid at the rate of 210 g a.i./kg of seeds and thiamethoxam 70WS at 140 and 210 g a.i./kg of seeds gave effective control of *A. gossypii* upto 30 days after germination. Imidacloprid 70 WS as seed treatment in cotton at 7 g/kg of seeds was effective for control of aphids and leafhoppers in cotton (Kumar and Santharam, 1999). Similarly, Sivaveerapandian (2000) also reported that seed treatment with imidacloprid 70 WS at 10 g/kg of bhendi seeds protected the crop from aphids, thrips and leafhoppers upto 9 weeks and resulted in higher fruit yield in the field.

2.3.2.2. Foliar application

Mullins and Christie (1995) reported that imidacloprid at 1.6 lb a.i./gallon was very effective against aphids, aleyrodids, delphacids and *Lygus* spp. in cotton and Lucas *et al.* (1999) reported that imidacloprid applied as foliar spray controlled *A. gossypii* in cotton for upto 10 days after application. Albuquerque *et al.* (1999) evaluated the efficacy of carbosulfan, oxydemeton methyl, prothiofos, imidacloprid and thiacloprid for the control of *A. gossypii* on cotton and reported that thiacloprid at 34 and 48 g a.i./ha and imidacloprid at 50 g a.i./ha gave satisfactory control of *A. gossypii* three days after application with atleast 96 per cent control and eight days after application with 80 per cent control.

Koenig *et al.* (2000) reported that thiamethoxam has excellent activity against number of sucking pests in cotton including, aphids, whiteflies, thrips and *Lygus* bugs and thiamethoxam at 0.023 to 0.047 lb a.i./ac provided significant control of cotton aphid populations. In cotton, acetamiprid when applied alone at 100 g pc/ha gave 81 per cent control of *A. gossypii* in cotton after 15 days of application and 88 and 94 per cent control was achieved in the mixtures with benfuracarb (40%) and acetamiprid 200 ml plus 100 g

and 300 ml plus 100 g pc/ha (Tomquelski *et al.*, 1999). Bellettini *et al.* (1999) also reported that acetamiprid at 10, 15 and 20 g a.i./ha gave greater than 91 per cent control of *A. gossypii* in cotton 2, 5, 7, 10 and 15 days after application.

Franco (1999) studied the chemical control of *A. gossypii* on cotton with both mixtures of insecticides and their individual efficacy and reported that endosulfan plus acetamiprid and acetamiprid alone gave efficient control of *A. gossypii* at high infestations upto eight days after application. Endosulfan and thiamethoxam controlled the pest upto five days. According to Santos and Santos (1999), acetamiprid 40g a.i./ha, acetamiprid plus endosulfan (20 plus 350 g a.i./ha), acetamiprid plus carbosulfan (20 plus 120 g a.i./ha) and thiamethoxam 50g a.i./ha gave more than 95 per cent control of *A. gossypii* upto eight days after treatment.

Lawson *et al.* (2000) reported that thiamethoxam provided excellent control of *A. gossypii*, *Lygus lineolaris*, *Bemisia tabaci* and *Bemisia argentifoli* in cotton with very low application rates. Foliar spray of imidacloprid 200 SL at 100 ml/ha reduced aphids, thrips and leafhoppers population significantly in bhendi field and increased the fruit yield (Sivaveerapandian, 2000).

2.3.3. Leafhoppers

The leafhopper, *A. biguttula biguttula* had been solely responsible for the failures of early introduction of American cotton in the country (Jaganatharao *et al.*, 1952). The depredations of this insect continue to this day by periodic outbreaks through out the country inspite of the development of resistant varieties and newer control measures.

2.3.3.1. Seed treatment

Mote *et al.* (1994) conducted experiments to study the efficacy of imidacloprid 70 WS as seed dresser against the sucking pests on bhendi at 5, 7.5, 10 and 15 g/kg of seed and reported that the jassid population was less in all the imidacloprid treated plots over untreated plot upto 50 days after sowing (DAS). Jarande and Dethé (1994a) found that seed dressing with imidacloprid 70 WS (15 g/kg) followed by seedling root dip with 0.03 per cent imidacloprid was the most effective in keeping the incidence of sucking

pests in brinjal down during pre- and post- transplantation period. They reported that population of jassids at 60 days after transplanting was 0.73/six leaves in treated plots as against 26.3/six leaves in untreated plots. Gupta *et al.* (1998) studied the effect of imidacloprid (0.005 and 0.02%) as foliar spray and (3 and 5 g/kg) as seed treatment in cotton against leafhoppers. The results revealed that seed treatment significantly reduced the leafhopper population upto 76 days even at 3 g/kg of seed treatment and significantly increased the seed cotton yield.

Patil *et al.* (1999) conducted experiments in cotton hybrids DCH 32 and NHM 44 to evaluate the efficacy of imidacloprid 70 WS as seed dressing agent against early sucking pests. Results clearly pinpointed that imidacloprid 70 WS at 10 g/kg of seed recorded leafhopper and whitefly below ETL (Economic Threshold Level) upto 35 days on DCH 22 and 40 days on NHM 44 cotton hybrids. Seed treatment with imidacloprid 600 FS at 12 ml/kg protected bhendi plants from leafhoppers, thrips and aphids upto nine weeks and resulted in higher fruit yield in the field (Sivaveerapandian, 2000).

2.3.3.2. Foliar application

Iwaya and Tsuboi (1992) conducted laboratory and field experiments with imidacloprid (Admire) against sucking pests of rice. They reported that imidacloprid was superior in controlling *Nephotettix cincticeps* (Uhler.), *Nilaparvatha lugens* (Stal.), *Sogatella furcifera* (Horv.), *Laodelphax striatellus* (Fallen) and *Lissorhoptus oryzophilus* compared to the standard ethofenprox. In nursery boxes, a single application of imidacloprid at 0.2 to 0.3 kg a.i./ha was found to be more effective than reported application of conventional products at 0.8 to 3.2 kg/ha. Foliar spraying of imidacloprid at 0.005 to 0.01 per cent concentrations at the rate of 0.5 to 1.0 kg/ha significantly controlled the leafhoppers and planthoppers. Similarly, Mao-Lixin *et al.* (1995) conducted experiments with imidacloprid against rice plant hoppers under field conditions and found that imidacloprid at 5 to 15 g a.i./mu (1 mu = 0.0067 ha) reduced more than 90 per cent of planthopper population at 20 to 30 days after application. In nursery, imidacloprid at 40 g a.i./mu applied 5 days prior to transplantation resulted in 70 to 90 per cent population reduction and gave good control upto ten weeks after transplanting.

Attique and Ghaffar (1996) reported that foliar application of imidacloprid 200 SL effectively controlled the early season attack of *A. biguttula biguttula*, *B. tabaci* and *T. tabaci* upto four weeks and resulted in increased cotton yield. Rigo and Mori (1997) evaluated the efficacy of different insecticides against green cicadellid, *Empoasca decedans* on peach and found that imidacloprid 200 SL, acetamiprid and ethofenprox were superior in controlling the pest.

Foliar application of imidacloprid 200 SL ranging from 0.2 to 1.6 ml/litre against mango hoppers (*Idioscopus napurensis* and *I. niveosparsus*) gave 100 per cent control in 24 h. and the effectiveness persisted upto three weeks and concluded that imidacloprid at 0.2 ml/l was effective in the control of mango hoppers for a period of 21 days (Verghese, 1998). Brar *et al.* (1999) tested various insecticides like oxydemeton methyl 25 EC at 750 ml/ha, imidacloprid 200 SL at 100 ml/ha, phosphamidon at 187 ml/ha and dimethoate at 625 ml/ha against *A. biguttula biguttula* and *B. tabaci* in cotton. Among the insecticides tested, oxydemeton methyl and imidacloprid gave significant reduction of leafhopper population. Sparks and Norman (1999) evaluated the effectiveness of different insecticides against cotton fleahoppers, aphids and whiteflies and observed that legends (Baythroid plus imidacloprid) gave promising control of these pests. Imidacloprid foliar spray on cotton at 100 ml/ha was effective for the control of both leafhoppers and aphids in cotton (Kumar and Santharam, 1999).

Khurana (2001) evaluated the efficacy of different insecticides both as seed dresser and foliar spray against jassids and whiteflies in field trials during kharif 1995-96 on Hirsutum cotton. Out of five insecticides tested, only imidacloprid at five and 10 g/kg of seed was found effective in reducing jassid population throughout the season and particularly effective in reducing whitefly population until mid September. Out of 11 insecticides evaluated as spray, acetamiprid (10 and 20g a.i./ha) imidacloprid (100 and 200 ml/ha) and oxydemeton methyl (875 ml/ha) were found effective against jassids.

2.4. Phytotoxicity of chloronicotinyls

Mote *et al.* (1994) reported that seed dressing with 15 g of imidacloprid 70 WS per kg of chilli seeds did not affect the germination and plant height. Walunj and Mote (1995) found that among the doses of imidacloprid tested (10 g/kg of seed and 0.04% seedling root dip), none of the treatments showed any phytotoxic symptoms on tomato plants.

Biase and Russo (1996) found that foliar treatment of imidacloprid 200 SL at 10 g a.i./ha caused no phytotoxic symptoms. No evidence of phytotoxicity by imidacloprid both as seed treatment and foliar spray on cotton was observed (Lucas *et al.*, 1999). Sivaveerapandian (2000) reported that imidacloprid 600 FS at 10, 20 and 40 ml/kg and imidacloprid 70 WS at 10, 20 and 40 g/kg of bhendi seeds (Mahyco hybrid No.10) had not affected germination when applied as seed treatment and also had not caused any phytotoxic symptoms. Similar were the results when imidacloprid 200 SL was applied as foliar spray at 100, 200 and 400 ml/ha.

2.5. Safety of chloronicotinyl compounds

Insecticides being an integral component of Integrated Pest Management (IPM), their effectiveness on the other potential component of IPM, the biocontrol agents and to non-target organisms has to be studied for implementing the IPM programme successfully. The safety of chloronicotinyl insecticides to various biocontrol agents and non-target organisms are reviewed hereunder.

Attique and Ghaffar (1996) reported that though predator populations in the imidacloprid 200 SL treated plots were lower than in the untreated control plots, the differences among the treatments were non-significant apart from higher number of bolls per ha and higher seed cotton yield in plots treated with imidacloprid 200 SL. Imidacloprid 1.6 F exhibited very little detrimental effect on big-eyed bugs (*Geocoris* sp.) and minute pirate bugs (*Orius* sp.) and a modest effect on damsel bugs (Nabidae) (McNally and Mullins, 1996). Kunkel *et al.* (1999) evaluated the impact of imidacloprid and halofenozide on earthworms and beneficial arthropods in turfgrass ecosystem. The results indicated that application of halofenozide or imidacloprid followed by irrigation

will have little impact on beneficial invertebrates (ants, carabids, spiders and staphylinids), although both are persistent.

2.5.1. *Trichogramma chilonis* (Ishii.)

Kumar (1998) studied the influence of imidacloprid 200 SL on adult emergence and parasitization of *T. chilonis* and the results revealed that there was no significant adverse effect on adult emergence and parasitization indicating the safety of imidacloprid to *T. chilonis*.

2.5.2. *Chrysoperla carnea* (Stephens)

Kumar (1998) reported that there was no significant adverse effect due to imidacloprid on egg hatchability of *Chrysoperla carnea*, but there was a significant adverse effect on grubs and adult longevity when imidacloprid was fed with honey solution.

Katole and Patil (2000) studied the biosafety of imidacloprid 70WS (8 and 10 g) and thiamethoxam 70WS (4 and 5 g/kg) as seed treatment and imidacloprid 17.8 SL and thiamethoxam 25 WG @ 0.005 and 0.01% each along with oxydemeton methyl to ladybird beetles and *C. carnea* adults in cotton. Results revealed that seed treatment was safer than foliar sprays. Imidacloprid @ 10 g/kg seed treatment allowed activities of maximum ladybird beetle adults and thiamethoxam @ 4 g/kg seed treatment allowed maximum oviposition of *C. carnea* which were on par with untreated control in cotton. Keillor and Godfrey (2000) reported imidacloprid 1.6 F had the least effects on natural enemies in California cotton.

2.5.3. Honey bees

The influence of imidacloprid 70 WS on honeybees, in sunflower when used as seed dressing chemical was examined in three tunnel trials and in eight field-tests in France. In none of these tests, did the seed dressing with imidacloprid affect the viability, foraging activity or the behaviour of the honeybees. In controlled feeding experiments under field conditions no adverse effects were observed on bees fed with spiked sugar solution upto 20 ppb imidacloprid. This confirmed that no adverse effects on honeybees

must be expected from the use of imidacloprid 70 WS in sunflower (Ambolet *et al.*, 1999).

2.6. Residues of chloronicotinyls in soil and plant parts

Gupta *et al.* (1998) found that no residues were detected at harvest in samples of cotton lint, seed and oil collected from plots containing treated seeds with imidacloprid at 3 and 5 g/kg seed. But, Iwaya *et al.* (1998) reported that the final crop residues of a single application of imidacloprid on rice at 200 g a.i/ha were 0.002 mg/kg.

Belal *et al.* (1999) studied the interrelationship between biological effects and persistence of aldicarb and imidacloprid in two different types of soil in Egypt. The two systemic pesticides were applied as granulated formulation and by seed dressing. For both the pesticides, the rate of disappearance in both types of soil (sandy-loam and clay-loam) was found to be rapid in the first seven days. The residue levels of imidacloprid as seed dressing chemical in cotton 280 g/40 kg seeds in the soil reached 3.65 ppm, then declined to the minimum on the sixth week (0.016 ppm) (El-Hamady and Sholoa, 1999).

Dikshit *et al.* (2000) conducted experiments in okra by seed dressing imidacloprid 600 FS and foliar application with imidacloprid 200 SL. The rates for seed dressing were 3, 5.4, 10.8 and 21.6 g ai/kg of seeds and for foliar application the dose was 40 g a.i./ha. They have reported that the residues of imidacloprid in okra fruits were found to be 0.08, 0.1, 0.4 and 0.24 mg/kg from 3, 5.4, 10.8 and 21.6 g a.i./kg seed treatments respectively, after 55 days of sowing (nearly 7-10 days after fruiting started) and became non detectable after 60 days of sowing (12-15 days after fruiting) and Sivaveerapandian (2000) estimated the residue present in okra in first three harvest of fruits and reported that seed treatment of imidacloprid at 40 ml/kg and imidacloprid 70 WS at 40 g/kg had residues at below detectable limit (BDL) while imidacloprid 200 SL foliar spray at 100 and 200 ml/ha was detected upto three days after treatment and it was BDL thereafter.

2.7. Bioefficacy of chloronicotinyls on other pests

Philip *et al.* (1998) reported either 280 or 560 g a.i/ha of imidacloprid applied to the soil at transplanting of tomato seedlings provided protection from all whitefly stages

of *Bemisia argentifolii* including the geminivirus infection vectors. McNally and Mullins (1996) evaluated the efficacy of imidacloprid 1.6 F foliar use on cotton for control of various sucking pests including *Lygus* bugs and aphids and the results pinpointed that imidacloprid 1.6 F provided 7-10 days control of *L. lineolaris* and upto 14 days of control of *A. gossypii*.

Field studies in Arizona with cotton indicated that efficacy of residues of insecticides declined rapidly, such that after three days all insecticides caused very little mortality to adult *Lygus* bugs. A marked difference between residual and direct contact toxicity of five insecticides namely, acephate, endosulfan, imidacloprid, methamidophos and oxamyl, was found. Even the insecticide treatments that result in relatively low toxicity in residual exposure tests killed 95-100 per cent of *Lygus* bugs that they contacted directly under field conditions. It is concluded that, crops experiencing severe problems with *Lygus* are advised to improve insecticide coverage (Dennehy and Denholm, 1998). Dively *et al.* (1998) reported that imidacloprid treated potato plants at the edges of field and untreated plants in alternate rows showed excellent control over Colorado potato beetle apart from minimizing the resistance development and environmental risks.

Holloway and Forrester (1998) studied the role of several new groups of insecticides in integrated pest management on Australian cotton and concluded that imidacloprid along with other chemicals like fipronil, diafenthiuron, pyronetrozine, buprofezin and pyriproxyfen can be used for control of sucking pests in cotton. Hopkins *et al.* (1998) reported that imidacloprid 1.6 F was extensively used for *Lygus* bug and *A. gossypii* control. A single application of imidacloprid on rice at 200 g a.i./ha gave a season-long control of *Nilaparvata lugens* Stal. (Iwaya *et al.*, 1998).

Kharboutli *et al.* (1998) reported that thiacloprid gave excellent square protection against *L. lineolaris* on cotton, while imidacloprid, oxamyl and dicrotophos provided adequate protection.

Lawson *et al.* (1999) reported that thiamethoxam, a new insecticide in the neonicotinoid chemical class provided excellent control of a wide range of insect pests (sucking and chewing pests) on cotton with very low application rates. Natwick (1999) conducted experiments in California to evaluate insecticides for the control of silverleaf whitefly, *B. argentifoli* in cotton. He reported that acetamiprid treatment provided the highest level of control for silverleaf whitefly adults, eggs and nymphs. Reed *et al.* (1999) found that chloronicotinyl and fiprole show promise for use in tarnished plant bug (*L. lineolaris*) management on cotton in Mississippi.

Wu Huiling (1999) conducted experiments on the efficacy of 20 per cent imidacloprid 200 SL to control *Laodelphax striatellus* (Fallen), the vector of rice-black-streaked dwarf virus in rice cv. Zhongyou 906, in comparison with 10 per cent Bichonglin and 25 per cent Pushiling (both of unspecified composition) and found that Confidor 20 per cent was superior to the other two by providing 67.63 per cent control after one day compared to 58.04 per cent and 27.60 per cent by Bichonglin and Pushiling respectively. Selected, registered and experimental insecticides were compared in terms of efficacy on *Lygus hesperus*, effects on beneficials and potential to flare secondary arthropod pests in cotton by Keillor and Godfrey (2000). Imidacloprid 1.6 F along with organophosphate products gave good, but short-term control.

Robbins *et al.* (2000) reported that thiacloprid 70 WG at 0.047 lb a.i./ha, significantly reduced plant bug *L. lineolaris* populations in cotton. Visigalli *et al.* (2000) conducted trials for control of eastern peach fruit moth, *Cydia molesta*. Of the insecticides applied, the most successful treatments were methoxyfenozide and triflumuron applied at the start of oviposition, thiacloprid at larval emergence. Thiacloprid SC and fenitrocap (fenitrothion) were the most effective on the shoots and thiacloprid WG on the fruits.

Hariprasadasrao *et al.* (2001) conducted experiments in cotton and developed an IPM (Integrated Pest Management) module for Andhra Pradesh. One of the components of the module was use of imidacloprid 70 WS @ 5 g/ha seed followed by stem application of imidacloprid 200 SL @ 1 ml/20 ml of water. Jaisingh *et al.* (2001)

reported that seed treatment with imidacloprid 70 WS lowered whitefly population, thus reflecting reduction in evidence of CLCV under field conditions of cotton crop.

Khurana (2001) evaluated the efficacy of 11 insecticides as foliar spray and seed treatment against jassids and whiteflies in cotton and reported that imidacloprid at 5 and 10 g/kg seed as seed dressing and 200 ml/ha as foliar spray was effective against whiteflies. Ravindersingh *et al.* (2001) investigated the efficacy of ten insecticides in cotton against the whitefly populations and intensity of CLCV (cotton leaf curl virus) and suggested that acetamiprid 20 SP @ 30 g/ha and difenthiuron 50 WP @ 400 g/ha were quite effective in reducing the population of whitefly, minimizing the speed of CLCV and increasing the yield of seed cotton.

2.8. Chemical control of coccids in ornamental plants

Insecticides namely acephate, chlorpyrifos, carbaryl, diazinon and malathion gave commendable control over the Lecanium scale, *Parthenolecanium corni* (Bouche) (Antonelli and Collman, 1991). Baker and Shearin (1992) evaluated the efficacy of oils and chemicals against *Pinnaaspis asidistrae* (Signoret) on fern. They have reported that ultra fine spray oil either alone or with malathion was found to be effective against the pest. Dhandapani *et al.* (1992) studied the effectiveness of chemical insecticides against *Planococcus lilacinus*(Ckll.) in *Jasminum auriculatum* and reported that monocrotophos (0.036%) was more effective.

Jermini and Brunetti (1994) found that two or five per cent mineral oil gave satisfactory control of Sanjose scale, *Quadraspidiotus perniciosus* (Comst.). Landi and Bene Del (1994) reported that Abamectin, white mineral oil, methomyl and lufenuron gave a commendable check of *Aonidia lauri* on *J. auriculatum*. Suresh (1994) studied the efficacy of different chemicals against *Pulvinaria maxima* (Green) and *Maconellicoccus hirsutus* (Green). He concluded that oxydemeton methyl 25 EC 0.025 per cent, dimethoate 30 EC 0.03 per cent and neem oil 2 per cent were effective in controlling the above pests. Either monocrotophos 36 WSC 0.04 per cent or phosphamidon 85 WSC 0.01 per cent or oxydemeton methyl 25 EC 0.025 per cent gave good check of *Coccidohystrix insolita* (Green)(Suresh, 1994).

Hole and Salunkhe (1997) tested the efficacy of nine insecticides against *Aonidiella aurantii* on rose cv. Gladiator and concluded that methidathion (0.05%) gave the most effective control of the pest followed by monocrotophos (0.05%) and phosphamidon (0.05%) when given in two sprays at three weeks intervals in the field experiment conducted at Pune.

Labanowski (1999) reported pirimiphosmethyl 500 EC combined with wetting agent Citowett AL was effective against two diaspidid scales, *Chrysomphalus aonidum* and *Pinnaspis aspidistrae*. Cranshaw *et al.* (2000) reported that imidacloprid and permethrin were the most effective treatments to control *Phenacoccus dearnessi* (King) on hawthorn (*Crataegus spp.*).

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present investigation was undertaken to assess the bioefficacy of a neonicotinoid, thiacloprid against sucking pests of cotton and coccids of ornamental plants. Field experiments, pot culture studies and laboratory experiments were conducted at the Department of Agricultural Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore during 2000-2001. In addition, safety of thiacloprid to natural enemies of pests on cotton ecosystem, honeybee, *Apis cerana indica* (Fab.) and phytotoxic effects of thiacloprid on cotton plants were also studied. The residues of thiacloprid in cotton seed, lint and oil were also estimated.

3.1. Insecticides used in the study

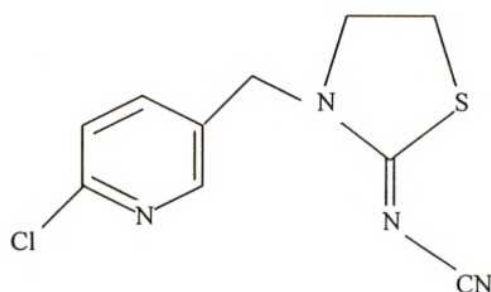
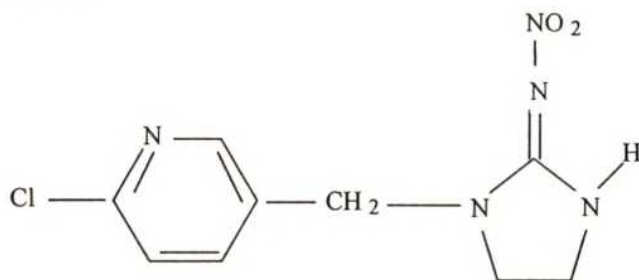
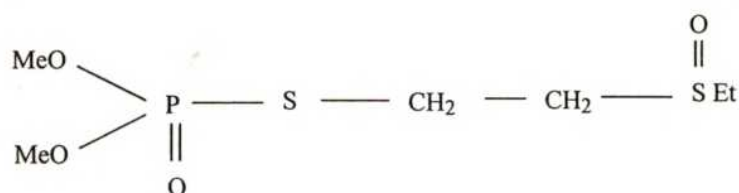
Details of insecticides used in the study are given in the Table:

Sl. No.	Common Name	Trade Name	Chemical (IUPAC)* Name	Dose (ml/ha)	Company
1.	Thiacloprid	Calypso [®] 240 SC	N-[3-(6-chloro-pyridin-3-ylmethyl)-thiazolidin-2-ylidene]-cyanamide	75 100 125	Bayer (India) Ltd., Mumbai
2.	Imidacloprid	Confidor [®] 200 SL	1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylideneamine	100	Bayer (India) Ltd., Mumbai
3.	Oxydemeton methyl	Metasystox [®] 25 EC	S-2-ethylsulphinyl ethyl 0,0-dimethyl phosphorothioate	500	Bayer (India) Ltd., Mumbai

*IUPAC - International Union for Pure and Applied Chemistry.



Plate 1. Acute toxicity test for *Aphis gossypii* (Glov.)

Structural formula**Thiacloprid****Imidacloprid****Oxydemeton methyl****3.2. Bioefficacy of thiacloprid****3.2.1. Acute toxicity of thiacloprid against aphids**

The acute toxicity of thiacloprid to *Aphis gossypii* (Glov.) was bioassayed by sachet test (Nauen, 1990; Elbert *et al.*, 1991) (Plate 1).

Aphids collected from the cotton fields were introduced into cages covering the potted cotton plants under greenhouse conditions and cultured for the experiment. The standard stock solution of 1000 ppm thiacloprid was prepared by dissolving 0.1003 g of thiacloprid technical material (99.7% purity) in 100 ml of acetone. Further dilutions were prepared from the standard stock solution using 15 per cent (w/v) sucrose solution. The

doses for acute toxicity were fixed from the results of the range finding test, which was done earlier with 500, 100, 50, 10, 5, 1, 0.5 and 0.1 ppm concentrations. The doses for acute toxicity tests were fixed at 1, 0.8, 0.6, 0.4, 0.2, 0.1 and 0.05 ppm levels. The experiment was conducted with aphids, which had been starved for four hours. These starved aphids were released into transparent plastic vials at the rate of ten aphids per vial. Then the vials were covered with thin parafilm membrane (parafilm 'M') over which 0.15 ml of thiacloprid active ingredient prepared with sucrose solution was placed using a pipette and covered with a second layer of parafilm. For control, 15 per cent sucrose solution alone was used. After incubating for 24 hours, mortality of aphids was recorded and the LC_{50} was worked out by probit analysis (Finney, 1971).

3.2.2. Persistent toxicity of thiacloprid

3.2.2.1. Persistent toxicity of thiacloprid as foliar application against aphids and leafhoppers

Laboratory experiments were conducted to assess the effect of thiacloprid foliar application against aphids, *A. gossypii* and leafhoppers, *Amrasca biguttula biguttula* (Ishida). The following treatments were replicated four times in a completely randomized design.

- | | |
|----------------------------|-----------|
| 1. Thiacloprid 240 SC | 75 ml/ha |
| 2. Thiacloprid 240 SC | 100 ml/ha |
| 3. Thiacloprid 240 SC | 125 ml/ha |
| 4. Imidacloprid 240 SC | 100 ml/ha |
| 5. Oxydemeton methyl 25 EC | 500 ml/ha |
| 6. Untreated check | |

The persistent toxicity of thiacloprid foliar treatments against *A. gossypii* and *A. biguttula biguttula* were studied using clip-on cage and microcage, respectively (Kumar, 1998 and Sivaveerapandian, 2000).

3.2.2.1.a. *A. gossypii*

Field - collected *A. gossypii* were released into cages covering cotton plants (MCU 5) grown under greenhouse condition and the culture was maintained to have



Plate 2. Clip-on cage for *A. gossypii*



Plate 3. Microcage for *Amrasca biguttula biguttula* (Ishida)

a continuous supply of test insects throughout the experimental period. The persistent toxicity of thiacloprid foliar treatment against *A. gossypii* was assessed using clip-on cage method (Plate 2). Cylindrical transparent blister pack covers of pharmaceutical tablets were used as clip-on cages to confine the aphids. Individual packs with 0.5 cm height and 1.5 cm width were selected after making perforations at the top. These selected cages were fixed in position by inserting a cotton leaf of treated plant in between the bottom of the cage and a transparent plastic sheet supported by two paper clips. Ten apterous aphids of uniform age were released into each cage and the mortality was recorded at 48 h. interval. Fresh batch of aphids were released at 48 hours interval and continued till no mortality was observed. Plants sprayed with distilled water served as control.

3.2.2.1.b. *A. biguttula biguttula*

The persistent toxicity of thiacloprid foliar treatment against leafhopper, *A. biguttula biguttula* was studied using a mylarfilm microcage (Plate 3) (176 µm thickness). Field collected leafhoppers were released into cages covering cotton plants grown under greenhouse condition and the culture was maintained to have a continuous supply of test insects throughout the experimental period.

After the potted plants were sprayed with respective treatments, 10 leafhoppers were released into each microcage and was held in position on the under surface of the leaves. Mortality of leafhoppers was recorded after 48h. Fresh batch of insects were released at 48 h. interval and continued till the mortality was equated to zero. A control was also maintained.

In both the experiments, mortality data were corrected with Abbott's formula (Abbott, 1925).

$$\text{Corrected per cent mortality} = \frac{\text{Per cent test mortality} - \text{Per cent control mortality}}{100 - \text{Per cent control mortality}} \times 100$$

These corrected mortality data were used for computing PT index (Saini, 1959) expressing the persistent toxicity of insecticides. Based on this PT the order of relative efficacy (ORE) was assigned to different concentrations of insecticides (Pradhan, 1967; Regupathy and Dhamu, 2001)

3.3. Phytotoxic effect of thiacloprid foliar application

Pot culture experiment was conducted to study the phytotoxic effect of thiacloprid foliar application on cotton plants (TCHB 213 and MCU 5).

The treatments were:

1. Thiacloprid 240 SC 1000 ml/ha
2. Thiacloprid 240 SC 2000 ml/ha
3. Untreated check

The above treatments were replicated five times in completely randomized block design (CRD). The potted cotton plants were sprayed with above - said concentrations at 30 days after sowing at the rate of 20 ml per plant. For untreated check only distilled water was sprayed.

Observations were made on 1, 3, 5, 7, 10 and 20 days after spraying for any phytotoxic symptoms like,

1. Injury to leaf tip and leaf surface
2. Wilting
3. Vein clearing
4. Necrosis and
5. Epinasty and hyponasty

The phytotoxic symptoms were recorded based on the rating scale, described below (Chelladurai, 1999):

Rating	Phytotoxicity (%)
0	No phytotoxicity
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

The per cent leaf injury was calculated by the formula:

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

3.4. Safety tests

Laboratory experiments were conducted to determine the safety of thiacloprid 240 SC to egg parasitoid, *Trichogramma chilonis* (Ishii), predatory green lacewing, *Chrysoperla carnea* (Stephens), predatory coccinellid beetle, *Menochilus sexmaculatus* (Fab.) and Indian honeybee, *Apis cerana indica* F.

The Treatments were:

1. Thiacloprid 240 SC 75 ml/ha
2. Thiacloprid 240 SC 100 ml/ha
3. Thiacloprid 240 SC 125 ml/ha
4. Untreated check

The experiments were conducted with four replications, under completely randomized block design.

3.4.1. Mass rearing of egg parasitoid, *T. chilonis*

Culturing of *Corcyra cephalonica* Staint.

C. cephalonica was reared following the procedure of Navarajan Paul (1973). The adult moths were allowed inside an oviposition cage of 21 x 25 cm size, which has wire mesh covering at bottom and has two wire mesh windows on the sides for ventilation. Adults were fed with 50 per cent honey solution. The eggs were collected from the oviposition cages daily for four days and cleaned. The cleaned eggs were sprinkled over half ground cumbu grains, at the rate of one cc per 2.5 kg of grains, fortified with ten grams of yeast taken in a plastic basin of 11 x 37.5 cm size and covered with kada cloth. Care was taken to maintain the culture free of storage mites and diseases by mixing five grams of wettable sulphur (80%) and spraying streptomycin sulphate 0.5 per cent respectively. The emerged adults were collected and used again for culturing both host (*C. cephalonica*) and parasitoid (*T. chilonis*). The culture was maintained at room temperature ($26 \pm 4^{\circ}\text{C}$).

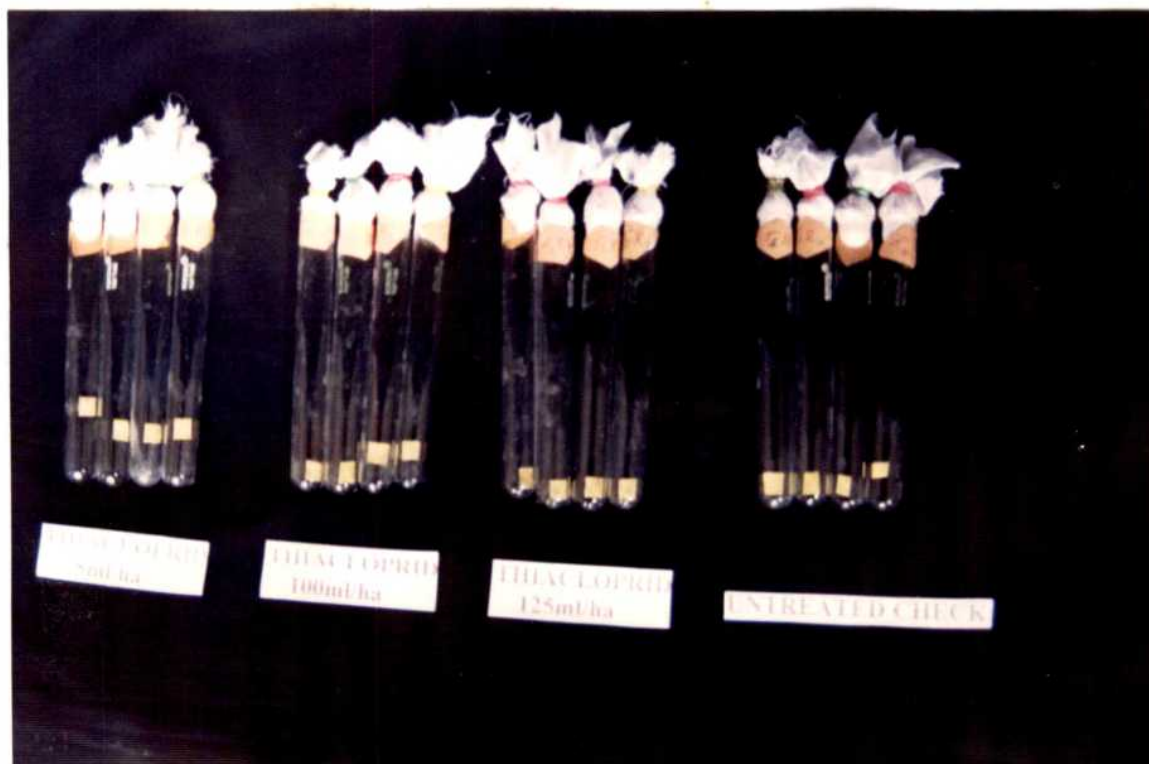


Plate 4. Effect of thiacloprid 240 SC on *Trichogramma chilonis* (Ishii) - adult emergence



Plate 5. Effect of thiacloprid 240 SC on *T. chilonis* - parasitization

Culturing of *T. chilonis*

The egg parasitoid *T. chilonis* was mass cultured at biocontrol laboratory on the eggs of rice moth, *C. cephalonica* as per the method developed by Prabhu (1991). Fresh *C. cephalonica* eggs collected in the early morning were sterilized under UV radiation of 15 W capacity for 20 min at a distance of 15 cm to avoid the emergence of *C. cephalonica* larvae. After that, these eggs were pasted on paper cards of 20 x 30 cm size having thirty, 7 x 2 cm rectangles. These egg cards were placed in polythene bags along with nucleus card at 6:1 ratio for parasitization by the egg parasitoids. The parasitized egg cards were cut into one cm² bits and three days old, 100 per cent parasitized eggs (eggs appearing black and plumpy) were used for the study.

3.4.1.1. Effect of thiacloprid 240 SC on the eggs of *T. chilonis*

After parasitization, the egg card was cut into one cm² size small bits. Only 100 per cent parasitized eggs (black and plumpy eggs) were sprayed with insecticides at various concentrations as mentioned in section 3.4. Only distilled water was sprayed for the untreated check. Spraying was done using an atomizer. There were four replications. Treated egg cards were shade dried and kept inside a test tube of 20 x 1.5 cm size and closed with cotton plug. Number of parasitoids emerged from each treatment was recorded and from this, per cent emergence was worked out. Fresh sterilized egg card was provided into each test tube at a ratio of 6:1 to find out per cent parasitization (Plates 4 & 5).

3.4.2. Mass production of predatory green lace wing, *C. carnea*

Mass rearing of *Chrysopa* was done using *C. cephalonica* eggs (Swamiappan, 1996).

Larval Rearing

Grubs of *C. carnea* was reared in GI round basins (28 cm dia) at 250 larvae/ basin covered with kada cloth. The eggs of *C. cephalonica* were provided as feed for the grubs in the laboratory. About 25 cc of *C. cephalonica* eggs per basin were given on alternate days. After five feedings the larvae pupated into round white coloured silken cocoon. Cocoons were collected and transferred into one litre plastic container with wire mesh window for emergence of adults.



Plate 6. Effect of thiacloprid 240 SC on *Chrysoperla carnea* (Stephens) - egg hatchability



Plate 7. Effect of thiacloprid 240 SC on grubs of *C. carnea* - Larval feeding method

Adult Rearing

The adults were collected and transferred to GI round troughs (30 cm dia. x 12 cm ht.), which were wrapped inside with brown sheets for receiving the eggs. The trough was covered with nylon cloth that was kept firm with the help of a rubber band. In the top of the cloth covering, two bits of foam sponge (two sq. inches) dipped in water were kept besides an artificial diet rich in protein in the form of semisolid paste was smeared. This diet consisted one part of yeast powder, one part of fructose, one part of honey and one part of proteinex[®]. Water was mixed to just make it as a paste. The adults fed the food and laid eggs on the brown sheet, which was wrapped inside the trough. The adults were collected daily and allowed into fresh rearing troughs with fresh feed from the old troughs and the brown paper sheets along with *Chrysopa* eggs were removed.

3.4.2.1. Effect of thiacloprid 240 SC on *C. carnea*

a. Effect on the eggs

Experiments were conducted under laboratory condition to study the effect of thiacloprid 240SC on eggs of *C. carnea* as per the method described by Krishnamoorthy (1985). The brown paper strips holding one day old eggs with stalk were sprayed with different treatments using an atomizer. There were four replications with 20 eggs per treatment. Untreated check was maintained by spraying distilled water. Number of grubs hatched from each treatment was recorded and per cent hatchability was worked out (Plate 6).

b. Effect on the grubs

i. Larval feeding method

Eggs of *C. cephalonica* were sterilized under UV radiation of 15 W capacity for 15 min. to kill the embryos and sprayed with different treatments with an atomizer. These eggs were shade dried and transferred to test tubes (1cc/test tube) of size 20 x 35 cm. For untreated check, the eggs were sprayed with distilled water. There were four replications. Second instar grubs of *C. carnea* were allowed to feed on these sprayed eggs at the rate of 10 grubs per test tube. After the treated eggs were exhausted, untreated eggs were provided until pupation. Observations were made on the grub mortality, pupation and adult emergence, and per cent mortality, pupation and adult emergence were worked out (Plate 7).



Plate 8. Contact toxicity of thiacloprid 240 SC to grubs of *C. carnea* - Dry film method

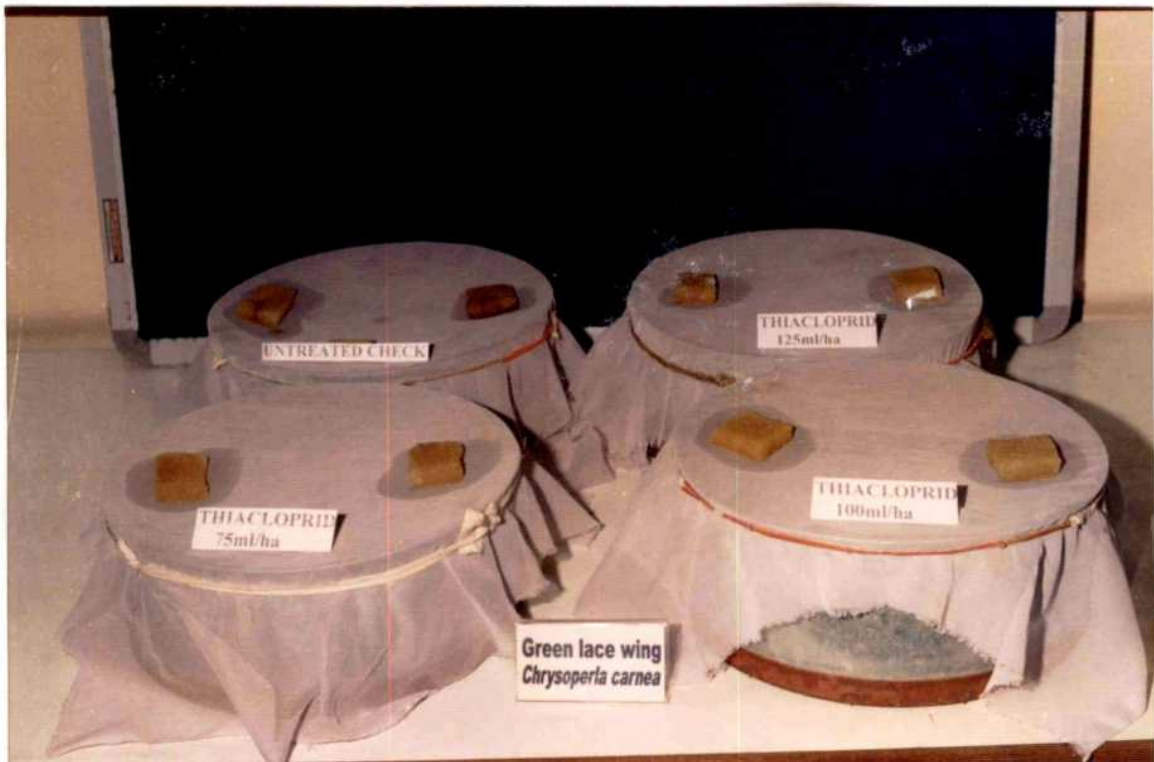


Plate 9. Effect of thiacloprid 240 SC on *C. carnea* - Adult feeding method

ii. Dry film method

The bioassay method described by Mc Cutchen and Plapp (1988) was adopted with modifications (Chelladurai, 1999). For obtaining different concentrations of thiacloprid 240 SC formulations, 0.015, 0.02 and 0.025 ml of thiacloprid 240 SC were dissolved in 20 ml of distilled water and 80 ml of analytical grade acetone was added to get acetone:water ratio of 8:2. Glass scintillation vials of 20 ml capacity were evenly coated with one ml of different concentrations of the insecticide formulations and dried for one hour. First instar grubs of *C.carnea* were released at the rate of ten per vial and covered with muslin cloth. After 24 hours exposure of the grubs, one cc of *C.cephalonica* eggs were given as feed and the observations were made on the mortality of grubs and pupation (Plate 8).

c. Effect on the adults

i. Adult feeding method

Five pairs of *C. carnea* adults were released into individual containers (30 cm dia. x 12 cm ht.) and allowed to feed ten per cent honey solution containing different treatments. For control, only ten per cent honey solution was given as feed. The eggs laid by the adults in each treatment were collected daily by keeping a brown paper sheet of 21 x 6 cm size along the inner side of the container. Observations were made on the number of eggs laid and adult longevity in all the treatments that were replicated four times (Plate 9).

3.4.3. Effect of thiacloprid 240 SC on the grubs and adults of predatory coccinellid beetle, *M. sexmaculatus*

The bioassay method described by Mc Cutchen and Plapp (1988) was adopted. Different concentrations of thiacloprid formulation were prepared in acetone : water mixture as in section 3.4.2.1.b(ii). Glass scintillation vials of 20 ml capacity were evenly coated with one ml of different concentrations of the insecticide formulations and dried for one hour. Field - collected third instar grubs of *M. sexmaculatus* were released at the rate of ten per vial and covered with muslin cloth. After 24 h. exposure of the grubs, 100 field collected *Aphis craccivora* (Koch.) were given as feed and the observations were made on the mortality of grubs.



Plate 10. Field Experiment to evaluate the bioefficacy of thiacloprid 240 SC against sucking pests of cotton hybrid TCHB 213

The same experiment was also carried out with field - collected adults of *M. sexmaculatus* and observations were made on adult mortality.

3.4.4. Effect on honey bee

One-day-old Indian worker bees (*A. cerana indica*.) were obtained from the Apiary of Tamil Nadu Agricultural University. Filter papers (seven cm dia.) were impregnated with 0.5 ml of the solution in acetone, dried and placed in petridishes. Ten worker bees were allowed into each of the petridishes. Small paper bits were placed between bottom and covers of petriplates so as to provide enough ventilation for the bees.

After one hour exposure, the bees were transferred into perforated polybags and provided with cotton soaked in 40 per cent sucrose solution as food. The bees were observed for mortality after 20 hours. Endosulfan treatment was included as standard for comparison. The LC₅₀ was estimated by probit analysis (Regupathy and Dhamu, 2001) and the safety index was worked out by the following formula (Regupathy *et al.*, 2000).

$$\text{Safety index} = \frac{\text{LC}_{50} \text{ of test compound}}{\text{LC}_{50} \text{ of standard}}$$

3.5. Bioefficacy of thiacloprid

3.5.1. Field Experiment I

A field trial was conducted during November, 2000 – May, 2001 at Agricultural College Farm (Eastern block), Tamil Nadu Agricultural University, Coimbatore as an irrigated crop with red sandy soil type, to study the bioefficacy of thiacloprid 240 SC, imidacloprid 200 SL and oxydemeton methyl 25 EC against sucking pests of cotton on hybrid TCHB 213. The experiment was laid out in a Randomised Block Design (RBD) with four replications with a plot size of 4 x 4 m. Delinted seeds of cotton hybrid TCH B 213 were sown at the rate of two seeds per hole with a spacing of 120 x 60 cm (Plate 10).

At the time of sowing, basal dose of NPK fertilizers were applied at the rate of 40:60:60 kg/ha. On 40 days after sowing during earthing up and on 60 days after sowing



Plate 11. Field experiment to evaluate the bioefficacy of thiacloprid 240 SC against sucking pests of cotton cv. MCU 5

40 kg per ha of nitrogen was top dressed separately, in a uniform manner to all treatments.

The treatments are as follows:

- | | | | |
|----|-------------------------|-----------|--------------|
| 1. | Thiacloprid 240 SC | 75 ml/ha | foliar spray |
| 2. | Thiacloprid 240 SC | 100 ml/ha | foliar spray |
| 3. | Thiacloprid 240 SC | 125 ml/ha | foliar spray |
| 4. | Imidacloprid 200 SL | 100 ml/ha | foliar spray |
| 5. | Oxydemeton methyl 25 EC | 500 ml/ha | foliar spray |
| 6. | Untreated check | | |

All the above said treatments were given using a high volume ASPEE backpack sprayer with a spray volume of 500 l/ha, when the population of all sucking pests crossed Economic Threshold Level (ETL).

3.5.1.1. Pest assessment

Incidence of *A. biguttula biguttula*, *A. gossypii* and *T. tabaci* were recorded in 5 plants per plot from 15 days after sowing at weekly intervals. At ETL, the foliar application was given. Pre- and post - treatment observations were recorded on 0, 1, 3, 7, 14, 21 and 28 days after treatment.

Observations on the population of *A. biguttula biguttula*, *A. gossypii* and *T. tabaci* were done on three leaves per plant, one each from top, middle and bottom region from five plants per plot selected at random leaving border rows. Finally, seed cotton yield was recorded.

3.5.2. Field Experiment II

Second field experiment was conducted at Perumal Koil Pudur (Erode district) in a farmer's field during summer season (January – June, 2001). The soil type was loam. The plot size maintained was 6 x 4 m. Delinted seeds of MCU 5 were sown at the rate of two per hole with the spacing of 75x 30 cm. Basal dose of 40:40:40 kg NPK/ha was applied before sowing and 40 kg of nitrogen was top dressed 45 days after sowing. Experiment was laid out in a RBD with four replications (Plate 11).

The foliar treatments were given as in section 3.5.1.

3.5.2.1. Pest Assessment

Observations were made on the incidence of *A. biguttula biguttula*, *A. gossypii* and *T. tabaci* as described in section 3.5.1.. Yield of seed cotton was also assessed.

3.6. Phytotoxic effect of thiacloprid

3.6.1. Field experiment I

A field experiment was conducted during November, 2000 – May, 2001 at the Agricultural College Farm (Eastern Block), Tamil Nadu Agricultural University, Coimbatore to study the phytotoxic effect of thiacloprid 240 SC as foliar treatment on cotton hybrid TCHB 213. Plot size maintained was 4 x 4m. Delinted seeds of TCHB 213 were sown at the rate of two seeds per hole with a spacing of 120 x 60 cm. Similar agronomic operations were carried out as in section 3.5.1.

The treatments are:

- | | | | |
|----|--------------------|------------|--------------|
| 1. | Thiacloprid 240 SC | 1000 ml/ha | foliar spray |
| 2. | Thiacloprid 240 SC | 2000 ml/ha | foliar spray |
| 3. | Untreated check | | |

The experiment was laid out in a randomized block design with seven replications. Foliar sprays of different treatments were given four weeks after sowing using a high volume sprayer (ASPEE Back pack) keeping 500 litres of spray fluid per hectare.

Observations made

Details on the post treatment observations were made as in section 3.3.

3.6.2. Field experiment II

Second field experiment was carried out in a farmer's field at Perumal Koil Pudur (Erode district) during summer (January – June, 2001) to study the phytotoxic effect of thiacloprid 240 SC as foliar spray on MCU 5 variety. The treatments were given as in section 3.6.1. in a RBD with seven replications with a plot size of 6 x 4 m. Spraying was given four weeks after sowing using high volume (ASPEE Backpack) sprayer with 500 litres spray fluid per hectare. The phytotoxic symptoms were recorded as given in Section 3.3.

3.7. Residues of thiacloprid

3.7.1. Field experiment I

A field experiment was conducted to assess the residue persistence of thiacloprid 240 SC foliar treatments in cotton hybrid TCHB 213 during November, 2000 – May, 2001 at Agricultural College farm (Eastern Block), Tamil Nadu Agricultural University, Coimbatore. Plot size maintained was 4 x 4 m. About two delinted seeds of hybrid TCH B 213 were sown per hole with the spacing of 120 x 60 cm. Other operations were similar to that of section 3.5.1.

The treatments are as follows:

- | | | | |
|----|--------------------|------------|--------------|
| 1. | Thiacloprid 240 SC | 125 ml/ha | foliar spray |
| 2. | Thiacloprid 240 SC | 500 ml/ha | foliar spray |
| 3. | Thiacloprid 240 SC | 1000 ml/ha | foliar spray |
| 4. | Untreated check | | |

The experiment was replicated five times in a RBD. Spraying was given four weeks after sowing using a back pack sprayer (High volume ASPEE) at the rate of 500 litres of spray fluid per hectare.

3.7.2. Field Experiment II

Second field experiment was conducted at Perumal Koil Pudur (Erode district) during January – June, 2001 to determine the residues of thiacloprid 240 SC as foliar application on cotton variety MCU 5. The treatments, replications and plot size were similar as in section 3.7.1.

Seed cotton and lint were collected during first and third harvest of treated and untreated cotton plants at the rate of 200 g per plot. The samples were ginned for analysing the residues of thiacloprid in the seed, lint and oil.

3.7.3. Preparation of standards

Thiacloprid technical obtained from Bayer (India) Ltd., was used to prepare the standard stock solution of thiacloprid 1000 ppm. By dissolving 0.1003 g of technical thiacloprid (99.7% purity) in 100 ml of acetonitrile (HPLC grade), the standard stock solution of 1000 ppm thiacloprid was prepared. From this, intermediate stock solution

of 100 ppm was prepared in acetonitrile/water (1/1, v/v), from which 10 ppm, and 2.5 ppm intermediate stock solutions were prepared. From 10 ppm, working standards of 1, 0.5, 0.25, 0.1 and 0.05 ppm were prepared in acetonitrile/water (1/1, v/v).

3.7.4. Analytical method

For determining the residues of thiacloprid 240 SC in cotton, analytical method developed by Placke (1996) was followed. The solvents used for residue analysis were High Performance Liquid Chromatography (HPLC) grade and Analytical Reagent (AR) grade.

3.7.4.1. Extraction

A. Lint and seed

Twenty five grams of weighed sample was soaked in 150 ml of acetone : water (3:1, v/v) in a 500 ml storage bottle and allowed to soak for two hours. Then the sample was blended using a blender for approximately three minutes. The mixture was filtered through five grams of celite filter using filter paper supported on a Buchner funnel into a 500 ml vacuum filter flask. Then the filtered solids were given a wash with 70 ml of acetone : water (3:1, v/v). After pressing the residual solvent from the solids using a rubber damming, the solids were discarded. The filtrate was transferred to a 250 ml graduated cylinder and sufficient acetone (AR grade) was added to make up the volume to 250 ml. The solution was mixed well and about 50 ml (5 g sample equivalent) of the solution was transferred to a 250 ml round bottom flask. The aliquot was concentrated to a remainder of five ml using rotary vacuum evaporator under a water bath temperature of 60⁰C. To the remainder, 15 ml of double distilled water was added to bring the total volume of the extracts to 20 ml.

B. Oil

Twenty five grams of weighed seed was blended and tumbled, placed in a soxhlet apparatus and ran for six to eight hours in petroleum ether. Petroleum ether portion was collected and separated the oil by evaporating the petroleum ether. Two grams of oil was weighed and to this 150 ml of acetone was added and kept for two hours. Then the contents were transferred to a 250 ml graduated cylinder and sufficient acetone

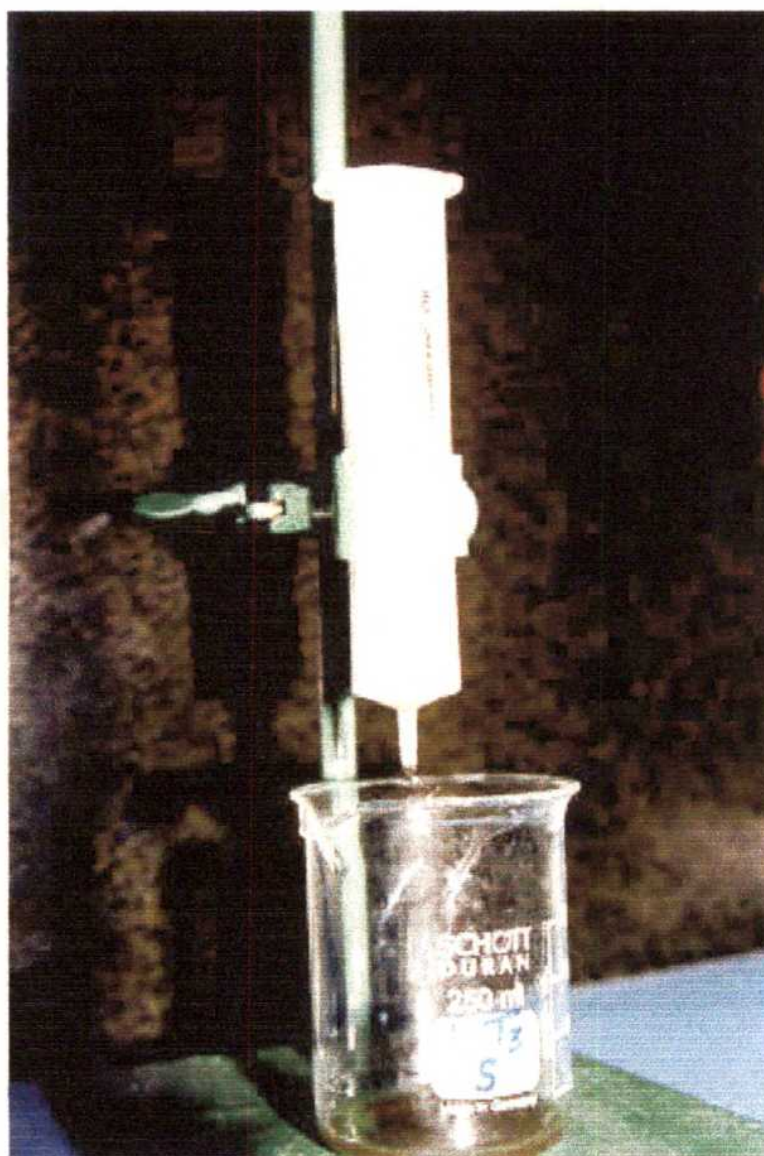


Plate 12. ChemElut Column Cleanup

(AR grade) was added to make up the volume to 250 ml. Further steps were followed as in the case of lint and seed.

3.7.4.2. Clean up

a. ChemElut® column clean up

The aqueous solution was placed on the top of the ChemElut® CE 1020 (diatomaceous earth fitted with a disposable stainless steel needle 20 ml volume) column and allowed to achieve an equal distribution of liquid on the column for 15 minutes. The residues of thiacloprid were eluted with 60 ml of cyclohexane/ethylacetate (HPLC grade 1/1, v/v). The eluate was collected in a 250 ml round - bottom flask, and evaporated to near dryness using a vacuum rotary evaporation at a bath temperature of 60°C. The residues were dissolved in two ml of ethylacetate (HPLC grade) (Plate 12).

b. Florisil® column clean up

Fifty ml of ethyl acetate was allowed to drain through a chromatography column (10 mm i.d.) packed with 10 g of Florisil® (deactivated with 5% water) and 0.5 cm layer of sodium sulphate, after the drip tip was plugged with cotton wool. The residue eluted from ChemElut® column was allowed on to the Florisil® column at a flow rate of one ml/min. The round bottom flask into which the residues were collected, was washed with two ml of ethyl acetate and applied on to the column. The column was washed further with 80 ml of ethyl acetate (HPLC grade) at a flow rate of one ml/min. Then the residue of thiacloprid was eluted using 30 ml of acetonitrile (HPLC grade) at a flow rate of one ml/min. The eluate was collected in a 100 ml flask and evaporated to dryness using a vacuum rotary evaporator at a bath temperature of 60°C. Then the residue was dissolved in one ml of acetonitrile / water (1/1, v/v) and fed into HPLC.

3.7.4.3. Recovery studies

Cottonseed, lint and oil samples were fortified with working standards of 2.5, 1.0 and 0.25 ppm level to determine the recovery of thiacloprid.

3.7.4.4. Final quantification

High Performance Liquid Chromatography (HPLC), Hitachi Model L 6200-Intelligent Pump, L-4000/L-4200 UV-VIS Detector and D 2500 Chromato- Integrator was used for the estimation of residues with the following parameters.

Column	: Lichrospher 60, RP – Select B (5 µm) 25 cm length x 0.4 cm i.d.		
Injection volume	: 20 µl		
Detection	: UV-detector, 242 nm.		
Eluant	: [A] Milli-Q-water with 0.4 ml HCl (35%)/l water [B] Acetonitrile		
Flow rate	: 1.5 ml/min.		
Gradient	: Time (min)	A (% V/V)	B (% V/V)
	0	80	20
	10	65	35
	12	10	90
	15	10	90
	16	80	20
	20	80	20
Retention time	: 7.82 min.		
Total run time	: 20 min.		

Quantification of thiaclopid residues was done using the formula:

$$R = \frac{F_A \times V_{END} \times W_{ST}}{F_{ST} \times V_{INJ} \times G \times AI}$$

where,

R	=	Determined amount of residue in ppm
F _A	=	Peak area for the analytical solution obtained from V _{INJ}
F _{ST}	=	Peak area for the standard solution obtained from W _{ST}
V _{END}	=	Final volume of the respective sample solution in ml.
V _{INJ}	=	Injection volume in µl
W _{ST}	=	Amount of thiaclopid in ng contained in V _{INJ} of the standard solution.
G	=	Weighed amount of analytical sample in g
AI	=	Aliquotation factor

Per cent recovery of thiacloprid was calculated by the formula,

$$\text{Recovery} = \frac{\text{Mean residue}}{\text{Fortification level}} \times 100$$

where,

Recovery = Recovered amount of thiacloprid found in fortified sample in per cent

Mean residue = Average residue in fortified sample determined according to previous formula.

Fortification level = Fortified concentration of thiacloprid in ppm.

3.8. Bioefficacy of thiacloprid against coccids on *Dobernaemontana coronaria*

3.8.1. Laboratory experiment

Effect of thiacloprid 240 SC against *Ferrisia virgata* (Ckll.) was assessed under laboratory condition. The foliar treatments are as follows:

Thiacloprid 240 SC : 0.15 ml/l

Thiacloprid 240 SC : 0.20 ml/l

Thiacloprid 240 SC : 0.25 ml/l

Oxydemeton methyl 25 EC : 1.00 ml/l

Untreated check

Treatments were replicated four times. Ten crawlers were allowed to feed on the treated twigs kept in petridishes lined with moist filter paper Whatman No.2 and mortality was observed periodically at 1, 12 and 24 hours interval.

3.8.2. Field Experiment

Field experiment was conducted at Insectary, Tamil Nadu Agricultural University, to find out the bioefficacy of thiacloprid 240 SC against *Saissetia oleae* (Oliv.) on *D. coronaria*. Plants which were severely infected by *S. oleae* were selected and different treatments were imposed on them. The experiment was laid out in a Randomized Block Design (RBD) with four replications. Different twigs were taken as replications.

The treatments are the same as in section 3.8.1.

Treatments were given using a hand sprayer of one litre volume (Ganesh sprayer). Observations on the population of *S. oleae* were recorded on 0, 1, 3, 5 and 7 days after treatment.

3.9. Statistical analysis

From the acute toxicity test, the median lethal concentration (LC_{50}) of thiacloprid was determined by probit analysis (Finney, 1971) and Abbott's correction (Abbott, 1925) was used to work out corrected percent mortality.

The data obtained from laboratory and pot culture studies were analysed in completely randomized design (CRD) (Gomez and Gomez, 1984). The data related to percent mortality in case of safety tests were transformed to corresponding angles (arc sin) for statistical analysis.

For field observations, RBD was followed (Gomez and Gomez, 1984). The data on insect population were transferred to square root transformation $\sqrt{x + 0.5}$ and the statistical analysis was carried out. Data on yield parameters were analysed as such without any transformation. Critical difference values were calculated at five per cent probability level and treatment mean values were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1951).

All analyses were carried out in IRRISTAT version 3/93.

EXPERIMENTAL RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

The results of field and greenhouse experiments conducted to assess the bioefficacy against sucking pests of cotton and coccids of ornamentals, toxicity to natural enemies, phytotoxicity and the residues of thiacloprid (Calypso 240 SC[®]) are presented in this chapter.

4.1. Bioefficacy of thiacloprid

4.1.1. Acute toxicity of thiacloprid against *Aphis gossypii* (Glov.)

The LC₅₀ value for the thiacloprid technical material was 0.119 ppm with the upper and lower fiducial limits 0.219 and 0.065 ppm respectively (Table 1; Fig.1). From the probit analysis, the regression equation, $Y = 2.047 + 1.422 X$ was obtained. The results indicated that fifty per cent mortality of aphids was obtained at a very low concentration of 0.119 ppm of the insecticide.

4.1.2. Persistent toxicity

4.1.2.1. *A. gossypii*

The results indicated that cent per cent mortality of *A. gossypii* was observed upto seven days after spraying for thiacloprid 240 SC at 75, 100 ml/ha and imidacloprid 200 SL at 100 ml/ha (Table 2; Fig.2), while thiacloprid at 125 ml/ha caused cent per cent mortality upto nine days. Oxydemeton methyl 25 EC 500 ml/ha produced 100 per cent mortality for only one day. Thiacloprid at 125 ml/ha persisted for 29 days after treatment (DAT), while thiacloprid at 100 ml/ha and imidacloprid at 100 ml/ha persisted for 25 DAT. The persistence of thiacloprid at 75 ml/ha and oxydemeton methyl at 500 ml/ha were 23 and 17 DAT respectively.

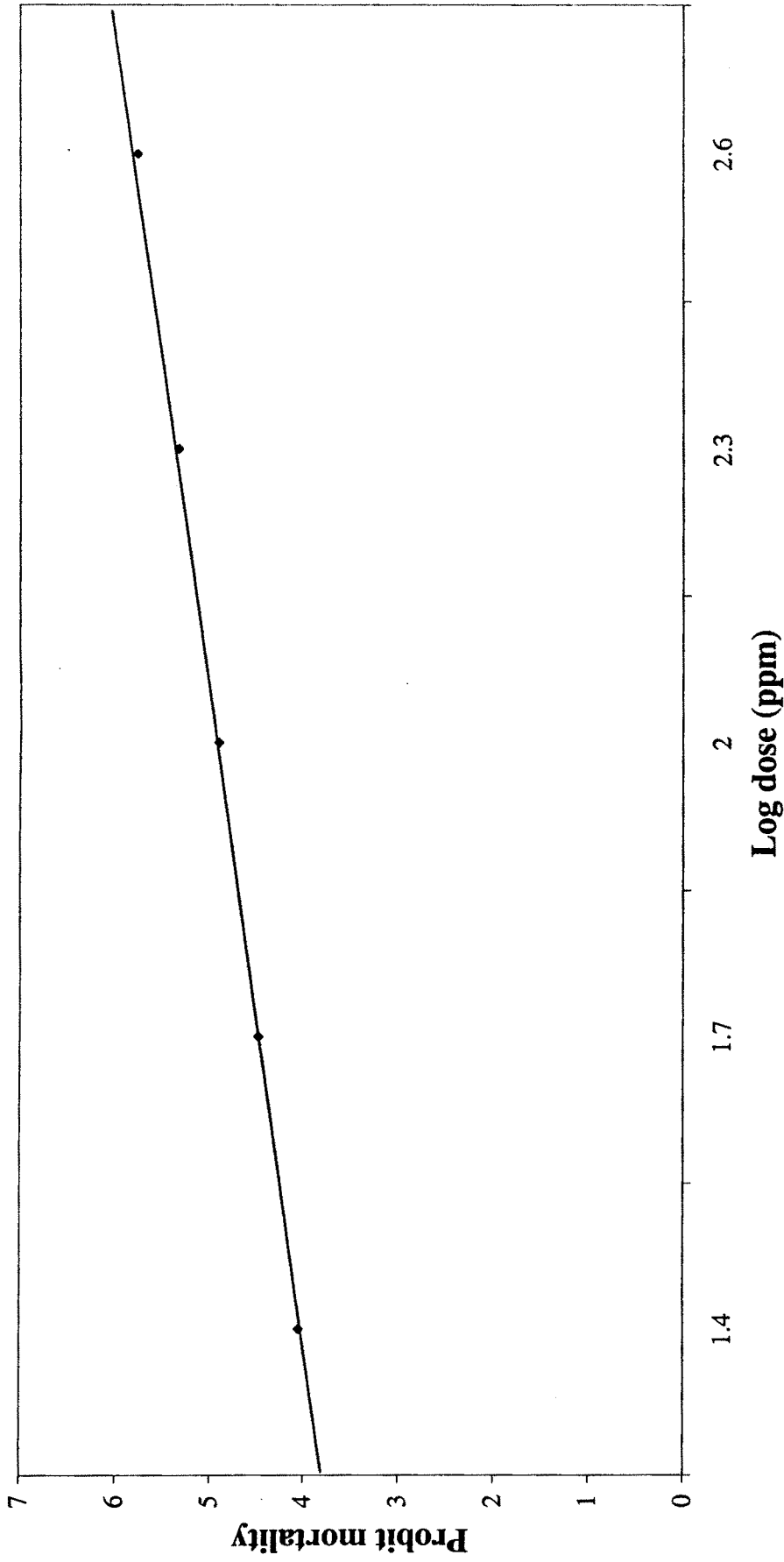
The Order of Relative Efficacy (ORE) of insecticides based on the Persistent Toxicity Index (PTI) is as follows:

Thiacloprid 240 SC @ 125 ml/ha > Thiacloprid 240 SC @ 100 ml/ha >
Imidacloprid 200 SL @ 100 ml/ha > Thiacloprid 240 SC @ 75 ml/ha >
Oxydemeton methyl 25 EC @ 500 ml/ha.

Table 1. Acute toxicity of thiacloprid to *Aphis gossypii* (Glov.)

Pesticide	LC ₅₀ (ppm)	95% fiducial limit		Intercept a	Slope b	y = a + bx	χ^2 at P = 0.05
		Upper limit	Lower limit				
Thiacloprid	0.119	0.219	0.065	2.047	1.422	2.047 + 1.422 X	0.560

All lines are good fit (P < 0.05)



**Fig.1. Log dose probit mortality curve for thiacloprid against
Aphis gossypii (Glov.)**

Table 2. Persistent toxicity of thiacloprid 240 SC foliar application against *A. gossypii* on cotton

Sl. No.	Insecticides	Dose (ml/ha)	Corrected per cent mortality period (days)													P	T	PTI	ORE				
			1	3	5	7	9	11	13	15	17	19	21	23	25					27	29	31	
1.	Thiacloprid 240 SC	75	100	100	100	100	91.07	77.27	65.00	57.95	37.50	17.50	12.50	5.50	0.00	0.00	0.00	0.00	0.00	23	63.69	1464.87	4
2.	Thiacloprid 240 SC	100	100	100	100	97.22	88.10	82.60	70.50	63.82	50.05	41.20	23.55	7.40	0.00	0.00	0.00	0.00	0.00	25	71.11	1777.75	2
3.	Thiacloprid 240 SC	125	100	100	100	100	97.40	89.50	85.30	79.65	66.25	58.95	47.92	35.00	27.50	13.87	0.00	0.00	0.00	29	73.40	2128.60	1
4.	Imidacloprid 200 SL	100	100	100	100	93.80	85.50	68.90	58.30	47.76	28.91	14.36	9.87	0.00	0.00	0.00	0.00	0.00	0.00	23	67.28	1547.44	3
5.	Oxydemeton methyl 25 EC	500	100	91.78	88.30	76.59	63.50	46.20	29.76	15.25	3.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17	57.24	973.08	5

P : Period of persistence (days)

T : Mean per cent mortality

PTI : Persistent toxicity index

ORE : Order of relative efficacy

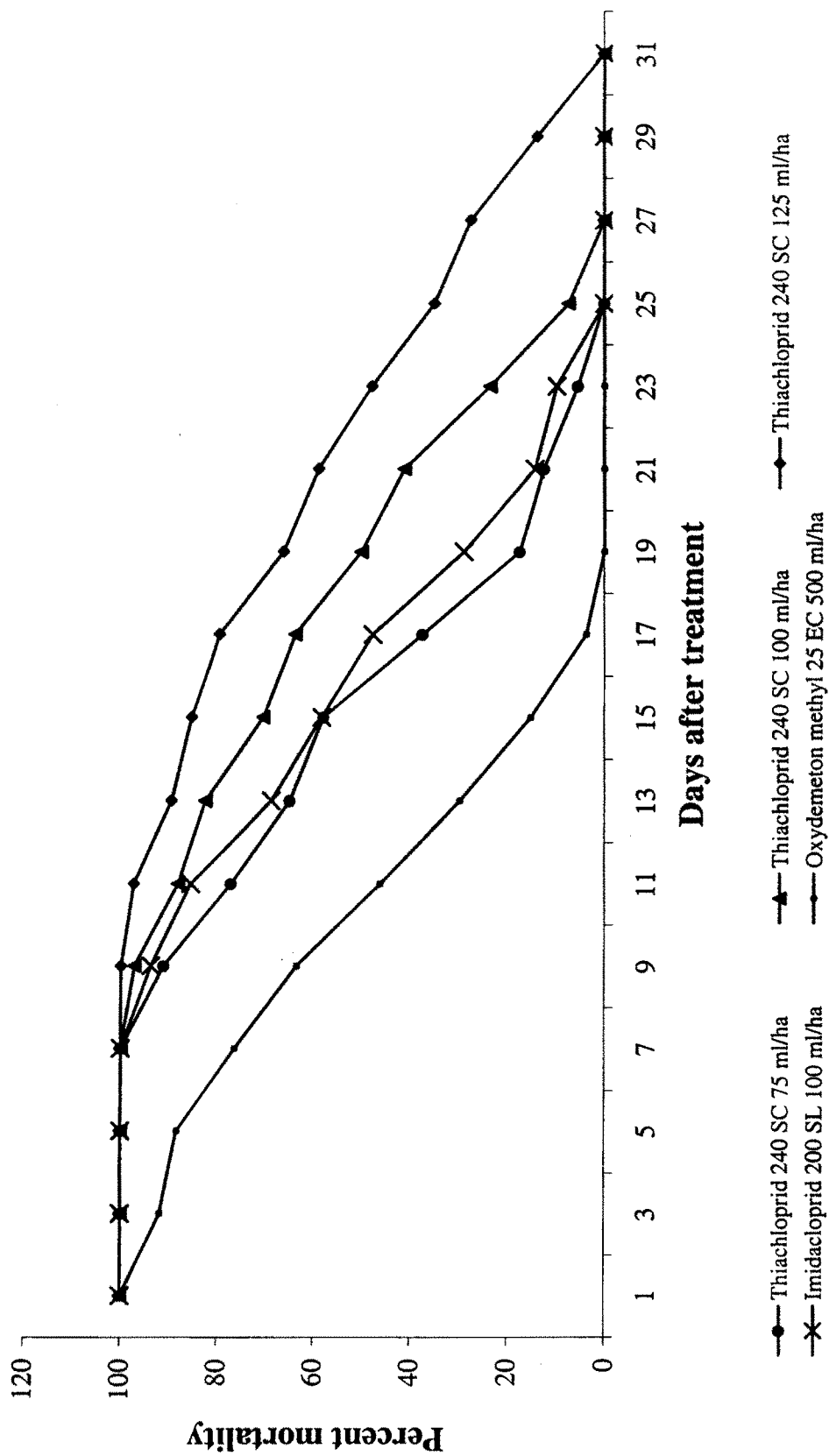


Fig.2. Persistent toxicity of thiachloprid 240 SC against *A. gossypii* on cotton

4.1.2.2. *Amrasca biguttula biguttula* (Ishida)

Thiacloprid 240 SC at 125 ml/ha and 100 ml/ha caused cent per cent mortality of leafhoppers for 13 and 11 DAT respectively (Table 3; Fig.3). Thiacloprid at 75 ml/ha and imidacloprid at 100 ml/ha resulted in cent per cent mortality for nine DAT. Thiacloprid at 125 ml/ha persisted for the longest period of 33 DAT, among the treatments compared, followed by thiacloprid 240 SC at 100 ml/ha and imidacloprid 200 SL at 100 ml/ha for 31 and 29 DAT respectively. Persistence remained for 27 and 17 DAT in case of thiacloprid at 75 ml/ha and oxydemeton methyl 25 EC at 500 ml/ha respectively. From the PTI, the order of relative efficacy of different insecticides compared are given below.

Thiacloprid 240 SC @ 125 ml/ha > Thiacloprid 240 SC @ 100 ml/ha >
 Imidacloprid 200 SL @ 100 ml/ha > Thiacloprid 240 SC @ 75 ml/ha >
 Oxydemeton methyl 25 EC @ 500 ml/ha.

4.1.3. Field Experiment I

4.1.3.1. *Thrips tabaci* (Lind.)

The results on the incidence of thrips in different treatments are given in Table 4. Foliar treatments were given four weeks after sowing, when the thrips population built upto 8.7/three leaves. Thiacloprid 240 SC at 125 ml/ha gave significantly higher reduction of thrips at one DAT. Thiacloprid 240 SC at 100 ml/ha and 75 ml/ha were on par with imidacloprid 200 SL at 100 ml/ha and oxydemeton methyl 25 EC at 500 ml/ha at one DAT. The effect persisted upto seventh week after sowing. On 28 DAT, thiacloprid 240 SC at 125 ml/ha recorded the least number of thrips population (0.13 / three leaves) while the other doses, 100 ml/ha and 75 ml/ha were on par with imidacloprid 200 SL at 100 ml/ha supporting 0.92, 1.5 and 0.75 thrips / three leaves respectively.

Second spray was given during eighth week when the population of thrips attained ETL (Economic Threshold Level). In the second round also similar results were obtained (Table 5). Thiacloprid 240 SC at 125 ml/ha supported the lowest number of thrips population which persisted upto 11th week of the crop. While the other two levels of thiacloprid 240 SC, 100 ml/ha and 75 ml/ha were on par with imidacloprid 200 SL at 100 ml/ha and the population of thrips in the standard oxydemeton methyl were higher

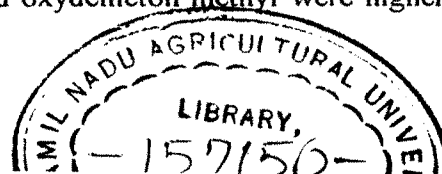


Table 3. Persistent toxicity of thiacloprid 240 SC foliar application against *Amrasca biguttula biguttula* (Ishida) on cotton

Sl. No	Insecticides	Dose (ml/ha)	Corrected per cent mortality period (days)															P	T	PTI	ORE							
			1	3	5	7	9	11	13	15	17	19	21	23	25	27	29					31	33					
1.	Thiacloprid 240 SC	75	100	100	100	100	100	100	100	94.40	88.30	76.10	63.80	54.42	43.74	26.72	10.80	5.00	0.00	0.00	0.00	0.00	0.00	0.00	27	68.81	1857.87	4
2.	Thiacloprid 240 SC	100	100	100	100	100	100	100	100	100	97.10	94.90	87.98	82.97	67.95	51.30	44.20	29.87	10.30	7.40	0.00	0.00	0.00	0.00	31	73.37	2274.47	2
3.	Thiacloprid 240 SC	125	100	100	100	100	100	100	100	100	100	97.50	90.00	82.80	73.96	69.80	62.75	55.00	42.10	37.70	11.50	0.00	0.00	0.00	33	77.83	2568.39	1
4.	Imidacloprid 200 SL	100	100	100	100	100	100	100	100	94.70	92.50	82.80	77.27	62.50	58.30	50.00	38.75	27.50	10.98	0.00	0.00	0.00	0.00	0.00	29	73.02	2117.58	3
5.	Oxydemeton methyl 25 EC	500	100	98.12	81.50	67.50	58.30	58.30	47.50	27.50	19.87	7.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17	56.42	959.14	5

P : Period of persistence (days)

T : Mean per cent mortality

PTI : Persistent toxicity index

ORE : Order of relative efficacy

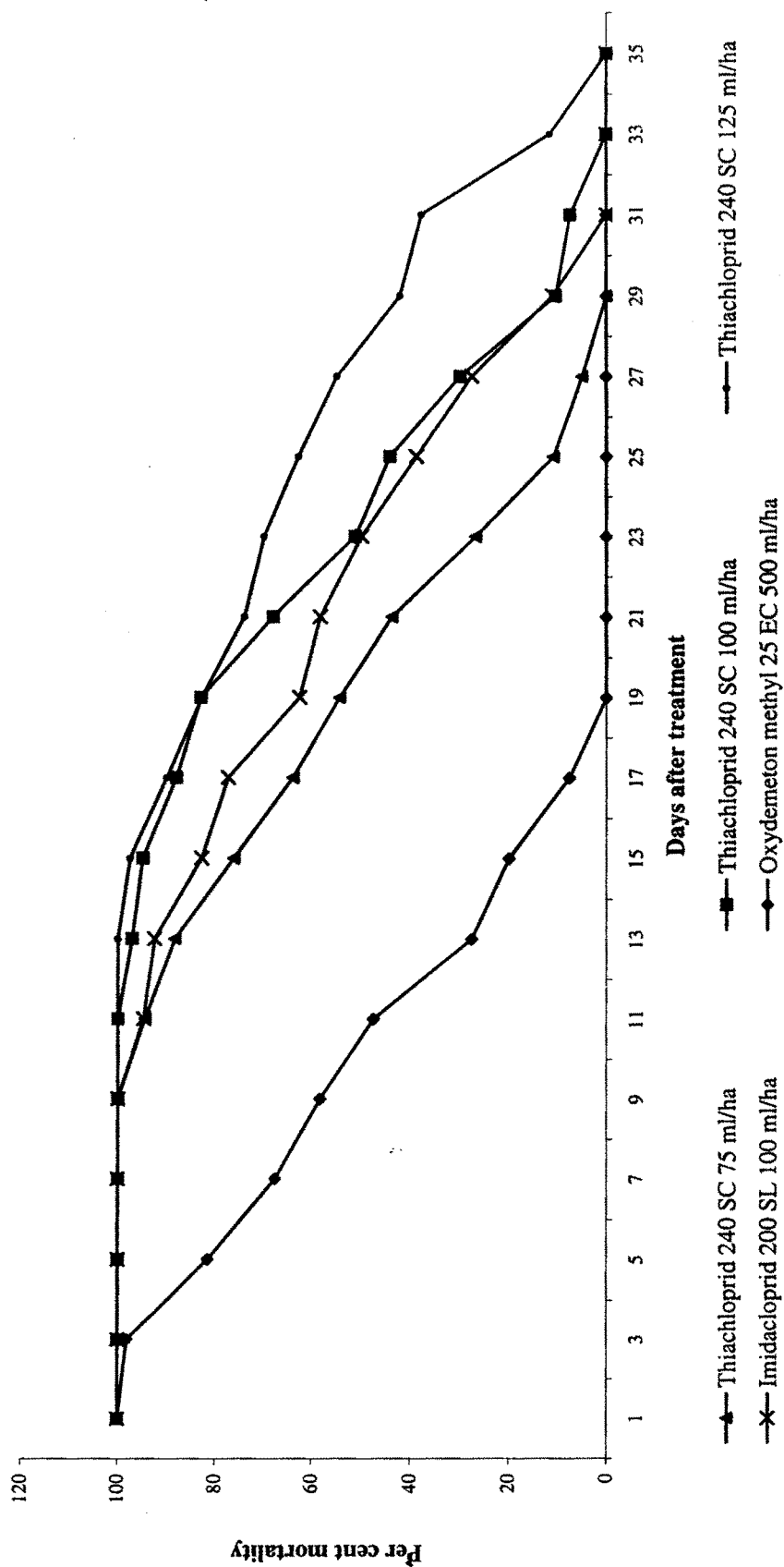


Fig.3. Persistent toxicity of thiacloprid 240 SC foliar application against *A. biguttula biguttula* on cotton

Table 4. Bioefficacy of thiacloprid 240 SC foliar application against *Thrips tabaci* (Lind.) on cotton hybrid TCHB 213 Field Experiment I (November, 2000 – May, 2001) Spray I

Sl. No.	Insecticides	Dose (ml/ha)	(4 th week) Pretreatment count	Mean population at different interval (days)							
				1*	3*	5**	7**	14*	21**	28**	
1.	Thiacloprid 240 SC	75	8.7	2.29 (1.61) ^{ab}	0.71 (1.02) ^a	4.0 (2.07) ^{ab}	2.79 (1.75) ^b	4.25 (2.10) ^{ab}	2.58 (1.74) ^b	1.50 (1.36) ^{ab}	
2.	Thiacloprid 240 SC	100	7.0	0.88 (1.07) ^{ab}	1.63 (1.40) ^a	2.04 (1.49) ^a	1.21 (1.23) ^{ab}	8.46 (2.89) ^{ab}	0.58 (0.95) ^a	0.92 (1.11) ^{ab}	
3.	Thiacloprid 240 SC	125	7.3	0.17 (0.81) ^a	0.58 (0.98) ^a	1.92 (1.54) ^a	0.42 (0.90) ^a	0.83 (1.12) ^a	0.71 (1.05) ^a	0.13 (0.78) ^a	
4.	Imidacloprid 200 SL	100	7.0	1.33 (1.25) ^{ab}	1.25 (1.22) ^a	2.59 (1.54) ^a	0.54 (0.99) ^a	1.88 (1.52) ^{ab}	0.67 (1.02) ^a	0.75 (1.06) ^{ab}	
5.	Oxydemeton methyl 25 EC	500	7.5	3.13 (1.81) ^{ab}	6.54 (2.47) ^b	9.92 (3.12) ^{bc}	1.79 (1.44) ^{ab}	5.96 (2.01) ^{ab}	0.83 (1.13) ^a	2.90 (1.83) ^b	
6.	Untreated check		6.5	4.46 (2.06) ^b	6.08 (2.41) ^b	15.25 (3.95) ^c	9.13 (3.05) ^c	14.63 (3.30) ^b	10.33 (3.29) ^c	8.50 (2.81) ^c	

Mean of four observations

*Significant at P = 0.05

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 5. Bioefficacy of thiacloprid 240 SC foliar application against *T. tabaci* on cotton hybrid TCHB 213
Field Experiment I (November, 2000 – May, 2001) Spray II

Sl. No.	Insecticides	Dose (ml/ha)	(8 th week) Pretreatment count	Mean population at different interval (days)						
				1**	3**	5**	7**	14**	21**	28**
1.	Thiacloprid 240 SC	75	5.39	2.13 (1.61) ^b	1.20 (1.27) ^b	1.25 (1.29) ^{ab}	1.40 (1.35) ^b	2.80 (1.76) ^{bc}	4.80 (2.28) ^b	7.30 (2.74) ^b
2.	Thiacloprid 240 SC	100	8.62	3.02 (1.83) ^b	0.90 (1.69) ^b	1.10 (1.23) ^a	1.90 (1.52) ^b	0.92 (1.18) ^{ab}	6.30 (2.42) ^b	6.40 (2.45) ^{ab}
3.	Thiacloprid 240 SC	125	7.09	1.21 (1.27) ^a	0.00 (0.71) ^a	0.33 (0.90) ^a	0.40 (0.93) ^a	0.70 (1.09) ^a	1.60 (1.42) ^a	3.41 (1.88) ^a
4.	Imidacloprid 200 SL	100	7.26	2.67 (1.76) ^b	0.70 (1.08) ^b	0.90 (1.18) ^a	1.68 (1.45) ^b	2.90 (1.79) ^{bc}	3.40 (1.88) ^{ab}	4.80 (2.28) ^{ab}
5.	Oxydemeton methyl 25 EC	500	9.09	4.22 (2.15) ^c	0.79 (1.14) ^b	2.25 (1.64) ^b	3.60 (2.02) ^c	4.30 (2.04) ^c	3.12 (1.79) ^{ab}	8.50 (2.96) ^b
6.	Untreated check		11.22	15.13 (3.94) ^d	14.20 (3.82) ^c	12.10 (3.54) ^c	10.40 (3.29) ^d	15.90 (4.03) ^d	10.70 (3.30) ^c	16.70 (4.11) ^c

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

than the highest level of thiacloprid 240 SC, but below the untreated check, which maintained the highest population of thrips all through the period of observation (10.40 to 16.70/three leaves).

4.1.3.2. *A. gossypii*

The results on the incidence of aphids in different treatments are given in Table 6. Foliar treatments were given four weeks after sowing, when the aphid population built upto 29.88/three leaves. Thiacloprid 240 SC at 125 ml/ha reduced the aphid population significantly and the counts were 0.42, 0.08 and 0.03/three leaves on one, three and five DAT respectively. The effect of this treatment lasted till seventh week. The other two levels of thiacloprid 240 SC, 100 ml/ha and 75 ml/ha were inferior to the highest dose of thiacloprid 240 SC (125 ml/ha) but superior to imidacloprid 200 SL at 100 ml/ha. The standard oxydemeton methyl 25 EC at 500 ml/ha was better when compared to untreated check.

Second spray was given during eighth week, when the population of aphids attained as high as 52.65/three leaves in untreated check. In the second round, thiacloprid 240 SC at 125 ml/ha gave significantly higher reduction of aphids on one DAT (0.05/ three leaves) while it recorded cent per cent reduction on three and five DAT (Table 7). The other two levels of thiacloprid 240 SC, 100 ml/ha and 75 ml/ha were on par with imidacloprid 200 SL at 100 ml/ha and were superior to oxydemeton methyl 25 EC at 500 ml/ha. Though the population of aphids started building up slowly after ninth week, the effect persisted till 11th week after sowing. Untreated check supported maximum number of aphids, as high as 61.00/three leaves.

4.1.3.3. *A. biguttula biguttula*

The results on the bioefficacy of different treatments against leafhoppers are presented in Table 8. Foliar treatments were given four weeks after sowing, when the leafhopper population ranged between 5.1 and 5.81/three leaves. Cent per cent reduction of leafhopper population was recorded in thiacloprid 240 SC at 125 ml/ha upto seven DAT, while for thiacloprid 240 SC at 100 ml/ha it was upto five DAT. Thiacloprid 240 SC at 75 ml/ha and imidacloprid 200 SL 100 ml/ha gave complete reduction of

Table 6. Bioefficacy of thiacloprid 240 SC foliar application against *A. gossypii* on cotton hybrid TCHB 213
Field Experiment I (November, 2000 – May, 2001) Spray I

Sl. No.	Insecticides	Dose (ml/ha)	(4 th week) Pretreatment count	Mean population at different interval (days)							
				1**	3**	5**	7**	14**	21**	28**	
1.	Thiacloprid 240SC	75	20.83	1.88 (1.45) ^{ab}	1.29 (1.30) ^{ab}	0.65 (1.06) ^a	1.94 (1.55) ^a	4.42 (2.14) ^a	7.67 (2.80) ^a	9.13 (2.98) ^{ab}	
2.	Thiacloprid 240 SC	100	23.90	0.96 (1.20) ^{ab}	0.67 (1.08) ^{ab}	0.33 (0.87) ^a	1.33 (1.34) ^a	2.08 (1.44) ^a	6.74 (2.65) ^a	7.34 (2.78) ^a	
3.	Thiacloprid 240 SC	125	29.00	0.42 (0.93) ^a	0.08 (0.76) ^a	0.03 (0.73) ^a	1.32 (1.19) ^a	2.83 (1.68) ^a	3.96 (2.11) ^a	3.17 (1.65) ^a	
4.	Imidacloprid 200 SL	100	24.58	1.97 (1.56) ^{bc}	4.42 (1.99) ^{bc}	7.42 (2.75) ^b	11.79 (3.41) ^b	14.63 (3.30) ^a	19.25 (4.37) ^b	28.9 (4.17) ^{ab}	
5.	Oxydemeton methyl 25 EC	500	29.88	3.88 (2.08) ^c	8.06 (2.79) ^c	17.33 (4.13) ^c	24.58 (4.91) ^c	27.49 (5.28) ^b	28.75 (5.32) ^{bc}	34.92 (4.83) ^{ab}	
6.	Untreated check		24.13	37.63 (6.16) ^d	55.20 (7.42) ^d	70.75 (8.25) ^d	87.13 (9.23) ^c	43.67 (6.62) ^b	37.25 (5.91) ^c	60.34 (7.22) ^b	

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 7. Bioefficacy of thiacloprid 240 SC foliar application against *A. gossypii* on cotton hybrid TCHB 213
Field Experiment I (November, 2000 – May, 2001) Spray II

Sl. No.	Insecticides	Dose (ml/ha)	(8 th week) Pretreatment count	Mean population at different interval (days)							
				1**	3**	5**	7**	14**	21**	28**	
1.	Thiacloprid 240 SC	75	10.20	0.91 (1.19) ^b	0.73 (1.11) ^b	2.00 (1.57) ^b	3.81 (2.07) ^b	6.40 (2.59) ^{ab}	29.10 (5.40) ^c	33.90 (5.86) ^c	
2.	Thiacloprid 240 SC	100	17.50	0.70 (1.09) ^{ab}	0.30 (0.89) ^{ab}	1.50 (1.39) ^b	2.30 (1.66) ^b	6.20 (2.55) ^a	24.60 (5.00) ^c	30.90 (5.60) ^c	
3.	Thiacloprid 240 SC	125	15.40	0.05 (0.74) ^a	0.00 (0.71) ^a	0.00 (0.71) ^a	0.80 (1.13) ^a	4.61 (2.24) ^a	5.40 (2.40) ^a	18.20 (4.31) ^a	
4.	Imidacloprid 200 SL	100	28.10	1.65 (1.47) ^b	0.30 (0.89) ^{ab}	1.09 (1.26) ^b	2.70 (1.78) ^b	9.10 (3.09) ^b	11.50 (3.46) ^b	27.30 (5.27) ^b	
5.	Oxydemeton methyl 25 EC	500	34.90	4.54 (2.17) ^c	1.50 (1.39) ^c	5.73 (2.46) ^c	8.00 (2.85) ^c	13.80 (3.78) ^c	36.00 (6.03) ^d	42.40 (6.55) ^d	
6.	Untreated check		52.65	53.89 (7.37) ^d	32.50 (5.74) ^d	36.12 (6.04) ^d	22.40 (4.78) ^d	40.70 (6.40) ^d	42.20 (6.53) ^d	61.00 (7.84) ^e	

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 8. Bioefficacy of thiacloprid 240 SC foliar application against *A. biguttula biguttula* on cotton hybrid TCHB 213
Field Experiment I (November, 2000 – May, 2001) Spray I

Sl. No.	Insecticides	Dose (ml/ha)	(4 th week) Pretreatment count	Mean population at different interval (days)						
				1**	3**	5**	7**	14**	21**	28**
1.	Thiacloprid 240 SC	75	5.81	0.08 (0.76) ^a	0.00 (0.71) ^a	0.13 (0.78) ^a	0.21 (0.83) ^a	0.13 (0.78) ^a	0.67 (1.03) ^{ab}	0.63 (0.96) ^a
2.	Thiacloprid 240 SC	100	5.10	0.00 (0.71) ^a	0.00 (0.71) ^a	0.00 (0.71) ^a	0.13 (0.78) ^a	0.08 (0.76) ^a	0.17 (0.81) ^a	1.04 (1.24) ^a
3.	Thiacloprid 240 SC	125	5.75	0.00 (0.71) ^a	0.00 (0.71) ^a	0.00 (0.71) ^a	0.00 (0.71) ^a	0.08 (0.76) ^a	0.54 (0.99) ^{ab}	0.83 (1.15) ^a
4.	Imidacloprid 200 SL	100	5.25	0.29 (0.88) ^a	0.00 (0.71) ^a	0.25 (0.85) ^a	0.46 (0.96) ^a	1.04 (1.18) ^a	0.25 (0.84) ^a	0.50 (0.98) ^a
5.	Oxydemeton methyl 25 EC	500	5.80	2.95 (1.77) ^b	3.25 (1.90) ^b	4.42 (2.15) ^b	5.83 (2.50) ^b	0.88 (1.13) ^a	1.33 (1.30) ^b	2.25 (1.57) ^a
6.	Untreated check		5.50	5.17 (2.35) ^c	3.71 (2.00) ^b	5.13 (2.37) ^b	5.04 (2.24) ^b	2.67 (1.77) ^b	3.62 (2.00) ^c	5.58 (2.39) ^b

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

leafhopper population on three DAT. All the above said treatments were on par with each other and superior to the standard oxydemeton methyl 25 EC at 500 ml/ha, which again was on par with the above said treatments at 28 DAT.

Population of leafhopper in all treatments after second spray are furnished in Table 9. Second spray was given during eighth week when the population of leafhoppers in all treatments ranged between 11.71 and 21.60/ three leaves. Cent per cent reduction of leafhopper population was observed in thiacloprid 240 SC at 125 ml/ha, 100 ml/ha and imidacloprid 200 SL at 100 ml/ha on three DAT. Thiacloprid 240 SC at 75 ml/ha was inferior to the above said treatments but superior to the standard oxydemeton methyl 25 EC at 500 ml/ha. Untreated check supported maximum number of leafhopper population throughout the experimental period that ranged between 19.5 and 34.06/three leaves.

4.1.3.4. Effect of thiacloprid 240 SC on seed cotton yield

The results on the influence of thiacloprid on seed cotton yield of hybrid TCHB 213 is furnished in Table 10. The results revealed that significantly higher yield of 1593.75 kg/ha was obtained in plots treated with thiacloprid 240 SC at 125 ml/ha. The per cent increase in seed cotton yield in respect of thiacloprid 240 SC at 100 ml/ha, 75 ml/ha, imidacloprid 200 SL at 100 ml/ha were in the order of 97.14, 91.43 and 82.86 per cent, respectively over untreated check (Fig. 4.).

4.1.4. Field Experiment II

4.1.4.1. *T. tabaci*

The results on the incidence of thrips on cotton variety MCU 5 are furnished in Table 11. Thiacloprid 240 SC at 125 ml/ha and imidacloprid 200 SL at 100 ml/ha reduced the population of thrips significantly and incidence of thrips at one DAT was negligible. All the treatments except untreated check were on par with each other. Similar trend was observed upto three DAT. At the end of observation period (28 DAT) thiacloprid 240 SC at 125 ml/ha and 100 ml/ha and imidacloprid 200 SL at 100 ml/ha checked the population of thrips effectively.

Table 9. Bioefficacy of thiacloprid 240 SC foliar application against *A. biguttula biguttula* on cotton hybrid TCHB 213
Field Experiment I (November, 2000 – May, 2001) Spray II

Sl. No.	Insecticides	Dose (ml/ha)	(8 th week) Pretreatment count	Mean population at different interval (days)						
				1**	3**	5**	7**	14**	21**	28**
1.	Thiacloprid 240 SC	75	12.84	0.60 (1.04) ^a	0.33 (0.91) ^b	3.62 (2.03) ^b	4.43 (2.20) ^b	6.30 (2.57) ^c	9.22 (3.12) ^d	12.80 (3.65) ^c
2.	Thiacloprid 240 SC	100	11.71	0.20 (0.84) ^a	0.00 (0.71) ^a	1.30 (1.31) ^a	2.03 (1.51) ^a	4.21 (2.17) ^b	7.66 (2.85) ^c	10.12 (3.26) ^b
3.	Thiacloprid 240 SC	125	13.67	0.12 (0.79) ^a	0.00 (0.71) ^a	0.87 (1.17) ^a	1.33 (1.35) ^a	2.04 (1.58) ^a	2.63 (1.75) ^a	5.95 (2.49) ^a
4.	Imidacloprid 200 SL	100	14.93	0.10 (0.77) ^a	0.00 (0.71) ^a	0.98 (1.21) ^a	1.80 (1.50) ^a	3.97 (2.11) ^b	5.82 (2.51) ^b	9.83 (3.21) ^b
5.	Oxydemeton methyl 25 EC	500	14.28	0.90 (1.18) ^a	1.37 (1.34) ^c	3.10 (1.89) ^b	5.83 (2.51) ^b	8.58 (3.01) ^d	10.68 (3.34) ^d	15.67 (4.02) ^d
6.	Untreated check		21.60	19.50 (4.20) ^b	20.11 (4.54) ^d	23.35 (4.88) ^c	21.71 (4.71) ^c	22.89 (4.83) ^e	31.15 (5.63) ^e	34.06 (5.88) ^e

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 10. Effect of thiacloprid 240 SC foliar application on seed cotton yield in hybrid TCHB 213 - Field Experiment I (November, 2000 – May, 2001)

Sl. No.	Insecticides	Dose (ml/ha)	Seed cotton yield (kg/ha)**	Per cent increase over check
1.	Thiacloprid 240 SC	75	1256.25 ^b	91.43
2.	Thiacloprid 240 SC	100	1293.75 ^b	97.14
3.	Thiacloprid 240 SC	125	1593.75 ^a	142.86
4.	Imidacloprid 200 SL	100	1200.00 ^b	82.86
5.	Oxydemeton methyl 25 EC	500	909.375 ^c	38.57
6.	Untreated check		656.25 ^d	-

Mean of four observations

**Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05)

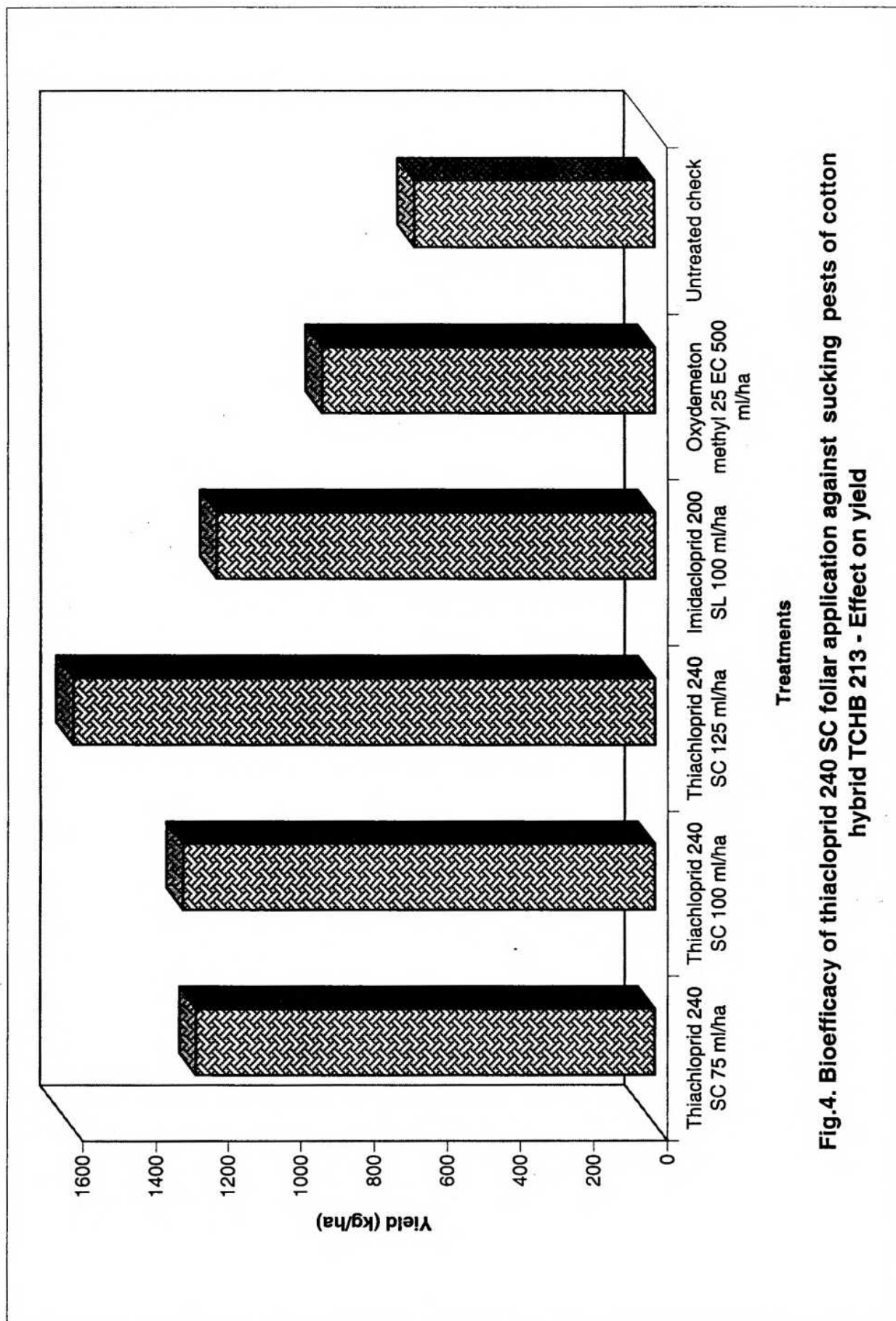


Table 11. Bioefficacy of thiacloprid 240 SC foliar application against *T. tabaci* on cotton cv. MCU 5
Field Experiment II (January - June, 2001) Spray I

Sl. No.	Insecticides	Dose (ml/ha)	(4 th week) Pretreatment count	Mean population at different interval (days)							
				1**	3**	5**	7**	14**	21*	28*	
1.	Thiacloprid 240 SC	75	12.60	0.29 (0.88) ^a	0.75 (1.06) ^a	0.71 (1.05) ^a	3.25 (1.88) ^{ab}	0.95 (1.11) ^a	8.67 (3.01) ^b	7.45 (2.81) ^{ab}	
2.	Thiacloprid 240 SC	100	15.00	0.50 (0.97) ^a	0.67 (1.02) ^a	0.79 (1.10) ^a	3.33 (1.90) ^{ab}	0.75 (1.06) ^a	8.13 (2.81) ^b	6.00 (2.46) ^a	
3.	Thiacloprid 240 SC	125	16.75	0.00 (0.71) ^a	0.25 (0.84) ^a	0.54 (1.01) ^a	2.40 (1.68) ^a	0.50 (0.97) ^a	1.50 (1.33) ^a	3.67 (1.99) ^a	
4.	Imidacloprid 200 SL	100	11.75	0.00 (0.71) ^a	0.75 (1.06) ^a	0.83 (1.13) ^a	2.50 (1.62) ^a	0.50 (0.93) ^a	4.25 (2.17) ^{ab}	5.33 (2.33) ^a	
5.	Oxydemeton methyl 25 EC	500	15.70	1.25 (1.27) ^a	1.50 (1.39) ^a	2.75 (1.76) ^b	6.75 (2.64) ^b	2.83 (1.74) ^a	2.00 (1.58) ^a	7.45 (2.81) ^{ab}	
6.	Untreated check		12.50	12.75 (3.57) ^b	13.43 (3.51) ^b	11.38 (3.44) ^c	15.25 (3.93) ^c	15.0 (3.76) ^b	9.00 (2.96) ^b	16.25 (3.86) ^b	

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Details of thrips population during the period of second spray, given during eighth week are furnished in Table 12. Thiacloprid 240 SC at 125 ml/ha significantly reduced the population of thrips to zero level at one DAT followed by imidacloprid 200 SL at 100 ml/ha (0.06/three leaves) and thiacloprid 240 SC at 100 and 75 ml/ha (0.55 and 0.87/three leaves, respectively). The effect of treatments persisted upto 11th week of the crop, and the thiacloprid at two higher levels were superior to all other treatments compared. Throughout the period of observation, thrips population in untreated plots was maintained as high as 18.99/three leaves.

4.1.4.2. *A. gossypii*

The results on the incidence of aphids in different treatments are given in Table 13. At one day after treatment there was no significant difference in the efficacy of different treatments in reducing the population of aphids except untreated check. At three DAT, thiacloprid 240 SC at 125 ml/ha significantly reduced the population (0.08/three leaves) and maintained its efficacy throughout the period of observation (till seventh week). At seven DAT, thiacloprid 240 SC at 100 ml/ha and 75 ml/ha were on par with each other followed by imidacloprid 200 SL at 100 ml/ha and the standard oxydemeton methyl 25 EC at 500 ml/ha, which recorded 24.58 aphids/three leaves.

Details of second spray of different treatments against aphids are furnished in Table 14. Thiacloprid 240 SC at 125 ml/ha and 100 ml/ha reduced the population of aphids significantly and the population was 0.03 and 0.29/three leaves at one DAT. At three DAT, there was cent per cent reduction of aphids by thiacloprid 240 SC at 125 ml/ha followed by thiacloprid 240 SC at 100 ml/ha (0.07/three leaves) and imidacloprid 200 SL at 100 ml/ha (0.35/three leaves). The effect of different chemical treatments persisted till 11th week after sowing that kept the aphid population low in all treatments while it was 62.3/three leaves in untreated check.

4.1.4.3. *A. biguttula biguttula*

The results on the incidence of leafhoppers in different treatments are given in Table 15. Thiacloprid 240 SC at 125 ml/ha and 100 ml/ha gave significant reduction of leafhopper population. Population of leafhoppers observed was nil upto seven and

Table 12. Bioefficacy of thiacloprid 240 SC foliar application against *T. tabaci* on cotton cv. MCU 5
Field Experiment II (January - June, 2001) Spray II

Sl. No.	Insecticides	Dose (ml/ha)	(8 th week) Pretreatment count	Mean population at different interval (days)						
				1**	3**	5**	7*	14*	21**	28**
1.	Thiacloprid 240 SC	75	8.12	0.87 (1.16) ^{ab}	1.96 (1.55) ^{bc}	4.26 (2.03) ^b	5.04 (2.35) ^a	9.65 (2.96) ^{ab}	11.25 (3.42) ^c	14.76 (3.89) ^{bc}
2.	Thiacloprid 240 SC	100	6.23	0.55 (1.02) ^{ab}	1.05 (1.21) ^b	2.92 (1.81) ^b	2.94 (1.81) ^a	5.75 (2.37) ^a	8.36 (2.98) ^b	9.49 (3.13) ^a
3.	Thiacloprid 240 SC	125	4.51	0.00 (0.71) ^a	0.07 (0.75) ^a	1.25 (1.29) ^a	2.20 (1.57) ^a	3.47 (1.90) ^a	6.41 (2.59) ^a	8.00 (2.87) ^a
4.	Imidacloprid 200 SL	100	6.93	0.06 (0.75) ^a	1.20 (1.27) ^b	3.50 (1.88) ^b	4.90 (2.22) ^a	5.20 (2.34) ^a	6.25 (2.56) ^a	10.29 (3.24) ^{ab}
5.	Oxydemeton methyl 25 EC	500	9.67	1.50 (1.33) ^b	2.96 (1.81) ^c	4.50 (2.12) ^b	5.06 (2.18) ^a	7.25 (2.76) ^a	9.83 (3.21) ^{bc}	15.01 (3.91) ^{bc}
6.	Untreated check		16.33	14.34 (3.78) ^c	11.56 (3.47) ^d	15.25 (3.94) ^c	12.70 (3.58) ^b	13.97 (3.79) ^b	11.21 (3.42) ^c	18.99 (4.37) ^c

Mean of four observations

* Significant at P = 0.05

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 13. Bioefficacy of thiacloprid 240 SC foliar application against *A. gossypii* on cotton cv. MCU 5 Field Experiment II (January - June, 2001) Spray I

Sl. No.	Insecticides	Dose (ml/ha)	(4 th week) Pretreatment count	Mean population at different interval (days)							
				1**	3**	5**	7**	14**	21**	28**	
1.	Thiacloprid 240 SC	75	27.40	2.63 (1.74) ^a	1.29 (1.31) ^b	0.65 (1.07) ^a	1.92 (1.52) ^a	4.42 (2.19) ^b	7.67 (2.85) ^a	9.13 (3.10) ^a	
2.	Thiacloprid 240 SC	100	26.00	0.96 (1.21) ^a	0.67 (1.08) ^b	0.33 (0.91) ^a	1.33 (1.35) ^a	2.08 (1.61) ^a	6.69 (2.68) ^a	7.34 (2.79) ^a	
3.	Thiacloprid 240 SC	125	26.70	0.42 (0.95) ^a	0.08 (0.76) ^a	0.03 (0.73) ^a	1.32 (1.35) ^a	2.83 (1.82) ^{ab}	3.96 (2.10) ^a	3.17 (1.90) ^a	
4.	Imidacloprid 200 SL	100	33.20	1.97 (1.51) ^a	4.42 (2.19) ^c	7.42 (2.75) ^b	11.79 (3.50) ^b	14.63 (3.89) ^c	20.50 (4.43) ^b	28.90 (5.40) ^b	
5.	Oxydemeton methyl 25 EC	500	29.95	3.88 (2.08) ^a	8.06 (2.91) ^d	17.33 (4.18) ^c	24.58 (5.00) ^c	27.49 (5.27) ^d	28.75 (5.31) ^{bc}	34.92 (5.93) ^b	
6.	Untreated check		28.25	37.63 (5.91) ^b	55.20 (7.46) ^e	70.75 (8.42) ^d	87.13 (9.34) ^d	43.67 (6.64) ^e	37.25 (6.13) ^c	60.34 (7.58) ^c	

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 14. Bioefficacy of thiacloprid 240 SC foliar application against *A. gossypii* on cotton cv. MCU 5 Field Experiment II (January - June, 2001) Spray II

Sl. No.	Treatments		(8 th week) Pretreatment count	Mean population at different interval (days)						
	Insecticides	Dose (ml/ha)		1**	3**	5**	7**	14**	21**	28**
1.	Thiacloprid 240 SC	75	10.75	4.25 (2.18) ^c	1.75 (1.56) ^b	2.53 (1.73) ^b	7.50 (2.82) ^c	11.31 (3.44) ^b	19.82 (4.45) ^d	25.11 (5.05) ^c
2.	Thiacloprid 240 SC	100	7.62	0.29 (0.89) ^{ab}	0.07 (0.75) ^a	2.00 (1.48) ^{ab}	4.16 (2.13) ^{ab}	6.38 (2.56) ^a	13.19 (3.68) ^b	17.24 (4.17) ^{ab}
3.	Thiacloprid 240 SC	125	6.55	0.03 (0.73) ^a	0.00 (0.71) ^a	1.01 (1.19) ^a	3.00 (1.86) ^a	4.21 (2.14) ^a	6.87 (2.70) ^a	13.65 (3.75) ^a
4.	Imidacloprid 200 SL	100	21.33	0.50 (1.00) ^b	0.35 (0.91) ^a	1.92 (1.54) ^{ab}	5.75 (2.46) ^{bc}	9.82 (3.18) ^b	14.25 (3.84) ^{bc}	20.50 (4.51) ^b
5.	Oxydemeton methyl 25 EC	500	38.90	4.50 (2.22) ^c	6.49 (2.64) ^c	12.27 (3.57) ^c	13.00 (3.66) ^d	15.57 (3.99) ^c	18.25 (4.32) ^{cd}	29.30 (5.43) ^c
6.	Untreated check		51.67	59.21 (7.23) ^d	62.70 (7.95) ^d	58.12 (7.64) ^d	71.67 (8.49) ^e	66.94 (8.21) ^d	67.05 (8.21) ^e	62.30 (7.92) ^d

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 15. Bioefficacy of thiacloprid 240 SC foliar application against *A. biguttula biguttula* on cotton cv. MCU 5
Field Experiment II (January - June, 2001) Spray I

Sl. No.	Insecticides	Dose (ml/ha)	(4 th week) Pretreatment count	Mean population at different interval (days)						
				1**	3**	5**	7**	14**	21**	28**
1.	Thiacloprid 240 SC	75	3.00	0.08 (0.76) ^a	0.00 (0.71) ^a	0.13 (0.78) ^a	0.21 (0.83) ^a	0.13 (0.79) ^a	0.67 (1.03) ^a	0.63 (1.03) ^a
2.	Thiacloprid 240 SC	100	1.75	0.00 (0.71) ^a	0.00 (0.71) ^a	0.00 (0.71) ^a	0.13 (0.78) ^a	0.08 (0.76) ^a	0.17 (0.80) ^a	1.04 (1.09) ^a
3.	Thiacloprid 240 SC	125	4.25	0.00 (0.71) ^a	0.00 (0.71) ^a	0.00 (0.71) ^a	0.00 (0.71) ^a	0.08 (0.76) ^a	0.54 (0.95) ^a	0.33 (0.89) ^a
4.	Imidacloprid 200 SL	100	2.50	0.29 (0.86) ^a	0.00 (0.71) ^a	0.25 (0.84) ^a	0.46 (0.96) ^a	1.04 (1.09) ^{ab}	0.25 (0.86) ^u	0.50 (0.96) ^a
5.	Oxydemeton methyl 25 EC	500	4.00	2.95 (1.70) ^b	3.71 (2.03) ^b	4.42 (2.08) ^b	5.83 (2.33) ^b	0.88 (1.14) ^{ab}	1.33 (1.30) ^{ab}	2.25 (1.65) ^b
6.	Untreated check		3.75	4.34 (2.11) ^b	5.25 (2.15) ^b	5.13 (2.36) ^b	12.60 (3.31) ^b	2.67 (1.66) ^b	3.62 (1.85) ^b	5.58 (2.44) ^c

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

five DAT in the above said treatments respectively. Imidacloprid 200 SL at 100 ml/ha and thiacloprid 240 SC at 75 ml/ha were on par with each other and gave cent per cent reduction at three DAT. Compared to all the above said treatments the efficacy of the standard oxydemeton methyl 25 EC at 500 ml/ha was inferior in controlling the leafhopper population. The population was maintained between 0.88 and 5.83/three leaves in this treatment and in untreated check it was between 2.67 and 12.60/three leaves during the period of observation.

Similar trend was maintained during the second spray also (Table 16). Thiacloprid 240 SC at 125 ml/ha and 100 ml/ha significantly reduced the population of leafhoppers at one DAT. At three DAT, cent per cent reduction was observed in all treatments except untreated check. The effects of different treatments persisted till 11th week and the leafhopper population was very low except in untreated check (11.04/three leaves).

4.1.4.4. Effect of thiacloprid 240 SC on seed cotton yield

The results on the yield of seed cotton in variety MCU 5 (Table 17) showed that thiacloprid 240 SC at 125 ml/ha recorded significantly higher yield (854.00 kg/ha) among the treatments compared. Thiacloprid 240 SC at 100 ml/ha, 75 ml/ha and imidacloprid 200 SL at 100 ml/ha were on par with each other but superior to the standard, oxydemeton methyl 25 EC at 500 ml/ha (504.65 kg/ha). When the yield increase over untreated check is considered, thiacloprid 240 SC at 125 ml/ha gave the maximum of 187.06 per cent followed by thiacloprid 240 SC at 100 ml/ha (139.92%), 75 ml/ha (133.66%), imidacloprid 200 SL at 100 ml/ha (126.99%) and oxydemeton methyl 25 EC at 500 ml/ha (69.63%) (Fig. 5).

4.2. Phytotoxic effect of thiacloprid

4.2.1. Pot culture studies

The results indicated that thiacloprid 240 SC at 1000 ml/ha and 2000 ml/ha had not caused any phytotoxic symptoms such as injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty in the cotton hybrid TCHB 213 and in cv. MCU 5.

Table 16. Bioefficacy of thiacloprid 240 SC foliar application against *A. biguttula biguttula* on cotton cv. MCU 5
Field Experiment II (January - June, 2001) Spray II

Sl. No.	Insecticides	Dose (ml/ha)	(8 th week) Pretreatment count	Mean population at different interval (days)							
				1**	3**	5**	7**	14**	21**	28**	
1.	Thiacloprid 240 SC	75	4.13	1.25 (1.29) ^b	0.00 (0.71) ^a	0.96 (1.20) ^b	2.85 (1.82) ^{bc}	3.50 (1.97) ^a	3.85 (2.06) ^a	4.19 (2.03) ^{ab}	
2.	Thiacloprid 240 SC	100	2.75	0.19 (0.83) ^a	0.00 (0.71) ^a	0.25 (0.86) ^{ab}	1.00 (1.18) ^{ab}	2.36 (1.63) ^a	3.84 (2.00) ^a	3.24 (1.79) ^a	
3.	Thiacloprid 240 SC	125	2.50	0.02 (0.72) ^a	0.00 (0.71) ^a	0.07 (0.76) ^a	0.34 (0.92) ^a	1.92 (1.54) ^a	2.05 (1.52) ^a	2.63 (1.71) ^a	
4.	Imidacloprid 200 SL	100	3.17	0.55 (1.02) ^{ab}	0.00 (0.71) ^a	0.75 (1.12) ^b	2.22 (1.58) ^{abc}	3.96 (2.01) ^a	3.92 (2.03) ^a	4.05 (1.96) ^a	
5.	Oxydemeton methyl 25 EC	500	6.42	2.71 (1.74) ^c	0.00 (0.71) ^a	1.13 (1.20) ^b	4.39 (2.08) ^c	3.59 (1.91) ^a	4.75 (2.19) ^a	5.35 (2.29) ^{ab}	
6.	Untreated check		7.67	9.30 (3.10) ^d	8.42 (2.95) ^b	7.57 (2.83) ^c	8.69 (2.99) ^d	12.07 (3.49) ^b	13.59 (3.70) ^b	11.04 (3.07) ^b	

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

Table 17. Effect of thiacloprid 240 SC foliar application on seed cotton yield in MCU 5 - Field Experiment II (January – June, 2001)

Sl. No.	Insecticides	Dose (ml/ha)	Seed cotton yield (kg/ha)**	Per cent increase over check
1.	Thiacloprid 240 SC	75	695.14 ^b	133.66
2.	Thiacloprid 240 SC	100	713.76 ^b	139.92
3.	Thiacloprid 240 SC	125	854.00 ^a	187.06
4.	Imidacloprid 200 SL	100	675.30 ^b	126.99
5.	Oxydemeton methyl 25 EC	500	504.65 ^c	69.63
6.	Untreated check	-	297.50 ^d	-

Mean of four observations

** Significant at P = 0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05)

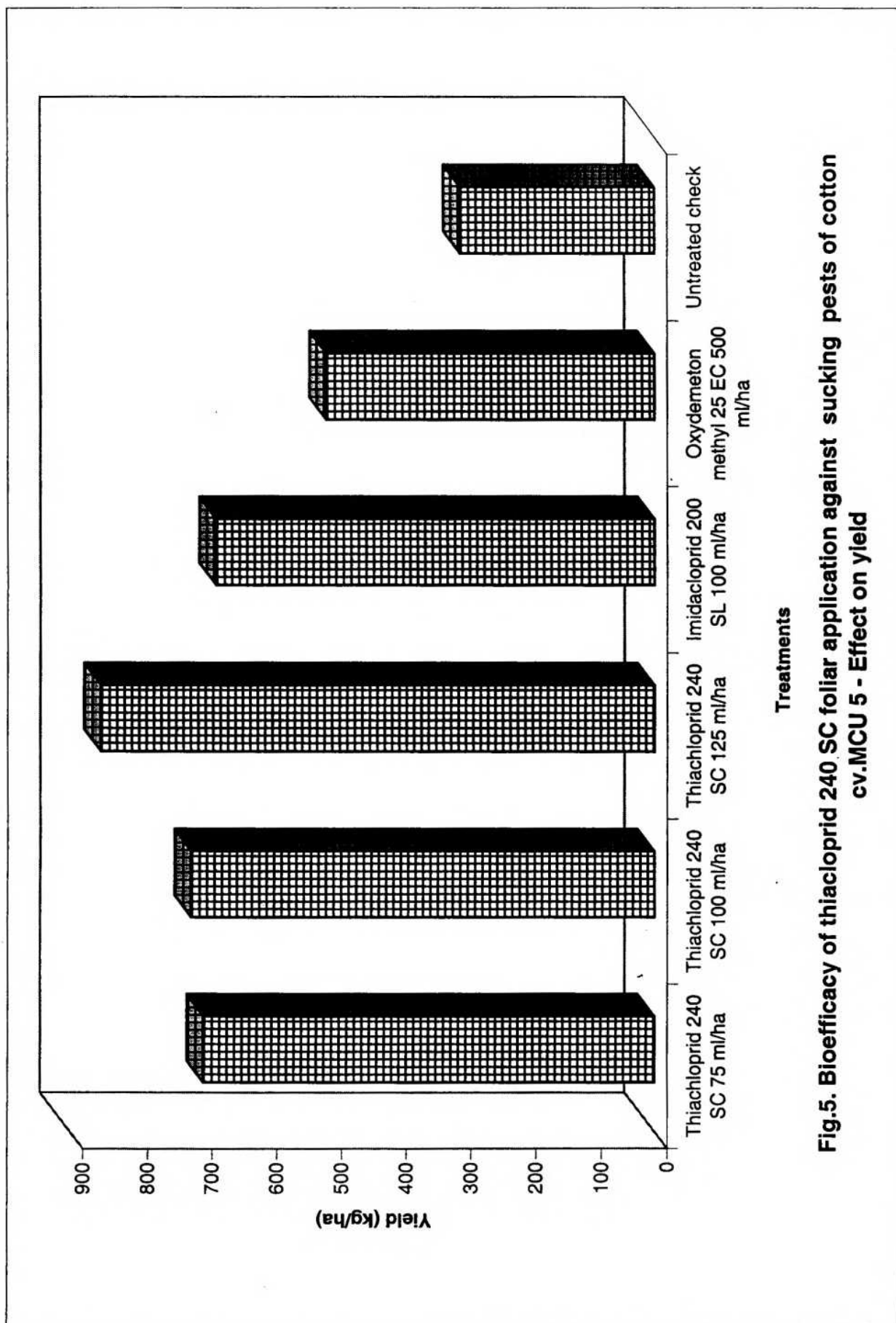


Fig.5. Bioefficacy of thiachloprid 240 SC foliar application against sucking pests of cotton cv.MCU 5 - Effect on yield

Table 18. Effect of thiacloprid 240 SC on the egg parasitoid, *Trichogramma chilonis* (Ishii)

Sl.No.	Insecticides	Dose (ml/ha)	Adult emergence (%) [#]	Parsitization (%) [#]
1.	Thiacloprid 240 SC	75	89.00 (70.87) ^a	88.67 (71.25) ^a
2.	Thiacloprid 240 SC	100	88.40 (70.82) ^a	89.33 (71.13) ^a
3.	Thiacloprid 240 SC	125	87.20 (69.46) ^a	87.07 (68.96) ^a
4.	Untreated check		90.40 (72.27) ^a	90.67 (74.28) ^a

Mean of four observations

[#] Not significant

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05)

Values in parentheses are arc sin transformed values.

4.2.2. Field Experiment

Results on the phytotoxic effect of thiacloprid 240 SC foliar applications under field conditions revealed that thiacloprid 240 SC at both the concentrations (1000 ml/ha and 2000 ml/ha) had not affected the growth of plants by imposing any of the phytotoxic symptoms like injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty.

4.3. Safety tests

4.3.1. Effect of thiacloprid on the parasitoid, *Trichogramma chilonis* (Ishii.)

The results on the safety of thiacloprid 240 SC on adult emergence and parasitization of *T.chilonis* (Table 18) revealed that thiacloprid 240 SC at all the doses tested did not affect both adult emergence and parasitization. The percentage of adult emergence and parasitization ranged from 87.20 to 90.40 per cent and 87.07 to 90.67 per cent respectively.

4.3.2. Effect of thiacloprid on the predator, *Chrysoperla carnea* (Stephens)

a. Ovicidal action

Effect of thiacloprid on egg hatchability of *C. carnea* showed that thiacloprid did not affect egg hatchability which ranged from 92.00 to 95.3 (Table 19).

b. Larval feeding method

Effect of thiacloprid 240 SC at all the doses tested is presented in the Table 20. From the results it is clear that thiacloprid at all doses caused grub mortality, the highest being 60 per cent at 125 ml/ha followed by 100 ml/ha (55%) and 75 ml/ha (54.75%). There was a significant difference in the grubs pupated. The highest pupation of 85 per cent was observed in untreated check and lowest being 40 per cent was observed in thiacloprid 240 SC at 125 ml/ha, followed by 100 ml/ha and 75 ml/ha (45%). The adult emergence was the highest (81%) in untreated check followed by thiacloprid 240 SC at 75 ml/ha (44%), 100 ml/ha (42.75%) and 125 ml/ha (39.25%).

Table 19. Effect of thiacloprid 240 SC on the predatory green lace wing, *Chrysoperla carnea* (Stephens) - eggs and adults

Sl. No.	Insecticides	Dose (ml/ha)	Ovicidal action		Adult feeding method	
			Hatchability (%) [#]	Mortality of eggs (%) [#]	Adult longevity (days) [*]	No. of eggs laid per 5 females ^{**}
1.	Thiacloprid 240 SC	75	92.50 (75.25) ^a	7.50 (14.75) ^a	12.30 ^b	345.42 ^b
2.	Thiacloprid 240 SC	100	92.80 (75.31) ^a	7.20 (14.69) ^a	11.76 ^b	328.57 ^{bc}
3.	Thiacloprid 240 SC	125	92.00 (74.39) ^a	8.00 (15.61) ^a	9.40 ^b	240.45 ^c
4.	Untreated check		95.30 (79.07) ^a	4.70 (10.93) ^a	19.60 ^a	556.64 ^a

Mean of four observations

[#] Not significant

^{*} Significant at P=0.05

^{**} Significant at P=0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are arc sin transformed values.

Table 20. Effect of thiacloprid 240 SC on the grubs of *C. carnea* - Larval feeding method

Sl. No.	Insecticides	Dose (ml/ha)	Mortality of grubs (%)**	Pupation (%)**	Adult emergence (%)**
1.	Thiacloprid 240 SC	75	54.75 (47.73) ^b	45.00 (42.70) ^b	44.00 (41.55) ^b
2.	Thiacloprid 240 SC	100	55.00 (47.89) ^b	45.00 (42.19) ^b	42.75 (40.83) ^b
3.	Thiacloprid 240 SC	125	60.00 (50.81) ^b	40.00 (39.19) ^b	39.25 (38.77) ^b
4.	Untreated check		15.00 (22.49) ^a	85.00 (67.51) ^a	81.00 (64.35) ^a

Mean of four observations

** Significant at P=0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are arc sin transformed values.

Table 21. Contact toxicity of thiacloprid 240 SC to the grubs of *C. carnea* - Dry film method

Sl. No.	Insecticides	Dose (ml/ha)	Mortality (%) at indicated h after treatment			Pupation (%) **
			12**	24**	48**	
1.	Thiacloprid 240 SC	75	20.00 (26.31) ^b	24.00 (29.27) ^b	28.00 (31.91) ^b	72.00 (58.33) ^b
2.	Thiacloprid 240 SC	100	22.00 (27.66) ^b	25.00 (29.96) ^b	28.00 (31.75) ^b	72.00 (58.21) ^b
3.	Thiacloprid 240 SC	125	27.00 (31.22) ^b	32.00 (34.42) ^c	38.00 (38.03) ^c	62.00 (52.00) ^b
4.	Untreated check		4.50 (11.91) ^a	9.50 (17.78) ^a	13.00 (20.99) ^a	87.00 (68.90) ^a

Mean of four observations

** Significant at P=0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are arc sin transformed values.

c. Dry film method

The results revealed that thiacloprid 240 SC at all doses tested caused grub mortality, the highest being 27 per cent at 125 ml/ha followed by 100 ml/ha (22%) and 75 ml/ha (20%) at 12 hours after treatment (HAT) (Table 21). Similar trend was observed at 24 and 48 HAT with highest mortality occurring at 48 HAT that ranged from 28 per cent to 38 per cent among the treatments. The highest pupation was observed in untreated check (87%) followed by thiacloprid 240 SC at 75, 100 (72%) and 125 ml/ha (62%).

d. Adult feeding method

Adult longevity was 19.6 days in untreated check while it was 12.3, 11.76 and 9.4 days in thiacloprid 240 SC at 75 ml/ha, 100 ml/ha and 125 ml/ha respectively. Significantly high egg laying was recorded in untreated check (556.64) followed by thiacloprid 240 SC at 75 ml/ha (345.42), thiacloprid 240 SC at 100 ml/ha (328.57) and thiacloprid 240 SC at 125 ml/ha (240.45) (Table 19).

4.2.3. Effect of thiacloprid on the predatory coccinellid beetle, *Menochilus sexmaculatus* (Fab.)

a. Grubs

Results on the mortality of grubs at 12, 24 and 48 HAT are furnished in Table 22, revealing that thiacloprid at all doses tested caused significant grub mortality, the highest being 78 per cent at 125 ml/ha followed by 100 ml/ha (74%) and 75 ml/ha (58%) at 12 HAT. Similar trend was observed till 48 HAT with no difference among the treatments.

b. Adults

The results of experiment based on dry film method to study the effect of thiacloprid 240 SC treatments on percent mortality of adults at 12, 24 and 48 HAT are furnished in Table 23. The results showed that thiacloprid 240 SC at all doses inflicted significant adult mortality, which ranged from 52.5 to 79.5 per cent at 12 HAT. Considerable increase in mortality was observed at 24 and 48 HAT. The per cent

Table 22. Contact toxicity of thiacloprid 240 SC to the grubs of predatory coccinellid, *Menochilus sexmaculatus* (Fab.)

Sl. No.	Insecticides	Dose (ml/ha)	Mortality (%) at indicated h after treatment		
			12**	24**	48**
1.	Thiacloprid 240 SC	75	58.00 (49.64) ^b	74.00 (59.50) ^b	86.50 (68.84) ^b
2.	Thiacloprid 240 SC	100	74.00 (59.38) ^c	82.50 (65.35) ^{bc}	90.50 (72.44) ^b
3.	Thiacloprid 240 SC	125	78.00 (62.36) ^c	86.50 (68.81) ^c	92.50 (74.18) ^b
4.	Untreated check		0.00 (0.74) ^a	2.10 (7.57) ^a	7.40 (15.54) ^a

Mean of four observations

** Significant at P=0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are arc sin transformed values.

Table 23. Contact toxicity of thiacloprid 240 SC to the adults of predatory coccinellid, *M. sexmaculatus*

Sl. No.	Insecticides	Dose (ml/ha)	Mortality (%) at indicated h after treatment		
			12**	24**	48**
1.	Thiacloprid 240 SC	75	52.50 (46.44) ^b	75.00 (60.13) ^b	90.00 (74.43) ^b
2.	Thiacloprid 240 SC	100	65.00 (53.79) ^c	80.00 (63.47) ^b	94.00 (76.00) ^b
3.	Thiacloprid 240 SC	125	79.50 (63.29) ^d	98.50 (84.04) ^c	99.75 (88.57) ^c
4.	Untreated check		0.00 (0.14) ^a	16.75 (23.99) ^a	25.00 (29.91) ^a

Mean of four observations

** Significant at P=0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are arc sin transformed values.

mortality of adults at 48 HAT ranged between 90 to 99.75 per cent, in the treatments, while in untreated check it was recorded as 25 per cent.

4.2.4. Indian Bee, *Apis cerana indica* F.

Results on the contact toxicity of thiacloprid to honey bees revealed that the median lethal concentration (LC_{50}) of thiacloprid was 7.65 ppm. The upper and lower fiducial limits were 17.62 and 3.32 respectively. The regression equation obtained from the probit analysis was $Y=1.032 + 1.022X$. LC_{50} value for the standard endosulfan was 9.02 and the regression equation obtained for endosulfan was $Y=2.22 + 1.39X$. The upper and lower fiducial limits for endosulfan were in the order of 13.00 and 5.00 respectively (Table 24; Fig.6.).

4.4. Residues of thiacloprid

The standard chromatogram and linearity curve of thiacloprid are illustrated in Fig.7 and 8. The mean recovery was 87.4, 82.5 and 82.7 per cent from fortified samples of lint, seed and oil at 2.5, 1.0 and 0.25 $\mu\text{g/g}$ levels respectively. The minimum detection limit of the instrument was 0.1 $\mu\text{g/g}$ and the determinability level in cotton lint and seed were 0.004 $\mu\text{g/g}$ as the weight of analytical sample was 25 grams and the final extract was 1 ml. The determinability in oil was 0.05 $\mu\text{g/g}$ considering two grams weight of sample and 1 ml of final extract.

For the first field experiment (November, 2000 - May, 2001) samples were collected on 45th and 55th days after last spray from the plots that received thiacloprid 240 SC at 125, 500 and 1000 ml/ha. Results of the High Performance Liquid Chromatographic analysis revealed that the residues of thiacloprid 240 SC were at below detectable limit (BDL) in samples of lint, seed and oil collected from the plots which received 125 ml/ha, except lint sample from first picking which contained 0.0079 $\mu\text{g/g}$ of thiacloprid residues. However, samples collected from the treatment 500 ml/ha contained residues that ranged from 0.0757 to 0.0851 $\mu\text{g/g}$ during first harvest but they were below detectable limit during third harvest. The lint, seed and oil samples collected from the plots, which received a higher dose of 1000 ml/ha contained residues ranging from 0.0994 to 0.1055 $\mu\text{g/g}$ from both the harvests (Table 25).

Table 24. Contact toxicity of thiacloprid to honeybees, *Apis cerana indica* F.

Sl. No.	Pesticides	Slope	Intercept	LC ₅₀ (µg/ml)			Safety Index
				Mean	LL	UL	
1.	Thiacloprid	1.0216	1.0324	7.65	3.32	17.62	0.85
2.	Endosulfan	1.3955	2.2181	9.02	5.00	13.00	1.00

All lines are good fit ($P < 0.05$)

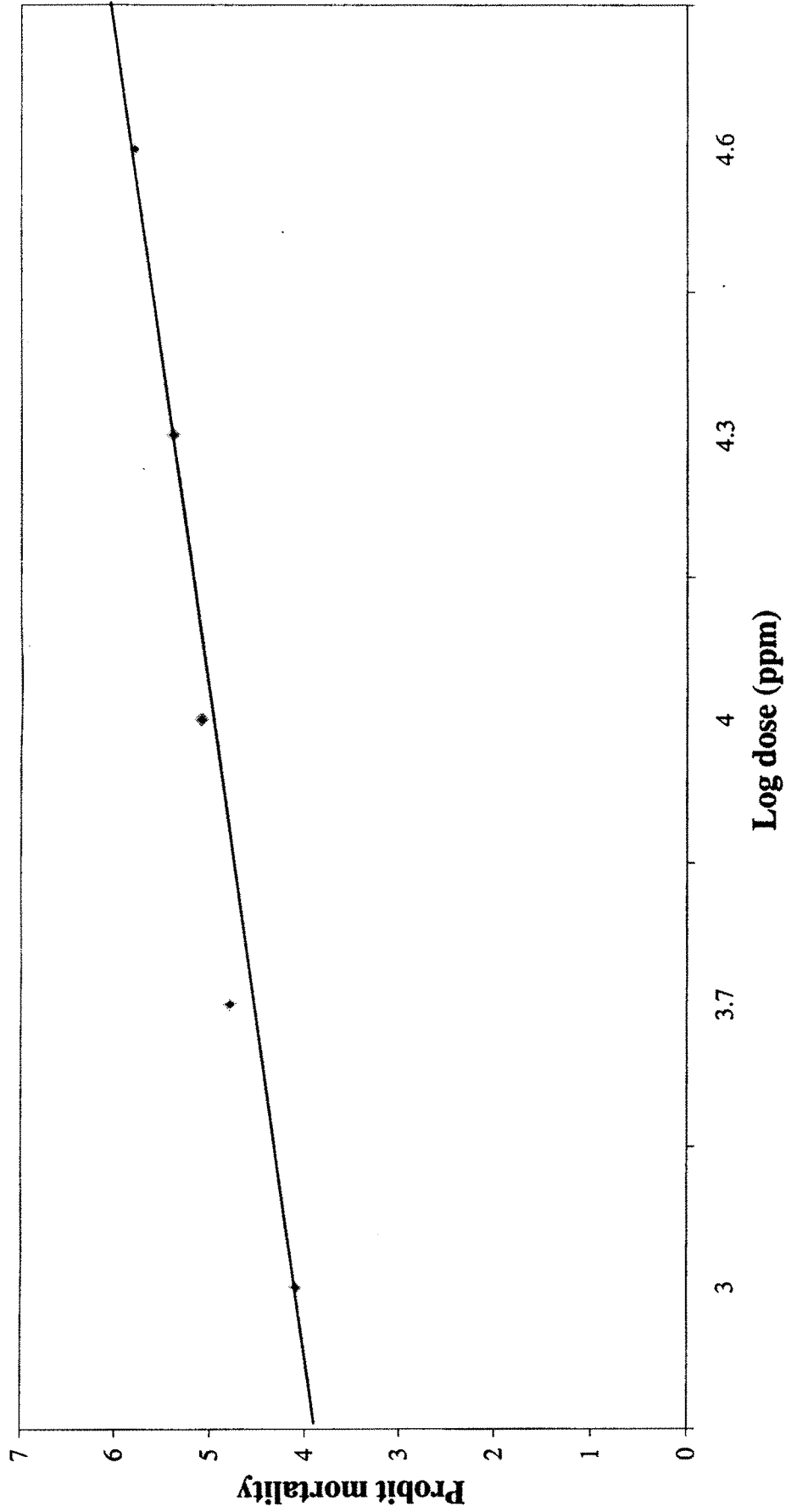
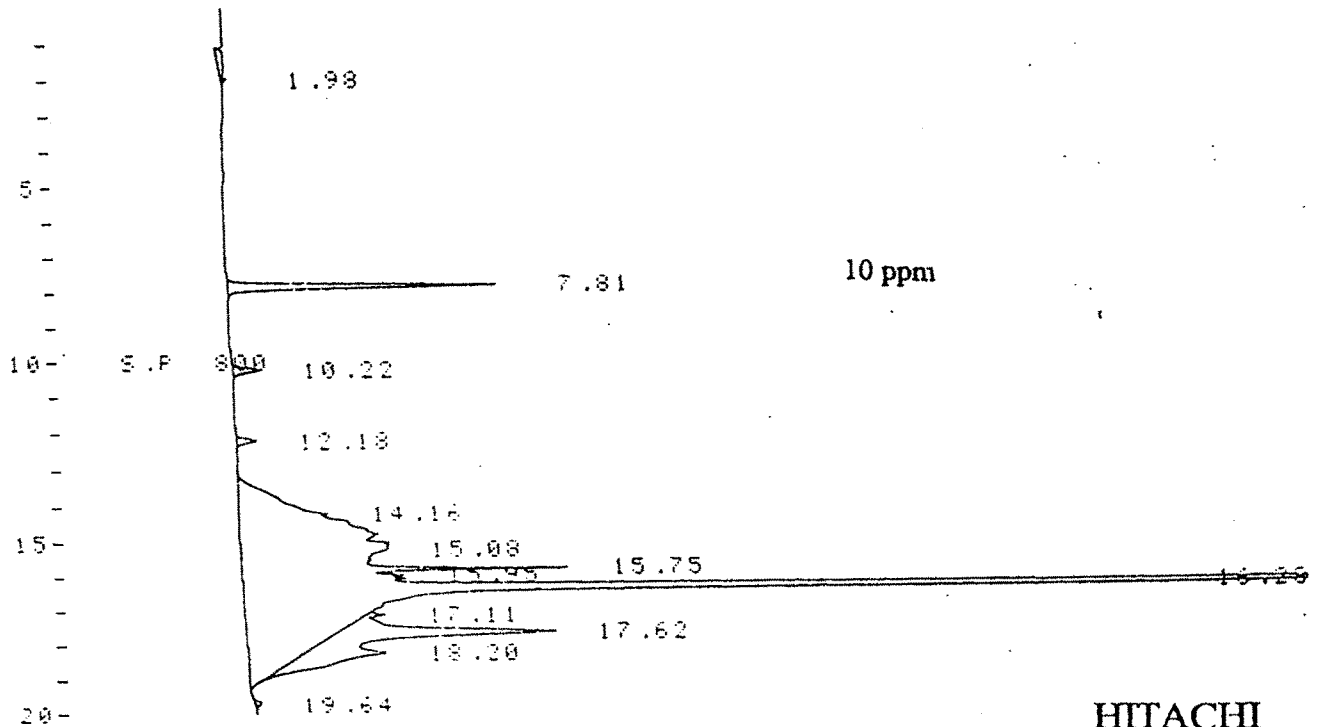
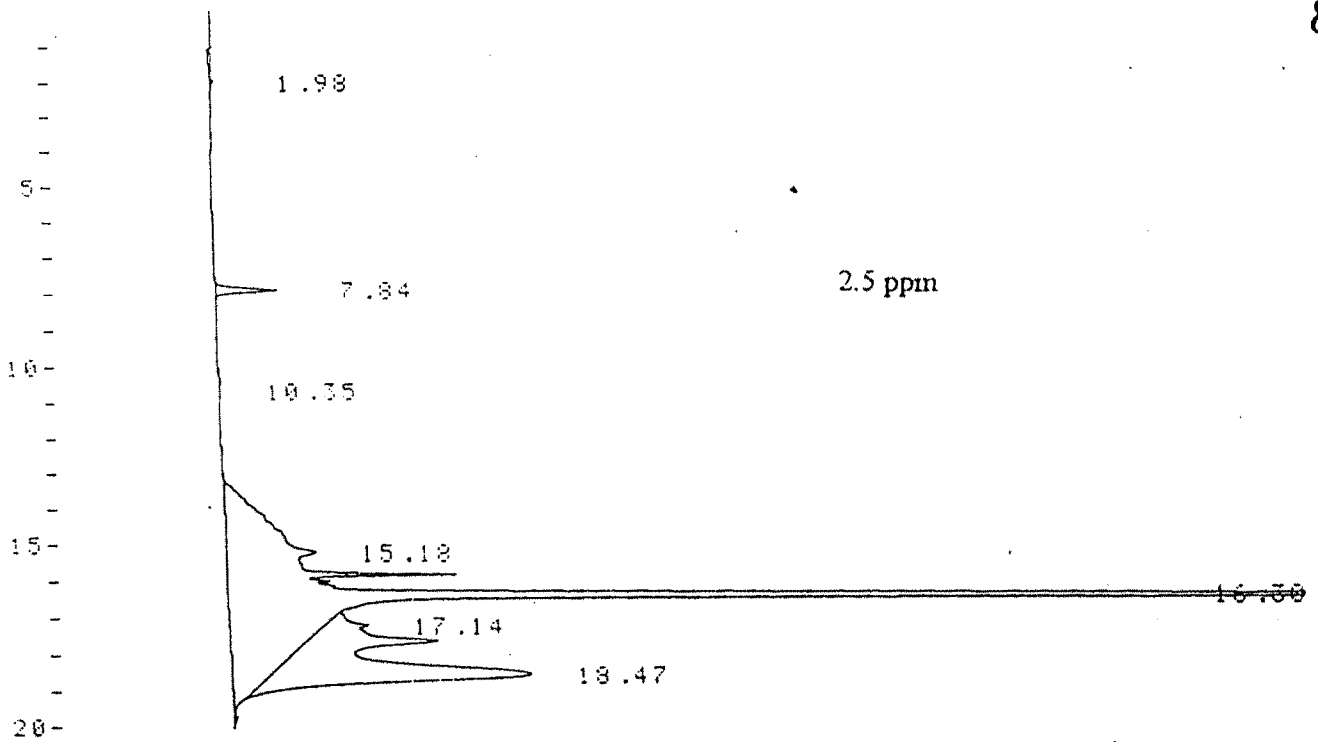


Fig.6. Log dose probit mortality curve for thiacloprid against *Apis cerana indica* F.



HITACHI
 Model L 6200-Intelligent Pu
 L-4000/L-4200 UV-VIS Det
 D 2500 Chromato integrator

Fig.7. Standard chromatogram of thiacloprid

X axis - concentration (ppm)

Y axis - area (mm²)

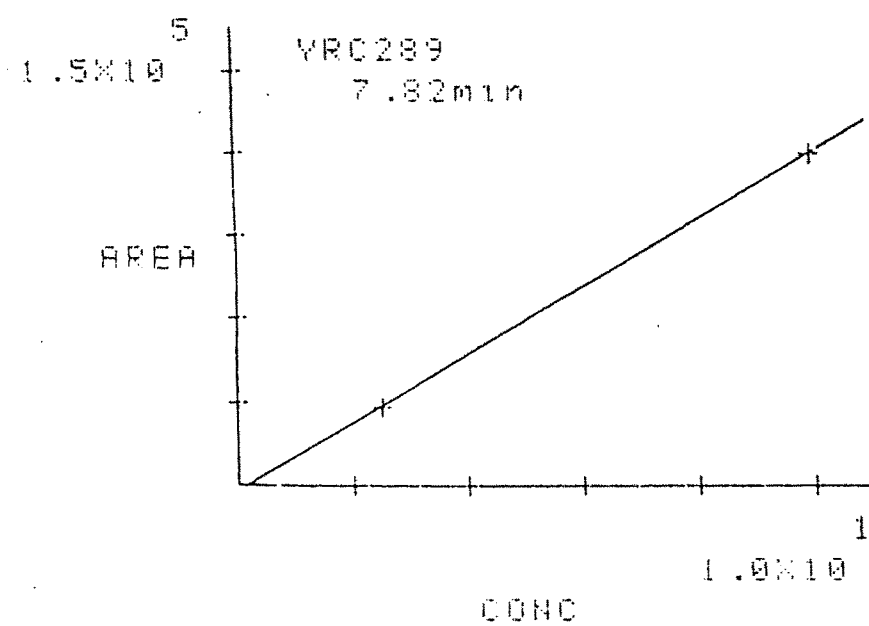


Fig.8. Linearity curve of thiacloprid

**Table 25. Harvest time residues of thiacloprid 240 SC on cotton seed, lint and oil
Field Experiment I (November, 2000-May, 2001)**

Sl. No.	Insecticides	Dose (ml/ha)	Lint		Seed		Oil	
			I Picking	III Picking	I Picking	III Picking	I Picking	III Picking
1.	Thiacloprid 240 SC	125	0.0079	BDL	BDL	BDL	BDL	BDL
2.	Thiacloprid 240 SC	500	0.0757	BDL	0.0851	BDL	0.0802	BDL
3.	Thiacloprid 240 SC	1000	0.1031	0.1016	0.1055	0.1007	0.1017	0.0994

Mean of five observations

BDL - Below Detectable Limit

Number of sprays - 2, on 28 and 60 days after sowing.

Sampling - 1st picking on 45 days after second spray
- 3rd picking on 55 days after second spray

For the second field experiment with cv. MCU 5 (January – June, 2001) samples were collected on 45th and 52nd days after second spray from the plots that received thiacloprid 240 SC at 125, 500 and 1000 ml/ha. Samples of lint, seed and oil collected from the treatment viz., 125 ml/ha contained 0.0967, 0.0901 and 0.0604 µg/g of residues during first harvest, which became untraceable during third harvest. But for the higher dose, 500 ml/ha the residues obtained in lint, seed and oil were in the order of 0.1316, 0.1344, 0.0994 µg/g and 0.1310, 0.1323 and 0.0555 µg/g respectively, during first and third harvests. Similarly, the treatment 1000 ml/ha resulted in 0.1336, 0.1479 and 0.1336 µg/g of thiacloprid residues on 45th day after second spray and 0.1317, 0.1334 and 0.1280 µg/g of thiacloprid on 52nd day after second spray (Table 26).

4.5. Effect of thiacloprid 240 SC foliar application against *Ferrisia virgata* (Ckll.) on *Dobernaemontana coronaria*

4.5.1. Laboratory Experiment

Influence of thiacloprid 240 SC on the development of crawlers were presented in Table 27. At one HAT, thiacloprid 240 SC at 125 ml/ha inflicted 90 per cent reduction followed by thiacloprid 100 ml (50%) and 75 ml/ha (49.50%). The standard oxydemeton methyl caused 20 per cent mortality while no mortality was observed in untreated check. Hundred per cent mortality observed at 12 HAT in thiacloprid 240 SC at 125 ml/ha and at 24 HAT, thiacloprid 240 SC at 100 ml/ha caused 100 per cent mortality followed by 75 ml/ha (85%) and the standard oxydemeton methyl caused 58 per cent mortality, while in untreated check 10 per cent mortality was observed.

4.6. Bioefficacy of thiacloprid 240 SC foliar application against *Saissetia oleae* (Oliv.) on *Dobernaemontana coronaria*

4.6.1. Field Experiment

Pre treatment population ranged from 98.75 to 160.50 per twig (Table 28). Thiacloprid 240 SC at 125 ml/ha significantly reduced the population (21.00 per twig) followed by thiacloprid 240 SC 100 ml/ha (29.75), 75 ml/ha (62.25) and oxydemeton methyl 25 EC 500 ml/ha (93.46) at one DAT. On three DAT, thiacloprid 240 SC at 100 ml/ha and 125 ml/ha were on par in controlling the black scale population. The effect persisted upto seven DAT and for the standard oxydemeton methyl, the effect persisted upto five DAT.

**Table 26. Harvest time residues of thiacloprid 240 SC on cotton seed, lint and oil
Field Experiment II (January-June, 2001)**

Sl. No.	Insecticides	Dose (ml/ha)	Lint		Seed		Oil	
			I Picking	III Picking	I Picking	III Picking	I Picking	III Picking
1.	Thiacloprid 240 SC	125	0.0967	BDL	0.0901	BDL	0.0604	BDL
2.	Thiacloprid 240 SC	500	0.1316	0.1310	0.1344	0.1323	0.0994	0.0555
3.	Thiacloprid 240 SC	1000	0.1336	0.1317	0.1479	0.1334	0.1336	0.1280

Mean of five observations

- BDL - Below Detectable Limit
 Number of sprays - 2, on 28 and 57 days after sowing.
 Sampling - 1st picking on 45 days after second spray
 - 3rd picking on 52 days after second spray

Table 27. Bioefficacy of thiacloprid 240 SC against *Ferrisia virgata* (Ckll.) under greenhouse condition

Sl. No.	Insecticides	Dose (ml/ha)	No. of crawlers released	% mortality at indicated h after treatment		
				1**	12**	24**
1.	Thiacloprid 240 SC	75	10	49.50 (44.71) ^b	55.00 (47.87) ^c	85.00 (67.24) ^b
2.	Thiacloprid 240 SC	100	10	50.00 (44.99) ^b	70.00 (56.77) ^b	100.00 (89.86) ^a
3.	Thiacloprid 240 SC	125	10	90.00 (71.62) ^a	100.00 (89.96) ^a	100.00 (89.86) ^a
4.	Oxydemeton methyl 25 EC	500	10	20.00 (26.55) ^c	36.75 (37.31) ^d	58.00 (49.61) ^c
5.	Untreated check	-	10	0.00 (0.05) ^d	0.00 (0.05) ^e	10.00 (18.38) ^d

Mean of four observations

** Significant at P=0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are arc sin transformed values.

Table 28. Bioefficacy of thiacloprid 240 SC foliar application against *Saissetia oleae* (Oliv.) - Field Experiment

Sl. No.	Insecticides	Dose (ml/ha)	Pre-treatment count	Mean population at different interval (Days)			
				1**	3**	5**	7**
1.	Thiacloprid 240 SC	75	160.50	62.25 (7.58) ^{bc}	31.5 (5.45) ^b	26.78 (5.04) ^b	24.64 (4.89) ^{bc}
2.	Thiacloprid 240 SC	100	98.75	29.75 (5.38) ^{ab}	14.88 (3.89) ^a	11.25 (3.37) ^{ab}	9.50 (3.12) ^{ab}
3.	Thiacloprid 240 SC	125	122.00	21.00 (4.50) ^a	8.40 (2.94) ^a	5.54 (2.27) ^a	3.55 (1.88) ^a
4.	Oxydemeton methyl 25 EC	500	135.45	93.46 (9.69) ^{cd}	67.73 (8.26) ^c	19.64 (4.43) ^b	38.14 (6.19) ^c
5.	Untreated check	-	117.25	119.00 (10.86) ^d	118.25 (10.86) ^d	134.25 (11.47) ^c	141.67 (11.70) ^d

Mean of four observations

** Significant at P=0.01

In a column, means followed by a common alphabet are not significantly different by DMRT (P=0.05).

Values in parentheses are transformed values $\sqrt{X+0.5}$.

DISCUSSION

CHAPTER V

DISCUSSION

Sustainability and environmental quality have become the key words for all agricultural development efforts in our country. The development of appropriate Integrated Pest Management (IPM) packages is an important and integral part of this effort (Raheja, 1993). Of the various components of IPM, pesticides are the most powerful tool since they are highly effective, rapid in curative action, adaptable to most situations, flexible in meeting the changing agronomic and ecological conditions and relatively economical. Several workers have reported the usefulness of chemical and botanical pesticides for the management of cotton sucking pests (Butani, 1967; Singh *et al.*, 1973 and Dhawan and Simwat, 1992) and till now, pesticides act as major tactic for their management.

Studies were conducted on the bioefficacy of thiacloprid 240 SC against sucking pests of cotton, coccids of ornamental plants; safety to natural enemies, phytotoxic effects, yield and harvest time residues in cotton. Since, thiacloprid 240 SC is in the early stage of evaluation and very few references are available, its performance has been compared with other standard chloronicotinyl insecticides too.

5.1. Bioefficacy of thiacloprid

5.1.1. Acute toxicity

The LC_{50} of thiacloprid to *A. gossypii* was 0.119 ppm. The low LC_{50} indicates that aphids are highly sensitive to thiacloprid (Table 1). According to Nauen and Elbert (1994) imidacloprid, another member of chloronicotinyl group of insecticides has also showed a very low LC_{50} value of 0.30 ppm for *A. gossypii* and 0.38 ppm for *M. persicae* from the assay using sachet test. Similar results were obtained by Kumar (1998) and Sivaveerapandian (2000) for *A. gossypii* and by Rameshbabu (1999) for *A. craccivora* with imidacloprid. The results from the present study have indicated that aphids are highly susceptible to chloronicotinyl insecticides and thiacloprid is more effective than imidacloprid in killing the aphid population.

5.1.2. Persistent toxicity

The results of persistent toxicity of thiacloprid 240 SC as foliar application against *A. gossypii* (Table 2) has shown that thiacloprid 240 SC at 125 ml/ha persisted for 29 days while thiacloprid 240 SC at 100 ml/ha and imidacloprid 200 SL at 100 ml/ha persisted for 25 days. The standard oxydemeton methyl persisted for 17 days and thiacloprid 240 SC at lower dose of 75 ml/ha persisted for 23 days. There was no marked difference in the persistent toxicity index (PTI) between the two higher doses (125 ml/ha and 100 ml/ha) of thiacloprid, but the difference do existed between the other treatments. Persistence of thiacloprid 240 SC was more against leafhoppers than against aphids. Thiacloprid 240 SC as foliar treatment persisted for 33 days at 125 ml/ha and for 31 days at 100 ml/ha. While the standard oxydemeton methyl persisted for 17 days, which showed no difference in the period of persistence against aphids and leafhoppers. There was a marked difference in the persistent toxicity index (PTI) between the treatments; the highest obtained by thiacloprid 240 SC at 125 ml/ha (2568.39) and the lowest from the standard oxydemeton methyl 25 EC, 500 ml/ha (959.14). This difference indicated the superiority of thiacloprid 240 SC over imidacloprid 200 SL and oxydemeton methyl 25 EC against aphids and leafhoppers on cotton. Kumar and Santharam (1999), Rameshbabu and Santharam (2000) and Sivaveerapandian (2000) have also confirmed that imidacloprid 200 SL at 200 ml/ha was superior to its lower level of 100 ml/ha and oxydemeton methyl. From afore said details it is clear that thiacloprid 240 SC at 125 ml/ha is more effective than imidacloprid 200 SL at 100 ml/ha against aphids and leafhoppers, both in period of persistence and persistent toxicity index (PTI).

5.1.3. Field experiments

The results from the laboratory studies indicated that thiacloprid 240 SC was effective in the control of aphids and leafhoppers. Hence two field experiments were conducted one during November, 2000 - May, 2001 with cotton hybrid TCHB 213 and the other during January - June, 2001 with cotton cultivar MCU 5. The results on the bioefficacy of thiacloprid 240 SC on population of thrips indicated that thiacloprid 240 SC at 125 ml/ha ranked first in controlling the thrips population and maintained its supremacy throughout the period of observation. However, thiacloprid 240 SC at 75 and

100 ml/ha were on par with imidacloprid 200 SL at 100 ml/ha and superior to oxydemeton methyl 25 EC 500 ml/ha. The effect of treatments persisted upto four weeks after spraying and after second spray also similar results were obtained.

The results on the bioefficacy of thiacloprid 240 SC during field experiment II (January - June, 2001) (Table 11) revealed that both thiacloprid 240 SC at 125 ml/ha and imidacloprid 200 SL at 100 ml/ha provided a complete control of thrips (0.0/three leaves) at one DAT. All the three doses of thiacloprid 240 SC (75, 100 and 125 ml/ha) and imidacloprid 200 SL at 100 ml/ha were superior to the standard oxydemeton methyl 25 EC at 500 ml/ha. Similar trend was maintained during the second spray also.

In case of aphids, the results from first and second field experiment clearly pointed out that thiacloprid 240 SC at 125 ml/ha was significantly superior over all other treatments followed by thiacloprid 240 SC at 100 ml/ha and 75 ml/ha. The bioefficacy of all thiacloprid treatments were greater than imidacloprid 200 SL at 100 ml/ha and oxydemeton methyl 25 EC at 500 ml/ha. The control of aphid population during second spray was comparatively higher than first spray, since the population recorded during pretreatment count was low when compared to first spray. The effect of different treatments persisted till 11th week after sowing while the population of aphids escalated as the season advanced. The results (Table 13) obtained from second field experiment clearly indicated that thiacloprid 240 SC at all levels was superior to imidacloprid 200 SL at 100 ml/ha and oxydemeton methyl 25 EC at 500 ml/ha. Similar were the results obtained during second spray (Table 14).

From the results of field experiment I, it is clear that thiacloprid 240 SC at 125 ml/ha gave excellent protection to cotton plants from leafhoppers. From Table 8, it is evident that this treatment gave complete control of leafhoppers upto seven DAT and even after four weeks after treatment the population was found to be very low (0.83/three leaves). Thiacloprid 240 SC at other two levels (75 and 100 ml/ha) was superior to oxydemeton methyl 25 EC at 500 ml/ha but on par with imidacloprid 200 SL at 100 ml/ha. Similar was the trend maintained during second spray also. It is inferred

(Table 15) from the second field experiment that the results obtained were same as that of field experiment I.

Seed treatment with imidacloprid was reported to be effective against thrips in many crops (Walunj and Mote 1995; Phipps *et al.*, 1996; Furr *et al.*, 1998; Cook *et al.*, 1999; El-Hamady and Sholoa, 1999 and Santos and Santos, 1999). Similarly Calafiori *et al.* (1999) proved that imidacloprid at 0.25 l/ha and thiacloprid 240 SC at 0.07 and 0.1 l/ha gave greater than 80 per cent control of thrips on Hirsutum cotton with a residual effect upto 20 days while Albuquerque *et al.* (1999) found that thiacloprid at 34 and 48 g a.i./ha and imidacloprid at 50 g a.i./ha were most effective treatments controlling thrips and aphids in cotton and this support the present finding.

In brinjal seed dressing with imidacloprid 70 WS (15 g/kg) followed by seedling root dip with 0.03 per cent imidacloprid was most effective in keeping the incidence of jassids and aphids down (Jarande and Dethe, 1994a). The satisfactory control of aphids in cotton exhibited by members of chloronicotinyls viz., imidacloprid and thiamethoxam was reported by Scarpellini and Nakamura (1999). The supremacy of imidacloprid 200 SL and 70 WS formulations to oxydemeton methyl 25 EC were demonstrated in cotton by Selim and Emam (1993); Kumar and Santharam (1999) and in bhendi by Mote *et al.* (1994) and Sivaveerapandian (2000). Similar were the results obtained by Mullins and Christie (1995); Belletini *et al.* (1999); Franco (1999) Koenig *et al.* (2000); Lucas *et al.* (1999); Santos and Santos (1999); Tomquelski *et al.* (1999); and Lawson *et al.* (2000) in various crops against *A.gossypii* and Woodford (1992) in potato, against *M. persicae*.

Patil *et al.* (1999) recorded least population of leafhoppers on cotton hybrids DCH 32 and NHM 44 treated with imidacloprid 70 WS at 10 g/kg of seed. Excellent control offered by imidacloprid against leaf and planthoppers in rice was observed by Mao-Lixin *et al.* (1995) and against green cicadellid, *Empoasca decedans* on peach by Rigo and Mori (1997) while in bhendi this was documented by Siva veerapandian (2000) and in wheat by Westhuizen *et al.* (1994), against Russian wheat aphid *Diuraphis hoxia* (Kurdjmov). Brar *et al.* (1999) found that imidacloprid 200 SL at 100 ml/ha was equivalent to oxydemeton methyl 25 EC 750 ml/ha in controlling leafhoppers in cotton.

Similar results were obtained by Khurana (2001). The above-mentioned reports about the influence of chloronicotinylns were also in close akin with present findings.

5.1.4. Effect on yield

The pest population had negative influence on the yield potential of cotton during both the field experiments. The yield loss due to sucking pests were reported to be 16.30 per cent and when neither sucking pests nor bollworms were controlled, 94.19 per cent yield was lost (Taley *et al.*, 1988). Highest yield of 1593.75 kg/ha was obtained in plots treated with thiacloprid 240 SC at 125 ml/ha, which gave 142.86 per cent increase over untreated check (Table 10), in cotton hybrid TCHB 213. All thiacloprid treatments recorded significantly higher yield. While in MCU 5 (Table 17), the same treatment (thiacloprid 240 SC at 125 ml/ha) again resulted in the highest yield of 854.00 kg/ha with 187.06 per cent increase over untreated check. (Highest yield obtained from this treatment was attributed to its optimal pest suppression coupled with other growth promoting characters, which was well documented previously by many authors (Attique and Ghaffar, 1996; Gupta *et al.*, 1998 and Kumar, 1998) in cotton, in bhendi by Sivaveerapandian (2000) and in wheat by Westhuizen *et al.* (1994).) Apart from that, the incidence of bollworms were also poor since the reproductive stage of the crop coincided with the hot months of April and May which might have had some indirect influence on the higher seed cotton yield. Jayaraj (1990) also documented earlier that the damage caused by American bollworm, *Helicoverpa armigera* (Hubner) was severe during the cooler months, i.e., from October to February, in many parts of South India. Irrespective of the seasons the untreated plots recorded higher levels of pest population and lowest yields and this was due to lack of effective pest control measure.

5.1.5. Phytotoxicity

From the greenhouse and field experiments, to find out the phytotoxicity effect of thiacloprid 240 SC applied as foliar spray the results indicated that the treatments even at 10 and 20 times the normal dose had neither affected the growth and development of plants nor caused any phytotoxic symptoms on the plants in both the hybrid TCHB 213 and the variety MCU 5. The results obtained by Kumar (1998) were also in agreement with the present finding, that seed treatment of imidacloprid 70 WS even at 40 g/kg of

cotton seed did not affect either the germination or the growth and development of cotton plants. Mote *et al.* (1994) observed the same results in okra. Similar were the results reported by Walunj and Mote (1995) on tomato and by Biase and Russo (1996); Jogindersingh *et al.* (1996) and Lucas *et al.* (1999) on cotton while in bhendi by Sivaveerapandian (2000). Apart from this, Elbert *et al.* (1991) reported that imidacloprid even at 1000 ppm caused no phytotoxicity on apple, bush bean, chrysanthemum, cucumber, cabbage, soybean and tomato. The present findings confirm that even at higher dose than the recommended dose this chemical had no adverse effect on the development and growth of cotton plants.

5.2. Safety of thiacloprid 240 SC to parasitoids and predators

Studies on the safety of thiacloprid 240 SC to the egg parasitoid, *Trichogramma chilonis* (Ishii) obviously revealed that thiacloprid 240 SC at all the doses tested was found to be totally innocuous to the adult emergence and parasitization. The adult emergence took place normally which ranged from 87.20 to 90.40 per cent and parasitization from 87.07 to 90.67 per cent. Kumar (1998) also indicated that imidacloprid 200 SL at 100 and 150 ml/ha had no adverse effect on the egg parasitoid *T. chilonis*. He reported that per cent adult emergence ranged between 87.82 and 89.53 per cent while the per cent parasitization between 88.09 and 90.50. The less toxic nature of thiacloprid 240 SC observed in the present study also agrees closely with the findings of Viggiani *et al.* (1998) who observed that imidacloprid 200 SL did not affect the development and adult emergence of *Encarsia formosa* in pupal cases of *Trialeurodes vaporarium*, under laboratory conditions. They also proved the safety of imidacloprid on the emergence of braconids, chalcids and cynipoids from mummies of *Aphis spiraecda* on mandarins in the field. This supports the present finding, that chloronicotinyls have no significant adverse effect on the egg parasitoid *T. chilonis* (Table 18).

The results on the ovicidal action on the predator, *Chrysoperla carnea* (Stephens) (Table 19) indicated that thiacloprid 240 SC at all the three doses had not prevented the per cent hatchability, which varied from 92.00 to 95.3. In the larval feeding method (Table 20) thiacloprid 240 SC at 125 ml/ha caused grub mortality to a maximum of 60 per cent, followed by 100 ml/ha (55%) and 75 ml/ha (54.75%). Similar trend kept

continued in case of per cent pupation and adult emergence with maximum pupation (85.00%) and adult emergence (81.00%) exhibited in untreated check. Kumar (1998) also reported that imidacloprid 200 SL at 100 and 150 ml/ha did not affect the hatchability of eggs but did affect the development of grubs and caused 70 per cent (150 ml/ha) and 60 per cent (100 ml/ha) mortality of grubs. In case of dry film method, mortality of grubs slightly increased from 12 HAT to 48 HAT with highest mortality recorded in thiacloprid 240 SC at 125 ml/ha (38%) followed by 100 ml/ha (28%) and 75 ml/ha (28%). Here (contact toxicity) the per cent pupation was higher when compared with the larval feeding method where the eggs of *C. cephalonica* were sprayed with different treatments that forced the grubs to ingest the chemical. Elzen *et al.*(1998) found that though *C.carnea* was highly sensitive to most of the insecticides including imidacloprid, Toda and Kashio (1997) reported that imidacloprid was less toxic to *C.carnea* larvae while most of the organophosphorous insecticides showed higher levels of toxicity.

The adult longevity in thiacloprid 240 SC at 75, 100 and 125 ml/ha was 12.3, 11.76 and 9.4 days respectively (Table 19), while it was 19.6 days in untreated check. Though thiacloprid 240 SC at all the doses tested reduced the adult longevity, there was no significant variation between these three doses. Significantly higher number of eggs were laid in untreated check (556.64) compared to 345.42, 328.57 and 240.45 in thiacloprid 240 SC at 75, 100 and 125 ml/ha, respectively indicating that egg laying was also affected. The results obtained from the present study were in accordance with the results obtained by Kumar (1998). He reported that imidacloprid 200 SL at 100 and 150 ml/ha reduced the adult longevity by eight to ten days and the eggs laid per five females were reported to be 308.0 and 268.2 at 100 and 150 ml/ha which were significantly less when compared to untreated check which produced a maximum of 603.8 eggs/five females. Keillor and Godfrey (2000) reported that imidacloprid (as Provado) had the least effects on natural enemies in California cotton. Katole and Patil (2000) also proved that seed treatment with imidacloprid 70 WS (8 and 10 g) and thiamethoxam 70 WS (4 and 5 g/kg) were safer than foliar sprays that thiamethoxam at

4 g/kg seed allowed maximum oviposition of *C. carnea* which was on par with untreated control.

The results (Table 22) on the mortality of grubs of *Menochilus sexmaxulatus* (Fab.) at 12, 24 and 48 hours after treatment (HAT) showed that significant mortality occurred compared to untreated check, which ranged from 86.5 to 92.5 per cent at 48 HAT. But there was no significant difference between the doses tested (75,100 and 125 ml/ha) in causing mortality of grubs. The results (Table 23) on mortality of adults at 12, 24 and 48 HAT indicated that all the doses of thiacloprid 240 SC tested inflicted significant adult mortality, which ranged from 52.5 per cent to 79.50 per cent at 12 HAT. In the present investigation, the results revealed that thiacloprid 240 SC at the doses tested had detrimental effects on both grubs and adults of *M. sexmaculatus*.

The present findings were in confirmity with the results obtained by Katole and Patil (2000) who studied the biosafety of imidacloprid 70 WS, 17.8 SL and thiamethoxam 70 WS, 25 WG along with oxydemeton methyl 25 EC. The results revealed that the populations of ladybird beetles were maximum in plants raised from imidacloprid 10 g/kg and thiamethoxam five g/kg seed treated plots, which were on par with untreated check. They concluded that seed treatment even at higher doses were more safer than foliar sprays. Patil and Lingappa (1999) also found that imidacloprid was 13.78 times as toxic as oxydemeton methyl under laboratory conditions at $27 \pm 1^{\circ}\text{C}$ and $70 \pm 5\%$ RH. Viggiani *et al.* (1998) reported the lethal persistence of imidacloprid 200 SL in the field, as tested against *Rodalia cardinalis*, was upto 20 days. Mullins (1993) reported that imidacloprid was physiologically active against a wide range of insects, including some beneficial species. Stark *et al.* (1995) found that imidacloprid was topically toxic to an aphidiid parasitoid, *Aphidius ervi* Haliday, adults and larvae of the coccinellid, *Hippodamia convergens* Guerin-Meneville. It also was toxic to a predatory pentotomid bug, *Podisus maculiventris* (Say), when exposure occurred topically, by residual contact, or from ingestion, although oviposition and egg hatch were not affected by sub lethal exposure of females (De Cock *et al.*, 1996). Similarly, Mizell and Sconyers (1992) reported topical toxicity of imidacloprid to eggs and adults of *Chrysoperla rufilabris* (Burmeister). Kunkel *et al.* (1999) reported that imidacloprid had

relatively little impact on most groups of beneficial invertebrates in turf grass ecosystem. The above reports support the results obtained from the present study.

From the results on the contact toxicity of thiacloprid to honeybee, *Apis cerana indica* F. (Table 24), the LC₅₀ value of thiacloprid (7.65ppm) was comparable with endosulfan (9.02ppm) since the safety index were in close proximity with each other (0.85 and 1.00). Malik (1999) reported that endosulfan 35 EC had least effect on the population in mustard fields after two sprays. The finding of Rathore (2000) also supports the safety of endosulfan to rockbee, *Apis dorsata* that proved to be least disruptive to the rockbee foragers. Mayer *et al.* (1994) also reported that late evening application of imidacloprid had minimal effect to leaf cutting bees, honeybees and bumble bees. Ambolet *et al.* (1999) found that the influence of imidacloprid on honeybees, in sunflower when used as seed dressing chemical was nil. In controlled feeding experiments also they observed no adverse effect when the bees were fed with spiked sugar solution containing upto 20 ppb imidacloprid, which was in consonance with the present finding. Bhuvaneswari (1991) found that LC₅₀ values of two pyrethroids namely alphasmethrin and cypermethrin were 0.0314 ppm and 0.2765 ppm respectively, which were found to be toxic to bees. The above finding confirms that chloronicotinyls are highly safer than pyrethroids and are equal in activity on honeybees with endosulfan. This reveals that thiacloprid is harmless to bees and can be used before, during and after flowering, giving flexibility offered by very few other insecticides.

A selective insecticide is one that is more toxic to some insect species than to others (Croft, 1990). Selectivity can be physiological, reflecting species-specific differences in uptake, detoxification, or excretion of a toxin or ecological, arising through differential exposure. Ecological selectivity may result from differences in behaviour, or be a function of pesticide distribution, spray timing, or other factors (Croft, 1990 and Jeppson *et al.*, 1995). Thus, laboratory toxicity tests may not always reflect a pesticide's impact on non-target invertebrates in the field (Stark *et al.*, 1995).

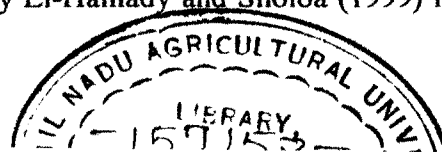
The present studies on the biosafety of thiacloprid 240 SC indicated that thiacloprid 240 SC at all doses tested were safe to *T. chilonis* (both parasitisation and

adult emergence) and the egg hatchability of *C. carnea*. But did affect the development of grubs and adult longevity and egg hatchability of both *C. carnea* and *M. sexmaculatus*. The chemical caused significant mortality of grubs and adults of predators in the laboratory where they were confined to a small container and exposed continuously. Further, the chances of degradation of the insecticide due to external environmental factors are meagre under laboratory conditions. However, in the field, chances of susceptible stages of natural enemies ingesting the chemical immediately after application are less. Also, there are chances, that the natural enemies may shift to adjacent plants which have not received the treatment. Further, the foliar treatments are given at four to five weeks interval. In the light of these, the adverse impact of thiacloprid 240 SC foliar application in the field will not be the same when compared to laboratory conditions. Finally it is concluded that the release of natural enemies can be done in such a way that there exists a gap of about three to five days between chemical treatment and the release of natural enemies, so as to avoid the harmful effects of the chemical, if any.

5.3. Residues of thiacloprid

Results on the estimation of residues of thiacloprid 240 SC in the lint, seed and oil from first and third harvest in both the field experiments are furnished in Table 25 and 26. The residues of thiacloprid 240 SC in the plot that received 125 ml/ha was detectable only during first harvest and it went below detectable limit during third harvest in the second field experiment (January – June, 2001). While it was below detectable limit during both the harvests in the case of first field experiment (November, 2000 - May, 2001). But the plants, which received higher doses of thiacloprid 240 SC (500 and 1000 ml/ha) recorded residues both during first and third harvests.

Iwaya *et al.* (1998) also found final crop residues of 0.002 mg/kg of imidacloprid in rice when applied at 200 g a.i./ha. The results of the present study are in agreement with Dikshit *et al.* (2000) who reported that the residues of imidacloprid in okra fruits when applied at 3, 5.4, 10.8 and 21.6 g a.i./kg of seeds were found to be 0.08, 0.10, 0.40 and 0.24 mg/kg respectively, after 55 days after sowing but became non-detectable after 60 days after sowing. Similar was the report made by El-Hamady and Sholoa (1999) in



cotton stating that the residue of imidacloprid seed dressed at 280 g/40 kg seeds reached to a minimum of 0.016 ppm in the soil on sixth week. The maximum residue limit (MRL) of thiacloprid for cotton has not established yet. In the case of imidacloprid it has been fixed at four ppm (Placke and Weber, 1993). Considering this, the terminal residues now detected even at a higher dose of 1000 ml/ha were well below the MRL and as such safe to consumers. Also, from the field efficacy studies it is obvious that thiacloprid was effective at 100 and 125 ml/ha. Hence there is no necessity to go in for higher doses like 500 and 1000 ml/ha though they have not produced any phytotoxic symptoms in cotton plants.

5.4. Bioefficacy of thiacloprid 240 SC against coccids

Considering the results of greenhouse experiment on the efficacy of thiacloprid 240 SC against *Ferrisia virgata* (Ckll.) (Table 27), thiacloprid 240 SC at 125 ml/ha was superior in causing mortality of crawlers followed by thiacloprid 240 SC at 100 ml/ha and 75 ml/ha. All the thiacloprid treatments were superior to the standard oxydemeton methyl 25 EC. Similar results were found by Cranshaw *et al.* (2000) and they reported imidacloprid as Merit was most effective to control *Phenaecoccus dearnessi* (King) on *Crataegus* spp. Suresh (1994) reported oxydemeton methyl 25 EC at 500 ml/ha (0.025%) was on par with dimethoate 30 EC 0.03 per cent and neem oil two per cent in controlling *Pulvinaria maxima* (Green) and *Maconellicoccus hirsutus* (Green).

In the case of field experiment (Table 28), all the doses of thiacloprid 240 SC were found to be superior than the standard, oxydemeton methyl 25 EC at 0.25 per cent. Suresh (1994) studied the efficacy of oxydemeton methyl 25 EC at 0.025 per cent along with monocrotophos 36 WSC at 0.04 per cent and phosphamidon 85 WSC at 0.01 per cent and concluded that all the treatments compared were equally effective in checking the population of *Coccidohystrix insolita* (Green). Dhandapani *et al.* (1992) reported that monocrotophos 36 WSC at 0.036 per cent was superior than oxydemeton methyl 25 EC at 0.025 per cent which gave 84.50 per cent reduction whereas oxydemeton methyl produced only 53.10 per cent reduction of jasmine mealybug, *Planococcus lilacinus* (Ckll.)

To conclude, the results of the studies have indicated that foliar treatment with thiacloprid can be given based on the population status of the pests in the field (at ETL) since thiacloprid 240 SC exhibits excellent physiological selectivity through its translaminar transport and interfering the cholinergic nervous system, rendering its adverse effects only upon the plant sap sucking insects and have no influence on other fauna on the foliage in the field. As the efficacy of thiacloprid persisted for 33 days under greenhouse conditions and 28 days under field conditions, foliar treatment of thiacloprid 240 SC can be harmoniously integrated in the IPM programme. The present finding confirms that thiacloprid shows high acute toxicity to its target organism but having low acute toxicity to non-target organism and stand out by virtue of its harmlessness to pollinating insects, and the other beneficial organisms are affected only slightly, if not at all. From the results of field trials it is obvious that thiacloprid treatment increased the seed cotton yield. Since the quantity of thiacloprid 240 SC applied at per unit cropped area is less when compared to the recommended chemicals that are in vogue at present.

In future, research can be taken up to study the dissipation of thiacloprid 240 SC in cotton, to fix the safe waiting period and also the maximum tolerance limit for its residues. It is inevitable that research should be triggered simultaneously to find out possible development of resistance in target insects to this molecule.

SUMMARY

CHAPTER VI

SUMMARY

Detailed studies were undertaken in cotton on the bioefficacy of thiacloprid 240 SC as foliar application against thrips, aphids and leafhoppers, persistence, phytotoxic effect, safety to non-target organisms, influence on seed cotton yield and harvest time residues. Besides, bioefficacy of thiacloprid 240 SC as foliar application against coccids of important ornamental crops was also studied. The results of the experiments are summarised in this chapter.

- The result on acute toxicity of thiacloprid to *Aphis gossypii* (Glov.) indicated that fifty per cent mortality (LC_{50}) was obtained at a very low concentration of 0.119 ppm.
- The effect of thiacloprid 240 SC as foliar application on *A. gossypii* and *Amrasca biguttula biguttula* (Ishida) revealed that the chemical persisted for 29 DAT against aphids and 33 DAT against leafhoppers at 125 ml/ha. While thiacloprid 240 SC at 100 ml/ha persisted for 25 DAT against aphids and 31 DAT against leafhoppers, indicating increase in dose increased the efficacy of the chemical.
- The influence of thiacloprid 240 SC on adult emergence and per cent parasitization of egg parasitoid, *Trichogramma chilonis* (Ishii) showed that, thiacloprid 240 SC at all the three levels did not affect the parasitoid.
- Thiacloprid 240 SC was totally innocuous to the egg hatchability of predatory green lacewing *Chrysoperla carnea* (Stephens). But there existed a significant mortality of grubs when the grubs were fed with eggs of *Corcyra cephalonica* Staint. treated with thiacloprid 240 SC (Larval feeding method) also when the surface was treated with thiacloprid 240 SC (Dry film method). Similarly, there was a significant adverse effect on the longevity and fecundity of *Chrysopa* adults when thiacloprid 240 SC was fed with honey solution. But these results indicated that the increase in dose hardly increased the adverse effect.

- The influence of thiacloprid 240 SC on grubs and adults of *Menochilus sexmaculatus* (Fab.) assessed using dry film method revealed that thiacloprid 240 SC at all the doses tested caused mortality.
- The LC₅₀ for *Apis cerana indica* F. obtained was 7.65ppm and the contact toxicity of thiacloprid to Indian bee foragers was comparable with endosulfan (9.02ppm).
- The results of two field experiments during November, 2000 - May, 2001 with cotton hybrid TCHB 213 and another during January - June, 2001 with cotton variety MCU 5 revealed that thiacloprid 240 SC as foliar application at 100 ml/ha and 125 ml/ha were effective against the sucking pests viz., thrips, aphids and leafhoppers. Between these two levels thiacloprid 240 SC at 125 ml/ha reigned superior.
- Thiacloprid 240 SC as foliar application at all the doses tested resulted in increased seed cotton yield.
- No phytotoxic symptoms were observed, when thiacloprid 240 SC was sprayed on cotton plants even at a higher doses like 1000 and 2000 ml/ha during both the field and greenhouse experiments.
- The residues of thiacloprid 240 SC at 125 ml/ha were at below detectable limit in lint, seed and oil samples collected from both the field experiments. The samples collected from the plots that received higher doses of thiacloprid 240 SC at 500 and 1000 ml/ha contained residues on 52nd and 55th days after treatment from both the field experiments.
- Thiacloprid 240 SC at 125 ml/ha inflicted hundred per cent mortality of crawlers within 12 hours after treatment (HAT) in *Ferrisia virgata* (Ckll.) followed by thiacloprid at 100 ml/ha which produced hundred per cent mortality at 24 HAT.
- Thiacloprid 240 SC at 125 ml/ha gave good control of *Saissetia oleae* (Oliv.) and was superior to oxydemeton methyl 25 EC at 500 ml/ha.

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* Originals not seen

