BIOEFFICACY OF CERTAIN INSECTICIDES AGAINST MAJOR PESTS OF CASTOR

BY

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CERTIFICATE

This is to certify that the thesis entitled **“BIOEFFICACY OF CERTAIN INSECTICIDES AGAINST MAJOR PESTS OF CASTOR”** submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Mr. N. SRINIVAS** under our guidance and supervision. The subject of the thesis has been approved by the student’s advisory committee.

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

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Mr. N. SRINIVAS, has satisfactorily prosecuted the course of research and that the thesis entitled **“BIOEFFICACY OF CERTAIN INSECTICIDES AGAINST MAJOR PESTS OF CASTOR”** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part there of has not been previously submitted by him for a degree of any university.

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Major Advisor

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DECLARATION

I, N. SRINIVAS, here by declare that the thesis entitled **"BIOEFFICACY OF CERTAIN INSECTICIDES AGAINST MAJOR PESTS OF CASTOR"** submitted to **ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY** for the post graduate degree of **MASTER OF SCIENCE IN AGRICULTURE** is a result of original research work done by me. I also declare that the thesis or part there of has not been published earlier elsewhere in any manner.

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LIST OF ABBREVIATIONS

±	:	Plus or minus
%		Per cent
$\chi 2$	:	Chi-square
^{o} C	:	degree centigrade
a.i./A	:	Active ingredient/Acre
Cm	:	Centimeter
DAS	:	Day(s) after spraying
etc.	:	Etcetera
et al	:	And others
fg/g	:	Femptogram per gram
fg/larvae	:	Femptogram per larvae
Fig	:	Figure
G a.i./ha	:	Gram active ingredient/hectare
G	:	Grams
G/ha	:	Gram/hectare
Hrs	:	Hours
i.e.	:	That is
kg a.i./ha	:	Kilogram active ingredient/hectare
lb a.i./ha	:	Pound active ingredient/hectare
LC	:	Lethal Concentration
LD	:	Lethal Dose
mg/kg	:	Milligrams/kilogram
mg/lit	:	Milligrams/litre
mg/ml	:	Milligram/milliliter
ml	:	Milliliter
viz.	:	Namely
µ	:	micron
RBD	:	Randomized block design
EC	:	Emelsifiable concentrate
SC	:	Soluble concentration
WP	:	Wettable powder

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ABSTRACT

A field study on bioefficacy of certain insecticides against major pests of castor was carriedout at Gunegel Research Farm, CRIDA, Ranga Reddy. Laboratory experiments with selected insecticides *viz.*, indoxacarb, thiodicarb and spinosad against third instar larvae of castor semilooper, *Achaea janata* (Linneaus), tobacco caterpillar, *Spodoptera litura* (Fabricius) and *Euproctis spp*. (Walker) were also conducted at CRIDA, Santhoshnagar, Hyderabad.

In field experiment insecticides *viz.*, spinosad, indoxacarb, thiodicarb profenofos, cartap hydrochloride, endosulfan and chlorpyrifos were applied at recommended concentrations as foliar sprays at 45 and 60days after sowing. The population of insect pests and natural enemies were recorded one day before as well as first, fifth and tenth day after imposing treatments.

Spinosad 0.01125, spinosad 0.015, thiodicarb 0.075, indoxacarb 0.0145, indoxacarb 0.0108 and thiodicarb 0.056 per cent were equally and highly effective against *A.janata*

In respect of *S. litura* indoxacarb 0.0108, thiodicarb 0.056 and indoxacarb 0.0145 per cent exhibited superior control over untreated check. Spinosad 0.015 recorded 82.76% reduction of *Euproctis spp*. population over untreated check.

Cartap hydrochloride 0.0375 as well as chlorpyrifos 0.04 and profenofos 0.05 per cent were toxic to *M.maculipennis* by recording 53.23, 48.05 and

47.63 per cent reduction. Indoxacarb 0.0108, spinosad 0.01125 and indoxacarb 0.0145 per cent were relatively less toxic to *M.maculipennis* population.

Thiodicarb 0.056, spinosad 0.0125, 0.015, indoxacarb 0.0108, 0.0145, thiodicarb 0.075 and endosulfan 0.07 per cent caused 28.2 to 36.5 per cent reduction of coccinellid predators and considered relatively safer to this predators.

Highest seed yield was recorded with spinosad 0.01125 per cent with 97.78 per cent increase over untreated check followed by spinosad 0.015, indoxacarb 0.0145, 0.0108 and thiodicarb 0.075 per cent. The benefit – cost ratio was more with spinosad 0.01125 per cent (2.58) foliar spray followed by thiodicarb 0.056 and 0.075 per cent.

The results about relative toxicity of selected insecticides to third instar larvae of *A.janata* indicated that spinosad (LC_{50}: 0.01036%) was highly toxic followed by indoxacarb (LC_{50}: 0.01212%) and thiodicarb (LC_{50}: 0.0689%).

Based on LC_{50} values, indoxacarb (0.0096%)was found more toxic against third instar larvae of *S.litura* followed by spinosad (0.01079%) and thiodicarb (0.05512%).

Spinosad (LC_{50}: 0.00828%) was more toxic closely followed by indoxacarb ($LC_{50:}$ 0.00904%) as compared to thiodicarb (LC_{50}: 0.0474%) to the larvae of *Euproctis spp*.

CHAPTER I

INTRODUCTION

Castor (*Ricinus communis* L.) is an ancient and important non – edible oil seed crop containing 48 – 55 per cent oil. It has immense industrial and medicinal values. India occupies the prime position with an area of more than ten lakh hectares and production of 8.7 lakh tonnes. Andhra Pradesh holds key position in castor production with an area of 3.3 lakh hectares and the production of about one lakh tonnes (Andra Pradesh Economic and Statistical Bulletin, 2003 – 2004).

The insect pests inflict serious losses to castor as sap suckers, defoliators and capsule borer. This crop is attacked by the insect pests throughout it's crop growth period. The work of researchers in this area revealed that red hairy caterpillar (*Amsacta albistriga* Walker) incidence will be seen immediately after onset of monsoon showers, later follows the other lepidopteron pests *viz.*, semilooper (*Achaea janata* Linnaeus), tobacco caterpillar (*Spodoptera litura* Fabricius), castor butterfly (*Ergolis merione* C), capsule borer (*Conogethes punctiferalis* Guenee), castor slug (*Latoia lepida* Klk.), tussock caterpillar (*Euproctis spp.* Walker), biharhairy caterpillar (*Diacrisia oblique* Walker) and garden hairy caterpillar (*Pericallia ricini* Fabricius). The sap suckers *viz.*, leaf hopper (*Amrasca biguttula biguttula* Ishida), thrips (*Retithrips syriacus* Mayet), white flies

(*Trialeurodes ricini* Mishra and *Trialeurodes rara* Singh) occur throughout the crop period.

Castor is attacked by number of insect pests at different stages of crop growth resulting in Substantial yield losses are being caused by pests and at times total failure of the crop has been experienced. Infestation of castor capsule borer, *C. punctiferalis* resulted in loss of 174 kg/ha in castor yield. The total loss in castor yield due to pest complex was estimated to the tune of 14.36 per cent at Junagadh during 1982 – 83. More or less same quantum (14.00%) of yield loss was recorded at Sardar Krushinagar during the same year, but in the subsequent year, the loss was tremendous (71.99%) due to severe pest damage. At Palem (A.P), the yield loss due to semilooper alone was estimated to be 35.8 per cent. The yield loss in GCH 4 and SH 41 cultivars were reported to be 21.8 and 27.7 per cent, respectively. Similar losses in corresponding varieties were estimated to be 23.8 and 21.1 per cent at Raichur.

The production levels of this crop grown in diversified agro ecosystems of the state are far below than the levels that are achieved in prominent castor growing regions of the country. The resource poor castor farmers of Nalgonda and Mahaboobnagar districts of Andhra Pradesh become victims due to the frequent failures of this crop. The assessment made by various scientists indicated that insect pests formed an important constraint in castor production.

This situation warrants the castor farmers invariably to go for interventions to save the crop from insect pests. Insecticide usage is the most popular option in spite of all the negative effects surfaced in the recent years.

In this context it was felt appropriate to findout an effective and economical chemical intervention to combat the pest menace so as to enhance the returns. Hence, the present study was conducted with the following objectives:

1. To study the bioefficacy of selected insecticides against major pests of castor in the laboratory.
2. To evaluate the field efficacy of the same insecticides against important pests of castor.
3. To observe the effects of insecticides on natural enemies like *Microplitis maculipennis* Szepligate, coccinellids and spiders etc.

CHAPTER II

REVIEW OF LITERATURE

The literature available pertaining to the efficacy of treatments studied during the investigation against major pests of castor is reviewed here under from 1983-2003. Wherever the literature is inadequate on major pests of castor in such case the literature pertaining to the efficacy of different insecticides included under study was collected on related pests.

2.1 BIOEFFICACY OF CERTAIN INSECTICIDES AGAINST MAJOR PESTS OF CASTOR IN THE LABORATORY

Peter and David (1990) found that among five insecticides chlorpyrifos (0.04 %) was the most effective insecticide against *S.litura*.

Patil *et al.* (1991) reported that among 11 insecticides methyl parathion (2%) caused higher larval mortality of *S.litura* followed by chlorpyrifos (0.1 %) and monocrotophos (0.1 %)**.**

Bhatnagar *et al.* (1992) observed that among 13 insecticides endosulfan, carbaryl and quinalphos (each at 0.075%) were superior to chlorpyrifos (0.075%), diazinon and malathion (each at 0.05%) against *E. fraterna*.

Leonard *et al.* (1996) reported that spinosad LD_{50}'s among several population of *H. virescens* was from 0.4 to 8.5 fg/g.

Khalid Ahmed *et al.* (2000) reported that among the 11 insecticides thiodicarb was the most effective and significantly superior to the rest of treatments, which recorded highest larval mortality of *S. exigua* (94.4%) at 72 hrs.

Kranthi *et al*. (2000) observed that LD_{50} range of 0.023 to 0.24 and an LD_{90} of 0.27 to 4.33 fg spinosad against *H.armigera*.

LC_{50} values of chlorpyrifos 0.0835, beta – cyfluthrin 0.0335, indoxacarb 0.0144 and spinosad 0.0165, were determined and found that chlorpyrifos was the least effective against cotton pink bollworm (Swamy *et al.*, 2000a).

Ahmed *et al*. (2001a) reported that indoxacarb (0.024%) showed 86.66 per cent ovicidal activity against *S.litura* followed by spinosad (0.015%) up to an extent of 73.33 per cent`

Ahmed *et al.* (2001b) reported that spinosad (0.015%) recorded 73.33 per cent ovicidal toxicity against *S.litura* followed by quinalphos (0.05%) to an extent of 71.11 per cent.

Ochou and Martin (2002) and reported that LD_{50} values of indoxacarb, spinosad and thiodicarb as 1.1, 0.88 and 3.06 μg a.i per larva against *H.armigera*, respectively.

Jadli (2003) reported that spinosad and indoxacarb were found highly toxic when applied by leaf – dip method recording the LC_{50} values of 0.029 and 0.028 per cent.

Venkanna (2003) found that LD_{50} value of indoxacarb was 0.0910μg a.i per larva of *H.armigera.*

2.2 BIOEFFICACY OF CERTAIN INSECTICIDES AGAINST MAJOR PESTS OF CASTOR IN FIELD CONDITIONS

Insecticidal spray is the most commonly practiced method for protecting the castor crop from various insect pests.

Nyirendra (1983) reported that thiodicarb gave 83 per cent larval mortality of fourth and fifth instar larvae *S. exempta* on maize.

Singh *et al.* (1984) evaluated five insecticides on chickpea, voltan and thiodicarb at 0.05 and 0.1 per cent respectively gave complete mortality of *H. armigera* on chickpea within 72 hrs.

Durant and Moore (1989) reported that thiodicarb (0.14%), profenofos (0.28%) and lambda – cyhalothrin + finoxycarb (0.002% + 0.14%) exhibited effective ovolarvicidal efficacy against *Heliothis spp*., comparable to that of standard treatment (clordimeform).

Sumalatha (1990) reported that the highest population reduction of cabbage leaf webber, *C. binotalis* was obtained with cartap hydrochloride (0.1%).

Ashok *et al.* (1991) reported that profenofos 0.75 per cent and 1.0 per cent were highly effective for the control of young larvae of *H. armigera* on red gram and cotton.

Dhamdhere and Sharma (1991) evaluated five insecticides against *L. orbonalis* and found that thiodicarb 0.15 per cent and monocrotophos 0.04 per cent were most effective on the basis of fruit infestation and yield of borer of free fruits.

Application of 4 to 5 g of cartap hydrochloride 4G followed by 0.05 per cent spray at 30 days after transplantation was effective in controlling brinjal shoot and fruit border, *L. orbonalis* (Somachoudhury and Mohasin, 1991).

Srinivasan and Moorthy (1991) recommended the sprays of cartap hydrochloride 0.05 per cent for the control of *P. xylostella* and *C. binotalis* on cabbage

Mala *et al*. (1992) reported maximum ovicidal activity of thiodicarb (0.75%), methyl (0.048%) and triazophos (0.08%) against *H.armigera* in chickpea by dipping and spraying methods.

Lowest pod damage by *H. armigera* and *S. litura* observed on chilli crop when sprayed with Polytrin 'C' 0.1 per cent followed by profenofos 0.1 and cartap hydrochloride 0.05 per cent (Jagannadh, 1993).

Siddiqui *et al.* (1994) reported that among 3 insecticides, thiodicarb was the most effective treatment against *Earias vitella* and *E. insulana* on cotton.

Dayakar *et al.* (1995) reported that fenvalerate 0.01 per cent occupied first position in bringing down the pod borers of pigeon pea and the next best was profenofos 0.05 per cent.

Mann *et al.* (1995) reported that thiodicarb was the most effective alternative for synthetic pyrethroids against *H.zea* and *H.virescens* on cotton.

Spinosad 48 SC proved selectively effective against lepidopteron pests on different crops including cotton at a dosage of 50 – 180 g a. i. ha^{-1} (Adan *et al.*, 1996).

Porteous *et al.* (1996) reported that spinosad @ 0.062 lb ai/acre gave excellent control of cotton bollworm (*H.zea*), tobacco budworm (*H.virescens*), beet armyworm (*S.exigua*) and cabbage looper (*Trichoplusia ni*).

Rao *et al.* (1996a) observed that cartap hydrochloride 0.05 per cent was effective in reducing the *L. orbonalis* damage on brinjal and cartap hydrochloride in combination with diflubenzuron mixture 0.075 per cent recorded highest mean marketable fruit

Cartap hydrochloride 0.05% recorded 22.87 per cent reduction of whitefly population over untreated control and was at par with chlorpyrifos 0.05% and endosulfan 0.07% (Rao *et al.*, 1996b).

Sharma *et al.* (1996) reported that profenofos 50 EC (0.2-0.3%) and methomyl 40 SP (0.03-0.04%) were found with ovicidal effect at peak egg laying stages and resulted in significant mortality of eggs and there by reduced the larval population and damage by *H.armigera* on cotton.

Walunj and Dethe (1996) reported that Larvin 75 WP @ 0.5, 0.75 and 1.0 kg a.i. ha^{-1} spray was most effective than the conventionally used carbamate insecticide i.e., carbaryl (Sevin 50 WP) at 1.0 kg a.i. ha^{-1} against brinjal shoot and fruit borer *L. orbonalis.*

Johnson *et al.* (1997) evaluated and reported that among four new insecticides, spinosad provided excellent control of pyrethroid resistant *H. virescens* on cotton.

Young *et al.* (1997) reported that profenofos and cyhalothrin provided the best level of control (>97%) of *H.zea* in cotton.

Hammes *et al.* (1998) reported that indoxacarb was the most effective in controlling the *H.zea*, *H.virescens*, *S.frugiperda*, *S.exigua*, *Trichoplusia ni* and *Lygus lineolaris* on cotton

Pawar *et al.* (1998) reported that butacarboxim 0.1 per cent and cartap hydrochloride 0.07 per cent were equally effective against cotton jassid, *A. biguttula biguttula* and whitefly, *B. tabaci.*

Birdar *et al.* (1999) evaluated the efficacy of thiodicarb against *H.armigera* on bengal gram and found that thiodicarb at 300 g/ha resulted in pod damage of 24.7 and with a highest seed yield (0.86 t/ha).

Kuwazawa (1999) reported that carbamates insecticides had relatively more effective against both egg and larvae of *H.armigera* on cotton with thiodicarb being the most effective agent.

Kharboutli *et al.* (1999) studied the efficacy of traditional and new insecticides against cotton bollworm *H. zea* and tobacco budworm *H. virescens* and reported that cyfluthrin and spinosad effectively controlled cotton bollworm. Tobacco budworm was well controlled by spinosad and chlorfenapyr.

Mahammad – Naveed *et al.* (1999) evaluated the two insecticides i.e., indoxacarb and chlorfenapyr and reported that larval mortality of *H.armigera* on cotton was 90% in indoxacarb and 60% in chlorfenapyr.

According to Papa *et al.* (1999) indoxacarb alone and in combination with methyl and lufenuron recorded 83, 92 and 83 per cent control of *S. litura*, respectively.

The application of spinosad @ 0.045 lb a.i/acre with Dyne - Amic @ 0.05 per cent was effectively controlled the *H.zea* and *H.virescens* on cotton (Thomas *et al.*, 1999).

Based on yield and cost – benefit ratio thiodicarb @ 650 g ha^{-1} has been recommended as an effective chemical for management of pod borers in pigeon pea (Yelshetty *et al.*, 1999).

Srikanth *et al.* (2000) evaluated that profenofos 0.05 per cent recorded superior control of *C. pavonana* (98.4%) and tobacco caterpillar *S. litura* (80.06%) on cabbage.

Swamy *et al.* (2000b) reported that spinosad 48 SC at 50 g a.i. ha^{-1} recorded minimum per cent of rosette flowers and green boll damage by the pink bollworm in cotton.

Dharne *et al.* (2001) evaluated seven insecticides and found that profenofos (0.01%) recorded maximum mortality against tobacco caterpillar (*S. litura*) on groundnut.

Cartap hydrochloride (0.05%) was significantly inferior to all the insecticidal treatments and was the least effective (26.68%) in checking the whitefly population on brinjal (Kumar *et al.,* 2001).

Spinosad 0.01 per cent was highly effective in controlling both *P.xylostella* and *C. binotalis* on mustard (Lakshmi, 2001a).

Studies conducted by Lakshmi (2001b) revealed that spinosad 2.5SC @ 0.005% was most effective in controlling the spotted pot borer *Maruca vitrata* Geyer on black gram by recording higher pod yield.

Mansoor – Ul – Hasan *et al.* (2001) reported that spinosad 288 g per acre against *H.armigera* on cotton gave significantly better control as compared to the conventional insecticides.

Indoxacarb @ 1 ml. l^{-1} was found highly effective in controlling *H.armigera* on cotton by giving cent per cent mortality (Rao *et al.,* 2001).

Rao and Lal (2001) reported that Cartap hydrochloride 0.05 per cent reduced *P.xylostella* on cabbage.

Vadodaria *et al.* (2001) noticed that spinosad 48 SC @ 75g a.i. ha^{-1} and bulldock 2.5 SC @ 18 g a.i. ha^{-1} recorded less larval population of *H.armigera* and with a minimum per cent bollworm damage to squares, bolls and locule with higher seed cotton yield.

Yadav *et al.* (2001) observed that chlorpyrifos 50 EC + cypermethrin 5 EC was found most effective in reducing the population of *S.litura* on chickpea.

Ramegouda *et al.* (2002) evaluated that Polytrin C-44 (0.044%), profenofos 50 EC (0.05%) and carbosulfon 25 EC (0.025%) were found highly effective against resistant population of *S.litura* and recorded more than 98 per cent mortality.

Investigations were carried on intrinsic toxicity of insecticides to early (2^{nd}) and late (4^{th}) instar larvae of castor semilooper (*A.janata*), among nine insecticides fenvalerate exerted highest toxicity at both 24 and 72 hrs intervals of observation, followed by profenofos (Basappa, 2003).

2.3 EFFECT OF INSECTICIDES ON VARIOUS NATURAL ENEMIES LIKE *MICROPLITIS MACULIPENNIS*, COCCINELLIDS AND SPIDERS

Osman *et al.* (1985) reported that *Coccinella undecimpunctata* and *Chrysoperla carnea* were found more tolerant to the five pesticides viz., Larvin, Baythroid, RUP 987, Cytrolane and Sumisidine than *Scymnus spp*.

Stefnove and Dimitrov (1986) found that profenofos and triazophos were toxic to coccinellid beetles.

Nurindath and Bondra (1988) observed that profenofos, endosulfan, cypermethrin and dimethoate at recommended dosages against *H. armigera* on cotton were found to have adverse effect on predatory insects.

Monocrotophos 0.02 per cent and chlorpyrifos 0.04 per cent were very toxic to all the stages of endoparasitoids, *Goniozous nephantidis* Mues. and *Bracon brevicornis* Wesm on *Corcyra cephalonica* Staint (Patil *et al.*, 1990).

Shukla *et al.* (1990) reported that oxydemeton – methyl (0.04%) was the most toxic and endosulfan (0.07%) was the least toxic to the both larvae and adults of the coccinellids.

Curinus coeruleus Mulsant a predator of Subabul psyllid when exposed to insecticidal films in the laboratory did not survive after 72 hours of exposure with monocrotophos, fenvalerate, malathion, carbaryl, cartap hydrochloride and ethofenprox (Diravian and Viraktamath, 1993).

Ganapathy and Durairaj (1995) recorded that among six insecticides, endosulfan 35 EC and demeton – s – methyl were less toxic to the larvae of *M.sexmaculatus*

Tillman (1995) reported that thiodicarb resulted in high survival of adult parasitoids, *M.croceipes* Gressm and *Cardiochiles nigriceps* on *H. virescens.*

Babu (1998) tested the efficacy of some insecticides against *Aphis craccivora* Koch on cowpea and found that endosulfan 0.07% was the safest insecticide for coccinellid predator, *M. Sexmaculatus* followed by 0.04% monocrotophos.

Standard insecticides methyleparathion and thiodicarb caused low indirect toxicity to hemipteran predators *Geocoris punctipes*, *Nabis capsiformis* Gen. *N.roseipennis* and *Podisus maculiventris* Say. (Boyd and Boethel, 1998).

Elzen *et al.* (1998) found that profenofos, cyflithrin, spinosad and oxamyl caused low mortality in *Geocoris punctipes*.

Vinuela *et al.* (1998) conducted laboratory studies to evaluate the toxicity of spinosad and azadirachtin against fifth instar nymphs of *Podisus maculiventris* Say. and observed significant mortality of nymphs by ingestion of spinosad applied @ 50 mg a.i. l^{-1} and topical application @ 15 mg l^{-1}.

Ruberson and Tillman (1999) reported that lambda cyhalothrin and spinosad were generally more toxic to the natural enemies and indoxacarb exhibited good to excellent selectivity to natural enemies natural enemies like *Chrysoperla spp. Geocoris spp.* and *T.pretiosum*.

Wilson *et al*. (1999) reported higher number of cotton aphid predators in cotton sprayed five times with thiodicarb @ 750 g.a.i. ha^{-1} than in unsprayed cotton.

Rathod and Bapodra (2002) evaluated the comparative toxicity of various systemic insecticides against adults and larvae of predatory coccinellids (*Coccinella septempunctata*, *C.transversalis* and *M. sexmaculatus*) associated with aphids in cotton field and observed that endosulfan (0.07%) and dimethoate (0.03%) were found significantly safer to the coccinellids followed by monocrotophos (0.04%) and phosalone (0.07%).

CHAPTER III

MATERIALS AND METHODS

The present study on the bioefficacy of certain insecticides against major pests of castor was carriedout during *kharif*, 2003 at Gunegel Research Farm, Gunegel, Ranga Reddy and laboratory studies were conducted in the research laboratories of Entomology, Central Research Institute for Dry land Agriculture, Santhoshnagar, Hyderabad, A.P.

The details of materials used and methodology followed in these studies are furnished in this chapter.

3.1 DETAILS OF FIELD EXPERIMENT

The crop was sown on 25-06-2003 at Gunegel Research Farm, Gunegel, Ranga Reddy, in *kharif* season 2003.

3.1.1 Layout

The experiment was laid in a randomized block design with 13 treatments replicated thrice the sub- plot size was $63m^2$ (plate 1).

3.1.2 Variety

Kranti (pcs-4) a popular variety of castor was selected for the experiment. The seed was obtained from CRIDA.

3.1.3 Preparatory Cultivation

The field was thoroughly ploughed thrice with the help of a tractor drawn cultivator and 2 tonnes of FYM were incorporated in the last ploughing. The field was properly levelled after removing the trash and levelled out as per the design.

Straight fertilizers of NPK were applied @ 60 kg N, 30 kg P_2O_5 and 30 kg K_2O in the form of Urea, Single Super Phosphate and Muriate of Potash respectively. The entire dose of phosphate and potash and half the dose of nitrogen were applied before sowing by broadcasting and the remaining half of nitrogen at 30 days after sowing.

Intercultivation

Two weedings were done during crop period whenever found necessary to keep the crop free of weeds.

3.1.4 Evaluation of Field Efficacy of Certain Insecticides Against Important Pests of Castor

A study has been designed to evaluate a suitable control schedule with 13 treatments consisting of seven insecticides in *kharif*, 2003 (Table-1).

Table 1: Details of treatments for field application

S.No.	Treatments	Formulation	Concentration (%)
1	Indoxacarb	14.5 SC	0.0108
2	Indoxacarb	14.5 SC	0.0145
3	Profenofos	50 EC	0.0375
4	Profenofos	50 SC	0.05
5	Spinosad	45 SC	0.01125
6	Spinosad	45 SC	0.015
7	Cartap hydrochloride	50 SP	0.0375
8	Cartap hydrochloride	50 SP	0.05
9	Thiodicarb	75 WP	0.056
10	Thiodicarb	75 WP	0.075
11	Endosulfan	35 EC	0.07
12	Chlorpyrifos	20 EC	0.04
13	Untreated		

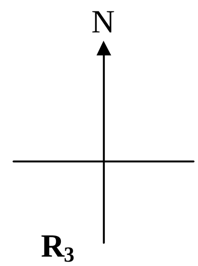
Fig –1: Field layout of the experimental plot

Crop: Castor   Design : RBD

Variety: Kranti   Treatments: 13

Plot Size: 63 m^2 Replications: 3

Date of sowing: 25^{th} June 2003



R_1	R_2	R_3
T_1	T_3	T_6
T_4	T_7	T_{10}
T_8	T_{11}	T_{13}
T_2	T_5	T_9
T_9	T_{10}	T_4
T_{13}	T_1	T_3
T_{11}	T_{12}	T_2
T_3	T_8	T_7
T_7	T_6	T_{12}
T_5	T_{13}	T_1
T_{10}	T_2	T_5
T_6	T_9	T_8
T_{12}	T_4	T_{11}

Table 2 : Details of insecticides for bioassay and field application

S.No	Insecticide Common name	Trade Name	Formulation or Strength	Price (Rs)	Source of Supply
1	Indoxacarb	Avaunt	14.5 SC	3500/l	Dupant India Ltd.
2	Thiodicarb	Larvin	75 WP	1080/kg	Aventis Crop Science Ltd
3	Spinosad	Tracer	45 SC	9800/l	DE – Nocil Crop Protection Ltd
4	Cartap – hydrochloride	Caldon	50 SP	2600/kg	Dhanuka Pesticides Ltd
5	Profenofos	Celcron	50 EC	640/l	Excel Industries Ltd
6	Chlorpyrifos	Starbon	20 EC	240/l	Shaw Wallace and Co. Ltd
7	Endosulfan	Endocel	35 EC	320/l	Excel Industries Ltd

3.1.5 Timing and Method of Application

Treatments were imposed after taking pretreatment counts and coinciding substantial level of infestation and repeated depending on necessity.

3.1.6 Observations and Recording of Data

Regular counts of insect population were recorded in each plot on 10 randomly selected labelled plants for each observation. Observations on various insect pests viz., castor semilooper *(A. janata*), tobacco caterpillar (*S. litura*) and hairy caterpillar (*Euproctis spp*.) and natural enemies population like

M. maculipennis, spiders and coccinellids were recorded in each plot on 10 randomly selected labelled plants.

Data on seed yield was recorded to relate with the treatmental efficacy.

3.1.7 Statistical Analysis

The data were subjected to sine arc (angular) transformation and subjected to analysis of variance outlined by Panse and Sukhatme (1978) with a view to narrow down the external variance factor. Statistical significance was tested by F value at 5 per cent level of probability. Critical difference values at 0.05 probability levels were worked out for testing significance of difference between treatments.

3.1.8 Yield Data

The yield of all 13 treatments including control was recorded on weight basis. The yield per plot was converted to yield per hectare on the basis of area of plot and subjected to statistical analysis to know significance difference among treatments.

While comparing the yield from different treatments, per cent increase in yield over control was calculated with the formula given below.

$$\text{Per centage increase in yield over control} = \frac{T - C}{C} \times 100$$

Where,

T = Yield from treated plot.

C = Yield from control plot.

3.1.9 Benefit – Cost Ratio

The ultimate objective of the present study was to develop an insect pest control schedule for the management of major insect pests of castor, which is effective but also economical to farmer. For this, benefit – cost ratio has been worked out for all the treatments. To work out the benefit – cost ratio, the prevailing prices of insecticides and existing wholesale market price of castor seeds during crop season of *kharif*, 2003 and labour charges were taken into account.

3.2 DETAILS OF LABORATORY EXPERIMENT

Laboratory experiment was carriedout from October 2003 to march, 2004 in the laboratory, Department of Entomology, Central Research Institute for Dry land Agriculture, Santhoshnagar, Hyderabad.

The details of materials used and methodology followed are as follows.

Pests of study

Three important defoliators *viz.,* castor semilooper, *A.janata,* tobacco caterpillar, *S. litura* and hairy caterpillar *Euproctis spp.* were chosen as the pests of study under laboratory conditions.

3.2.1 Collection and Rearing of Insect Pests

3.2.1.1 Rearing of *A. janata* in laboratory

The larvae of *A.janata* collected from castor field were brought to the laboratory and reared in plastic trays by providing fresh castor leaves daily till pupation.

2.1.1.1 Pupae

Pupae were taken out after two to three days of pupation, soaked in water containing formaldehyde solution (10%) for 10 minutes, washed with distilled water to avoid contamination, transferred to uncovered petri plates and placed in an oviposition cage. The abnormal pupae were discarded. Healthy pupae were kept in a cage for moth emergence.

3.2.1.1.2 Moths

Immediately after emergence, the moths were transferred to oviposition cage (50 adults per cage). Three to four castor leaves petioles were dipped in a conical flask containing water and placed in the cage to enable the adults to lay eggs on these leaves. The honey laced cotton swabs and castor leaves were changed daily.

3.2.1.1.3 Eggs

After oviposition, the eggs were sterilized with formaldehyde solution (10%) for 20 minutes and washed three times with distilled water. The sterilized eggs were made moisture free on a tissue paper placed in a petri plate.

3.2.1.1.4 Larvae

Freshly hatched larvae were transferred to plastic container or tub containing freshly collected tender castor leaves and mouth of container covered with a piece of muslin cloth.

The culture was maintained at 27 ± 2 ^{0} C in BOD incubator. The larvae reached third instar five to six days after hatching. Larvae ranging from 30 – 40 mg of weight were used for the leaf dip method of bioassay with the selectived insecticides.

3.2.1.2 Rearing of *S.litura* in the laboratory

Preparation of semi synthetic diet

Ingredients:

Fraction – A	
Water	200 ml
Chickpea flour	438.4 g
Yeast	32.0 g
Sorbic acid	4.0 g
Vitamin E	4.6 g
Methyl para hydroxy benzoyate	6.4 g
Ascorbic acid	10.4 g
Sorghum leaf powder	160.0 g
Fraction – B	
Agar – agar	40.8 g
Water	1600 ml
Formaldehyde (40%)	3.2 g

3.2.1.2.1 Preparation:

Chickpea flour (438.4 g), yeast (32 g), sorbic acid (4 g), vitamin E (4.6 g), methyl para hydroxy benzoyate (6.4 g) and ascorbic acid (10.4 g) were blended for one minute (fraction – A).

Sorghum leaf powder was soaked in 2000 ml of warm water (70^0 c) and blended with above ingredients for three minutes. Agar agar (40.8 g) was boiled in 1600 ml of water and cooled to 40^0 c before adding to the blender containing fraction A ingredients. Formaldehyde was finally added and all the constituents were blended in a blender for three minutes. The diet was then poured in to plastic jars to about 2 cm depth and cooled. These diet containing jars were used for mass rearing of larvae.

Rearing of *S.litura* on Semi Synthetic diet: The egg masses were collected from castor field along with leaves and brought to the laboratory. They were sterilized by soaking in 10 per cent clorax for 10 minutes and rinsed in running tap water to remove excess clorax and shade dried. Then the egg masses were pinned in rearing jars.

3.2.1.2.3 Larvae

After hatching larvae were shifted on to the diet and then the leaves were removed. After attaining second instar stage, about half population of the larvae were transferred to other jar to avoid over crowding to facilitate proper growth. The larvae reached third instar seven to eight days after hatching and those with weight ranging 30 – 40 mg were used for the study.

2.1.3 Rearing of *Euproctis spp*. in the laboratory

Euproctis spp. was reared on leaves of castor in the laboratory under aseptic conditions at room temperature (27±4 ^{0}C). Egg masses collected from the field formed the initial culture.

Euproctis spp. was reared in wire cages after disinfecting them with 4 per cent formaldehyde. The glassware was disinfected with general cleaning solution and subsequently swabbed with 4 per cent formaldehyde.

Two tender castor leaves were taken whose petioles were dipped in a small conical flask containing water to keep the leaves fresh throughout the day and it was placed in a glass trough (25 cm height and 15 cm diameter). Fresh egg masses of *Euproctis spp* were kept on the leaves and the open end of the trough was closed with white muslin cloth.

Newly hatched larvae were transferred to a new container and reared by providing them with fresh leaves. From third instar onwards only 20 – 25 larvae were allowed in a container (15X15 cm) to provide sufficient space. The grown up larvae were fed once a day with fresh clean castor leaves. Whenever the larvae reached prepupal stage they were transferred to glass jar containing a layer of fine sterilized moist sand at the bottom. After pupation, pupae were taken out and kept in a separate container for adult emergence. The adults emerged were transferred to another container lined with butter paper. The newly emerged adults were fed by providing cotton swab dipped in a 10 per cent honey which was changed daily. The egg batches laid on the butter paper were collected daily and transferred on castor leaves, whose petioles were kept in a conical flask containing water. Freshly hatched larvae were transferred to container containing freshly collected castor leaves. The larvae when reached to third instar (5-6 days after hatching) were used for the study.

3.2.2 Test Insecticides

In the evaluation of relative toxicity of insecticides to castor semilooper, *A. janata*, tobacco caterpillar, *S. litura* and hairy caterpillar *Euproctis spp*., three new insecticides *viz.*, spinosad, indoxacarb and thiodicarb were selected and each at seven concentrations.

3.2.3 Preparation of Insecticide Solutions

Desired concentrations of all the insecticides were prepared in the laboratory using distilled water as diluent. The treatments were replicated thrice. Initially a wider range of concentrations were tested and on the basis of mortality recorded, a series of concentrations in a narrow range were selected so as to get mortality of in the ranging 15 to 85 per cent. The details of insecticidal treatments of used in the study are furnished here under.

A. janata :

1) **Spinosad:** 0.005,0.007,0.009,0.011,0.013,0.015 and 0.017 per cent.
2) **Indoxacarb**:0.004,0.008,0.010,0.012,0.015,0.015,0.018 and 0.021 per cent
3) **Thiodicarb:** 0.01,0.03,0.05,0.07,0.09,0.11and 0.13 per cent.

S. litura :

1) **Spinosad:** 0.002,0.004,0.008,0.012,0.015,0.018 and 0.021per cent.
2) **Indoxacarb:** 0.003,0.006,0.009,0.010,0.012,0.014and0.016per cent.

3) **Thiodicarb:** 0.01,0.03,0.05,0.07,0.09,0.11 and 0.13 per cent

Euproctis spp.:

1. **Spinosad:**0.002, 0.004, 0.006, 0.008, 0.010, 0.012 and 0.015 per cent.
2. **Indoxacarb:** 0.002,0.004,0.006,0.008,0.010,0.012 and 0.015 per cent.
3. **Thiodicarb:**0.0125,0.0250,0.0375,0.05,0.0625,0.075 and 0.0875 per cent.

3.2.4 Bioefficacy of insecticides to test insect pests

The leaf dip method was followed as a suggested by Ahmed *et al*. (1995) for evaluating the efficacy of selected insecticides to test insect pests. The tender succulent green leaves of castor were brought from the field, dipped in the test of insecticide emulsion for 10 seconds with gentle agitation. Leave surfaces were allowed to dry on filter paper and then placed in container. To avoid desiccation of leaves, the moistened cotton was wrapped to the cut end of the petioles, enclosed them in a plastic cover using a rubber band and placed in a container. The third instar larvae of *A.janata, S.litura*, and *Euproctis spp*. were released 10 larvae in each container. Each treatment was replicated thrice. The leaf dipped in the water was used as control. The plastic containers with the larvae were kept at a constant temperature of 25±2 ^{0} C and 75 per cent relative humidity. The mortality of the larvae was observed at 24, 48 and 72 hrs after the treatment.

3.2.5 Statistical analysis of data

The mortality of the test larvae due to insecticidal treatment was calculated by subjecting the observed mortality to Abbott's (1925) formula wherever mortality recorded in control.

$$\text{Corrected mortality (\%)} = \frac{\text{Test mortality (\%)} - \text{control mortality (\%)}}{100 - \text{control mortality (\%)}} \times 100$$

The corrected mortality data of each insecticide was subjected to probit analysis (Finney, 1971), LC_{50} and LC_{90} values were calculated. Based on these values, toxicity of selected insecticides to *A.janata*, *S.litura* and *Euproctis spp*. was assessed. To compare the relative toxicity of insecticides, toxicity of thiodicarb was considered as unity.

$$\text{Relative toxicity} = \frac{LC_{50} \text{ of thiodicarb}}{Lc_{50} \text{ of test insecticide}}$$

CHAPTER IV

RESULTS

4.1 EFFICACY OF INSECTICIDES AGAINST MAJOR PESTS OF CASTOR DURING *KHARIF*, 2003

Seven insecticides with thirteen treatments were tested for their efficacy against *A.janata, S. litura* and *Euproctis spp* during *kharif,* 2003.Two foliar sprayings were given at 30 days interval starting from 45 days after sowing.

Bioefficacy of insecticidal treatments were determined in terms of per cent reduction in the insect population over untreated check.

4.1.1 Efficacy of Insecticides Against *A. Janata* During *Kharif*, 2003

The efficacy of insecticidal treatments during *kharif,* 2003 against *A.janata* was presented in table 3 - 5. The per cent reduction of *A.janata* population in insecticidal treatments were calculated over untreated check (Plate 2).

4.1.1.1 First spraying

First spraying was adopted at 45 days after sowing with different insecticides for different treatments. The pretreatmental observations were recorded one day before spraying. The *A.janata* population in different treatments ranged from 2.66 to3.93 per plant suggesting uniform distribution of pest load in all the treatments (Table 3-5 and Fig 1).

4.1.1.1.1 Reduction of *A.janata* population at one day after first spraying

Data revealed that thiodicarb 0.056 per cent recorded 63.36 per cent reduction of *A. janata* population over untreated check and was on par with spinosad 0.01125 (63.16%), spinosad 0.015 (61.36%), thiodicarb 0.075 (61.2%) and cartap hydrochloride 0.05 per cent (53.86%).

Remaining all treatments, profenofos 0.0375, indoxacarb 0.0108, indoxacarb 0.0145, chlorpyrifos 0.04, profenofos 0.05, cartap hydrochloride 0.0375 and endosulfan 0.07 per cent were on par with one another with 50.86, 49.23, 47.36, 47.26, 41.96 and 41.66 per cent reduction, respectively and these treatments were less effective than thiodicarb 0.056 per cent (Table 3).

The efficacy of insecticides was found in the following order.

$T_{1} > T_5 > T_6 > T_{10} > T_8 > T_3 > T_1 > T_2 > T_{12} > T_4 > T_7 > T_{11}$

4.1.1.1.2 Reduction of *A.janata* population at five days after first spraying

The observations revealed that thiodicarb 0.056 per cent foliar spray was recorded 82.63 per cent reduction of *A.janata* population, which was on par with spinosad 0.015 (81.96%), spinosad 0.01125 (80.53%), indoxacarb 0.0145 (76.33%) and thiodicarb 0.075 per cent (76.16%) (Table3).

The treatments, cartap hydrochloride 0.05, indoxacarb 0.0108, chlorpyrifos 0.04 and profenofos 0.05 per cent were on par with 68.3, 63.3, 61.8 and 59.13 per cent reduction, respectively.

Remaining all treatments, profenofos 0.0375 and 0.05, chlorpyrifos 0.04, endosulfan 0.07 and cartap hydrochloride 0.0375 per cent were on par with one another and showed that 54.66, 59.13, 61.83, 47.13 and 44.1 per cent reduction over untreated check, respectively.

The efficacy of insecticides was found in the following order.

$T_9 > T_6 > T_5 > T_2 > T_{10} > T_8 > T_1 > T_{12} > T_4 > T_3 > T_{11} > T_7$

4.1.1.1.3 Reduction of *A.janata* population at ten days after first spraying

The data on per cent reduction of *A.janata* at ten days after spraying indicated that spinosad 0.015 per cent was significantly superior among all other treatments with 88.23 per cent reduction, which was on par with indoxacarb 0.0108 (87.4%), indoxacarb 0.0145 (86.33%), spinosad 0.01125 (84.7%), thiodicarb 0.075 (83.93%) and thiodicarb 0.056 per cent (80.93%).

Among remaining all the treatments, profenofos 0.05, cartap hydrochloride 0.05, chlorpyrifos 0.04, profenofos 0.035, endosulfan 0.07 and cartap hydrochloride 0.05 per cent were on par with one another and recorded 66.66, 65.76, 64.7, 63.63, 57.36 and 56.83 per cent reduction, respectively (Table 3).

The efficacy of insecticides was found in the following order.

$T_6 > T_1 > T_2 > T_5 > T_{10} > T_9 > T_4 > T_8 > T_{12} > T_3 > T_{11} > T_7$

4.1.1.1.4 Overall efficacy after first spraying

Overall efficacy of different insecticides showed that all the treatments were significantly superior over untreated check in reducing the *A.janata* population.

Spinosad 0.015 per cent (77.1%) constantly proved its efficacy over others by recording higher reduction in population and was on par with spinosad 0.01125 (76.0%), thiodicarb 0.05 (73.7%) and thiodicarb 0.075 per cent (73.77%) (Table 3)

The treatments, indoxacarb 0.0145 and 0.0108 per cent were on par with each other with 70.1 and 66.6 per cent reduction.

Remaining treatments cartap hydrochloride 0.05, indoxacarb 0.0108, profenofos 0.05 and chlorpyrifos 0.04 per cent showed 52.3, 54.7, 57.6 and 57.9 per cent reduction, respectively. Amongst remaining treatments, profenofos 0.0375 per cent showed 56.35 per cent reduction and was on par with profenofos 0.05 (57.6%) and chlorpyrifos 0.04 per cent (57.9%).

In comparison with all the treatments, cartap hydrochloride 0.0375 per cent (47.62%) was the least effective and on par with endosulfan 0.07 per cent (48.7%).

The overall efficacy of insecticides was found in the following order.

$T_6 > T_5 > T_9 > T_{10} > T_2 > T_1 > T_8 > T_{12} > T_4 > T_3 > T_{11} > T_7$

4.1.1.2 Second spraying

Second spraying was given at 30 days after first spraying with same insecticidal treatments. Pretreatmental observations were recorded one day before spraying. The *A.janata* population in different treatments ranged between 2.93 – 4.00 per plant suggesting uniform distribution of pest load in all the treatments (Table 4 and Fig 2).

4.1.1.2.1 Reduction of *A.janata* population at one day after second spraying

Observations revealed that all the insecticidal treatments were found effective in reducing the *A.janata* and the per cent of reduction ranged in between 61.9 to71.93 except chlorpyrifos 0.04 per cent was the least effective with 47.06 per cent reduction (Table 3)

The efficacy of insecticides was found in the following order.

$T_2 > T_1 > T_7 > T_3 > T_{11} > T_4 > T_8 > T_5 > T_6 > T_{10} > T_9 > T_{12}$

4.1.1.2.2 Reduction of *A.janata* population at five days after second spraying

Indoxacarb 0.0108, spinosad 0.01125, indoxacarb 0.0145, cartap hydrochloride 0.0375, cartap hydrochloride 0.05, endosulfan 0.07 and spinosad 0.015 per cent were effective treatments though they were on par one another with 83.9, 79.9, 79.3, 79.1, 78.6, 77.8 and 76.2 per cent reduction of *A.janata* population, respectively.

Among the remaining treatments, profenofos 0.0375, 0.05, chlorpyrifos 0.04, thiodicarb 0.056 and thiodicarb 0.075 per cent recorded 66.4 to 75.05 per cent reduction (Table 4).

The efficacy of insecticides was found in the following order.

$T_1 > T_5 > T_2 > T_7 > T_8 > T_{11} > T_6 > T_3 > T_4 > T_{12} > T_9 > T_{10}$

4.1.1.2.3 Reduction of *A.janata* population at ten days after second spraying

Indoxacarb 0.0108 showed its supremacy with 89.4 per cent reduction followed by indoxacarb 0.0145 (87.6%), spinosad 0.015 (84.4%), spinosad 0.01125 (82.96%), profenofos 0.0375 (81.9%), cartap hydrochloride 0.0375 (80.5%) and cartap hydrochloride 0.05 per cent (79.86%) and were statistically on par with each other.

The remaining treatments, thiodicarb 0.075 per cent was superior with 78.1 per cent reduction and did not differ significantly with thiodicarb 0.05 (76.26%), profenofos 0.05 (73.7%), chlorpyrifos 0.04 (72.3%) and endosulfan 0.07 per cent (69.8%).

The efficacy of insecticides was found in the following order.

$T_1 > T_2 > T_6 > T_5 > T_3 > T_7 > T_8 > T_{10} > T_9 > T_4 > T_{12} > T_{11}$

4.1.1.2.4 Overall efficacy of insecticides after second spraying

Overall efficacy of different treatments showed that all the treatments were significantly superior than untreated check to reducing *A.janata* population. Among all the treatments indoxacarb 0.0108 per cent constantly proved it's efficacy over others by recording higher reduction (81.05%) in population and was on par with indoxacarb 0.0145 (78.39%), cartap hydrochloride 0.037 (76.82%) and spinosad 0.01125 per cent (76.02%) (Table 4)

Cartap hydrochloride 0.05 (74.76) was next best and was on par with profenofos 0.0375 (75.56%), spinosad 0.015 (74.6%), profenofos 0.05 (72.4%), endosulfan 0.07 (72.1%), thiodicarb 0.056 (69.7%) and thiodicarb 0.075 per cent (68.79%).

Chlorpyrifos 0.04 per cent recorded the least effective with 64.4 per cent, which was on par with thiodicarb 0.056 (69.76%) and thiodicarb 0.075 per cent (68.79%).

The efficacy of insecticides was found in the following order.

$T_1 > T_2 > T_6 > T_5 > T_3 > T_8 > T_6 > T_4 > T_{11} > T_9 > T_{10} > T_{12}$

4.1.1.3 Overall efficacy of insecticides against *A.janata*

Overall efficacy of different treatments showed that all the treatments were significantly superior than untreated check to reducing *A.janata* population. Observations revealed that spinosad 0.01125 per cent was superior with 76.03 per cent reduction of *A.janata* population, which was on par with spinosad 0.015 (78.88%), thiodicarb 0.075 (75.55%), indoxacarb 0.0145 (74.28%), indoxacarb 0.0108 (73.2%) and thiodicarb 0.056 per cent (72.79%) and cartap hydrochloride 0.05 per cent was recorded intermediate per cent reduction (68.71). Where as endosulfan 0.07 per cent was least effective with 60.43 per reduction, which was on par with profenofos 0.05 (65.03%), profenofos 0.0375 (64.95%), cartap hydrochloride 0.0375 (62.05%) and chlorpyrifos 0.04 per cent (61.2%) (Table- 4 Fig- 3).

The overall efficacy of insecticides was found in the following order.

$$T_5 > T_6 > T_{10} > T_2 > T_1 > T_9 > T_8 > T_4 > T_3 > T_7 > T_{12} > T_{11}$$

4.1.2 Efficacy of Insecticides Against *S. litura* During *kharif*, 2003

The efficacy of insecticidal treatments during *kharif,* 2003 against *S.litura* was presented in table 6-8 and Fig 4-6. The per cent population reduction of *S.litura* in chemical treatments were calculated over untreated check (Plate 3).

4.1.2.1 First spraying

First spraying was given at 45 days after sowing coinciding with peak level of pest infestation. The pretreatmental observations were taken one day before treatment. The *S.litura* population in different treatments ranged between 2.13 – 3.7. The details of different treatments were given in the table 6.

4.1.2.1.1 Reduction of *S.litura* population at one day after first spraying

Observations obtained at one day after spraying, thiodicarb 0.056 per cent was significantly superior than all other treatments with 73.08 per cent reduction, which was on par with cartap hydrochloride 0.05 (69.5%), indoxacarb 0.0108 (64.82%), profenofos 0.0375 (62.83%), profenofos 0.05 (60.8%), and endosulfan 0.07 per cent (58.1%).

Cartap hydrochloride 0.0375 (72.02%) was least effective and was on par with chlorpyrifos 0.04 (51.64%), spinosad 0.01125 (49.63%), thiodicarb 0.075 (47.87%), indoxacarb 0.0145 (46.49%) and spinosad 0.015 per cent (44.43%).

The efficacy of insecticides was found in the following order.

$T_9 > T_8 > T_1 > T_3 > T_4 > T_{11} > T_{12} > T_5 > T_{10} > T_2 > T_6 > T_7$

4.1.2.1.2 Reduction of *S.litura* population at five days after first spraying

The efficacy of cartap hydrochloride 0.05 per cent was significantly superior than all other treatments with 73.89 per cent reduction of *S.litura* population and was on par with indoxacarb 0.0108, profenofos 0.0375, thiodicarb 0.056, endosulfan 0.07, spinosad 0.01125, 0.015, indoxacarb 0.0145 and profenofos 0.05 per cent with 71.67, 64.63, 64.58, 60.03,58.87, 58.12 and 56.46 per cent reduction, respectively.

The chlorpyrifos 0.04 per cent was the least effective with 47.75 per cent reduction and was on par with thiodicarb 0.075(50.91%), and cartap hydrochloride 0.0375 per cent (48.5%).

The efficacy of insecticides was found in the following order.

$T_8 > T_1 > T_3 > T_9 > T_{11} > T_5 > T_6 > T_2 > T_4 > T_{10} > T_7 > T_{12}$

4.1.2.1.3 Reduction of *S.litura* population at ten days after first spraying

At 10 days after spraying and revealed cartap hydrochloride 0.05 per cent was highly effective and recorded 78.99% reduction followed by indoxacarb 0.0108, cartap hydrochloride 0.0375, thiodicarb 0.056, profenofos 0.05, endosulfan 0.07, profenofos 0.0375, indoxacarb 0.0145, thiodicarb 0.075, spinosad 0.015, chlorpyrifos 0.04, spinosad 0.01125 per cent were recorded with 77.8, 77.1, 73.3, 72.36, 70.35, 69.73, 69.56, 68.37, 66.63, 60.07 and 60.03 per cent reduction, respectively.

The efficacy of insecticides was found in the following order.

$T_8 > T_1 > T_7 > T_9 > T_4 > T_{11} > T_2 > T_3 > T_{10} > T_6 > T_{12} > T_5$

4.1.2.1.4 Overall efficacy after first spraying

The overall mean per cent reduction of *S.litura* revealed that cartap hydrochloride 0.05 per cent was significantly superior than all other treatments with 74.15 per cent reduction of *S.litura* population and was on par with indoxacarb 0.0108, thiodicarb 0.056, profenofos 0.0375, endosulfan 0.07 and profenofos 0.05 per cent with 72.03, 70.3, 65.6, 64.9, and 63.5 per cent reduction, respectively.

In the treatments *viz.*, indoxacarb 0.0145, spinosad 0.01125, spinosad 0.015, thiodicarb 0.075, cartap hydrochloride 0.0375, and chlorpyrifos 0.04 per cent ranged in between 55.26to57.6 and were on par with each other.

The efficacy of insecticides was found in the following order.

$T_8 > T_1 > T_9 > T_3 > T_{11} > T_4 > T_2 > T_5 > T_6 > T_{10} > T_7 > T_{12}$

4.1.2.2 Secondspraying

The second spraying was given at 30 days after first spraying. The pretreatmental observations were taken one day before treatment. The *S.litura* population in different treatments ranged between 2.10 to 2.9 per plant suggesting uniform distribution of pest load in all treatments (Table 7and Fig 5).

4.1.2.2.1 Reduction of *S.litura* population at one day after second spraying

Spinosad 0.01125,indoxacarb 0.0145, spinosad 0.015, indoxacarb 0.0108 and thiodicarb 0.056 per cent controlled the *S.litura* population by recording with 76.23, 72.3, 71.4 and 69.16 per cent reduction of *S.litura* population, respectively.

The treatments, profenofos 0.05, profenofos 0.0375, thiodicarb 0.075, cartap hydrochloride 0.0375 and cartap hydrochloride 0.05 per cent were on par with each other 64.96, 63.43, 62.83, 55.7 and 55.2 per cent reduction, respectively.

The treatments, chlorpyrifos 0.04 per cent was least effective with 40.33 per cent reduction and was on par with endosulfan 0.07 per cent (47.9%).

The efficacy of insecticides was found in the following order.

$T_5 > T_2 > T_6 > T_1 > T_9 > T_4 > T_3 > T_{10} > T_7 > T_8 > T_{11} > T_{12}$

4.1.2.2.2 Reduction of *S.litura* population at five days after second spraying

Observations revealed that indoxacarb 0.0108 (90.1%) indoxacarb 0.0145 (88.5%), spinosad 0.015 (86.13%), thiodicarb 0.075 (83.4%) and spinosad 0.01125 per cent (82.86%) maintained their supremacy over rest of treatments and endosulfan 0.07 per cent was least effective with 52.1 per cent reduction (Table6).

The treatments thiodicarb 0.056 per cent was superior with 80.83 per cent reduction, which was on par with profenofos 0.05 (74.93%).

Remaining treatments cartap hydrochloride 0.0375 per cent was recorded with 72.83 per cent reduction and was on par with profenofos 0.05 (74.93%), cartap hydrochloride 0.05 (65.83%), profenofos 0.0375 (65.43%) and chlorpyrifos 0.04 per cent (65.2%).

The efficacy of insecticides was found in the following order.

$T_1 > T_6 > T_3 > T_{10} > T_5 > T_9 > T_4 > T_7 > T_8 > T_3 > T1_2 > T_{11}$

4.1.2.2.3 Reduction of *S.litura* population at ten days after second spraying

Observations obtained after spraying indoxacarb 0.0108 per cent was significantly superior than all other treatments with 90.1 per cent reduction of *S.litura* population and was on par with indoxacarb 0.0145, spinosad 0.015, thiodicarb 0.056 per cent with 88.5, 86.13, and 84.6 per cent reduction of *S.litura* population, respectively and endosulfan 0.07 per cent was least effective with 51.8 per cent reduction

Profenofos 0.05, cartap hydrochloride 0.0375, chlorpyrifos 0.04, cartap hydrochloride 0.05, and profenofos 0.0375 per cent and were on par with each other with 71.5, 70.3, 67.6, 66.5 and 66.4 per cent reduction, respectively.

The efficacy of insecticides was found in the following order.

$T_1 > T_2 > T_6 > T_9 > T_5 > T_{10} > T_4 > T_7 > T_{12} > T_8 > T_3 > T_{11}$

4.1.2.2.4 Overall efficacy after second spraying

Overall efficacy of different treatments showed that all treatments were significantly superior over untreated check in reducing *S.litura* population.

The treatments indoxacarb 0.0145 per cent was significantly superior with 84.14 per cent reduction and was on par with indoxacarb 0.0108 (83.4%), spinosad 0.015 (80.0%) and spinosad 0.01125 per cent (81.06%).

Thiodicarb 0.056 per cent was recorded 78.18 per cent reduction, which was significantly different from other treatments and on par with thiodicarb0.075, profenofos 0.05 per cent (70.036%) and cartap hydrochloride 0.0375 per cent (66.26%).

Remaining treatments profenofos 0.0375 and cartap hydrochloride 0.05 per cent were on par with each other with 65.0 and 62.42 reduction, respectively.

The efficacy of insecticides was found in the following order.

$T_2 > T_1 > T_6 > T_5 > T_9 > T_{10} > T_4 > T_7 > T_3 > T_8 > T_{12} > T_{11}$

4.1.2.3 Overall efficacy of insecticides against *S.litura*

Overall efficacy of different treatments showed that all the treatments were significantly superior over untreated check in reducing *S.litura* population (Table 7).

Observations revealed that indoxacarb 0.0108 per cent was superior with 77.75 per cent reduction, which was on par with thiodicarb 0.056 (74.24%) and indoxacarb 0.0145 per cent (70.91%).

Remaining treatments revealed that spinosad 0.01125, 0.015, cartap hydrochloride 0.05, profenofos 0.05, thiodicarb 0.075 and profenofos 0.0375 per cent on par with one another and ranged in between 65.6-69.8 per cent reduction and followed by cartap hydrochloride 0.0375 (60.88), endosulfan 0.07 (58.77%) and chlorpyrifos 0.04 per cent (48.7%).

The efficacy of insecticides was found in the following order.

$T_1 > T_9 > T_2 > T_5 > T_6 > T_8 > T_4 > T_{10} > T_3 > T_7 > T_{11} > T_{12}$

4.1.3 Efficacy of insecticides against *Euproctis spp.* during *kharif*, 2003

The efficacy of insecticidal treatments during *kharif,* 2003 against *Euproctis spp*. was presented in table 9-11 and Fig 7-9. The per cent population reduction of *Euproctis spp.* in chemical treatments were calculated over untreated check.

4.1.3.1 First spraying

First spraying was given at 45 days after sowing. Spraying coinciding with peak level of pest infestation. The pretreatmental observations were recorded one day before spraying. The *Euproctis spp*. population in different treatments ranged from 2.6 to 3.96 per plant. The details of different treatments were given in the table 9.

4.1.3.1.1 Reduction of *Euproctis spp.* population at one day after first spraying

The data indicated that spinosad 0.015 per cent foliar spray was recorded 75.36 per cent reduction of *Euproctis spp*. population over untreated check and significantly superior than rest of treatments.

The treatments, spinosad 0.01125, thiodicarb 0.075, thiodicarb 0.056 and indoxacarb 0.0145 per cent were on par with each other with 67.00, 64.13, 62.3 and 61.3 per cent reduction, respectively. Remaining treatments indoxacarb 0.0108 and cartap hydrochloride 0.05 per cent were on par with 53.33 and 53.13 per cent reduction of *Euproctis spp*. population, respectively (Table 8).

Endosulfan 0.07, cartap hydrochloride 0.0375 and profenofos 0.375 per cent reduction of population and ranged in between 39.56-44.03.

Among all the treatments chlorpyrifos 0.04 per cent was the least effective with 34.7 per cent reduction and was on par with profenofos 0.05 per cent (37.9%).

The efficacy of insecticides was found in the following order.

$T_6 > T_5 > T_{10} > T_9 > T_2 > T_8 > T_1 > T_{11} > T_7 > T_3 > T_4 > T_{12}$

4.1.3.1.2 Reduction of *Euproctis spp.* population at five days after first spraying

The data revealed that five days after spraying, spinosad 0.01125 per cent was recorded 78.1 per cent reduction of *Euproctis spp*. population and was on par with spinosad 0.015 (76.5%), indoxacarb 0.0145 (72.7%), thiodicarb 0.056 (71.76%), thiodicarb 0.075 (70.43%) and indoxacarb 0.0108 per cent (70.03%) (Table 9). Cartap hydrochloride 0.05 per cent recorded 57.76 per cent reduction and was on par with endosulfan 0.07 (56.76%) and cartap hydrochloride 0.0375 per cent (50.43%).

Among all the treatments chlorpyrifos 0.04 and profenofos 0.05 per cent were the least effective treatments with 42.36 and 41.43 per cent reduction, respectively and these two treatments were on par with endosulfan 0.07 (56.76%) and cartap hydrochloride 0.0375 per cent (50.43%).

The efficacy of insecticides was found in the following order.

$T_5 > T_6 > T_2 > T_9 > T_{10} > T_1 > T_8 > T_{11} > T_7 > T_{12} > T_4 > T_3$

4.1.3.1.3 Reduction of *Euproctis spp.* population at ten days after first spraying

Spinosad 0.015 per cent foliar spray was recorded 85.96 per cent reduction of *Euproctis spp.* population over untreated check and was on par with thiodicarb 0.075 (85.13%), indoxacarb 0.0145 (83.1%), thiodicarb 0.056 (82.83%) and spinosad 0.01125 per cent (81.26%) and profenofos 0.375 and 0.05 per cent were the least effective treatments with 44.13 and 44.73 per cent reduction respectively

The treatments indoxacarb 0.0108 per cent recorded 79.3 per cent reduction and was on par with cartap hydrochloride 0.05 (67.13%) and endosulfan 0.07 per cent (54.8%).

The efficacy of insecticides was found in the following order.

$T_6 > T_{10} > T_2 > T_9 > T_5 > T_1 > T_8 > T_{11} > T_7 > T_{12} > T_4 > T_3$

4.1.3.1.4 Overall efficacy after first spraying

Overall efficacy of different insecticides showed that all the treatments were significantly superior over untreated check in reducing the *Euproctis spp*. population. The treatment spinosad 0.015 per cent was significantly superior than other treatments with 79.26 per cent reduction and was on par with spinosad 0.01125 per cent (75.43%) and profenofos 0.0375 per cent was the least effective with 41.06 per cent reduction, which was on par profenofos 0.05 (41.86%) and chlorpyrifos 0.04 per cent (41.46%).

Thiodicarb 0.075, indoxacarb 0.0145, thiodicarb 0.056 and indoxacarb 0.0108 per cent were recorded with 73.23, 72.15, 71.23 and 67.46 per cent reduction, respectively.

Among the remaining treatments cartap hydrochloride 0.05, endosulfan 0.07 and cartap hydrochloride 0.0375 per cent were recorded 56.6, 51.8 and 48.13 per cent reduction, respectively.

The overall efficacy of insecticides was found in the following order.

$$T_6 > T_5 > T_{10} > T_2 > T_9 > T_1 > T_8 > T_{11} > T_7 > T_4 > T_{12} > T_3$$

4.1.3.2 Second spraying

Second spraying was given at 30 days after first treatment with same insecticides. The pre treatment observations recorded one day before spraying.

The *Euproctis spp.* population in different treatments ranged between 3.06 to 5.16 per plant, suggesting uniform distribution of pest load in all the treatments (Table-10 Fig- 8).

4.1.3.2.1 Reduction of *Euproctis spp*. population at one day after second spraying

The spinosad 0.015 per cent was significantly superior than all other treatments with 84.7 per cent reduction of *Euproctis spp*. population and chlorpyrifos 0.04 per cent was the least effective with 55.06 per cent reduction and was on par with cartap hydrochloride 0.05 per cent (55.8%).

Among remaining treatments, spinosad 0.01125 per cent was recorded 75.83 per cent reduction, which was on par with indoxacarb 0.0145 (72.5%) and indoxacarb 0.0108 per cent (69.9%) followed by thiodicarb 0.75 and 0.056 per cent were recorded 66.9 and 65.9 per cent reduction respectively and was on par with indoxacarb 0.0145, 0.0108, profenofos 0.05, 0.0375, cartap hydrochloride 0.0375 and endosulfan 0.07 per cent with 72.5, 69.9, 63.7, 62.3 60.7 and 57.7 per cent reduction, respectively.

The efficacy of insecticides was found in the following order.

$T_6 > T_5 > T_2 > T_1 > T_{10} > T_9 > T_4 > T_3 > T_7 > T_{11} > T_8 > T_{12}$

4.1.3.2.2 Reduction of *Euproctis spp.* population at five days after second spraying

Thiodicarb 0.075 (89.16%) spinosad 0.015 (85.56%) and spinosad 0.01125 (82.00%) maintained their supremacy over rest of treatments.

Remaining treatments thiodicarb 0.056 per cent, indoxacarb 0.0108 and indoxacarb 0.0145 per cent was on par with each other with 80.83, 77.23 and 76.06 per cent reduction.

Among the remaining treatments profenofos 0.05 per cent recorded 70.06 per cent reduction, which was on par with indoxacarb 0.0108 (77.23%), indoxacarb 0.0145 (76.06%), profenofos 0.0315 (67.76%), cartap hydrochloride 0.0375 (65.56%) and endosulfan 0.07 per cent (60.93%) (Table -10).

The efficacy of insecticides was found in the following order.

$T_{10} > T_6 > T_5 > T_9 > T_1 > T_2 > T_4 > T_3 > T_7 > T_{11} > T_{12} > T_8$

4.1.3.2.4 Reduction of *Euproctis spp.* population at ten days after second spraying

The data revealed that thiodicarb 0.075 per cent was superior than all other treatments with 89.93 per cent reduction of *Euproctis spp.* population, which was on par with spinosad 0.015 and thiodicarb 0.056 per cent recorded with 85.73 and 85.70 per cent reduction, respectively.

The treatments indoxacarb 0.0145, spinosad 0.01125 and indoxacarb 0.0108 per cent showed 82.8, 82.23 and 80.36 per cent of reduction, respectively and followed by indoxacarb 0.0108 (80.36%), profenofos 0.05 (74.06),profenofos 0.0375 (68.16%) and cartap hydrochloride 0.0375 per cent (67.46%).

Among all treatments chlorpyrifos 0.04 per cent was the least effective with 57.13 per cent reduction and was on par with endosulfan 0.07 (60.06%) and cartap hydrochloride 0.05 per cent (58.97%).

The overall efficacy of insecticides was found in the following order.

$$T_{10} > T_6 > T_9 > T_2 > T_5 > T_1 > T_4 > T_3 > T_8 > T_{11} > T_7 > T_{12}$$

4.1.3.2.4 Overall efficacy after second spraying

Overall efficacy of different insecticides showed that all the treatments were significantly superior over untreated check in reducing the *Euproctis spp*. population. Spinosad constantly proved it's efficacy over others by recording higher reduction in population and the treatment cartap hydrochloride 0.05 per cent was the least effective with 57.13 per cent reduction, which was on par with endosulfan 0.07 (59.7%) and chlorpyrifos 0.04 per cent (57.16%) (Table-10).

Among all treatments spinosad 0.015 per cent was significantly superior with 86.26 per cent reduction, which was on par with thiodicarb 0.075(81.96%), spinosad 0.01125 (79.93%), thiodicarb 0.056 (77.15%), indoxacarb 0.0145 (77.1%) and indoxacarb 0.0108 per cent (75.75%) and nest best was profenofos 0.05, 0.0375 and cartap hydrochloride 0.0375 per cent showed 69.36, 66.03 and 64.4 per cent reduction, respectively.

The efficacy of insecticide was found in the following order.

$$T_6 < T_{10} > T_5 > T_9 > T_2 > T_1 > T_4 > T_3 > T_7 > T_{11} > T_{12} > T_8$$

4.1.3.3 Overall efficacy of insecticides against *Euproctis spp.*

Overall efficacy of different treatments showed that all the treatments were significantly superior over untreated check in reducing the *Euproctis spp*. population. The treatment spinosad 0.015 per cent was significantly superior than other treatments recording 82.76 per cent reduction. Where as chlorpyrifos 0.04 per cent was revealed least effective with 49.3 per cent.

The spinosad 0.01125 per cent was recorded 77.68 per cent reduction, which was on par with thiodicarb 0.075 (77.6%), indoxacarb 0.0145 (74.6%) and thiodicarb 0.056 per cent (74.2%) (Table -11and Fig -9).

Remaining treatments indoxacarb 0.0108 per cent was recorded 71.57 per cent reduction, which was on par with indoxacarb 0.0145 (74.6%) and thiodicarb 0.056 per cent (74.2%) and cartap hydrochloride 0.05 per cent was superior with 56.59 per cent reduction, which was on par with cartap hydrochloride 0.0375 (56.26%), endosulfan 0.07 (55.75%), profenofos 0.05 (55.6%) and profenofos 0.0375 per cent (53.5%).

The efficacy of insecticides was found in the following order.

$T_6 > T_5 > T_{10} > T_2 > T_9 > T_1 > T_8 > T_7 > T_{11} > T_4 > T_3 > T_{12}$

4.2 EFFECTS OF INSECTICIDES ON NATURAL ENEMIES LIKE *M. MACULIPENNIS*, COCCINELLIDS AND SPIDERS DURING *KHARIF*, 2003

Seven insecticides with thirteen treatments were tested for their effects on natural enemies like *M. maculipennis*, coccinellids and spiders during *kharif*, 2003.Two foliar sprayings were given at 30 days interval starting from 45 days after sowing.

Effects of insecticidal treatments were determined in terms of per cent reduction in the insect population over untreated check.

4.2.1 Effects of Insecticides Against *M. maculipennis*

4.2.1.1 First spraying

The data presented in table12 and Fig 10 revealed that significantly effect of all the treatments on *M. maculipennis* population (Plate 8).

The data of one day after first spraying showed that thiodicarb 0.056 per cent was the safest chemical with only 10.13 per cent reduction of *M.maculipennis* population followed by indoxacarb 0.0108 per cent with 11.16 per cent reduction and were on par with each other. Endosulfan 0.07 per cent recorded 17.86 per cent reduction and spinosad 0.01125, indoxacarb 0.0145, spinosad 0.015 per cent were on par with one another. Thiodicarb 0.075, profenofos 0.0375, profenofos 0.05, cartap hydrochloride 0.05 per cent were recorded in between 26.36- 32.40 per cent reduction and were on par with one another and followed by chlorpyrifos 0.04 per cent recorded 36.3 per cent reduction. Among all treatments cartap hydrochloride 0.0375 per cent was found highly toxic with 43.8 per cent reduction.

At five days after first spraying also thiodicarb 0.056 per cent recorded the lowest reduction (16.6%) of *M. maculipennis* population. The treatment spinosad 0.01125 per cent recorded 21.8 per cent reduction followed by endosulfan 0.07 (22.76%), indoxacarb 0.0108 (22.76%) and indoxacarb 0.0145 per cent (25.16%) and therefore treatments were on par with one another. Spinosad 0.015, cartap hydrochloride 0.05 and thiodicarb 0.075 per cent were on par with each other ranging between 38.63- 44.43 per cent reduction. Chlorpyrifos 0.04, profenofos 0.0375, profenofos 0.05 and cartap hydrochloride 0.0375 per cent recorded 50.16, 51.96, 53.10 and 56.56 per cent reduction, respectively and were on par with one another.

At ten days after first spraying the lowest reduction of *M. maculipennis* population was recorded in spinosad 0.01125 (23.9%) followed by indoxacarb 0.0108 per cent (25.76%) and were on par with one another. Endosulfan 0.07 and indoxacarb 0.0145 per cent recorded 27.67 and 32.60 per cent reduction, respectively and were on par with one another. Thiodicarb 0.075, spinosad 0.015 and profenofos 0.0375 per cent were on par one another and recorded 45.86, 50.66 and 52.93 per cent reduction, respectively. Chlorpyrifos 0.04 and cartap hydrochloride 0.0375 per cent were on par and recorded 54.13 and 62.56 per cent reduction, respectively. The highest reduction of *M. maculipennis* population was noticed in the treatments profenofos 0.05 and cartap hydrochloride 0.05 per cent with 67.0 and 70.56 per cent, respectively.

The overall effects of insecticides on *M. maculipennis* population after first spraying revealed that indoxacarb 0.0108 per cent was the safest treatment by recording the lowest per cent reduction (19.85%) followed by spinosad 0.01125 per cent with 21.66 per cent reduction and were on par with each other. The treatments, thiodicarb 0.056 and endosulfan 0.07 per cent were the next safer treatments with 22.33 and 22.73 per cent reduction, respectively. Indoxacarb 0.0145 per cent recorded 26.46 per cent reduction. Spinosad 0.015(36.96%) and thiodicarb 0.075 (38.86%) were on par in population reduction. Profenofos 0.0375, cartap hydrochloride 0.05 and chlorpyrifos 0.04 per cent were on par with each other and ranging in between 45.03 to 48.5 per cent reduction. The treatment cartap hydrochloride 0.0375 per cent was recorded maximum effect with 54.3 per cent reduction.

4.2.1.2 Second spraying

The effect of insecticides after second spraying revealed that all the treatments affected the *M. maculipennis* population significantly when compared to the untreated check.

The data at one day after second spraying (Table 13and Fig 11) showed that indoxacarb 0.0108 per cent recorded the lowest (9.44%) reduction of *M. maculipennis* population followed by spinosad 0.01125 per cent (13.4%) and these two treatments were on par with one another and followed by indoxacarb 0.0145 per cent was recorded 14.73 per cent reduction. The treatments spinosad 0.015, thiodicarb 0.056 and endosulfan 0.07 per cent recorded 19.73, 22.74 and 23.2 per cent reduction, respectively and on par with each other. The remaining treatments recorded intermediate effect with ranging in between 32.27to 40.33 per cent reduction. Among all treatments, cartap hydrochloride 0.0375 per cent recorded 46.05 per cent reduction.

At five days after second spraying also indoxacarb 0.0145 per cent (16.56%) recorded the lowest per cent reduction followed by spinosad 0.01125 per cent (17.06%) and these treatments were on par with one another and followed by spinosad 0.05 (20.4%), indoxacarb 0.0108 (20.92%) and thiodicarb 0.056 per cent (24.06%). The treatment endosulfan

0.07 per cent recorded 26.06 per cent reduction and on par with thiodicarb 0.056 per cent (24.06%). Remaining treatments recorded in between 36.26 to 47.33 per cent reduction. Among all treatments cartap hydrochloride 0.0375 (54.0%)recorded the highest per cent reduction.

Similar trend was noticed at ten days after second spraying also indoxacarb 0.0108 (21.6%) and 0.0145 per cent (21.97%) were recorded the lowest per cent reduction of *M. maculipennis* population followed by spinosad 0.015 per cent (23.10%) and were on par with on another. The remaining treatments recorded almost similar to one day and five days after treatment and per cent reduction ranged in between30.83 to56.63.

Among all treatments profenofos 0.05 per cent proved to be highly toxic to *M. maculipennis* population with 66.10 per cent reduction.

The overall effects of insecticidal treatments on *M. maculipennis* population after second spraying showed that indoxacarb 0.0108 (24.5%) and 0.0145 per cent (24.9%) were the safest treatments and were on par with each other. Spinosad 0.015 and 0.01125 per cent were the next safer treatments with 21.00 and 22.2 per cent reduction of *M. maculipennis* population. Thiodicarb 0.056 and endosulfan 0.07 per cent were on par with each other with 26.53 and 26.66 per cent reduction and followed by thiodicarb 0.075, cartap hydrochloride 0.05 profenofos 0.0375, 0.05 and chlorpyrifos 0.04 per cent were recorded in between 35.06 to 46.76 per cent reduction, respectively. Among all treatments, cartap hydrochloride

0.0375 per cent proved highly toxic to *M. maculipennis* population with 52.2 per cent reduction.

The overall insecticidal effect after two sprayings (Table-14 and Fig-12) showed that indoxacarb 0.0108 per cent (18.57%) recorded the lowest reduction of *M. maculipennis* population and was considered to be the safest. Spinosad 0.01125 (21.93%) and indoxacarb 0.0145 per cent (22.11%) were on par with each other and were considered next safer treatments. Thiodicarb 0.056 (24.43%) and endosulfan 0.07 (24.7%), spinosad 0.015 (28.98%) and thiodicarb 0.075 per cent (36.96%) were less toxic. The treatments cartap hydrochloride 0.05, Profenofos 0.0375, chlorpyrifos 0.04 and profenofos 0.05 per cent recorded in between 41.36 to 48.05 per cent reduction and were considered to be moderately toxic. Cartap hydrochloride 0.0375 per cent recorded 53.23 per cent reduction and considered to be toxic.

4.2.2 Effects of Insecticidal Treatments against Coccinellid Predator

4.2.2.1 First spraying

The data pertaining to the mean number of coccinellids predators per ten plants were recorded simultaneously along with the larval counts of major pests at first, fifth and tenth day after spraying to evaluate the toxicity of different insecticides against coccinellid predators. Pretreatmental counts showed that the population ranged between 6.0 to 9.0 in different treatments including untreated check (Plate 9).

One day after spraying

The data recorded at one day after spraying showed that thiodicarb 0.056 per cent (20.9%) recorded the lowest reduction of coccinellid beetles over untreated check followed by spinosad 0.015 (21.4%), indoxacarb 0.0145(22.5%), thiodicarb 0.075 (25.1%), endosulfan 0.07 (26.1%) and spinosad 0.01125 (27.2%) and were on par with one another. Chlorpyrifos 0.04 (34.6%), indoxacarb 0.0108 (34.8%) recorded medium reduction of coccinellid beetles followed by profenofos 0.0375 (35.0%), cartap hydrochloride 0.05 (35.3%) and profenofos 0.05 (36.9%) per cent and were on par with one another.

Five days after spraying

Efficacy of the treatments revealed that thiodicarb 0.056 per cent was found the safest with 29.0 per cent reduction of coccinellid population and significantly superior over other treatments. The next safe treatments were spinosad 0.15 (32.9%), 0.01125 (35.3%), indoxacarb 0.0145 (36.2%), endosulfan 0.07 (37.4%), indoxacarb 0.0108 (40.36%) and thiodicarb 0.075 (41.0%) per cent and were on par with one another. Highest per cent reduction was observed in profenofos 0.0375 (47.5%), chlorpyrifos 0.04 (48.0%), cartap hydrochloride 0.05 (50.9%), profenofos 0.05 (51.4%) and cartap hydrochloride 0.0375 (51.4%).

Ten days after spraying

The data recorded ten days after first spraying showed that spinosad 0.01125 (28.3%) was found least toxic to the coccinellids followed by indoxacarb 0.0108 (34.8%) and thiodicarb 0.056 (37.0%) and were on par with one another.

Moderate toxicity was observed with thiodicarb 0.075, profenofos 0.0375, indoxacarb 0.0145, endosulfan 0.07, spinosad 0.015, profenofos 0.05 and cartap hydrochloride 0.0375 with 41.0 to 48.5 per cent reduction over untreated check. Chlorpyrifos 0.04 and cartap hydrochloride 0.05 per cent recorded 53.6 and 55.6 per cent reduction of coccinellid predators.

Overall efficacy of insecticides after first spraying

The overall effect of insecticides on lady bird beetle population after first spraying (Table16) showed that thiodicarb 0.056 (28.9%) was safer treatment followed by spinosad 0.01125 (30.2%) and 0.015 (33.3%) indoxacarb 0.0145 (34.6%), endosulfan 0.07 (36.4%), and indoxacarb 0.0108 per cent (36.6%) were on par with one another. Profenofos 0.0375 and 0.05, chlorpyrifos 0.04, cartap hydrochloride 0.0375 and 0.05 per cent recorded 42.0, 45.2, 45.4 47.0 and 49.4 per cent reduction and considered moderate toxic.

4.2.2.2 Effects of insecticides against coccinellids after second spraying

The effects of insecticides after second spraying revealed that all the treatments affected the ladybird beetle population significantly when compared to untreated check (Table - 17).

One day after spraying

The data at one day after second spraying showed that thiodicarb 0.056 (20.4%) recorded the lowest reduction of coccinellid predators when compared with untreated check followed by spinosad 0.01125 (24.7%), 0.015 (25.3%) thiodicarb 0.075 (27.3%), indoxacarb 0.0408 (28.9%)

endosulfan 0.07 (28.9%) and 0.0145 per cent (32.4%) and these treatments were on par with one another. Cartap hydrochloride 0.0375, 0.05, profenofos 0.05, chlorpyrifos 0.04 and profenofos 0.0375 per cent recorded 35.5, 35.6, 36.0, 37.2 and 39.5 per cent reduction respectively and were on par with one another.

Five days after spraying

At 5 days of second spraying spinosad 0.015 recorded the lowest reduction (22.6%) of lady bird beetles population compared to untreated check followed by spinosad 0.01125 (33.2%), thiodicarb 0.056 (35.0%), 0.075 (36.9%), indoxacarb 0.0145 (37.8%) and 0.0108 per cent (38.6%) were on par with one another. High toxicity was observed with endosulfan 0.07, cartap hydrochloride 0.05, profenofos 0.05, 0.0375, cartap hydrochloride 0.0375 and chlorpyrifos 0.04 per cent recorded 43.3, 44.9, 45.7, 49.7, 51.4 and 55.8 per cent reduction and were on par with one another.

Ten days after spraying

At ten days after second spraying spinosad 0.01125 per cent (28.5%) recorded the lowest per cent reduction of lady bird beetle population followed by thiodicarb 0.056 per cent (29.4%) and were on par with one another. Endosulfan 0.07, thiodicarb 0.075, profenofos 0.0375, indoxacarb 0.0108 and 0.0145, cartap hydrochloride0.0375, spinosad 0.015, chlorpyrifos 0.04, cartap hydrochloride 0.05 and profenofos0.05 per cent were recorded in ranging between 36.6 – 54.4 per cent reduction of coccinellid beetles population.

Overall effects of insecticides after second spraying

The data of overall effect of different treatments on the reduction of predatory beetle population revealed that relatively safer treatments were thiodicarb 0.056, spinosad 0.01125, thiodicarb 0.075, indoxacarb 0.0108, spinosad 0.015 per cent with 27.6,28.4, 33.2 33.4 and 34.8 per cent reduction over untreated check. Indoxacarb 0.0145, endosulfan 0.07 and cartap hydrochloride 0.0375 per cent were observed moderately toxic and were recorded 36.2, 36.6 and 43.8 per cent reduction respectively. Profenofos 0.05, cartap hydrochloride 0.05, profenofos 0.0375 and chlorpyrifos 0.04 per cent were highly toxic with 45.7, 46.3,47.9 and 48.4 per cent reduction, respectively.

4.2.2.3 Overall insecticidal effect against coccinellid beetles

The overall insecticidal effect after the two sprayings (Table 17) that thiodicarb 0.056 per cent (28.2%) recorded the lowest reduction of lady bird beetle population over untreated check followed by spinosad 0.01125 (29.3%) and 0.015 per cent (33.3%) were on par with one another and considered to be safe. Indoxacarb 0.0108 (34.9%), thiodicarb 0.0375 (35.2%), indoxacarb 0.0145 (35.4%) and endosulfan 0.07 per cent (36.5%) reduction of coccinellid predator population. Profenofos 0.0375, cartap hydrochloride 0.0375, profenofos 0.05, chlorpyrifos 0.04 and cartap hydrochloride 0.05 per cent recorded 44.9, 45.4, 45.7, 46.8 and 47.8 per cent reduction and were moderate toxic to coccinellid beetles.

4.3 EFFECTS OF DIFFERENT TREATMENTS ON THE YIELD OF CASTOR DURING *KHARIF*, 2003

In the present investigation, the results revealed that highest seed yield of 1027.1 kg/ha was recorded in spinosad 0.001125 per cent with 97.8 per cent increase over control followed by spinosad 0.015, indoxacarb 0.0145 and 0.0108, thiodicarb 0.075 and 0.056, cartap hydrochloride 0.05 and 0.0375, endosulfan 0.07, profenofos 0.05 and 0.0375, chlorpyrifos 0.04 per cent with 996.5, 984.1, 928.4, 850, 815.6, 777.7, 730.2, 678.3, 642.5, 621.3 and 598.2 kg/ha, respectively. In unprotected treatment the seed yield was 519.3 kg/ha.

Table 18:Effects of different treatments on the yield of castor during *kharif*, 2003

Treatment	Concen-tration (%)	Seed Yield Kg/ha	Per centage Increase Over control	Cost of cultivation Rs/ha	Gross returns Rs/ha	Net returns Rs/ha	Benefit-cost ratio
Indoxacarb	0.0108	928.4	78.8	8150	18578	10428	2.27
Indoxacarb	0.0145	984.1	89.5	9200	19682	10482	2.13
Profenofos	0.0375	621.3	19.6	5576	12426	6850	2.22
Profenofos	0.05	642.5	23.7	5768	12850	7082	2.22
Spinosad	0.01125	1027.1	97.7	7940	20542	12602	2.58
Spinosad	0.015	996.5	91.8	8880	19930	11050	2.24
Cartap hydrochloride	0.0375	730.2	40.0	7340	14604	7264	1.98
Cartap hydrochloride	0.05	777.7	49.7	8120	15554	7434	1.91
Thiodicarb	0.056	815.6	57.0	6620	16312	9692	2.46
Thiodicarb	0.075	850	63.6	7160	17000	9840	2.37
Endosulfan	0.07	678.3	30.5	5768	13560	7792	2.35
Chlorpyrifos	0.04.	598.2	15.1	5576	11960	6384	2.14
Control		519.3		5200	8380	3180	1.61

4 .4 TOXICITY OF SELECTED INSECTICIDES AGAINST *A.JANATA*

4 .4.1 Toxicity of Spinosad to *A.janata*

The mortality of treated larvae was 3.5, 17.8, 32.1, 53.5, 67.8, 78.5 and 92.8 per cent at .005, 0.007, 0.009, 0.011, 0.013, 0.015 and 0.017 per cent concentrations of spinosad, respectively. The χ^2 value worked out in the study was 4.802 indicating homogenous larval population and the slope of the lcp line was 1.922. The LC_{50} and LC_{90} values were 0.01036 and 0.01703 per cent with fiducial limits ranging from 0.00938 to 0.01135 per cent and 0.01549 to 0.01939 per cent, respectively. (Table-19, Fig.17 & Plate 5).

Table -19: Toxicity of spinosad to *A.janata*

Concentration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.005	3.5	$\chi^2_{(6)}$= 4.802	0.01036 (0.00938-0.01135)	0.01703 (0.01549-0.01939)	1.922±0.2504
0.007	17.8				
0.009	32.1				
0.011	53.56				
0.013	67.8				
0.015	78.5				
0.017	92.8				

4.4.2 Toxicity of Indoxacarb to *A.janata*

The mortality of larvae treated with indoxacarb was 7.1, 14.2, 35.7, 46.4, 64.2, 78.5 and 89.2 per cent at 0.004, 0.008, 0.010, 0.012, 0.015, 0.018 and 0.021 per cent concentrations, respectively. The χ^2 tests indicated that the *A.janata* larval population used in this experiment was homogenous ($\chi^2_{(6)}$ = 1.417) and the slope of the lcp line was 1.4042. The LC_{50} and LC_{90} values for indoxacarb were 0.01212 and 0.0225 per cent with fiducial limits ranging from 0.01081 to 0.01349 and 0.01908 to 0.02451 per cent, respectively (Table-20 and Fig-18).

Table -20: Toxicity of indoxacarb to *A.janata*:

Concen-tration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.004	7.1				
0.008	14.2				
0.010	35.7	$\chi^2_{(6)}$ = 1.4042	0.01212 (0.01081-0.01349)	0.0225 (0.01908-0.02450)	1.404±0.215
0.012	46.4				
0.015	64.2				
0.18	78.5				
0.021	89.28				

4.4.3 Toxicity of Thiodicarb to *A.janata*

The larval mortality was significantly affected at all concentrations of thiodicarb by leaf – dip method on *A.janata*. The larval mortality was concentration dependent and it was 7.0, 20.6, 37.9, 51.7, 64.6, 75.3 and 86.1 per cent in the concentrations of 0.01, 0.03, 0.05, 0.07, 0.09, 0.11 and 0.013per cent respectively. The LC_{50} and LC_{90} values for larval mortality were 0.06989 and 0.1329 with fiducial limits ranging from 0.06087 to 0.07941 and 0.01178 to 0.1553 per cent, respectively. Slope (b) of the regression line drawn (Fig-19) was 2.031 and χ^2 was 1.818 (Table-21).

Table -21: Toxicity of thiodicarb to *A.janata*

Concentration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.01	7.07	$\chi2_{(6)}$=1.818	0.06089 (0.06087-0.07941)	0.1329 (0.11788-0.15534)	2.031±0.180
0.03	20.68				
0.05	37.95				
0.07	51.7				
0.09	64.63				
0.11	75.34				
0.13	86.1				

4.4 TOXICITY OF SELECTED INSECTICIDES AGAINST *S.LITURA*

4.4.1 Toxicity of Spinosad to *S.litura*

Spinosad with leaf dip method resulted in the mortality of *S.litura* larvae ranging from 10.7 to 89.2 per cent with the concentrations ranging from 0.002 to 0.021 per cent, respectively. The χ^2 value obtained in the study was 1.314 indicating that *S.litura* larval population used in the study was homogenous and the slope of the lcp line was 1.1521. The LC_{50} and LC_{90} values worked out for spinosad were 0.01079 and 0.02194 per cent with fiducial limits ranging from 0.00906 to 0.01254 per cent and 0.01924 to 0.02592 per cent, respectively. (Table-22 and Fig-20).

Table -22: Toxicity of spinosad to *S.litura*

Concentration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.002	10.7				

0.004	14.2	$\chi^2_{(6)} = 1.314$	0.01079 (0.00906-0.01234)	0.02194 (0.01954-0.02592)	1.152±0.1782
0.008	39.2				
0.012	53.5				
0.015	64.2				
0.018	74.9				
0.021	89.2				

4.4.2 Toxicity of Indoxacarb to *S.litura*

The mortality of *S.litura* larvae due to indoxacarb by leaf – dip method was 10.34, 14.16, 31.02, 55.1, 62.04, 79.3 and 89.65 per cent at 0.003, 0.006, 0.009, 0.010, 0.012, 0.014 and 0.016 per cent concentrations, respectively. The χ^2 value and slope of the lcp line were 3.089 and 2.368, respectively. The LC_{50} and LC_{90} values of indoxacarb were 0.00996 and 0.01656 per cent with fiducial limits ranging from 0.00899 to 0.01096 and 0.01501 to 0.01887 per cent, respectively (Table-23 and Fig-21).

Table -23: Toxicity of indoxacarb to *S.litura*

Concentration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.003	10.34				
0.006	14.16				
0.009	31.02	$\chi^2_{(6)}$ =	0.00996	0.01656	2.368±0.24

0.010	55.1	3.089	(0.00899-0.01096)	(0.01501-0.01887)	1
0.012	62.04				
0.14	79.3				
0.016	89.65				

4.4.3 Toxicity of Thiodicarb to *S.litura*

It was observed that as high as 89.2 and as low as 14.2 per cent mortality of larvae were obtained with 0.13 and 0.01 per cent concentrations of thiodicarb, respectively.. The χ^2 test indicated that the *S.litura* larval population used in this experiment was homogenous ($\chi^2_{(6)}$ = 1.848) and the slope of the lcp line was 1.848. The LC_{50} and LC_{90} values of thiodicarb obtained were 0.05512 and 0.1244 per cent with fiducial limits ranging from 0.0449 to 0.0649 and 0.1090 to 0.14781 per cent, respectively (Table- 24 and Fig-22).

Table -24: Toxicity of thiodicarb to *S.litura*

Concentration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.01	14.29				

0.03	32.14				
0.05	49.14	$\chi^2_{(6)=3.818}$	0.05512 (0.0449-0.0649)	0.1244 (0.1090-0.1478)	1.848±0.159
0.07	60.68				
0.09	74.99				
0.11	82.1				
0.13	89.2				

4.4 TOXICITY OF SELECTED INSECTICIDES AGAINST *EUPROCTIS SPP.* (Plate 7)

4.4.1 Toxicity of Spinosad to *Euproctis spp*.

It was observed that as high as 91.2 and as low as 13.3 per cent mortality of larvae was observed with 0.015 and 0.002 per cent concentrations of spinosad, respectively. The χ^2 test indicated that *Euproctis spp*. larval population used in this study was homogenous ($\chi^2_{(6)}$ = 2.919). The slope of the lcp was 1.9872. The LC_{50} and LC_{90} values of spinosad obtained were 0.00823 and 0.01481 per cent with fiducial limits ranging from 0.00728 to 0.00924 and 0.01321 to 0.1721 per cent, respectively. (Table-25 and Fig-23).

Table - 25: Toxicity of spinosad to *Euproctis spp*

Concentration (%)	Corrected per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.002	13.3				

0.004	27.0				
0.006	40.33	$\chi^2_{(6)} = 2.919$	0.00823 (0.00728-0.00924)	0.01481 (0.01321-0.1721)	1.987±0.1069
0.008	43.33				
0.010	57.3				
0.012	79.1				
0.015	91.2				

4.4.2 Toxicity of Indoxacarb to *Euproctis spp*.

The response of treated *Euproctis spp*. larvae was 3.5, 10.7, 21.1, 35.7, 53.5, 71.3 and 85.7 per cent mortality for concentrations of 0.002, 0.004, 0.006, 0.008, 0.010, 0.012 and 0.015 per cent indoxacarb, respectively. The χ^2 test indicated that the *Euproctis spp*. larval population used in this experiment was homogenous ($\chi^2_{(6)}$ = 0.491). The slope of the lcp was 1.842 (Table-26and Fig-24). The LC_{50} and LC_{90} values of indoxacarb were 0.00904 and 0.01600 per cent with fiducial limits ranging from 0.00804 to 0.01017 and 0.01420 to 0.01875 per cent, respectively.

Table -26: Toxicity of indoxacarb to *Euproctis spp*

Concentration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.002	3.5				
0.004	10.7				
0.006	21.04	$\chi^2_{(6)}= 0.491$	0.00904 (0.00804-0.01017)	0.01600 (0.01420-0.01875)	1.842±0.1979
0.008	35.7				
0.010	53.53				
0.012	71.3				
0.015	85.7				

4.4.3 Toxicity of Thiodicarb to *Euproctis spp.*

The mortality of *Euproctis* larval population was ranging from 10.34 to 93.07 per cent for the concentrations ranging from 0.0125 to 0.0875 per cent thiodicarb. The LC_{50} and LC_{90} values of thiodicarb were 0.0475 and 0.08495 per cent with fiducial limits ranging from 0.04192 to 0.05309 and 0.07630 to 0.09763 per cent, respectively. The χ^2 test indicated that the *Euproctis spp*. larval population used in this study was homogenous ($\chi^2_{(6)}$ = 0.866). The slope of lcp line was 3.414 (Table-27 and Fig-25).

Table -27: Toxicity of thiodicarb to *Euproctis spp.*

Concentration (%)	Corrected Per cent mortality	Heterogeneity (χ^2)	LC_{50} (95%FL)	LC_{90} (95%FL)	Slope (b)±S.E
0.0125	10.34				

0.0250	20.6				
0.0375	34.4				
0.0500	55.1	$\chi^2_{(6)}$= 0.866	0.0474 (0.04192-0.05309)	0.08495 (0.07630-0.09763)	3.414±0.2004
0.0625	65.4				
0.0750	79.3				
0.0875	93.07				

4.5 RELATIVE TOXICITY OF INSECTICIDES TO *A.JANATA*, *S.LITURA* AND *EUPROCTIS SPP.*

4.5.1 Relative Toxicity of Insecticides to *A.janata*

The data presented in table- 28 indicated that thiodicarb registered the highest LC_{50} value (0.06089%) among the three insecticides tested and was considered as relatively less toxic to *A.janata* larvae while spinosad was highly toxic as it recorded the lowest LD_{50} value of 0.01036 per cent. Indoxacarb stood in between these two with LC_{50} of 0.01212.

It was clear from the data that spinosad and indoxacarb showed 5.87 and 5.02 fold toxic as compared to thiodicarb.

4.5.2 Relative Toxicity of Insecticides to *S.litura*

The data present in table-27 indicated that among the three insecticides tested, indoxacarb was highly toxic to *S.litura* as it recorded the lowest LC_{50} value of 0.00996. While thiodicarb was less toxic as it recorded the highest LC_{50} value of 0.05512 per cent.

It was clear from the data that spinosad and indoxacarb showed 5.1 and 5.53 fold toxic as compared to thiodicarb.

4.5.3 Relative Toxicity of Insecticides to *Euproctis spp.*

The data presented in table-28 indicated that thiodicarb registered the highest LC_{50} value (0.0474%) among the three insecticides tested and was considered as relatively less toxic to *Euproctis spp.* larvae while spinosad was highly toxic as it recorded the lowest LC_{50} value of 0.0828 per cent. Indoxacarb stood in between these two with LC_{50} of 0.00904.

It was clear from the data that spinosad and indoxacarb showed 5.72 and 5.24 fold toxic as compared to thiodicarb.

Table 28:Relative toxicity of insecticides to third instar larvae of *A.janata*,

S.litura* and *Euproctis spp.

S.No	Insecticide	*A.junta*		*S.litura*		*Euproctis spp.*	
		LC_{50} (%)	Relative toxicity	LC_{50} (%)	Relative toxicity	LC_{50} (%)	Relative toxicity
1	Spinosad	0.01036	5.87	0.01079	5.1	0.00828	5.72
2	Indoxacarb	0.01212	5.02	0.00996	5.53	0.00904	5.24
3	Thiodicarb	0.06089	1.0	0.05512	1.0	0.0474	1.0

CHAPTER-V

DISCUSSION

The results of the investigations carried out discussed here under.

5.1 EFFICACY OF INSECTICIDES AGAINST ON *A.JANATA*

The results of the efficacy of seven insecticides against *A.janata* on castor are here under (Table5).

Spinosad 0.015 and 0.01125 per cent foliar sprays were most effective against *A.janata*. It was reported to be highly effective against number of lepidopterous caterpillars such as *M.vitrata* on black gram Vadodaria *et al.* (2001) Lakshmi (2001a), *P.xylostella* on mustard Lakshmi (2001b) and eggs of *S.litura* Ahmed *et al*. (2001b).

Thiodicarb was next in the order of toxicity after spinosad at concentration of 0.075per cent (75.55%). Dhamdhere and Sharma (1991) reported that thiodicarb 0.5 per cent was most effective on the basis of fruit infestation and yield of borer free fruits of brinjal. Walunj and Dethe (1996) reported that thiodicarb 75 WP @ 0.5, 0.75 and 1 kg a.i /ha was most effective than the conventionally used carbaryl @ 1 kg a.i/ha against *L.orbonalis*. Nyirendra (1983) reported that thiodicarb recorded 83 per cent larval mortality of 4th and 5th instar larvae of *S.exempta* on maize. Singh *et al.* (1984) found that thiodicarb 0.1 per cent recorded complete mortality of *H.armigera* on chickpea. Siddiqui *et al.* (1994) reported that thiodicarb was the most effective treatment against *E.vitella* and *E.insulana* on cotton.

Mann *et al.* (1995) reported that thiodicarb was the most effective alternative for synthetic pyrethroids against *H.zea* and *H.virescens* on cotton.

Indoxacarb at 0.0145 per cent (74.28%) and 0.0108 per cent (73.2%) also showed better efficacy against *A.janata* population. Papa *et al* (1999) noted that indoxacarb at 400ml/ha gave effective control of *S.frugiperda* on cotton. Mahammad – Naveed *et al.* (1999) reported that indoxacarb recorded 90 per cent mortality of *H.armigera* on cotton.

Cartap hydrochloride 0.05 per cent also proved effective against *A.junta*

(68.71%). Somachoudary and Mohasin (1991) found that application of four to five grams of cartap hydrochloride 4G per plant followed by 0.05 per cent spray at 30 days after transplantation reduced shoot and fruit borer damage to brinjal crop.

Profenofos at 0.05 per cent (65.03%) and 0.0375 per cent (64.94%) showed better efficacy against *A.janata*. Basappa (2003) reported that profenofos was next best insecticide after fenvalerete for controlling *A.janata* population. Ramegouda *et al.* (2002) observed that profenofos 0.05 per cent was highly effective against resistant population of *S.litura*. Dharne *et al.* (2001) reported that profenofos 0.01 per cent recorded maximum control of *S.litura* on groundnut.

Endosulfan 0.07 per cent (60.43%) and chlorpyrifos 0.04 per cent (61.2%) were ineffective in reducing *A.janata* population.

5.2 EFFECTS OF INSECTICIDAL TREATMENTS ON *S.LITURA*

The best insecticidal effect on *S.litura* was achieved with indoxacarb 0.0108 per cent (77.75%). The superior performance of indoxacarb against *S.litura* gains support from the findings of Papa *et al.* (1999) who revealed that indoxacarb alone and in combination with methomyl and lufenuron recorded 83, 92 and 83 per cent control of *S.litura,* respectively. Ahmed *et al.* (2001a) reported that indoxacarb (0.024%) showed 86.66 per cent ovicidal activity against *S.litura*. Indoxacarb @ 1 ml./litre was found to be highly effective in controlling *H.armigera* on cotton (Rao *et al.,* 2001). Hammes *et al.* (1998) reported that indoxacarb was most effective in controlling *H.zea*, *H.virescens, S.frugiperda* and *S.exigua.*

Thiodicarb was the next best chemical in reducing *S.litura* population and similar observations were made by Singh *et al.* (1984) against *H.armigera* on cotton. Siddiqui *et al.* (1994) reported that thiodicarb was the most effective against *Earias vitella* and *E.insulana* on cotton. Mann *et al*. (1996) reported that thiodicarb was the most effective alternative for synthetic pyrethroids against *H.zea* and *H.virescens* on cotton. Kuwakawa (1999) observed that thiodicarb was most effective against both eggs and larvae of *H.armigera.*

The efficacy of spinosad against *S.litura* in the present investigation is in tune with the finding of Porteous *et al.* (1996) who reported that spinosad @ 0.062 lb a.i/acre recorded excellent control of *H.zea* and

H.virescens on cotton. Pirate and spinosad provided control greater than that of pyrethroid, organophospate and carbamate standards (Leonard *et al.*, 1996).

Profenofos 0.05 (66.95%) and 0.0375 per cent (65.6%) exhibited moderate efficacy against *S.litura* population. Dayaker *et al.* (1995) reported that profenofos 0.05 per cent was effective against pod borer on pigeon pea after fenvalerate 0.01 per cent. Srikanth *et al.* (2000) evaluated that profenofos 0.05 per cent exerted superior control of *C.pavonana* and tobacco caterpillar *S.litura*.

The intensively used chlorpyrifos 0.04 per cent was found less effective by recording lower reduction of *S.litura* population.

5.3 EFFECT OF INSECTICIDAL TREATMENTS ON THE POPULATION OF *EUPROCTIS SPP.*

Results showed that the maximum reduction of *Euproctis spp*. population was by spinosad both at 0.015 and 0.01125 concentrations. It was already reported that spinosad highly effective against number of other lepidopterous caterpillars *viz*; *M.vitrata* on black gram Vadodaria *et al.* (2001) Lakshmi (2001a), *P.xylostella* on mustard Lakshmi (2001b) and eggs of *S.litura* Ahmed *et al.* (2001).

Thiodicarb at both concentrations of 0.075 per cent (77.6%) and 0.056 per cent (74.2%) and indoxacarb at both concentrations of 0.0145 (74.6%) and 0.0108 per cent (71.5%)were next best in the order of toxicity after spinosad. Cartap hydrochloride 0.05 (56.59%) and 0.0375 per cent (56.2%), profenofos 0.05 (55.6%) and 0.0375 per cent (53.5%) were recorded moderate efficacy. Ashok (1991) reported that profenofos 0.75 and 1.0 per cent were highly effective against young larvae of *H.armigera* on red gram. Young *et al.* (1997) also reported best control of *H.zea* on cotton with profenofos.

Chlorpyrifos was least effective in controlling the population of *Euproctis spp.*. In contrast to the present observation, chlorpyrifos was reported as an effective treatment against *S.litura* (Obulapathi *et al.*, 2000).

5.4 INFLUENCE OF INSECTICIDAL TREATMENTS AGAINST *M.MACULIPENNIS*

Greater reduction of *M.maculipennis* was observed with cartap hydrochloride 0.0375 (53.2%), profenofos 0.05 (48.0%) and chlorpyrifos 0.04 per cent (47.6%). Similarly greater toxicity of chlorpyrifos was documented against *Curinus coeruleus* (Diravian and Virakthainath, 1993) and *Lycosa pseudoannulata* and *Apantles sp* (Logiswaran *et al.*, 1987).

Indoxacarb 0.0108 (18.57%), spinosad 0.01125 (21.93%), indoxacarb 0.0145 (22.1%), thiodicarb 0.056 (24.4) and endosulfan 0.07 per cent (24.7%) were less toxic to *M.maculipennis*. These were reported to be safe insecticides against number of other natural enemies. Tillman (1995) reported that thiodicarb 0.075 per cent was relatively safer to adult parasitoid, *Microplitis cruceipes* on *H.virescens*. Boyd and Boethel (1998) reported that thiodicarb caused low indirect toxicity to hemipteran predators *Geocoris punctipes, Nabis roseipennis* and *Podisus maculiventries.* Wilson *et al.* (1999) recorded higher number of cotton aphid predators in cotton sprayed five time with thiodicarb @ 750g.a.i /ha than in unsprayed cotton.

5.5 EFFECT OF INSECTICIDAL TREATMENTS ON COCCINELLID PREDATORS

Higher reduction of coccinellid predators was observed with cartap hydrochloride at both concentrations of 0.05 and 0.0375, chlorpyrifos 0.04 and profenofos. Similarly higher reduction of *Curinus coeruleus* a predator of subabul psyllid with cartap hydrochloride was reported by Diravian and Virakthamath (1993) on Chlorpyrifos 0.04 per cent was very toxic to all stages of endoparasitoids. Stefnove and Dimitrov (1986) found that profenofos was toxic to coccinellid beetles.The moderate toxicity of indoxacarb at both concentrations of 0.0108 and 0.0145, thiodicarb 0.075per cent to coccinellid predators observed in the present investigations is in tune with the findings of Rubberson and Tillman (1999) who noticed good selectivity of indoxacarb to natural enemies like *Chrysoperla spp., Geocoris spp*. and *T.pretiosum*.Endosulfan 0.07per cent also showed moderate toxicity to coccinellid predators and similar observation was made by Ganapathy and Durairaj (1995) against larvae of *M.sexmaculatus*.

5.6 EFFECT OF DIFFERENT INSECTICIDAL TREATMENTS ON THE YIELD OF CASTOR

The results revealed that highest seed yield of 1027.1 kg/ha was recorded in spinosad 0.001125 per cent with 97.78 per cent increase over control followed by spinosad 0.015,indoxacarb 0.0145 and 0.0108, thiodicarb 0.075 and 0.056, cartap hydrochloride 0.05 and 0.0375 endosulfan 0.07 profenofos 0.05 and 0.0375 chlorpyrifos 0.04per cent with 996.5, 984.1, 928.4, 850, 815.6, 777.7, 730.2, 678.3, 642.5, 621.3 and 598.2 kg/ha, respectively. In unprotected treatment the seed yield was 519.3 kg/ha.

5.7 ECONOMICS OF DIFFERENT INSECTICIDAL TREATMENTS AGAINST INSECT PESTS OF CASTOR DURING *KHARIF*, 2003

Spinosad 0.01125 per cent foliar spray had more benefit – cost ratio(2.58) and it might be due to higher efficacy of spinosad against major pests of castor. This treatment was most economical compared to all other treatments.

5.8 BIOEFFICACY OF SELECTED INSECTICIDES AGAINST MAJOR PESTS OF CASTOR IN LABORATORY

5.8.1 Relative Toxicity of Insecticides Against *A.janata*

Spinosad registered the lowest LC_{50} value (0.01036%) among the three insecticides tested (Table 28) was considered as relatively highly toxic insecticide to *A.janata*, while thiodicarb was less toxic as it recorded the highest LC_{50} value (0.06089). The indoxacarb stood in between these two with LC_{50} of 0.01212 per cent. Similar investigations were conducted by Ochou and Martin (2002) and reported the LD_{50} value of indoxacarb was 1.1µ g a.i per larva against *H.armigera*. Kranti *et al.* (2000) also reported LD_{50} with range of 0.023 to 0.24 and an LD_{90} of 0.27 to 4.33 fg spinosad against *H.armigera*.

Jadli (2003) reported that spinosad was found highly toxic when applied by leaf – dip method recording the LC_{50} value of 0.029 per cent against *H.armigera*.

5.8.2 Relative Toxicity of Insecticides Against *S.litura*

Thiodicarb registered the highest LC_{50} value (0.05512%) among the three insecticides tested and is considered as relatively less toxic insecticide while indoxacarb was highly toxic as it recorded the lowest LC_{50} value (0.0099%)and spinosad stood in between these two with LC_{50} of 0.01079 per cent against *S.litura.*

Similar investigation conducted by leaf – dip method by Jadli (2003) indicated that indoxacarb exercised very high toxicity against *H.armigera* larvae as it recorded LC_{50} of 0.028 per cent. Venkanna (2003) also reported that LD_{50} of indoxacarb was 0.0910μg a.i. per larva of *H.armigera*.

5.8.3 Relative Toxicity of Insecticides Against *Euproctis spp.*

Spinosad was found highly toxic by recording the LC_{50} value of 0.00823 per cent. In larval topical tests with spinosad, Leonard *et al.*(1996) reported that range of LD_{50} was 0.4 to 8.5 fg/g against *H.armigera*.

The less efficacy of thiodicarb against *A.janata*, *S.litura* and *Euproctis spp*. noted in the present study might be due to its comparison with more potent new insecticides like indoxacarb and spinosad etc. The better performance of thiodicarb is in agreement with the finding of Yelshetty *et al.* (1999), Mann *et al.* (1995), Javaid Iqbal (1997) and Birdar *et al.*(1999) who reported effective control of *H.armigera* in pigeon pea, cotton, tobacco, and check pea crops, respectively.

CHAPTER – VI

SUMMARY

Field experiments were carried out during *kharif,* 2003 to study the "Bioefficacy of certain insecticides against major pests of castor." Laboratory experiments were conducted from October 2003 to march 2004 to determine the relative toxicity of selected insecticides to *A.janata, S.litura* and *Euproctis spp*. at CRIDA, Santhoshnagar, Hyderabad.

The field experiment was laidout in a simple randomized block design with 13 treatments replicated thrice. The insecticides include spinosad, indoxacarb, thiodicarb, profenofos, cartap hydrochloride, endosulfan and chlorpyrifos. A hand compression knapsack sprayer was used for imposing the spray treatments. The sprayings were imposed 45 days after sowing. The population counts of different pests and natural enemies were recorded one day before and first, fifth and tenth day after each spray. To assess the efficacy of different treatments, the per cent reduction of pests and natural enemies over untreated check was worked out. The effect of treatments on seed yield of castor was also assessed.

All the insecticidal treatments were superior to untreated check and recorded lower population of *A.janata, S.litura* and *Euproctis spp*. Greater reduction of *A.janata* population was obtained with spinosad 0.01125 (76.03%), 0.015 (75.88%), thiodicarb 0.075 (75.55%), indoxacarb 0.0145 (74.24%), 0.0108 (73.32%) and thiodicarb 0.05 per cent (72.7%).

The treatments indoxacarb 0.0108, thiodicarb 0.056 and indoxacarb 0.0145 per cent recorded higher reduction of *S.litura* population (77.75, 74.24 and 70.91% respectively).

The reduction of *Euproctis spp*. population was more with spinosad spray both at 0.015 (82.76%), 0.01125 (77.68%) and thiodicarb 0.075 per cent (77.6%). Indoxacarb 0.0145per cent (74.6%) and thiodicarb 0.056 per cent (74.2%) also proved effective against *Euproctis spp.*

Cartap hydrochloride 0.0375, profenofos 0.05 chlorpyrifos 0.04 and profenofos 0.0375 per cent were toxic to *M.maculipennis* population by recording 53.2, 48.05, 47.6 and 43.21 per cent reduction, respectively over untreated check. Indoxacarb 0.0108, spinosad 0.01125, indoxacarb 0.0145, thiodicarb 0.056 and endosulfan 0.07 per cent were relatively less toxic to *M.maculipennis* population.

Thiodicarb 0.056, spinosad 0.01125 and 0.015, indoxacarb 0.0108 and 0.0145, thiodicarb 0.075 and endosulfan 0.07 per cent caused 28.2, 29.3, 33.3, 34.9, 35.2, 35.4 and 36.5 per cent reduction of coccinellid predators respectively and considered relatively safe.

Highest seed yield was recorded with spinosad 0.01125 per cent with 97.78 per cent increase over untreated check followed by spinosad 0.015, indoxacarb 0.0145 and 0.0108 and thiodicarb 0.075 per cent.

The benefit – cost ratio was more with spinosad 0.01125 per cent foliar spray followed by thiodicarb 0.056 and 0.075 per cent.

The relative toxicity of spinosad, indoxacarb and thiodicarb were 5.87, 5.02 and 1.00 against *A.janata,* 5.1, 5.3 and 1.00 against *S.litura* and 5.72, 5.24 and 1.0 against *Euproctis spp.*

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* Originals not seen

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

Table – 9: Per cent Reduction of *Euproctis spp*. population after first spraying

Treatment	Concentration (%)	Pretreatment data	Mean % reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	2.60	53.15 (46.8)[c]	70.03 (56.8)[ab]	79.33 (53.2)[b]	67.46 (55.2)[b]
Indoxacarb	0.0145	2.96	61.30 (51.5)[b]	72.17 (58.5)[a]	83.10 (65.7)[a]	72.15 (58.1)[b]
Profenofos	0.0375	3.43	39.56 (38.9)[d]	39.63 (38.9)[c]	44.13 (41.6)[c]	41.06 (39.8)[d]
Profenofos	0.05	3.53	37.90 (37.9)[d]	41.43 (40.0)[c]	44.73 (41.9)[c]	41.86 (40.3)[d]
Spinosad	0.01125	3.60	67.00 (54.9)[b]	78.10 (62.1)[a]	81.26 (64.4)[a]	75.43 (60.2)[ab]
Spinosad	0.015	3.76	75.36	76.56	85.96	79.26 (62.9)[a]

			(60.2)[a]	(61.2)[a]	(68.3)[a]	48.13
Cartap	0.0375	3.56	42.00	50.43	51.93	(43.9)[c]
hydrochloride			(40.3)[d]	(45.2)[bc]	(46.1)[cb]	
						56.05
Cartap	0.05	3.46	53.33	57.76	67.13	(48.4)[c]
hydrochloride			(46.9)[c]	(49.5)[b]	(49.1)[bc]	71.60
Thiodicarb	0.056	2.70	62.30	71.76	82.83	(57.8)[b]
			(52.1)[b]	(58.0)[a]	(65.7)a	73.23
Thiodicarb	0.075	3.10	64.13	70.43	85.13	(58.8)[b]
			(53.2)[b]	(57.1)[ab]	(67.6)[a]	51.80
Endosulfan	0.07	2.60	44.03	56.76	54.80	(46.0)[c]
			(41.5)[d]	(48.8)[bc]	(47.7)[bc]	41.46
Chlorpyrifos	0.04	3.76	34.70	42.36	47.40	(40.0)[d]
			(36.0)[e]	(40.5)[c]	(43.5)[c]	0.00
Untreated		2.73	0.00	0.00	0.00	

F – Test S.Em ± C.D (P = 0.05)			1.33 3.89	2.83 8.27	2.26 6.70	1.20 3.50

Figures in the parentheses are angular transformed values

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table – 3: Per cent reduction of *A. janata* population after first spraying

Treatment	Concentration (%)	Pretreatment data	Mean % of reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall

Indoxacarb	0.0108	3.93	49.23 (44.5)^{b}	63.33 (52.8)^{bc}	87.4 (69.3)^{a}	66.6 (54.7)^{bc}
Indoxacarb	0.0145	3.13	47.93 (43.8)^{b}	76.33 (60.9)^{a}	86.33 (68.8)^{a}	70.16 (56.8)^{b}
Profenofos	0.0375	2.66	50.86 (45.5)^{b}	54.66 (47.9$^{)c}$	63.63 (52.9)^{b}	56.35 (48.6)^{d}
Profenofos	0.05	2.86	47.26 (43.4)^{b}	59.13 (50.2$^{)bc}$	66.66 (54.7)^{b}	57.6 (49.3)^{cd}
Spinosad	0.01125	2.76	63.16 (52.6)^{a}	80.53 (64.0)^{a}	84.7 (67.2)^{a}	76.05 (60.7)^{a}
Spinosad	0.015	3.6	61.36 (51.5)^{a}	81.96 (65.2$^{)a}$	88.23 (70.1)^{a}	77.16 (61.4)^{a}
Cartap hydrochloride	0.0375	2.93	41.96 (40.3)^{b}	44.1 (41.6)^{c}	56.83 (48.9)^{b}	47.62 (43.6)^{c}
Cartap hydrochloride	0.05	3.26	53.86 (47.2)^{a}	68.3 (55.7)^{b}	65.76 (54.2)^{b}	62.61 (52.3)^{c}

Thiodicarb	0.056	2.63	63.36 (52.8)[a]	82.63 (65.4)[a]	80.93 (64.1)[a]	75.6 (60.4)[a]
Thiodicarb	0.075	3.1	61.2 (51.3)[a]	76.16 (61.2)[a]	83.93 (66.8)[a]	73.7 (59.3)[a]
Endosulfan	0.07	3.2	41.66 (40.1)[b]	47.13 (43.3)[c]	57.36 (49.2)[b]	48.7 (44.2)[e]
Chlorpyrifos	0.04	3.62	47.36 (43.4)[b]	61.83 (51.9)[bc]	64.7 (53.5)[b]	57.9 (49.5)[cd]
Untreated		3.7	0.00	0.00	0.00	0.00
F – Test						
S.Em ±			2.09	2.26	2.30	0.92
C.D (P=0.05)			6.10	6.61	6.82	2.69

Figures in the parentheses are angular transformed values.

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table – 6: Per cent reduction of *S.litura* population after first spraying

Treatment	Concentration (%)	Pretreatment Data	Mean % of reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	3.33	64.82 (53.7)[a]	71.67 (58.0)[a]	77.80 (61.9)[a]	72.03 (58.0)[a]
Indoxacarb	0.0145	3.83	46.49 (42.9)[b]	58.12 (49.7)[a]	69.73 (56.7)[a]	57.68 (49.4)[b]
Profenofos	0.0375	2.53	62.83 (52.4)[a]	64.63 (53.6)[a]	69.56 (56.5)[a]	65.6 (54.1)[a]
Profenofos	0.05	2.13	60.8 (51.4)[a]	56.46 (48.7)[a]	72.36 (59.2)[a]	63.5 (52.9)[a]
Spinosad	0.01125	2.33	49.63 (44.7)[b]	60.00 (50.8)[a]	60.03 (50.8)[a]	56.84 (48.7)[b]
Spinosad	0.015	2.66	44.43	58.87	66.63	56.67

			(41.7)^{b}	(50.2)^{a}	(55.5)^{a}	(48.9)^{b}
Cartap hydrochloride	0.0375	2.86	41.02 (39.8)^{b}	48.50 (44.1)^{b}	77.10 (62.6)^{a}	55.50 (48.1)^{b}
Cartap hydrochloride	0.05	3.40	69.5 (56.7)^{a}	73.89 (59.9)^{a}	78.99 (62.9)^{a}	74.15 (59.7)^{a}
Thiodicarb	0.056	3.70	73.08 (59.0)^{a}	64.58 (55.9)^{a}	73.30 (59.4)^{a}	70.30 (57.1)^{a}
Thiodicarb	0.075	3.06	47.87 (43.7)^{b}	50.91 (45.5)^{b}	68.37 (55.9)^{a}	55.70 (48.2)^{b}
Endosulfan	0.07	2.06	58.1 (49.7)^{a}	63.82 (52.7)^{a}	70.35 (57.0)^{a}	64.9 (54.9)^{a}
Chlorpyrifos	0.04	3.00	51.64 (45.9)^{b}	47.75 (43.7)^{b}	60.07 (50.8)^{a}	55.26 (48.0)^{b}
Untreated		2.70	0.00	0.00	0.00	0.00

F – Test						
S.Em±			3.31	3.90	4.21	2.65
C D (P=0.05)			9.67	11.59	12.7	7.76

Figures in the parentheses are angular transformed values

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table – 10: Per cent reduction of *Euproctis spp*. population after second spraying

Treatment	Concentration (%)	Pretreatment Data	Mean % of reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	4.03	69.93 (56.7)[bc]	77.23 (61.5)[bc]	80.36 (63.7)[bc]	75.75 (60.5)[a]
Indoxacarb	0.0145	3.73	72.56 (58.4)[bc]	76.06 (60.7)[bc]	82.80 (65.9)[b]	77.10 (61.4)[a]
Profenofos	0.0375	4.00	62.30 (52.1)[cd]	67.76 (55.5)[cd]	68.16 (55.7)[c]	66.03 (54.3)[b]
Profenofos	0.05	3.06	63.70 (52.9)[cd]	70.46 (57.0)[c]	74.06 (59.4)[c]	69.36 (56.3)[b]
Spinosad	0.01125	4.20	75.83 (60.5)[b]	82.00 (65.0)[a]	82.23 (65.0)[b]	79.93 (63.4)[a]
Spinosad	0.015	4.26	84.70	85.73	88.50	86.26

			(67.0)^{a}	(68.0)^{a}	(70.3)^{a}	(68.4)^{a}
Cartap hydrochloride	0.0375	3.16	60.75 (51.2)^{cd}	65.56 (54.0)^{cd}	67.46 (55.2)^{c}	64.4 (53.3)^{bc}
Cartap hydrochloride	0.05	3.53	55.80 (48.3)^{d}	56.04 (48.8)^{d}	58.97 (50.1)^{d}	57.13 (49.1)^{c}
Thiodicarb	0.056	3.46	65.90 (54.2)^{c}	80.83 (64.2)^{b}	85.70 (68.0)^{a}	77.15 (61.5)^{a}
Thiodicarb	0.075	5.16	66.96 (54.9)^{c}	89.16 (71.1)^{a}	89.93 (71.6)^{a}	81.96 (64.8)^{a}
Endosulfan	0.07	3.50	57.76 (49.4)^{cd}	60.93 (51.3)^{cd}	60.6 (51.05)^{d}	59.70 (50.6)^{c}
Chlorpyrifos	0.04	3.93	55.06 (47.9)^{d}	58.56 (49.9)^{d}	57.13 (49.5)^{d}	57.16 (49.1)^{c}
Untreated		3.72	0.00	0.00	0.00	0.00

F – Test S.Em +_ C.D (P = 0.05)			1.39 4.08	2.02 5.90	1.70 4.98	1.51 4.43

Figures in the parentheses are angular transformed values.

Means followed by the same letters are not significantly different at 5% level by Duncan’s Multiple Range Test.

Table – 7: Per cent reduction of *S. litura* population after second spraying

Treatment	Concentration (%)	Pretreatment Data	Mean % of reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	2.40	71.40 (57.8)^{a}	88.90 (70.6)^{a}	90.10 (71.7)^{a}	83.46 (66.0)^{a}
Indoxacarb	0.0145	2.53	76.23 (61.0)^{a}	87.73 (69.6)^{a}	88.50 (70.4)^{a}	84.14 (66.5)^{a}
Profenofos	0.0375	2.33	63.43 (52.8)^{b}	65.43 (54.0)^{c}	66.43 (55.6)^{c}	65.0 (53.7)^{d}
Profenofos	0.05	2.53	64.96 (53.7)^{b}	74.93 (60.1)^{bc}	71.53 (57.8)^{c}	70.36 (57.0)^{c}
Spinosad	0.01125	2.30	78.26 (62.2)^{a}	82.86 (65.6)^{a}	82.16 (65.0)^{b}	81.06 (64.2)^{a}
Spinosad	0.015	2.50	72.30	87.90	86.13	82.02

			(58.4)^{a}	(69.7)^{a}	(68.1)^{a}	(64.9)^{a}
Cartap hydrochloride	0.0375	2.20	55.70 (48.2)^{bc}	72.83 (58.6)^{c}	70.33 (57.0)^{c}	66.26 (58.5)^{c}
Cartap hydrochloride	0.05	2.10	55.20 (48.0)^{bc}	65.83 (54.3)^{c}	66.53 (54.7)^{c}	62.42 (52.2)^{de}
Thiodicarb	0.056	2.90	69.16 (56.4)^{a}	80.83 (64.0)^{b}	84.60 (67.0)^{a}	78.18 (62.1)^{bc}
Thiodicarb	0.075	2.43	62.83 (52.4)^{b}	83.40 (66.0)^{a}	77.76 (61.9)^{bc}	74.65 (57.7)^{c}
Endosulfan	0.07	2.46	47.9 (53.7)^{c}	52.10 (46.2)^{d}	51.83 (46.0)^{d}	50.58 (45.3)^{f}
Chlorpyrifos	0.04	2.36	40.33 (39.4)^{d}	65.20 (53.8)^{c}	67.60 (55.3)^{c}	57.68 (49.4)^{e}
Untreated		2.73	0.00	0.00	0.00	0.00

F - Test						
S.Em ±			2.34	1.68	1.68	1.09
C.D (P=0.05)			6.84	4.91	4.90	3.18

Figures in the parentheses are angular transformed values

.Means followed by the same letters are not significantly different at 5% level by Duncan’s Multiple Range Test.

Table – 4: Per cent reduction of *A. janata* population after second spraying

Treatment	Concentration (%)	Pretreatment Data	Mean % of reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	4.00	71.56 (57.8)[a]	83.93 (66.6)[a]	89.40 (71.2)[a]	81.05 (64.4)[a]
Indoxacarb	0.0145	3.13	71.93 (58.0)[a]	79.36 (63.0)[a]	87.6 (69.2)[ab]	78.39 (62.3)[a]
Profenofos	0.0375	3.86	69.67 (56.7)[a]	75.05 (60.0)[b]	81.96 (64.8)[ab]	75.56 (60.3)[ba]
Profenofos	0.05	3.53	68.77 (56.1)[a]	74.60 (59.7)[b]	73.76 (59.3)[ab]	72.49 (58.4)[b]
Spinosad	0.01125	3.10	65.13 (53.8)[a]	79.94 (63.4)[a]	82.96 (65.6)[ab]	76.02 (60.6)[a]
Spinosad	0.015	2.96	63.23	76.23	84.40	74.60

			(52.6)^{a}	(66.8)^{a}	(67.0)^{ab}	(59.7)^{b}
Cartap Hydrochloride	0.0375	3.50	69.86 (56.8)^{a}	79.13 (62.8)^{a}	80.56 (63.8)^{ab}	76.52 (61.0)^{a}
Cartap hydrochloride	0.05	3.23	65.86 (54.3)^{a}	78.60 (62.7)^{a}	79.86 (63.4)^{ab}	74.76 (59.9)^{b}
Thiodicarb	0.056	3.70	61.96 (51.9)^{a}	71.06 (57.4)^{b}	76.26 (60.8)^{b}	69.76 (56.6)^{bc}
Thiodicarb	0.075	3.13	63.15 (52.6)^{a}	66.43 (54.6)^{b}	78.16 (62.2)^{b}	68.79 (56.0)^{bc}
Endosulfan	0.07	3.46	68.86 (56.4)^{a}	77.83 (61.9)^{a}	69.83 (56.8)^{b}	72.17 (58.1)^{b}
Chlorpyrifos	0.04	2.93	47.06 (43.3)^{b}	74.13 (59.7)^{b}	72.30 (58.8)^{b}	64.47 (53.4)^{c}
Untreated		3.70	0.00	0.00	0.00	0.00

F – Test S.Em± C.D (P = 0.05)			2.84 8.31	1.95 5.69	2.57 7.50	1.30 3.80

Figures in the parentheses are angular transformed values

.Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table – 12:Per cent reduction of *M.moculipennis* population after first spraying

Treatment	Concentration (%)	Pretreatment Data	Mean % of reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	1.30	11.16 (19.4)^{a}	22.76 (28.4)^{b}	25.76 (30.47)^{a}	19.85 (26.4)^{a}
Indoxacarb	0.0145	1.13	21.66 (27.7)^{bc}	25.16 (30.1)^{b}	32.60 (34.80)^{b}	26.46 (30.9)^{c}
Profenofos	0.0375	1.43	30.31 (33.3)^{cd}	51.96 (46.1)^{d}	52.93 (46.68)^{d}	45.03 (42.1)^{e}
Profenofos	0.05	1.26	30.76 (33.6)^{cd}	53.10 (46.7)	67.00 (54.95)^{f}	50.40 (45.2)^{f}
Spinosad	0.01125	1.03	19.30 (26.0)^{b}		23.90 (29.25)^{a}	21.66 (27.7)^{a}

Spinosad	0.015	1.40	21.70 (27.6)^{bc}	^{d} 21.80 (27.8)^{b}	50.66 (45.39)^{d}	36.96 (37.4)^{d}
Cartap hydrochloride	0.0375	1.04	43.80 (41.4)^{e}	38.63 (38.4)^{c}	42.56 (52.28)^{e}	54.30 (47.4)^{g}
Cartap hydrochloride	0.05	0.70	32.40 (34.6)^{cd}	56.56 (48.7)^{d}	70.86 (57.34)^{f}	47.26 (43.4)^{e}
Thiodicarb	0.056	1.30	10.13 (18.4)^{a}		40.33 (39.41)^{c}	22.33 (28.1)^{b}
Thiodicarb	0.075	1.13	26.36 (30.8)^{c}	38.66 (38.4)^{c}	45.86 (42.62)^{d}	38.86 (38.5)^{d}
Endosulfan	0.07	1.26	17.86 (24.9)^{b}		27.67 (31.72)^{b}	22.73 (28.4)^{b}
Chlorpyrifos	0.04	1.06	36.30 (37.0)^{d}	16.60 (23.9)^{a}	59.13 (50.27)^{e}	48.5 (44.1)^{ef}
Untreated		1.30	0.00	44.43 (41.7)	0.00	0.00

				c 22.76 (28.4) b 50.16 (45.0) d 0.00		
F – Test S.Em ± C.D (P=0.05)			1.27 3.71	1.10 3.21	1.23 3.59	0.41 1.20

Figures in the parentheses are angular transformed values

.Means followed by the same letters are not significantly different at 5% level by Duncan’s Multiple Range Test.

Table 13: Per cent reduction of *M. maculipennis* population after second spraying

Treatment	Concentration (%)	Pretreatment Data	Mean % of reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	0.97	9.44 (17.8)[a]	20.92 (27.1)[b]	21.60 (27.6)[a]	17.30 (24.5)[a]
Indoxacarb	0.0145	0.96	14.73 (22.5)[b]	16.56 (23.9)[a]	21.97 (27.9)[a]	17.79 (24.9)[a]
Profenofos	0.0375	1.46	36.38 (37.0)[d]	38.53 (38.3)[d]	49.66 (44.8)[d]	41.40 (40.0)[e]
Profenofos	0.05	1.33	33.96 (35.6)[d]	37.17 (37.5)[d]	66.10 (54.4)[f]	45.70 (42.5)[f]
Spinosad	0.01125	0.96	13.40 (21.4)[ab]	17.06 (24.3)[a]	36.16 (36.9)[c]	22.20 (28.1)[b]
Spinosad	0.015	1.46	19.73	20.43	23.10	21.00

			(26.3)[c]	(26.8)[b]	(28.7)[ab]	(27.2)[b]
Cartap hydrochloride	0.0375	1.03	46.05 (42.7)[f]	54.00 (47.2)[f]	56.63 (48.8)[e]	22.20 (46.2)[g]
Cartap hydrochloride	0.05	1.47	33.56 (35.40)[d]	37.06 (37.5)[d]	35.90 (36.8)[c]	35.46 (36.5)[d]
Thiodicarb	0.056	1.13	22.74 (28.4)[c]	24.06 (29.3)[bc]	33.00 (35.0)[bc]	26.53 (31.0)[c]
Thiodicarb	0.075	0.80	32.27 (34.6)[d]	35.26 (36.4)[d]	37.86 (37.9)[c]	35.06 (33.3)[d]
Endosulfan	0.07	1.16	23.20 (28.7)[c]	26.06 (30.6)[c]	30.83 (33.7)[b]	26.66 (31.0)[c]
Chlorpyrifos	0.04	1.30	40.33 (39.4)[e]	47.33 (43.4)[e]	52.78 (46.5)[d]	46.76 (43.1)[f]
Untreated		1.43	0.00	0.00	0.00	0.00

F – Test S.Em ± C.D (P=0.05)			 1.02 3.00	 0.87 2.56	 0.71 2.30	 0.40 1.19

Figures in the parentheses are angular transformed values

.Means followed by the same letters are not significantly different at 5% level by Duncan’s Multiple Range Test.

Table 14: Overall effect of insecticides against *M. maculipennis* population

Treatment	Concentration (%)	Mean % of reduction over untreated check		
		I Spray	II Spray	Overall
Indoxacarb	0.0108	19.85 (26.45)[a]	17.30 (24.57)[a]	18.57 (25.52)[a]
Indoxacarb	0.0145	26.46 (30.95)[c]	17.76 (24.92)[a]	22.11 (28.04)[b]
Profenofos	0.0375	45.03 (42.14)[e]	41.40 (40.04)[e]	43.21 (41.09)[g]
Profenofos	0.05	50.40 (45.22)[f]	45.70 (42.53)[f]	48.05 (43.88)[h]
Spinosad	0.01125	21.66 (27.73)[a]	22.20 (28.10)[b]	21.93 (27.92)[b]
Spinosad	0.015	36.96	21.00	28.98

		(37.43)[d]	(27.27)[b]	(32.57)[d]
Cartap hydrochloride	0.0375	54.30 (47.46)[g]	52.20 (46.26)[g]	53.23 (46.85)[i]
Cartap hydrochloride	0.05	47.26 (43.43)[e]	35.46 (36.54)[d]	41.36 (40.02)[f]
Thiodicarb	0.056	22.33 (28.19)[b]	26.53 (31.00)[c]	24.43 (29.56)[c]
Thiodicarb	0.075	38.86 (32.56)[d]	35.06 (36.30)[d]	36.96 (37.44)[e]
Endosulfan	0.07	22.73 (28.47)[b]	26.66 (31.08)[c]	24.70 (29.80)[c]
Chlorpyrifos	0.04	48.52 (44.15)[ef]	46.76 (43.14)[f]	47.63 (43.64)[h]
Untreated				

F – Test				
S.Em ±		0.41	0.40	0.27
C.D (P=0.05)		1.22	1.18	0.80

Figures in the parentheses are angular transformed values.

Means followed by the same letters are not significantly different at 5% level by Duncan’s Multiple Range Test.

Table 11: Overall efficacy of insecticides against *Euproctis spp*. Population

Treatment	Concentration (%)	Mean % of reduction over untreated check		
		I Spray	II Spray	Overall
Indoxacarb	0.0108	67.40 $(55.2)^{b}$	75.75 $(60.5)^{d}$	71.57 $(57.7)^{c}$
Indoxacarb	0.0145	72.15 $(58.1)^{b}$	77.10 $(61.4)^{b}$	74.6 $(59.7)^{bc}$
Profenofos	0.0375	41.06 $(39.8)^{e}$	66.03 $(54.3)^{c}$	53.55 $(47.0)^{d}$
Profenofos	0.05	41.86 $(40.3)^{d}$	69.36 $(56.3)^{c}$	55.61 $(48.2)^{d}$
Spinosad	0.01125	75.43 $(60.2)^{a}$	79.93 $(63.4)^{a}$	77.68 $(61.8)^{b}$
Spinosad	0.015	79.26	86.26	82.76

		(62.9)[a]	(68.3)[a]	(65.5)[a]
Cartap hydrochloride	0.0375	48.13 (43.9)[d]	64.40 (53.3)[cd]	56.26 (48.6)[d]
Cartap hydrochloride	0.05	56.05 (48.4)[c]	57.13 (49.1)[d]	56.59 (48.7)[d]
Thiodicarb	0.056	71.60 (57.8)[b]	77.15 (61.5)[b]	74.2 (59.5)[bc]
Thiodicarb	0.075	73.23 (58.8)[b]	81.96 (64.8)[a]	77.60 (61.7)[b]
Endosulfan	0.07	51.00 (46.0)[cd]	59.71 (50.6)[d]	55.75 (48.3)[d]
Chlorpyrifos	0.04	41.46 (40.0)[de]	57.16 (49.1)[d]	49.31 (44.6)[e]
Untreated				

F – Test S.Em ± C.D (P = 0.05)		1.20 3.51	1.24 3.63	0.74 2.18

Figures in the parentheses are angular transformed values.

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table – 5: **Overall efficacy of insecticides against *A. janata* population**

Treatment	Concentration	Mean % of reduction over untreated check

	(%)	I Spray	II Spray	Overall
Indoxacarb	0.0108	66.60	80.93	73.2
		(54.7)^{bc}	(64.1)^{a}	(58.8)^{a}
Indoxacarb	0.0145	70.16	78.39	74.28
		(56.8)^{b}	(62.3)^{a}	(59.5)^{a}
Profenofos	0.0375	56.35	75.56	64.95
		(48.6)^{d}	(60.3)^{a}	(53.7)^{c}
Profenofos	0.05	57.61	72.46	65.03
		(49.3)^{c}	(58.4)^{bc}	(53.7)^{c}
Spinosad	0.01125	76.03	76.02	76.03
		(60.6)^{a}	(60.6)^{a}	(60.6)^{a}
Spinosad	0.015	77.16	74.60(	75.88
		(61.4)^{a}	59.7)^{b}	(60.5)^{a}
Cartap	0.0375	47.62	76.52	62.05
hydrochloride		(43.6)^{e}	61.0)^{a}	(51.9)^{c}
Cartap	0.05	62.61	74.83	68.71

hydrochloride		(52.3)[c]	(60.0)[a]	(56.0)[b]
Thiodicarb	0.056	75.60	69.76	72.79
		(60.4)[a]	(56.6)[b]c	(58.5)[a]
Thiodicarb	0.075	73.97	67.12	75.55
		(59.3)[a]	(55.0)[c]	(57.1)[b]
Endosulfan	0.07	48.70	72.17	60.43
		(44.2)[e]	(58.1)[bc]	(51.0)[c]
Chlorpyrifos	0.04	57.93	64.47	61.20
		(49.5)[cd]	(53.4)[c]	(51.4)[c]
Untreated				
F – Test		Sig	Sig	Sig
S.Em ±		0.93	1.32	0.90
C.D (P = 0.05)		2.73	3.86	2.65

Figures in the parentheses are angular transformed values

.Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table – 8: Overall efficacy of insecticides against *S. litura* population

Treatment	Concentration (%)	Mean % of reduction over untreated check		
		I Spray	II Spray	Overall
Indoxacarb	0.0108	72.03 (58.0)[a]	83.46 (66.0)[a]	77.75 (61.8)[a]
Indoxacarb	0.0145	57.68 (49.4)[b]	84.14 (66.5)[a]	70.91 (57.3)[a]
Profenofos	0.0375	65.60 (54.1)[a]	65.21 (53.8)[cd]	65.60 (54.1)[bc]
Profenofos	0.05	63.53 (52.9)[a]	70.36 (57.0)[c]	66.95(54.9)[bc]
Spinosad	0.01125	56.54 (48.7)[b]	83.06 (65.7)[a]	69.80 (56.7)[b]
Spinosad	0.015	56.67 (48.9)[b]	82.02 (64.9)[a]	69.34 (56.4)[b]
Cartap	0.0375	55.50	66.26	60.88

hydrochloride		(48.1)[b]	(54.5)[b]	(51.3)[c]
Cartap	0.05	74.15z	62.42	68.28
hydrochloride		(59.7)[a]	(52.2)[cd]	(55.8)[bc]
Thiodicarb	0.056	70.30	78.18	74.24
		(57.1)[a]	(62.1)[b]	(59.5)[a]
Thiodicarb	0.075	55.70	74.65	66.17
		(48.2)[b]	(59.7)[bc]	(53.8)[bc]
Endosulfan	0.07	66.96	50.58	58.77
		(54.9)[a]	(45.3)[e]	(50.0)[c]
Chlorpyrifos	0.04	55.20	57.68	56.44
		(48.0)[b]	(49.4)[d]	(48.7)[c]
Untreated				
F – Test				
S.Em ±		2.66	1.09	1.60
C.D (P =		7.76	3.19	4.69

0.05)				

Figures in the parentheses are angular transformed values.

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table 17: Overall effect of insecticides against Coccinellid population

Treatment	Concentration (%)	Mean % of reduction over untreated check		
		I Spray	II Spray	Overall
Indoxacarb	0.0108	36.6 (37.2)[ab]	33.2 (35.2)[ab]	34.9 (36.2)
Indoxacarb	0.0145	34.6 (35.9)[a]	36.2 (36.9)[b]	35.4 (36.4)
Profenofos	0.0375	42.0 (40.38)[b]	47.9 (43.7)[c]	44.9 (42.1)
Profenofos	0.05	45.2 (42.2)[b]	45.7 (42.5)[c]	45.7 (42.5)
Spinosad	0.01125	30.2 (33.3)[a]	28.4 (32.1)[ab]	29.3 (32.7)
Spinosad	0.015	33.3 (35.2)[ab]	33.4 (35.3)[ab]	33.3 (35.2)

Cartap hydrochloride	0.0375	47.0 (43.2)[b]	43.8 (31.4)[bc]	45.4 (42.3)
Cartap hydrochloride	0.05	49.4 (44.7)[b]	46.3 (42.8)[c]	47.8 (43.7)
Thiodicarb	0.056	28.9 (32.5)[a]	27.6 (31.6)[a]	28.2 (32.1)
Thiodicarb	0.075	35.7 (36.6)[ab]	34.8 (36.1)[b]	35.2 (36.3)
Endosulfan	0.07	36.4 (37.0)[ab]	36.6 (37.2)[bc]	36.5 (37.1)
Chlorpyrifos	0.04	45.4 (42.3)[b]	48.4 (44.1)[c]	46.8 (43.2)
Untreated		0.00	0.00	0.00
F – Test				

			1.8	
S.Em ±		1.74	5.4	1.08
C.D (P=0.05)		5.1		3.19

Figures in the parentheses are angular transformed values.

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table – 15: Per cent Reduction of Coccinellid population after first spraying

Treatment	Concentration.(%)	Pretreatment Data	Mean % reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall
Indoxacarb	0.0108	6.66	34.8 (36.0)^{b}	40.33 (39.3)^{ab}	34.8 (36.0)^{ab}	36.6 (37.2)^{ab}
Indoxacarb	0.0145	7.33	22.5 (28.1)^{a}	36.2 (36.9)^{ab}	45.1 (42.2)^{bc}	34.6 (35.9)^{a}
Profenofos	0.0375	7.66	35.0 (36.1)^{b}	47.56 (43.6)^{b}	43.4 (41.1)^{bc}	42.0 (40.38)^{b}
Profenofos	0.05	7.00	36.9 (37.4)^{b}	51.4 (45.8)^{b}	47.3 (43.4)^{bc}	45.2 (42.2)^{b}
Spinosad	0.01125	9.00	27.2 (31.3)^{ab}	35.3 (36.3)^{ab}	28.3 (31.8)^{a}	30.2 (33.3)^{a}
Spinosad	0.015	8.00	21.4	32.9	45.7	33.3

			(27.4)[a]	(34.9)[a]	(42.5)[bc]	(35.2)[ab]
Cartap hydrochloride	0.0375	6.00	41.1 (39.8)[b]	51.4 (45.8)[b]	48.5 (44.1)[bc]	47.0 (43.2)[b]
Cartap hydrochloride	0.05	6.66	35.3 (36.4)[b]	50.9 (45.5)[b]	55.6 (48.2)[c]	49.4 (44.7)[b]
Thiodicarb	0.056	8.00	20.9 (26.9)[a]	29.0 (32.5)[a]	37.0 (37.4)[ab]	28.9 (32.5)[a]
Thiodicarb	0.075	6.66	25.1 (29.9)[ab]	41.0 (39.7)[ab]	41.0 (39.7)[b]	35.7 (36.6)[ab]
Endosulfan	0.07	6.33	26.1 (30.7)[ab]	37.4 (37.5)[ab]	45.7 (42.5)[bc]	36.4 (37.0)[ab]
Chlorpyrifos	0.04	7.66	34.6 (36.0)[b]	48.0 (43.8)[b]	53.6 (47.1)[c]	45.4 (42.3)[b]
Untreated		8.33	0.00	0.00	0.00	0.00

F – Test S.Em ± C.D (P = 0.05)			2.6 6.6	2.6 7.8	2.19 6.40	1.74 5.10

Figures in the parentheses are angular transformed values

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.

Table 16: Per cent Reduction of. Coccinellid population after second spraying

Treatment	Concentration (%)	Pretreatment data	Mean % reduction over untreated check			
			1 DAS	5 DAS	10 DAS	Overall

Indoxacarb	0.0108	7.0	28.9 (29.9)[ab]	38.6 (38.4)[ab]	37.6 (37.7)[ab]	33.2 (35.2)[ab]
Indoxacarb	0.0145	7.66	32.4 (30.8)[ab]	37.8 (37.9)[ab]	41.9 (40.3)[ab]	36.2 (36.9)[b]
Profenofos	0.0375	6.66	39.5 (38.9)[b]	49.7 (44.8)[b]	54.4 (47.5)[b]	47.9 (43.7)[c]
Profenofos	0.05	7.3	36.0 (36.9)[b]	35.7 (32.5)[b]	54.4 (48.1)[b]	45.7 (42.5)[c]
Spinosad	0.01125	7.0	24.7 (28.8)[a]	33.2 (35.1)[ab]	28.5 (32.2)[a]	28.4 (32.1)[a]
Spinosad	0.015	7.33	25.3 (29.8)[ab]	30.0 (33.2)[a]	45.0 (42.1)[b]	33.4 (35.3)[ab]
Cartap hydrochloride	0.0375	6.66	35.5 (36.5)[b]	51.4 (45.8)[b]	34.7 (41.9)[b]	43.8 (41.4)[bc]
Cartap hydrochloride	0.05	6.00	35.6 (36.5)[b]	44.9 (49.7)[b]	53.4 (47.2)[b]	46.3 (42.8)[c]

Thiodicarb	0.056	8.00	20.4 (26.7)[a]	35.0 (35.7)[a]	29.4 (32.7)[a]	27.6 (31.6)[a]
Thiodicarb	0.075	7.33	27.3 (31.5)[a]	30.9 (33.2)[a]	40.9 (39.7)[ab]	34.8 (36.1)[b]
Endosulfan	0.07	8.33	28.9 (32.4)[a]	43.3 (41.1)[ab]	37.8 (37.9)[ab]	36.6 (37.2)[bc]
Chlorpyrifos	0.04	5.66	37.2 (37.4)[b]	55.8 (48.5)[b]	52.3 (46.3)[b]	48.4 (44.1)[c]
Untreated		8.00	0.00	0.00	0.00	0.00
F – Test						
S.Em ±			2.6	2.7	2.7	1.8
C.D(P = 0.05)			7.8	8.0	7.9	5.4

Figures in the parentheses are angular transformed values

Means followed by the same letters are not significantly different at 5% level by Duncan's Multiple Range Test.