BIOEFFICACY AND DISSIPATION OF CERTAIN INSECTICIDES ON PESTS OF CABBAGE

By

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CERTIFICATE

Mr. K. MALLA REDDY has satisfactorily prosecuted the course of research and that the thesis entitled **"BIOEFFICACY AND DISSIPATION OF CERTAIN INSECTICIDES ON PESTS OF CABBAGE"** submitted is the result of original research work done and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

Date : 25/3/2003
Place : Hyderabad

(Dr. K. LOKA REDDY)
Major Advisor

CERTIFICATE

This is to certify that the thesis entitled **"BIOEFFICACY AND DISSIPATION OF CERTAIN INSECTICIDES ON PESTS OF CABBAGE"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the **Acharya N.G. Ranga Agricultural University, Hyderabad,** is a record of the bonafide research work carried out by **K. MALLA REDDY** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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

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CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

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Date: 25.03.2003.

(K. MALLA REDDY)

DECLARATION

I, **K. MALLA REDDY** hereby declare that the thesis entitled **"BIOEFFICACY AND DISSIPATION OF CERTAIN INSECTICIDES ON PESTS OF CABBAGE"** submitted to the **ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY** for the degree of **MASTER OF SCIENCE IN AGRICULTURE** is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier in any manner.

Date : 25. 03. 2003

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ABSTRACT

The efficacy of endosulfan (0.07%), profenofos (0.05%), carbaryl (0.15%), thiodicarb (0.14%), cartap hydrochloride (0.4%), indoxacarb (0.02%), spinosad (0.00005%), *B.t.* formulation (Delfin) (0.005%) and neem (5%) sprays against diamondback moth *Plutella xylostella*, cabbage leaf webber, *Crocidolomia binotalis* tobacco caterpillar *Spodoptera litura*, cabbage head borer *Hellula undalis* and aphid, *Lipaphis erysimi* on cabbage was studied under field conditions during *rabi*, 2001-2002 at College of Agriculture, Acharya N.G. Ranga Agricultural University, Hyderabad. The dissipation and decontamination of selected insecticides viz.,endosulfan (0.07%), carbaryl (0.15%) and profenofos (0.05%) in cabbage heads were also studied at AICRP on Pesticide Residue Laboratory.

Spinosad exerted superior control of diamondback moth (65.78%), tobacco caterpillar (62.20%), cabbage head borer (61.26%) and cabbage leaf webber (60.45 %). While thiodicarb recorded 60.54, 58.33 and 57.72 per cent reduction of diamondback moth, cabbage leaf webber and cabbage head borer population respectively. Indoxacarb treatment resulted in 60.06 and 57.46 per cent reduction of tobacco caterpillar and cabbage head borer

respectively. Profenofos and endosulfan sprays were found to be effective against aphids with 75.75 and 72.43 per cent reduction in population, respectively.

Among the different treatments, spinosad, thiodicarb and indoxacarb were found to be effective against lepidopterous insect pests. Cartap hydrochloride was moderately effective in controlling diamondback moth (47.23%), cabbage leaf webber (43.75%) and tobacco caterpillar (50.27%), Profenofos and endosulfan were proved to be effective against aphids . While, neem and *B.t.* formulation (Delfin) were ineffective as they could not bring the desirable control of lepidopterous insect pests as well as aphids.

The residue of profenophos (0.05%), endosulfan (0.07%) and carbaryl (0.15%) dissipated from cabbage heads to an extent of 93.40, 88.2 and 86.67 per cent respectively in ten days after three sprayings. The removal of upper most layer on cabbage heads and subsequent water washings reduced the initial deposits of profenofos, endosulfan and carbaryl to an extent of 91.20, 75.00 and 62.22 per cent respectively. The waiting periods worked out for endosulfan, profenofos and carbaryl were 2.92, 1 and 1 days, respectively.

LIST OF ABBREVIATIONS

%	:	per cent
°C	:	degree centigrade
a.i./A	:	active ingredient/Acre
cm	:	centimeter
cm^2 (or) sq.cm	:	square centimeter
et al	:	and others
Fig	:	Figure
g a.i./ha	:	gram active ingredient/hectare
g	:	grams
gal	:	gallon
IU/mg	:	International Units/milligram
IU/ml	:	International Units/millilitre
kg a.i./ha	:	kilogram active ingredient/hectare
kg/ha	:	kilograms per hectare
lb	:	pound
lb a.i./A	:	pound active ingredient/Acre
lb a.i./ha	:	pound active ingredient/hectare
Lit/ha	:	litre/hectare
m.ha	:	million hectares
m.tonnes	:	million tonnes
mg	:	milligram
mg/gal	:	milligrams/gallon
mg/g (or) mg g^{-1}	:	milligram per gram
mg/g dw	:	milligram per gram dry weight
mg/kg	:	milligrams/kilogram
mg/lit	:	milligrams/litre
min	:	minutes
ml	:	millilitre
ml/min	:	millilitre/minute

mm	: millimeter
nm	: nanometer
number mm^{-2} (or) number/mm^2	: number per square millimeter
r	: correlation coefficient
ppm	: parts per million
SD	: Standard deviation
t/ha	: tonnes per hectare
viz.	: namely
w/w	: weight/weight
μ	: micron

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is the second most important cruciferous vegetable crop, through out the world. In India, the average productivity of cabbage is 156.80 q/ha as against 216.20 q/ha in the world, (Kalloo and Pandey, 2002). Among the various factors responsible for low productivity, one of the major constraints is the damage done by various insect pests starting from transplanting till harvest.

The cabbage like other cruciferous crops is ravaged by wide array of insect pests among which diamondback moth, *Plutella xylostella* L., cabbage leaf webber, *Crocidolomia binotalis* Zell. tobacco caterpillar, *Spodoptera litura* Fab., cabbage head borer, *Hellula undalis* Fab., green peach aphid, *Myzus persicae* Sculz., cabbage aphid, *Brevicoryne brassicae* L. and mustard aphid *Liphaphis erysimi* Kalt. are the most important. The yield loss due to these pests has been estimated to be around 31 (Abraham and Padmanabhan, 1968) to 66 per cent (Srihari and Satyanarayana, 1992). According to Raju (1996), resistance to insecticides by *P. xylostella*, has become a limiting factor in the commercial cultivation of cabbage and cauliflower in India.

In spite of several insecticidal recommendations against these pests (Krishnaiah and Mohan, 1977; Butani and Juneja, 1984; Mohite and Moholkar, 1988; Thakur and Deka, 1997) desirable control has been far away. So, a constant search for effective chemicals has become a regular feature of entomological research to offer timely suggestions to the growers. Several commercial insecticides have been evaluated against these pests by earlier workers (Shaw *et al.*, 1999; Divakar *et al.*, 1999 and Biradar *et al.*, 2001).

However, repeated use of conventional and synthetic pyrethroids posed problems such as development of insecticide resistance, environmental pollution, destruction of natural enemies and high productivity cost. As a result, more and more insecticides belonging to different groups are being developed and marketed in quick succession. The cultivators being highly impressed by the apparent advantages of the insecticides, are using the chemicals indiscriminately without caring for the ill effects.

The crop protection strategies, now-a-days however experienced a paradigm shift from pest "control" to pest "management". As exclusion of chemical insecticides is impracticable and hence, the most selective and effective insecticide has to be brought up. Vegetables retain residues of a varietable cocktail of chemicals since these are applied at different stages of crop growth and even immediately prior to frequent harvests resulting in health hazards to the consumers.

Eventually, testing the efficacy of newer insecticides, their toxic residues on the produce and techniques to decontaminate them have gained importance to ensure effective pest control and safer produce for consumption.

In this background, it was proposed to study the bioefficacy, dissipation and decontamination of certain selected insecticides in cabbage with the following objectives:

1. To evaluate the bioefficacy of insecticides against pest complex of cabbage.

2. To establish dissipation pattern of selected insecticides in cabbage and to prescribe waiting periods.

3. Decontamination studies for removal of residues of selected insecticides in cabbage.

Chapter II

Review of Literature

CHAPTER II
REVIEW OF LITERATURE

The information regarding the bio-efficacy of certain conventional, newer and botanical insecticides on major pests of cabbage, dissipation and decontamination of a few insecticides on cabbage and other crops in India and abroad pertinent to present experimentation has been reviewed and presented below:

2.1 Bioefficacy of insecticides

2.1.1 Bioefficacy of Endosulfan

Endosulfan is an organochlorine insecticide and acaricide which acts as both contact and stomach poison. It has broad spectrum of activity and considered safer to non target insects.

Singh *et al.* (1976) recorded 94 per cent mortality of *P. xylostella* with endosulfan in 48 hrs after spraying. Murthy *et al.* (1982) reported the effectiveness of endosulfan (0.07%) against *Hellula undalis*, *P. xylostella* and *Brevicoryne brassicae*. Srinivasan and Krishna Kumar (1986) reported significant reduction in the abundance of *P. xylostella* on radish by the application of endosulfan at 0.07 per cent. Endosulfan at 500 g a.i./ha offered the most effective control against pests of cabbage (Lal, 1990). However, Prasad (1993) reported that endosulfan (0.07%) was significantly effective in reducing the larval population of *P. xylostella*. Under laboratory conditions, endosulfan (0.07%) caused 35, 80 and 80 per cent mortality of second instar *P. xylostella* larvae after 24, 48 and 72 hrs, respectively (Raju *et al.*, 1994).

Krishnaiah and Mohan (1977) opined that *C. binotalis* could be kept in check with quinalphos, endosulfan, carbaryl, acephate, fenitrothion, methamidophos, chlorpyriphos. Endosulfan gave effective control of *C. binotalis* and *P. xylostella* over a fortnight, while Dipel suppressed the population for a week in cabbage fields (Krishnaiah and Mohan, 1983). Application of endosulfan (680 g a.i./ha) on mustard resulted in 94.6 and 97.6 per cent reduction of *C. binotalis* at 24 and 48 hrs after spray over initial population (Rabindra and Jayaraj, 1988).

Patel and Patel (1996) found effective control of *L. erysimi* and *P. xylostella* by endosulfan (0.035%) and neem seed kernel suspension (NSKS) in Gujarat. Endosulfan was recommended against *C. binotalis* @ 0.07 per cent on radish (Srinivasan and Krishna Kumar, 1986). Endosulfan at 0.05 and 0.1 per cent reduced the mustard aphids population on cabbage and cauliflower (Varela *et al.*, 1988).

Kushawa (1983) based on his studies recommended three fortnightly applications of endosulfan (0.05%), malathion (0.05%) + dipel (500 g/ha) and lindane (0.075%) against pest complex of cabbage. Shukla *et al.* (1990) carried out field trials with endosulfan and malathion at 0.05 per cent against *L. erysimi* and observed significant reduction of aphid population in all the treated plots.

2.1.2 Bioefficacy of Profenofos

Profenofos is an organophosphorus insecticide and acaricide which acts as both contact and stomach poison. The product has a broad spectrum activity against wide range of chewing, mining and sucking pests with a swift knock down action.

Mohan (1987) reported that profenofos at 0.5 kg ai/ha was very effective in controlling aphids on cabbage. Profenofos at 238 - 310 g ai/ha offered more than 68 per cent control of aphids after 21 days of treatment on cabbage (El-Sayed and El-Ghar, 1989). Mohan (1987) while evaluating insecticides against cabbage pest complex found that profenofos at 0.5 kg ai/ha was very effective in controlling cabbage leaf webber *C. binotalis*. Similarly, chemical control of insect pest on cauliflower studied by Murthy (1994) also indicated efficient control of *C. binotalis* by profenofos (0.05%). Profenofos was reported to be most effective against tobacco caterpillar *S. liturà* at 0.05% (Prasad and Nandihalli, 1985) and 0.075% (Haratna and Sarjono, 1986) on tobacco.

Similarly, Murthy (1994) observed effective control of *S. litura* with profenofos (0.05%) on cauliflower. Murthy *et al.* (1997) recorded profenofos (0.05%) to be effective against *S. litura* at second day after spraying on cauliflower.

Profenofos at 0.25 - 0.5 kg ai/ha applied at 7-10 days intervals effectively reduced the larval population of *P. xylostella* on cabbage and Chinese kale (Calderson and Hare, 1986). Mohan (1987) while working on cabbage pest complex, observed that efficient control of *P. xylostella* can be achieved with profenofos at 0.5 kg ai/ha. Thistaton (1987) recommended profenofos for the control of *P. xylostella* on brassicas. Sastrosiswojo *et al.* (1989) recorded that *P. xylostella* to be well controlled by profenofos on cruciferous crops. Williamson and Murray (1993) found the most effective suppression of *P. xylostella* with profenofos at 0.3 and 1.2 ml/l at two weeks after spray on cabbage. Sreekanth (2000) reported that profenofos (0.05%) gave excellent control of *C. pavonana* (98.14%), *S. litura* (80.06%) while imidacloprid (0.02%) effectively suppressed *P. xylostella* with 67.76% reduction of population on cabbage.

2.1.3 Carbaryl

It is a carbamate insecticide with long residual action, and acts as both stomach and contact insecticide. Carbaryl has broad spectrum activity with no-phytotoxic effect.

Charles (1958) reported that sevin (2.0%) or thiodan (4%) dusts were ineffective against cabbage pests *viz.*, cabbage looper, imposted cabbage worm. Abraham and Padmanabhan (1968) reported that carbaryl @ 1.13 kg ai/ha gave ineffective reduction in pest population of *Plutella maculipennis* curt., on cabbage and cauliflower crops. Rajamohan and Jayaraj (1978) reported carbaryl dust

(10%) @ 25 kg ai/ha to be moderately effective aganist *S. litura* and *P. xylostella* on cabbage when compared to sprays of Biotrol XK @ 2.5%, carbaryl @ 2 kg ai/ha, dichlorvos @ 1 lit/ha and fenthion @ 1 lit/ha. Bortoli (1989) reported that carbaryl @ 2.1 and 2.6 kg ai/ha was least effective against *P. xylostella* and *Thrips tabaci* on cabbage in comparision to dichlorvos @ 70 ml and 100 ml/100 lit of water and chloropyriphos @ 0.6 and 1.5 lit/ha.

Verma (1972) reported that carbaryl (0.15%) and endosulfan (0.05%) gave 80 per cent mortality of *P. xylostella* on cabbage. Efficient control of lepidopteran larvae were observed on cabbage by carbaryl sprays at 8 weeks after transplanting (Morallo-Rajesus and Eroles,1976). Sachin and Srivastava (1977) stated that sprays of carbaryl (0.2%) gave efficient protection of cabbage from *P. xylostella* and *H. undalis*. Rao (1979) reported that carbaryl (0.2% and 0.15%) and quinolphos (0.2 and 0.15%) were highly effective and superior to malathion, endosulfan and fenthion against *H. undalis*. Yadav (1988) reported that dimeton-S-methyl @ 0.025% and endosulfan @ 0.05% were effective against cabbage aphids resulting in high mortality and residual effectiveness, whereas carbaryl @ 0.15% was least effective.

2.1.4 Thiodicarb

It is a carbamate insecticides with broad spectrum activity. It acts as both stomach and contact poison and is highly efficient against lepidopterous insect pests.

Leibee (1992) reported endosulfan, chlorpyrifos and *B.t.* sub sps kurstaki (Dipel 2A and javelin) were more effective in controlling *P. xylostella* than cypermethrin, permethrin, methomyl and thiodicarb. The laboratory examination of selected populations from the field study indicated that poor efficacy of the pyrethroids and carbamates was probably due to insecticide resistance.

Thiodicarb showed superior control of the fifth instar larvae of fall army worm, when compared to spinosad on cotton (Adamczyk and Leonard, 1999). Umeda (2000) reported that Thiodicarb (1.0 lb a.i./ha) was less effective on *P. xylostella* when compared to indoxacarb (0.07 lb a.i./ha) and spinosad 0.09 (lb a.i./ha). Thiodicarb (48 larvae/10 plants) was effective in controlling *P. xylostella* on cabbage when compared to indoxacarb or DPX-MP062 (6.5 larvae/10 plants), emamectin benzoate (6.8 larvae/10 plants) and methonyl (5.8 larvae/10 plants).

2.1.5 Cartap hydrochloride

Cartap Hydrochloride is a slow acting nereistoxin isolated from the marine annelids *Lumbrineris heteropoda* and *L. brevicirra*. The insecticidal activity of cartap hydrochloride is attributed to its blocking action on the central nervous system that leads to paralysis. It acts both as stomach and contact poison (David and Swami, 1982).

Jagannadh (1993) recorded lowest pod damage by *S. litura* on chillies when sprayed with cartap hydrochloride (0.05 %). Ravi Kumar (1993) reported

100 per cent mortality of first instar larvae of *S. litura* on groundnut at 24 hours after treatment when sprayed with triazophos (0.05%), profenofos (0.1%), chlorpyriphos (0.05%), whereas, cartap hydrochloride (0.05%) recorded only 60 per cent mortality of the pest. Manmadha Rao (1995) found cartap hydrochloride at 0.25 and 0.05 per cent in bait form to be very effective and recorded 70 and 100 per cent larval mortality of *S. litura* respectively.

According to Omoy (1987) dichlorvos (0.2%) and Padan (0.2%) as ineffective treatments in reducing *C. binotalis* on cabbage. Sumalatha (1990) recorded highest population reduction of *C. binotalis* with 0.1 per cent cartap hydrochloride one day after treatment.

Srinivasan and Krishna Murthy (1988) found that cartap hydrochloride at 350 g a.i. and pyraclophos at 175 and 350 g ai/ha gave excellent control of *P. xylostella* on cabbage as compared to sprays of cypermethrin (30 g), deltamethrin (10 g) and fenvalerate (50 g) ai/ha. Clement Peter *et al.* (1989) considered cartap hydrochloride at 200 g ai/ha to be minimum effective dosage for the control of *P. xylostella* on cabbage.

Rajavel and Babu (1989) observed cartap hydrochloride (100 g ai/ha) as moderately effective treatment (0.33 to 0.66 larvae/cabbage) in comparison to fenvalerate (75 g ai/ha) (0-0.66 larvae/cabbage) in reducing the larval population of *P. xylostella* on cabbage. Srinivasan and Moorthy (1991) recommended cartap hydrochloride (0.05%) for the control of *P. xylostella* and *C. binotalis* on cabbage. Singh *et al.* (1993) reported cartap hydrochloride @ 100 g ai/ha was the next best treatment after fenvelerate @ 75 g ai/ha in controlling the larvae of *P. xylostella* on cabbage. Panda (1991) reported that foliar application of cartap and endosulfan resulted in 46.8 and 26.0 per cent reduction of *P. xylostella* on cabbage. Sharma *et al.* (2000) reported that Bioasp and Biolep @ 2 kg/ha gave highest larval mortality i.e., equivalent to cartap hydrochloride 50 wp @ 1 kg/ha.

Rai and Saxena (1992) reported that granular formulation of cartap hydrochloride (Paden 4G) to give highest reduction in the larval population (87%) of *P. xylostella* as against the sprayable formulations of flufenoxuron (Cascade 10 EC) and cartap hydrochloride (Padan 50 SP). Nagesh and Shashi Verma (1997) reported that cartap followed by diflubenzuron and *B.t.* were effective against *P. xylostella* and suggested that sequential spraying of these chemicals with different mode of actions can be recommended to overcome the problem of resistance in *P. xylostella.* Cartap hydrochloride gave moderate control of *P. xylostella* when compared with flufenoxuron @ 37.5 g ai/ha, tebufenzuron @ 56.25 g ai/ha, neem seed kernel extract (4%) and *B.t.* products like Biobit, Dipel, and Delfin (Sannaveerappanavan and Viraktamath ,1997). Babu and Krishnaiah (1998) reported that individual treatments of cartap, quinalphos and their combinations were highly effective and required only fewer sprays (2-3) at much longer intervals (12-15 days), in comparison to neem oil, *B.t.* sub sps, Kurstaki and their combinations which were relatively less effective against cauliflower caterpillars in Andhra Pradesh.

2.1.6 Indoxacarb

It is a newly introduced broad spectrum neurotoxin, acting as contact and stomach poison having translaminar action.

David and Telley (1999) reported that indoxacarb (0.065 lb a.i./ha) and spinosad were statistically on par and inferior to methomyl, esfenvelarate and emamectin benzoate (0.0075 lb a.i./ha) in controlling *P. xylostella* in Yuma county of Arizona. Leibee (2000) reported that indoxacarb @ 0.065 lb a.i./A was superior to spinosad @ 0.025 lb a.i./A, chlorofenapyr @ 0.075 and 0.015 lb a.i./A and emamectin benzoate @ 0.0075 lb a.i./A, *B.t.* sub sps aizawai @ 1.0 lb a.i./A in controlling *P. xylostella* on cabbage in Florida.

Indoxacarb (6.5 larvae/10 plants) was found inferior to spinosad (4.5 larvae/10 plants) and thiodicarb (4.8 larvae/10 plants) in controlling *P. xylostella* on cabbage (Umeda, 1999). Umeda (2000) reported that indoxacarb (0.07 lb a.i./A) was inefficient on *P. xylostella* on cabbage when compared to spinosad (0.09 lb a.i./A) and thiodicarb (1.00 lb a.i./A).

Khar boutli *et al.* (1999) reported that indoxacarb was effective against *H. zea* and spinosad against *H. virescens*.

2.1.7 Spinosad

Spinosad is a newly introduced insecticide derived from fermentation of the naturally occuring soil bacterium, *Saccharpolyspora spinosa*. It has broad spectrum activity and acts as both neurotoxin and stomach poison. It has translaminar flow in plant.

Hendrix *et al.* (1997) reported spinosad as an ecofriendly insecticide whose performance was better than other chemicals and noted that its efficacy against *S. exigua* under threshold and out break situation was comparable to commercial threshold. Adamczyk and Leonard (1999) reported the toxicity of spinosad to the fifth instar larvae of fall army worms was significantly less when compared to thiodicarb in laboratory bioassay studies on cotton. Umeda (2000) reported that thiodicarb @ 1.00 lb ai/ha, spinosad @ 0.09 lb ai/A gave efficient control of *P. xylostella* on cabbage whereas indoxacarb @ 0.07 lb ai/A was not.

Khar boutli *et al.* (1999) reported indoxacarb to be effective against *Helicoverpa zea* and spinosad against *Helicoverpa virescens*. Liu-TongXian (1999) reported that all formulations of *B.t.* spin Tor were highly toxic to third instar larvae under laboratory conditions. The least effective formulations were ABG-6405, Troy-Bt and Dipel D F (46.6 - 67.9 mg/l). Moderate control was shown by ABG 6406 and ABG -6505 D. Formulations of SS-6696A and ABG-6475 were highly efficient indicating the efficacy of Bt formulations was varied whereas SpinTor was highly effective when pest pressure was high. Hill and Foster (2000) reported that larval mortalities of *P. xylostella* and *Diadegma insulare* at field rates were significantly higher with carbaryl, permethrin, Spinosad and tebufenozoide when compared with *Bacillus thuringiensis* or imidacloprid in larval bioassay studies conducted 72 hrs after treatment. In the leaf dip and residual bioassay both permethrin and spinosad caused 100 per cent mortality of diamonback moth larvae and adults respectively, 72 hrs after treatment. Spinosad was found nontoxic to *Diadigma insulare* 30 minutes after treatment. However, 100 per cent mortality was observed 8 hrs after treatment.

Harris (1999) reported that spinosad gave high level of control of *P. xylostella*, cabbage butterfly *Pieris rapae* and leaf miner *Scaptomyza* sps., larvae as yields were equivalent or superior to pyrethroids like deltamethrin, cypermethrin, etc. Spinosad (0.25%) and indoxacarb (0.75%, 0.5%) showed efficient control of *P. xylostella* on cabbage when compared to chlorfenapyr (1.25%), emamectin benzoate (3.0), tabufenozoide (2.5) in a trial at Texas. Hutchinson (1999) reported spinosad has consistent efficacy against *P. xylostella*, cabbage looper and cabbage worm. Umeda (1999) reported that thiodicarb (4.8 larvae/10 plants), spinosad (4.5 larvae/10 plants) were efficient in controlling *P. xylostella* on cabbage. As DPX-MP062 (6.5 larvae/10 plants) gave moderate control.

2.1.8 Bioefficacy of *Bacillus thuringiensis* Sub. Sp. Kurstaki

It is a microbial insecticide, acts as stomach poison. It is an eco-friendly insecticide, non toxic to plants, animals, human beings and predators.

Helson (1960) found that the wettable powder containing 3,000 million viable spores of *B.t.*. per gram applied in a spray at 16 lb/100 gal water proved to be most effective in controlling the larvae of *Pieris rapae* (L.) and *Plutella* *maculipennis* Curt., on cabbage in New Zealand. Three applications (at two week intervals) of *B. thuringiensis* containing 30 x 10^9 viable spores per g at 1 lb/acre gave good control of the larvae of *P. rapae* and *P. macullipennis* on cabbage (Fox and Jaques, 1961). Laboratory tests of Rautappa (1967) indicated that dusts of Biotrol BTB containing 25 x 10^9 spores of *B.t.* per g were effective against *P. xylostella* within 23 days. Field studies of Cadapan and Gabriel (1974) in Philippines revealed that weekly application of Dipel at 0.5 kg a.i./ha from transplanting to harvest gave good control of *P. xylostella* and other pests of cabbage.

Laboratory studies by Verma and Gill (1977) at Punjab revealed that Thuricide HPSC and Dipel WP (10 x 10^3 IU/Mg) gave more promising control at 1 and 1.5 g/l of water against *P. xylostella* on cabbage and cauliflower while Bactospine or Thuricide 90 TS were comparatively less effective. According to Brunner and Stevens (1986) sprays of Thuricide HP (*Bt.* Sub sp., Kurstaki) exerted good control of *P. xylostella* better than standard organophosphorus insecticides in trials conducted in India at various locations and efficacy was the greatest when thuricide is applied at hatching time and/or at first to third larval instars on cabbage and cauliflower.

Sastrosiswojo and Nuswantara (1986) reported that application of *B.t.* at 500 ppm resulted in 44.65, 67.29, 94.97 and 84.90 per cent mortality of I, II, III and IV instar larvae of *P. xylostella*, respectively under laboratory conditions. Dibyantoro and Siswojo (1988) reported that bactospine and *B.t.* sub sps Kurstaki gave cent per cent mortality of *P. xylostella* in laboratory and in the fields. Dipel 0.2% (*B.t.* sub sps Kurstaki) also exerted good control of *P. xylostella* in cabbage. On the contrary, Kirsch and Schmutterer (1988) reported low effectiveness of Thuricide HP (*B.t.* sub sps. Kurstaki) in controlling *P. xylostella* on cabbage in comparison with other treatments of synthetic insecticides and neem seed kernel extracts. But, Carballo *et al.* (1989) reported effective control of *P. xylostella* on cabbage with (*B.t.* sub sps Kurstaki) at 0.016 kg ai/ha. Thuricide sprayed at 0.08 per cent concentration alone was ineffective against *P. xylostella* on cabbage but in combination with triazophos and acephate was very effective (Nagamani *et al.*, 1994).

Field trials on cabbage and cauliflower revealed that Biobit (*B.t.* sub sps. Kurstaki) resulted in 13.5 to 44.4 per cent reduction in *P. xylostella* larval population, a day after application (Chandrasekaran *et al.*, 1994). Laboratory studies of Chandale and Anita mane (1994) revealed that Agree 50 WP (*Bt.*. Sub sps. Kurstaki) caused 13.3 per cent mortality and 96.67 per cent mortality of *P. xylostella* at 0.005 and 0.1 per cent concentrations respectively. Panchbhavi and Sudhindra (1994) in their studies found that Delfin (*B.t.* sub sps Kurstaki) was better than Wock Biological 01 (Halt), a *B.t.* sub sps Kurstaki formulation, recording 64.27, 74.87 and 61.07 per cent mortality of *P. xylostella* after first, second and third sprays, respectively.

Ooi (1980) obtained 100 per cent mortality of 1-3 days old *C. binotalis* larvae with Bactospine when the larvae were fed with blocks of semi synthetic diet dipped in *B. thuringiensis* suspension containing 5.6 x 10 IU/ml. Krishnaiah *et al.* (1981) reported successful control of *C. binotalis* and *P. xylostella* on cabbage with weekly sprays of dipel at 0.5 kg/ha in Karnataka, India. On the contrary, Rabindra and Jayaraj (1988) opined that *B. thuringiensis* was not as effective as chemical insecticides like monocrotophos or endosulfan. Dutta (1997) evaluated efficacy of *B.t.* fenvalcrate and quinalphos alone and in combination in the field against *S. litura* infestation and reported that quinolphos at 0.16 kg a.i./ha or fenvelcrate at 0.4 kg a.i./ha followed by one spray of *B.t.* at 0.5 kg formulation/ha gave maximum larval mortalities, as the effect of *B.t.* alone was observed after 120 hrs of spraying. However, *B.t.* in combination with chemical insecticides has shown its effect within 48 hrs of spraying. The application of chemical insecticides prior to *B.t.* gave higher larval mortalities.

Oblisami *et al.* (1969) reported that *B.t.* caused very high mortality of (above 90 per cent) soft bodies caterpillars like *Prodenia litura*. Rangasami *et al.* (1970) reported that *B.t.* has resulted in 70.0 to 95.5 per cent mortality of *Spodoptera litura*. Raja Mohan and Jayaraj (1978) conducted an insecticidal trial against cabbage pests and showed that the spray of *B.t.* was effective in reducing the larval population of *S. litura* and *P. xylostella*, but did not persist in the field for 10 days.

Malathi (2000) reported that *B.t.* formulations Dipel, Delfin, Biobit, Biolep and Bioasp at 0.075% against second instar of lepdiopterous pests on cabbage *viz.*, *P. xylostella* [(*Crocidolomia binotalis*), (*C. pavonana*)] resulted in 86.66 -100 and

96.60 - 100 per cent mortality respectively in 72 hrs, whereas endosulfan gave 100 per cent mortality of *S. litura*. Neem gold (extracts of *A. indica*) (0.03%) and nematode formulation, Green commandos @ 25 sponges/acre were less effective.

Fenthion, Fenitrothion, endosulfan, dichlorovos, phoxim and malathion were equally effective with no significant differences and retained their toxicity better than *B. thuringiensis*. Prasad and Kushwaha (1979) reported 70 to 95.5 per cent mortality of *S. litura* on cauliflower treated with *B.t.* under field conditions. Among the 5 formulations of *B.t.* on noctuid *S. littoralis* in laboratory at 5 concentrations, Bactospine (*B.t.* sub sps thuringiensis) and Thiodan (endosulfan) were the most effective followed by Dipel (*B.t.* sub. Sps Kurstaki) and ABG 6105 (Hosny *et al.*, 1983). *B.t.* was shown to be effective against *S. litura* causing upto 87.5 per cent mortality of first instar larvae in the laboratory (Zaz and Kushwaha, 1983). Working on first instar to fifth instar larvae of *S. litura,* Zaz and Kushwaha (1984) reported that mortality gradually decreased from first instar (87.5%) to fifth instar (43.75%) and with decrease in concentration, there was corresponding decrease in mortality.

Pathogenicity of different strains of *B.t* was tested on first instar larvae of *S. litura* in the laboratory and the effective doses were 10^8 and 10^9 spores/ml with 73.32 and 96.66 per cent mortality respectively eight days after treatment (Amonkar *et al.*, 1985). Similarly, *B.t.* (6.4×10^7 spores/ml) was found to be most effective against *S. litura* causing 61 per cent mortality in the first two larval instars and then the mortality decreased with increase in age and the maximum cumulative kill from larvae to adult emergence ranged from 37.25 per cent (I instar) to 51.25 per cent (V instar) as reported by Zaz (1989).

2.1.9 Neem

It is a plant extract obtained from neem seed. It has a broad spectrum activity. It acts as both systamic and contact poison.

Neem oil (0.25%) treatment on *P. xylostella* resulted in 30.14 and 77.25 per cent mortality after 24 and 72 hrs respectively (Kadam, 1976). Fagoonee (1986) reported that neem seed kernel extract was found to be as effective as deltamethrin against *P. xylostella* and *H. undalis* (Drayer, 1987). On contrary, Chandrasekaran *et al.* (1994) reported poor efficacy of neem oil against *P. xylostella* on cauliflower. Neem oil extract at 2 ml/lit gave 45 per cent mortality of second instar larvae of *P. xylostella* at 72 hrs after treatment (Raju *et al.*, 1994).

Moorthy and Kumar (2000) reported that neem seed kernel powder extract (NSKE) prepared by grinding (4%) was best alternative to the insecticide resistant *P. xylostella*.

Fagoonee and Large (1981) demonstrated the anti-feedant property of neem kernel extract at the test concentrations (0.001 - 5.0 per cent) against all instars of *C. binolatis*. Patnaik *et al.* (1987) observed higher larval mortality of *C. binotalis* with neem oil at 1.5 per cent concentration, Mani *et al.* (1990) recorded 79.76 per cent larval mortality of *C. binotalis* with neem oil at 1.5 per cent. Neem guard 0.1 per cent recorded 89.30, 72.25 and 75.53 per cent reduction of *C. binotalis, P. xylostella* and *S. litura*, respectively at 10 days after application (Sumalatha, 1990). Joshi and Ram Prasad (1975) reported that the neem seed kernel suspension in water at 3% was effective as antifeedant against all the fifth instars of *S. litura*. Mortality was observed only in the first two larval instars. El-Sayed (1985) reported that the treatment of the first and fifth instar larvae of *S. littoralis* with the pounded seeds of neem at 0.2 - 0.5 per cent concentration caused cent per cent mortality by the end of the larval stage. Venkateshwarlu *et al.* (1988) reported the loss of antifeedent property of neem oil after 5 days at 0.5, 1.0 per cent, 6 days at 2 per cent. Repellin (1.0%) caused 84.85 per cent mortality of V instar larvae of *S. litura* (Obulapathy, 1994).

Meadow (1999) reported that neem extracts sprayed on cabbage at a concentration above 2 ppm prevented larval development and at a concentration above 8 ppm prevented plant damage for nearly 1-2 weeks from lepidopterous insect pests.

Javaid (2000) reported the use of neem extracts as part of IPM for *P. xylostella* control since all the neem treatments recorded significantly higher yield of marketable heads of cabbage and significantly better control of *P. xylostella* than the commonly used mixture of pyrethroids or the untreated control. Manjunatha (2000) reported Nivaar neem based pesticide was on par with malathion and monocrotophos after the first and second sprays and superior to them after the third spraying for two consecutive years and effective for control of

P. xylostella at 0.2, 0.3 and 0.4 per cent of Nivaar. But, it was less effective against aphids.

Improved neem seed kernel extract was observed to give best results in reducing the population of *S. litura* and *P. xylostella* when compared to aqueous neem seed kernal extract (Sombatsine and Temboonkeat, 1987). Ramachandra Rao (1980) tested four neem products *viz.*, Biosol, Neemark, Repellin and Neem oil against *S. litura*, and reported that repellency, feeding deterrancy of the insect increased with increase in concentration. Repellin (1%), Dichlorethene extract of neem (1%) and neem seed kernel suspension gave the best and significant protection to tobacco seedlings upto 9 DAS from *S. litura* (Chari, 1993).

Saucke (2000) reported that in comparison to *Bacillus thuringiensis* products (Delfin and Thuricide) and the synthetic IGR chlorfluazuron (Atabron), better results were achieved in field trials with commercial neem formulation. Neem Azal (*Azaridacta indica*) and an aqueous neem seed kernel extract were effective in controlling the lepidopterous insect pests among biological methods. Besides its high efficacy against lepidopterous insect pests it also controlled the mustard aphid *Lipaphis erysimi*.

2.2 DISSIPATION

Spraying of carbaryl at 0.05, 0.10 and 0.20 per cent on cabbage resulted in the average initial deposits of 31.5, 43.61 and 157.5 ppm on cabbage heads. These deposits dissipated to an extent of cent per cent in 22.30 days and the half life values varied from 2.74 to 3.72 days (Gangwar and Singh, 1988).

Bordia and Gupta (1992) reported initial deposits of 12.80, 29.27 and 1.17 ppm on cauliflower when sprayed with 0.1 per cent carbaryl, 0.07 per cent endosulfan and 0.05 per cent monocrotophos respectively. In monocrotophos and endosulfan 50 per cent loss of residues was reported within three days of application while in case of carbaryl, 50 per cent loss in residues was reported within seven days.

Balwinder Singh and Chahal (1993) reported that total endosulfan residues on cauliflower heads decreased to less than MRL of 2 mg/kg in 3 and 5 days at 500 and 1000 g a.i./ha respectively. In cauliflower leaves residues decreased to below detectable limits (0.01 mg/ha) in 15 days at both application rates.

Quinolphos and Malathion had faster rate of dissipation followed by fenitrothion, endosulfan, phosalone which were relatively more persistent as residues on leaves ranged from 34.5 to 40.7 ppm. Endosulfan has the maximum period of protection of 4.4 days (Duhra and Hameed, 1990).

A waiting period of 5, 4 and 11 days was found to be essential after spraying cauliflower at the head-bearing stage with recommended doses of endosulfan, fenvalerate and monocrotophos, respectively. Washing followed by cooking of sprayed cauliflower curds reduces residue levels by 78 - 100 per cent as reported by Dethe (1991).

2.3 DECONTAMINATION

Endosulfan @ 0.07 per cent when sprayed on cauliflower curds showed initial deposits of 24.15 and 14.50 ppm in first and fourth sprayings, respectively. The loss of endosulfan from cauliflower curds due to washing and boiling, cooking at various sampling intervals varied from 37.02 to 82.21 and 56.49 to 79.11 per cent, respectively (Jaglan and Yadav, 1986).

Washing twice with solution of 1% alcohol or 0.05% solution of sodium bicarbonate removed over 70% of residues of quinalphos and endosulfan from cauliflower curds obtained from the market where as 1% of table salt or vinegar removed about 60% of above chemicals (Senapati *et al.*, 1990).

Washing cabbage heads reduced Malathion and carbaryl residues to 64.60 and 75.40 per cent, respectively. While cooking resulted in 83.97 and 89.62 per cent reduction in the residues of the two chemicals, respectively (Bhatia and Verma, 1994).

Chapter III

Material & Methods

CHAPTER III
MATERIALS AND METHODS

Field bioefficacy studies were undertaken with nine insecticides against the pests of cabbage during *rabi*, 2001-02 at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The dissipation and decontamination studies on three insecticides viz., endosulfan, carbaryl and profenofos in cabbage was carried out at All India Coordinated Research Project on Pesticide Residues, College of Agriculture, Rajendranagar. The materials used in conducting the experiment and the various methods employed during the course of investigations are given below:

3.1 EXPERIMENTAL DETAILS

The field was ploughed thoroughly thrice with a tractor drawn cultivator and evenly levelled after removing all the stubbles and weeds. The experiment was laid out in a Randomised Block Design (RBD) with 10 treatments each replicated thrice (Fig.1). The plot size was 18 m^2 (3.6 x 5 m). A popular short duration variety "Golden Acre" was chosen for the study. Seedlings were raised at green house, College of Agriculture, Rajendranagar and were utilized for transplanting in the main field of red loamy soil of fine tilth with pH of 7.2. One month old seedlings were transplanted after providing irrigation by adopting an inter row spacing of 45 cm and intra row spacing of 45 cm. This is followed by

T_8	T_6	T_1
T_{10}	T_8	T_3
T_6	T_1	T_5
T_7	T_5	T_{10}
T_5	T_{10}	T_9
T_2	T_7	T_4
T_4	T_9	T_6
T_1	T_2	T_8
T_9	T_3	T_2
T_3	T_4	T_7

Plot size : 3.6m x 5 m
Design : RBD
Replications : Three
Treatments : 10

T_1 Endosulfan : 2 ml/lit
T_2 Profenofos : 1 ml/lit
T_3 Carbaryl : 3 gm/lit
T_4 Thiodicarb : 2 gm/lit
T_5 Inodxacarb : 1 ml/lit
T_6 Cartap Hydrochloride 3 gm/lit
T_7 Spinosad : 0.02 ml/lit
T_8 Bacillus thuringiensis 1 gm/lit
T_9 Neem : 2.5 ml/lit
T_{10} Control

Fig-1 Field Layout Plan of the Experiment

gap filling after 10 days of transplanting. The experimental plots were adequately irrigated at the time of transplanting followed by irrigation whenever required throughout the crop period. The recommended dose of fertilizers *viz.*, 80 kg N, 200 kg P_2O_5 and 100 kg K_2O per hectare was applied. Nitrogen in the form of urea was applied as basal and pocket application in three equal splits at different growth stages of crop. The crop was kept free from weeds by hand weeding whenever needed and was kept well managed throughout the period of experiment by adopting the recommended package of practices.

3.1.1 Application of insecticidal treatments

All the test insecticides were applied as foliar sprays and details of test insecticides are given in Table-1. The first spray was given soon after the incidence of pest and thereafter, repeated at 15 days interval. A total of three sprays were given during the experimentation.

The measured quantities of test insecticides were mixed with small quantity of water and remaining quantity of water added to it subsequently to make up the volume. The spray fluid was evenly mixed with a stick before spraying.

3.1.2 Pests observed

The efficacy of different treatments was studied against the following pests:

Table-1 Details of the insecticides used in the experimentation

S.No.	Common name	Dosage (%)	Trade name and formulation	Source of supply
1.	Profenofos	0.05	Curacron-50 EC	M/s Novartis (India) Ltd., Mumbai
2.	Spinosad	0.00005	Success (2.5% SC)	Denocil Crop Protection Ltd., Mumbai
3.	Endosulfan	0.07	Thiodan 35% EC	Aventis Crop Science India Ltd., Mumbai
4.	Thiodicarb	0.14	Larvin 75% WP	Rhone Poulence Agrochemicals (India), Mumbai
5.	Indoxacarb	0.02	Avaunt 14.5 % SC	El Dupont India Ltd., Gurgaon
6.	Cartap Hydrochloride	0.4	Caldan 50 SP	Dhanuka Pesticides Ltd., Haryana
7.	Carbaryl	0.15	Sevin 50 WP	Aventis Crop Science Ltd., Mumbai
8.	*Bacillus thuringiensis* sub sps. Kurstaki	0.005	Delfin WG	Margo Biocontrols Ltd., Bangalore
9.	Neem 0.15% *W/W*	5	Nivaar	Sri Disha Biotech Pvt. Ltd., Hyderabad

S.No.	Common name	Scientific name	Family / Order
1.	Diamondback moth	*Plutella xylostella* (Linn.)	Yponomeutidae : Lepidoptera
2.	Cabbage leaf webber	*Crocidolomia binotalis* (Zell.)	Pyralidae : Lepidoptera
3.	Tobacco caterpillar	*Spodoptera litura* (Fab.)	Noctuidae : Lepidoptera
4.	Cabbage head borer	*Hellula undalis* (Fab.)	Pyralidae : Lepidoptera
5.	Aphids	*Lipaphis erysimi* (Kalt..)	Aphididae : Homoptera

3.1.3 Counting the pests

3.1.3.1 Sucking pests

The population of aphids was recorded on five randomly selected plants per plot leaving the border rows. The population counts were recorded from top, bottom and middle leaf in each of the five selected plants in every plot and mean number of aphids per five plants were calculated (Rout and Senapathi, 1970).

3.1.3.2 Borers

Lepidopteran insects infesting cabbage heads were recorded at frequent intervals during the period of study. The data were recorded from 5 plants randomly selected from a given plot which was tagged in each treatment and the population counts were recorded. The number of larvae of *P. xylostella, S. litura, C. binotalis* and *H. undalis* were recorded from the tagged plants. The data on all the pests were collected one day before spraying and also at 1, 5, 10 and 15 days after each spray. The counts on fifteenth day after each spray were taken as a pre-treatment count for the next spray. The larval counts of diamondback moth, tobacco caterpillar, leaf webber and head borer were recorded on plant basis from five tagged plants.

3.1.4 Statistical analysis

3.1.4.1 Sucking pests

The per cent reduction of sucking pests in different treatments over control was calculated by modified Abbot's formula (Fleming and Ratnakaran, 1985) as given below:

$$\text{Population reduction (\%)} = 1 - \left[\frac{\text{Post - treatment population in treatment}}{\text{Pre - treatment population in treatment}}\right] \times \left[\frac{\text{Pre - treatment population in control}}{\text{Post - treatment population in control}}\right] \times 100$$

The percentage reduction at 1, 5, 10 and 15 days after each spraying were pooled and transformed into angular values which were further subjected to statistical analysis. The overall effect of treatments by combining the four (1, 5, 10 and 15^{th} day) observations were also done by analysing the data through ANOVA of RBD.

3.1.4.2 Borers

In the case of borers, the data recorded were pooled and the percentage was calculated. Analysis of variance was carried out after effecting arc sin transformation of these percentages.

3.2 DISSIPATION OF INSECTICIDES IN CABBAGE

The dissipation pattern of endosulfan, carbaryl and profenofos was studied by collecting cabbage head samples from the bio-efficacy trial. The samples of cabbage heads were collected randomly at 0, 1, 3, 5, 7, 10 and 15 days after the third spraying.

3.2.1 Analysis of endosulfan residues

3.2.1.1 Preparation of standard stock solution

In 100 ml n-hexane 100 mg of technical endosulfan I, II and endosulfan sulphate was dissolved to get 1000 ppm solution. From the standard stock solution (1000 ppm), fortification standard containing one ppm of endosulfan I, II and endosulfan sulphate was prepared.

3.2.1.2 Recovery

Cabbage heads were collected from control plots and after chopping and blending the material was transferred (100 g) to the reagent bottles. A known amount of standard solution (equal to 1 ppm) was added. The contents of reagent bottles were shaken and the samples were subjected to extraction and clean up procedure. The recovery obtained was 99 per cent for endosulfan I and II and 98 per cent for endosulfan sulphate at 1 ppm level of fortification.

3.2.1.3 Extraction and clean up

The chopped and blended cabbage head sample (25 gms) was taken and extracted with 150 ml mixture of n-hexane : isopropanol (2:1). The filtered extract was washed with distilled water and the aqueous phase was discarded. The hexane layer was collected through anhydrous sodium sulphate. A drop of keeper was added and extract was concentrated (ISI 12611 : 1989).

The concentrated extract was dissolved in 45-50 ml of hexane : acetone (9:1) and little quantity of Draco G 60 (activated charcoal) was added with occasional shakings. This was filtered through filter paper and residues were washed with 3 x 15 ml of hexane : acetone (9:1) mixture. The contents were dried and dissolved in 10 ml of hexane : acetone (9:1) mixture and analysed on chrompackGC.

3.2.1.4 Determination

The residues of endosulfan were determined by Gas Chromotography (GC) with the following parameters, and the standard peaks of the isomers was shown in Fig-2.

GC	:	Chrompack (CP 9001)
Detector	:	ECD (Ni^{63}) Electron Capture Detector
Column	:	HP-1 (cross linked methyl biloxane) 10m x 0.53mm x 2.65 µm film thickness, 530 µm fused silica column
Injection (Port) temperature (°C)	:	250

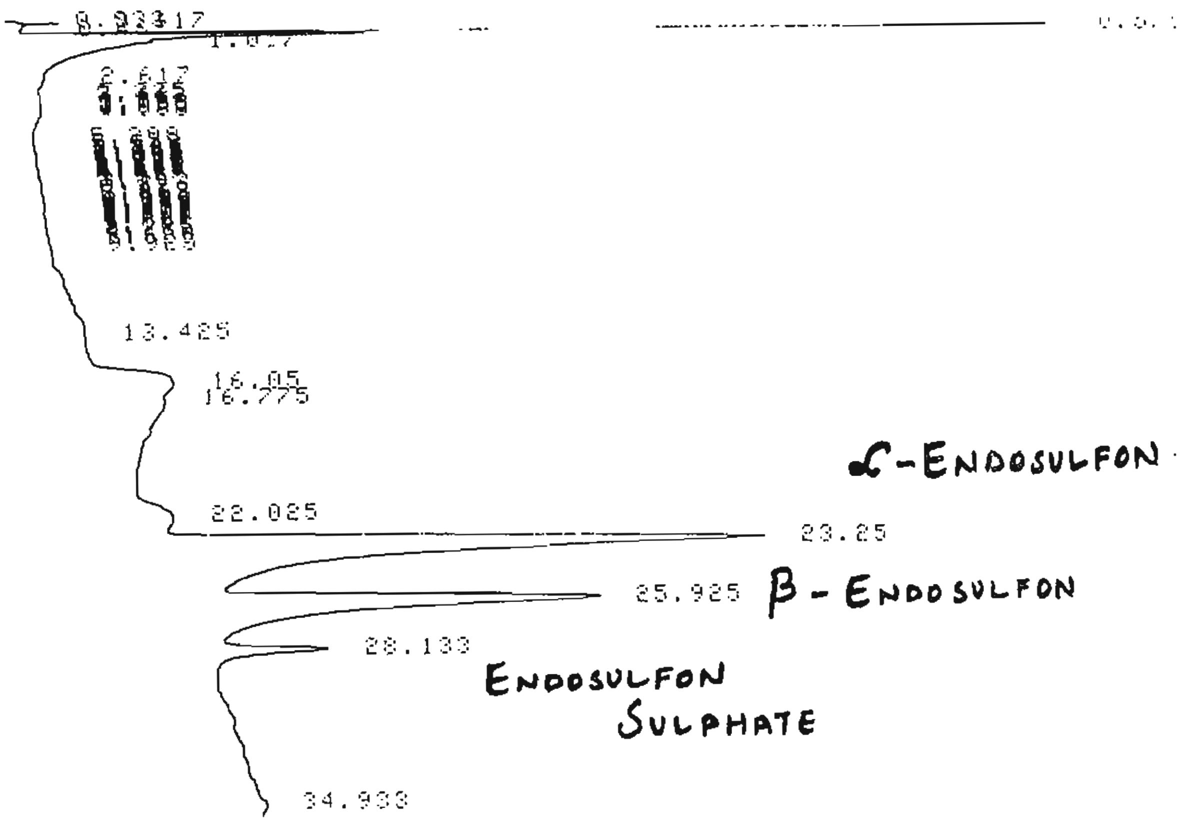

Fig-2 Standard peak of Endosulfan isomers

Column (oven) temperature (°C)	:	200		
Detector temperature (°C)	:	300		
Carrier gas and flow (ml/min)	:	Nitrogen, 3		
Retention time (min):	:	Endosulfan I	:	23.2
		Endosulfan II	:	25.37
		Endosulfan sulphate:		28.017

3.2.2 Analysis of carbaryl residues

3.2.2.1 Preparation of standard stock solution

In 100 ml of methanol 100 mg of technical carbaryl was dissolved to get 1000 ppm solution. From the standard stock solution (1000 ppm), fortification standard containing one ppm of carbaryl was prepared.

3.2.2.2 Recovery

Cabbage heads were collected from control plots and transferred (100 g) to the reagent bottle after chopping and blending. A known amount of standard solution (equal to 1 ppm) was added. The contents of reagent bottles were then shaken and the samples were subjected to extraction clean up and determination procedures. The recovery obtained was 91.5 per cent at 1 ppm level of fortification.

3.2.2.3 Extraction and clean up

The samples collected at 0, 1, 3, 5, 7, 10 and 15 days after third spraying were chopped and blended and dichloromethane (DCM) 100 ml was added to 50 g blended samples taken from composite (500 g). The method given by Oeij and Kanazawa (1974) was followed for extraction, clean up and determination of residues. The extract was suction filtered and then evaporated to near dryness. Later the residues were dissolved in 50 ml hexane and transferred to a separating funnel and 100 ml of acetonitrile was added and thereafter upper hexane layer was discarded and left over organic phase was transferred to another separating funnel and 250 ml of 5 per cent sodium chloride was added. It was cleaned up later with 2 x 30 ml of dichloromethane (DCM).

The cleaned up DCM extract thus obtained was concentrated. The concentrated extract was passed through column having 5 g of florosil and eluted using 20-25 ml of DCM. The elute was again concentrated and dissolved in n-hexane and later subjected to alumina column clean up.

The final elution was done with hexane : acetone (9:1) and evaporated to dryness. To this residual contents, 2 ml of 5% methanolic potassium hydroxide (KOH) was added followed by 1 ml of 0.01 per cent of colour reagent (Nitrobenzene diazonium tetrafluoroborate). This was further diluted to 10 ml and allowed to stand for half an hour and absorbence was measured using Spectronic-20 at 530 nm wavelength., the calibaration curve was derived.

Table-2 Standard curve of carbaryl

Concentration of standard carbaryl (ppm)	Absorbance at 530 nm
0.1	0.02
0.5	0.07
0.75	0.09
1	0.13
1.5	0.15
2	0.17
2.5	0.22
3	0.26
3.5	0.31
4	0.38
4.5	0.41
5	0.47

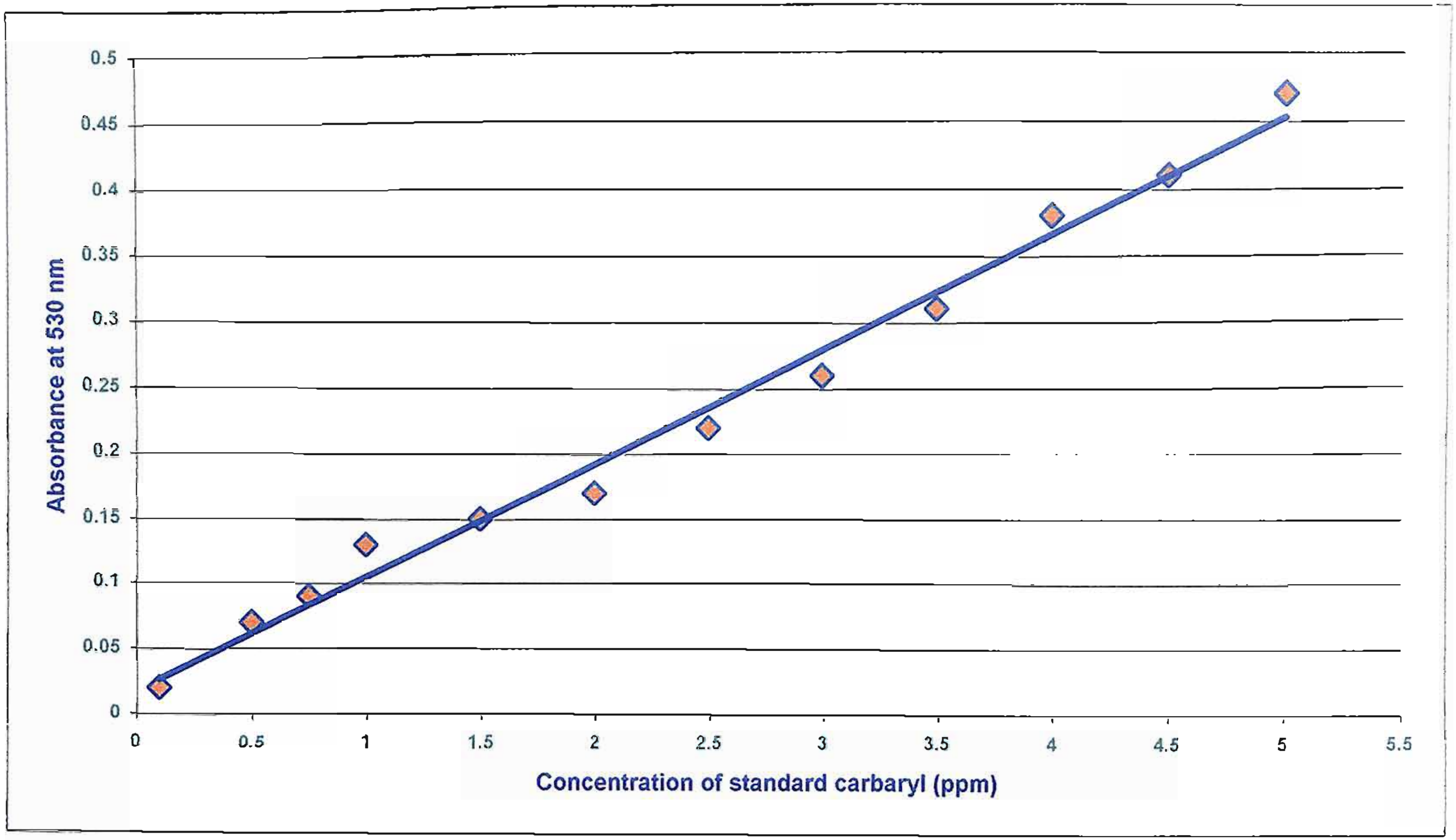

Fig-3 Standard curve of carbaryl

3.2.2.4 Standard curve preparation

A quantity of 100 ml technical carbaryl was weighed and dissolved in 100 ml redistilled methanol to give stock solution of 1000 ppm and from this standard solution subsequent dilutions were made.

Series of solutions containing 0.1 to 5 ppm carbaryl were prepared. To this solution 2 ml of 5 per cent methanolic KOH was added followed by 1 ml of 0.01 per cent of colour reagent (Nitrobenzene diazonium tetrafluoroborate). This was further diluted to 10 ml and allowed to stand for half an hour and later absorbence was measured using Spectronic-20 at 530 nm wavelength. A standard curve of carbaryl was prepared by plotting absorbence values against the standard concentrations in ppm (Table-2 and Fig-3).

3.2.3 Analysis of profenofos residues

3.2.3.1 Preparation of standard stock

In 100 ml n-hexane 100 mg of technical profenofos was dissolved to get 1000 ppm solution. From the standard stock solution (1000 ppm) fortification standard containing one ppm of profenofos was prepared.

3.2.3.2 Recovery

Cabbage heads were collected from control plots and after chopping and blending transformed (100 g) to the reagent bottles. A known amount of standard solution (equal to 1 ppm) was added. The contents of reagent bottles were then shaken and the samples were subjected to extraction and clean up procedure. The recovery obtained was 95 per cent at 1 ppm level of fortification.

3.2.3.3 Extraction and clean up

The samples collected at 0, 1, 3, 5, 7, 10 and 15 days after thrid spraying were chopped and blended. Acetone (100 ml) was added to 50 g blended sample taken from composite (500 g). The extract was suction filtered and then evaporated to near dryness. Later the residues were dissolved in 50 ml hexane and transferred to a separating funnel and 100 ml of acetonitrile was added. Upper hexane layer was discarded and left over organic phase was transformed to another separating funnel and 250 ml of 5 per cent sodium chloride was added. It was cleaned up later with 2 x 30 ml of dichloromethane (DCM). The cleaned up DCM extract thus obtained was concentrated. The concentrated extract was passed through column 5 g of florosil and eluted using 20-25 ml of DCM. The elute was concentrated again and dissolved in n-hexane and later subjected to alumina column clean up. The final elution was done with hexane : acetone (9:1) and evaporated to dryness and analysed on chrompackGC. This method was suggested by Luke (1975).

3.2.3.4 Determination

The residues of profenofos were determined by Gas Chromotography (GC) with the following parameters, and standard ppeak of profenofos was shown in Fig-4.

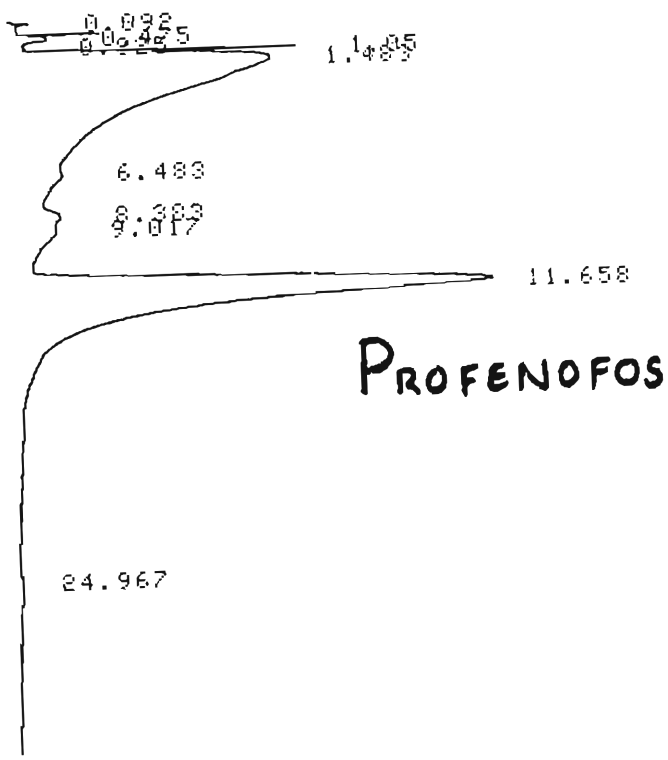

Fig-4 Standard peak of profenofos

GC	=	Chrompack (CP 9001)
Detection	=	Electron Capture Detection (ECD)(N_i^{63})
Column	=	HP-1 (cross linked methyl biloxane) 10 m x 0.53mm x 2.65 μm film thickness, 530 μm fused silica column
Column (oven) temperature (°C)	=	200
Detection temperature (°C)	=	300
Injection temperature (°C)	=	250
Carrier gas flow (ml/min)	=	3 ml (N_2 gas)
Retention time (min)	=	11.65

3.3 DECONTAMINATION STUDIES

To take up decontamination studies, cabbage samples were collected immediately after third spraying from endosulfan, carbaryl and profenofos treated plots. The decontamination of insecticide residues was studied by subjecting the harvested cabbage samples to different procedures. First, by simple water washing of cabbage heads; secondly by dipping of cabbage head samples in 2% salt solution for 15 min followed by washing and lastly by removal of upper most layer of cabbage heads and washing with water . After subjecting to the above decontamination, processing procedure, the residue estimations was done using standard procedure as described earlier for the three different insecticides in 3.2(Materials and Methods).

3.3.1 Interpretation of data

3.3.1.1 Residues (mg/kg)

The following formula was utilized to arrive the residues:

$$\frac{\text{Area of sample}}{\text{Area of standard}} \times \frac{\mu\text{l of sample injected}}{\mu\text{g of standard injected}} \times \frac{\text{Final volume}}{\text{Weight of sample in g}} \times \text{Recovery factor}$$

3.3.1.2 Safety interval

Safety interval (T_{tol})for the permissible consumption of crops sprayed with insecticides is defined as the minimum number of days to lapse before insecticides reaches the tolerance limit.

The safety interval were computed by using Hoskins (1961) formula:

$$T_{tol} = (\text{Log } K_2 - \log_{tol}) / k_1$$

Where, T_{tol} = minimum number of days to lapse before the insecticide reaches the tolerance limit

K_2 = Initial deposit (ppm)

tol = Tolerance limit of the insecticide

K_1 = Regression coefficient of the equation of RL 50

(b) of log ppm residue (y) on the number of lapsed days and (x) is calculated by the formula:

$$b = \frac{\Sigma (X - \overline{X})(Y - \overline{Y})}{\Sigma (X - \overline{X})^2}$$

i.e., sum of the products of the deviations from means divided by the sum of the squares of the deviations from the mean X.

b = slope of the line

3.3.1.3 Prediction of approximate time required to dissipate the residue below the tolerance limit

The period to be allowed to expect the residues to reach below the tolerance limit after treatment for safe use of the treated material was calculated by using the formula (Gunther and Blinn, 1955)

$$Y = a + bx$$

Where,

y = log of tolerance limit

a = log of initial deposit

b = slope of regression line

Chapter IV

Results

CHAPTER IV
RESULTS

Field evaluation of nine insecticides was under taken to assess their efficacy against the pests of cabbage and dissipation and decontamination studies were taken up for endosulfan, carbaryl and profenofos to prescribe waiting periods and for removal of insecticides on cabbage at Agricultural College Farm and AICRP Laboratory at Rajendranagar during *rabi*, 2001-2002. The results obtained are presented hereunder:

4.1 FIELD EFFICACY OF INSECTICIDES

The relative efficacy of the test insecticides at their recommended concentrations has been determined against five pests of cabbage *viz.*, diamondback moth (DBM) *Plutella xylostella* (L.), cabbage leaf webber *Crocidolomia binotalis* (Zell.), tobacco caterpillar *Spodoptera litura* (Fab.) and cabbage head borer *Hellula undalis* (Fab.) and aphid *Liphaphis erysimi* (Kalt).

4.1.1 Diamondback moth (*Plutella xylostella*)

4.1.1.1 One day after treatment

The cumulative efficacy of different insecticides against *P. xylostella* were presented in Table-3 and Fig-5. Spinosad showed its supremacy over other treatments with 89.90 per cent reduction followed by thiodicarb and indoxacarb with 78.39 and 76.69 per cent reduction respectively in controlling diamondback

Table-3 Efficacy of insecticides against diamond back moth after three sprays

Treatments	Reduction in population (%)				Overall mean
	Day 1	Day 5	Day 10	Day 15	
Endosulfan	68.33^{c} (55.77)	78.13^{b} (62.12)	55.85^{c} (48.37)	2.77^{a} (7.84)	51.27^{d} (45.73)
Profenofos	70.67^{c} (57.26)	90.31^{a} (72.27)	59.18^{c} (50.30)	2.47^{b} (7.10)	55.66^{c} (48.25)
Carbaryl	60.43^{d} (51.03)	72.29^{b} (58.26)	53.06^{d} (46.76)	4.49^{a} (9.89)	48.57^{d} (43.61)
Thiodicarb	78.39^{b} (62.38)	91.10^{a} (73.14)	66.68^{b} (54.77)	5.98^{a} (13.96)	60.54^{b} (51.09)
Cartap hydrochloride	58.93^{d} (50.15)	73.69^{b} (59.19)	53.51^{c} (47.01)	2.77^{a} (7.83)	47.23^{d} (43.41)
Indoxacarb	76.69^{b} (61.25)	89.51^{a} (74.43)	67.18^{b} (55.07)	6.14^{a} (14.06)	59.88^{b} (50.7)
Spinosad	89.90^{c} (71.55)	96.71^{a} (81.80)	75.48^{a} (60.36)	1.01^{b} (3.34)	65.78^{a} (54.20)
Delfin	53.28^{d} (46.89)	57.74^{c} (49.46)	59.20^{c} (50.30)	9.15^{a} (17.14)	44.84^{c} (42.03)
Neem	51.20^{c} (45.69)	54.46^{c} (47.56)	56.04^{c} (48.47)	7.61^{a} (15.68)	42.33^{c} (40.58)
Mean	67.53 (55.77)	78.22 (64.25)	60.69 (51.27)	4.71 (10.76)	52.79 (46.62)
Significance	**	**	**	NS	**
SEm±	1.4215	3.2896	1.0713	3.1806	0.6405
CD (P=0.05)	4.2236	9.7744	3.1832	-	1.9204

Figures in parentheses are angular transformed values

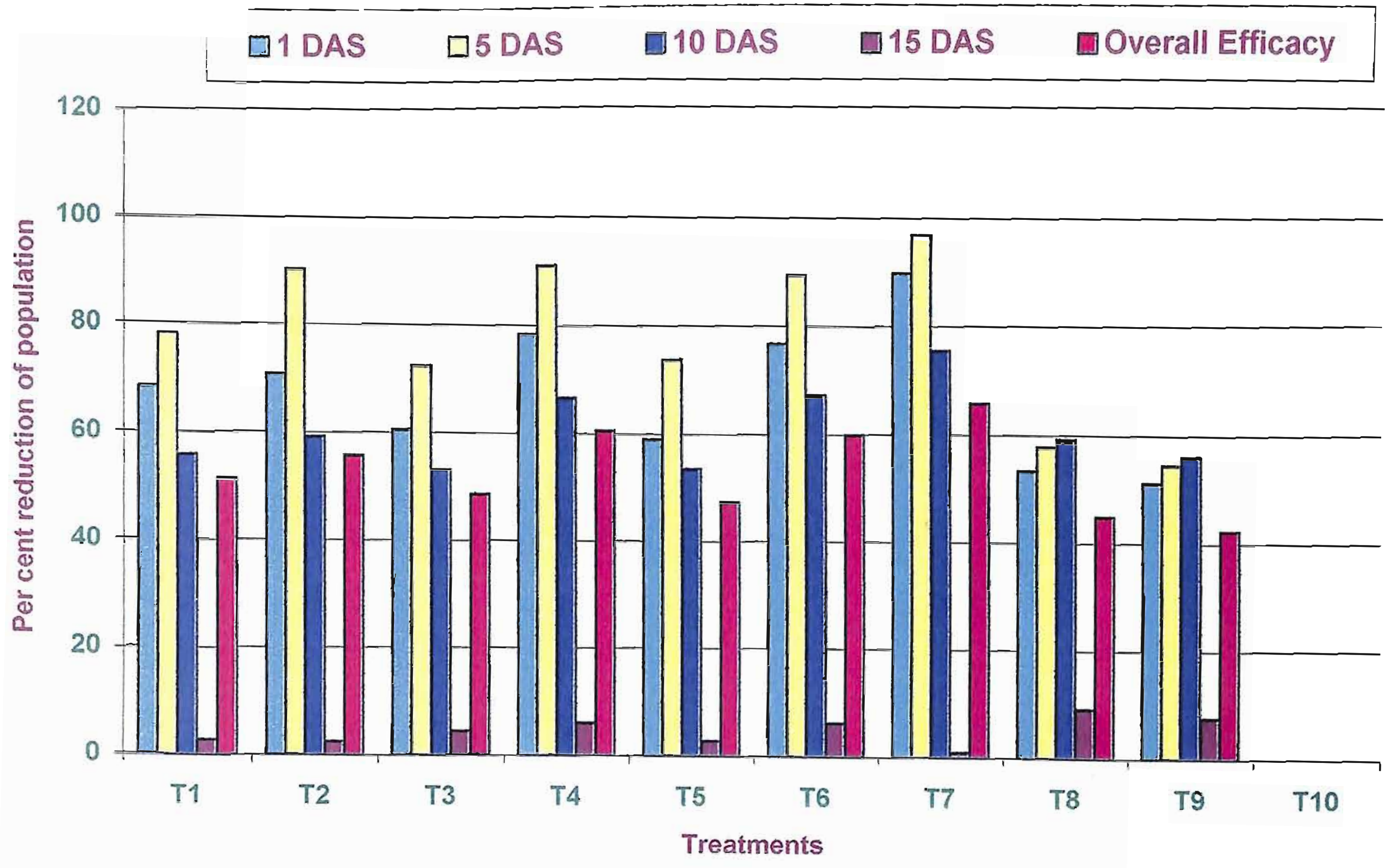

Fig-5 Efficacy of insecticides against diamond back moth after three sprayings moth. Profenofos (70.67%) and endosulfan (68.33%) were on par whereas moderate efficacy was shown by cartap hydrochloride (58.93%), carbaryl (60.43%) and delfin (53.28%) without any significance. The least effective treatment was neem at one day after treatment resulting 51.20 per cent reduction in *P. xylostella* population.

4.1.1.2 Five days after treatment

Spinosad maintained its superiority which was closely followed by thiodicarb, profenofos and indoxacarb with 96.71, 91.10, 90.31 and 89.51 per cent reduction of *P. xylostella* respectively. Endosulfan (78.13%), cartap hydrochloride (73.69%) and carbaryl (72.29%) which were on par statistically were moderately efficient. The least efficacy shown by delfin (57.74%) and neem (54.45%) were on par with each other statistically. All the insecticidal treatments were however significantly superior to control.

4.1.1.3 Ten days after treatment

Even at 10 DAT spinosad showed its efficacy with 75.48 per cent reduction and proved to be the best treatment followed by thiodicarb and indoxacarb with 66.68 and 67.18 per cent reduction of *P. xylostella* which were found to be statistically on par. Moderate efficacy was shown by profenofos (59.18%), Delfin (59.20%), neem (56.04%), endosulfan (55.85%) and cartap hydrochloride (53.06%) in reducing diamondback moth population. The least moth. Profenofos (70.67%) and endosulfan (68.33%) were on par whereas moderate efficacy was shown by cartap hydrochloride (58.93%), carbaryl (60.43%) and delfin (53.28%) without any significance. The least effective treatment was neem at one day after treatment resulting 51.20 per cent reduction in *P. xylostella* population.

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4.1.1.4 Fifteen days after treatment

At 15 days after treatment, no treatment exerted any significant effect in controlling diamondback moth population. Delfin (9.15%), neem (7.61%), indoxacarb (6.14%), thiodicarb (5.98%), carbaryl (4.49%), cartap hydrochloride (2.77%), profenofos (2.47%) and spinosad (1.01%) were found to be ineffective in controlling *P. xylostella* without much significance at 15 DAT.

4.1.1.5 Overall efficacy

A perusal of data on the overall efficacy distinctly showed that spinosad (0.00005%) was successful in reducing *P. xylostella* population (65.78 %) which was closely followed by thiodicarb (60.54%) and indoxacarb (59.88%) which were statistically on par. Moderate efficacy was shown by profenofos (55.66%) followed by cartap hydrochloride (47.23%) and carbaryl (48.57%). Least efficacy was shown by Delfin (44.84%) followed by neem (42.33%) when compared to other treatments but highly significant over control.

4.1.2 Cabbage leaf webber (*Crocidolomia binotalis* Zella.)

4.1.2.1 One day after treatment

The cumulative data of all the three rounds of insecticidal treatments on *C. binotalis* provided in Table-4 and Fig-6 showed that spinosad (0.00005%) was

Table-4 Efficacy of insecticides against cabbage leaf webber after three sprays

Treatments	Reduction in population (%)				Overall mean
	Day 1	Day 5	Day 10	Day 15	
Endosulfan	55.38[d] (48.10)	74.37[b] (59.58)	44.47[b] (41.82)	8.01[a] (16.17)	45.56[c] (42.45)
Profenofos	69.06[c] (56.23)	88.59[a] (70.97)	49.47[b] (44.70)	5.21[a] (12.55)	53.08[b] (46.77)
Carbaryl	60.42[d] (51.02)	70.92[b] (57.41)	40.86[c] (39.70)	3.68[a] (10.60)	43.97[c] (41.53)
Thiodicarb	76.25[b] (60.85)	89.06[a] (70.74)	56.48[a] (48.73)	9.10[a] (16.18)	57.72[a] (49.45)
Cartap hydrochloride	55.35[d] (48.07)	75.43[b] (60.32)	38.14[c] (38.13)	6.07[a] (14.23)	43.75[c] (41.41)
Indoxacarb	75.20[b] (60.17)	85.89[a] (71.74)	56.82[a] (48.93)	6.32[a] (13.64)	56.06[a] (48.48)
Spinosad	80.08[a] (63.53)	91.40[a] (73.14)	62.02[a] (51.97)	8.30[a] (15.59)	60.45[a] (51.03)
Delfin	45.21[c] (42.25)	68.17[b] (55.70)	42.88[b] (40.89)	4.19[a] (10.90)	40.11[d] (39.29)
Neem	41.88[c] (40.30)	66.70[b] (54.76)	43.62[b] (41.33)	5.31[a] (12.83)	39.38[d] (38.87)
Mean	62.09 (52.28)	78.95 (63.82)	48.31 (44.02)	6.24 (13.63)	48.90 (44.37)
Significance	**	**	**	NS	**
SEm±	1.2568	3.4942	1.4432	3.0013	0.77
CD (P=0.05)	3.7341	10.3822	4.2881	-	2.31

Figures in parentheses are angular transformed values

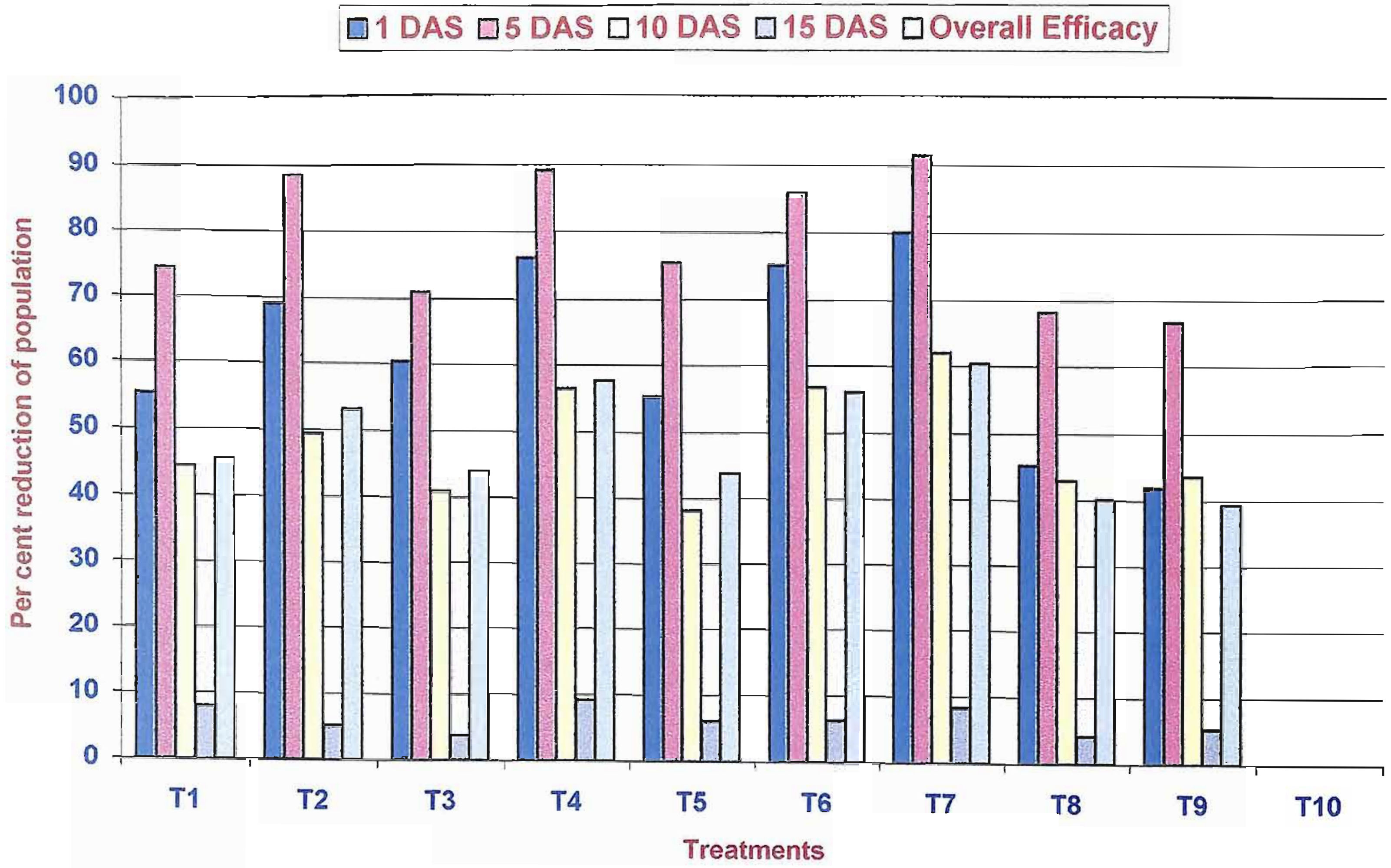

Fig-6 Efficacy of insecticides against cabbage leaf webber after three sprayings the best treatment with 80.08 per cent reduction over control. Thiodicarb (0.14%) and indoxacarb (0.02%) were considered the next best treatments with 76.25 and 75.20 per cent reduction and were on par statistically. Profenofos (0.05%) showed moderate efficacy with 69.06 per cent reduction of pest population followed by carbaryl (0.15%), endosulfan (0.07%) and cartap hydrochloride (0.4%) showed little efficacy with 60.42, 55.38 and 55.35 per cent reduction, respectively. Delfin (0.005%) and Neem (5%) were least effective with 45.21 and 41.88 per cent reduction and were on par with each other.

4.1.2.2 Five days after treatment

Spinosad showed its supremacy with 91.40 per cent reduction followed by thiodicarb (89.06%), profenofos (88.59%) and indoxacarb (85.89%) against *C. binotalis* and were statistically on par with each other. Cartap hydrochloride, endosulfan, carbaryl, Delfin and neem resulted in 75.43, 74.37, 70.92, 68.17 and 66.70 per cent reduction of larval population, respectively and were statistically on par.

4.1.2.3 Ten days after treatment

Even after 10 days after treatment spinosad showed its supremacy closely followed by thiodicarb and indoxacarb with 62.02, 56.48 and 56.82 per cent reduction of *C. binotalis*, respectively without much significant difference. Profenofos (49.47%), endosulfan (44.47%), Delfin (42.88%) and neem (43.62%) which were on par with moderate efficacy, followed by the least efficient cartap hydrochloride (38.14%) and carbaryl (40.86%) which were on par statistically.

4.1.2.4 Fifteen days after treatment

At 15 DAT all the treatments remained statistically on par with each other without much significant differences over control in respect to the per cent reduction of leaf webber. Spinosad (8.30%), profenofos (5.21%), endosulfan (8.01%), indoxacarb (9.10%), thiodicarb (6.32%), cartap hydrochloride (6.07%), carbaryl (3.68%), Delfin (4.19%) and neem (5.31%) were found to be ineffective in reducing the larval population of *C. binotalis*.

4.1.2.5 Overall efficacy

The overall efficacy of insecticidal treatments on *C. binotalis* showed that spinosad closely followed by thiodicarb and indoxacarb were on par with 60.45, 57.72 and 56.06 per cent reduction respectively showing the best results closely followed by profenofos (53.08%). Moderate efficacy shown by endosulfan (45.56%), cartap hydrochloride (43.75%) and the carbaryl (43.97%) which were significantly on par. The least efficient treatments were the Delfin and neem with 40.11 and 39.38 per cent reduction respectively with statistical parity.

4.1.3 Tobacco caterpillar (*Spodoptera litura* Fab.)

4.1.3.1 One day after treatment

The cumulative data of all the three sprays indicated in Table-5 and Fig-7 revealed that spinosad registered highest per cent reduction (82.15%) of *S. litura*

Table-5 Efficacy of insecticides against tobacco caterpillar after three sprays

Treatments	Reduction in population (%)				Overall mean
	Day 1	Day 5	Day 10	Day 15	
Endosulfan	67.79[b] (55.51)	65.30[b] (54.05)	53.25[c] (46.86)	7.57[a] (15.11)	48.48[b] (44.13)
Profenofos	73.57[b] (59.10)	76.65[b] (61.50)	52.91[c] (46.67)	10.35[a] (18.49)	53.37[b] (46.93)
Carbaryl	58.77[c] (50.06)	75.84[b] (60.56)	47.41[d] (43.51)	5.64[a] (13.55)	46.91[d] (43.23)
Thiodicarb	79.15[a] (62.88)	84.65[a] (67.63)	64.40[b] (53.41)	9.72[a] (17.48)	59.48[a] (50.47)
Cartap hydrochloride	66.02[b] (54.44)	72.73[b] (58.54)	53.85[c] (47.22)	8.46[a] (15.87)	50.27[c] (45.15)
Indoxacarb	78.98[a] (62.73)	86.93[a] (69.31)	65.96[b] (54.30)	8.40[a] (16.78)	60.07[a] (50.81)
Spinosad	82.15[a] (65.09)	90.45[a] (72.02)	71.06[a] (57.47)	5.16[b] (10.76)	62.20[a] (52.06)
Delfin	53.97[c] (47.28)	67.01[b] (54.95)	53.55[c] (47.04)	13.55[a] (21.31)	47.02[d] (43.29)
Neem	51.85[c] (46.06)	65.20[b] (53.88)	50.87[c] (45.50)	12.33[a] (20.51)	45.06[d] (42.17)
Mean	68.03 (55.90)	76.09 (61.38)	57.03 (49.11)	9.02 (16.65)	52.54 (46.47)
Significance	**	**	**	NS	**
SEm±	1.7284	2.8277	0.9919	3.2222	0.6976
CD (P=0.05)	5.1819	8.4780	2.9737	-	2.0914

The fig in parentheses are angular transformed values.

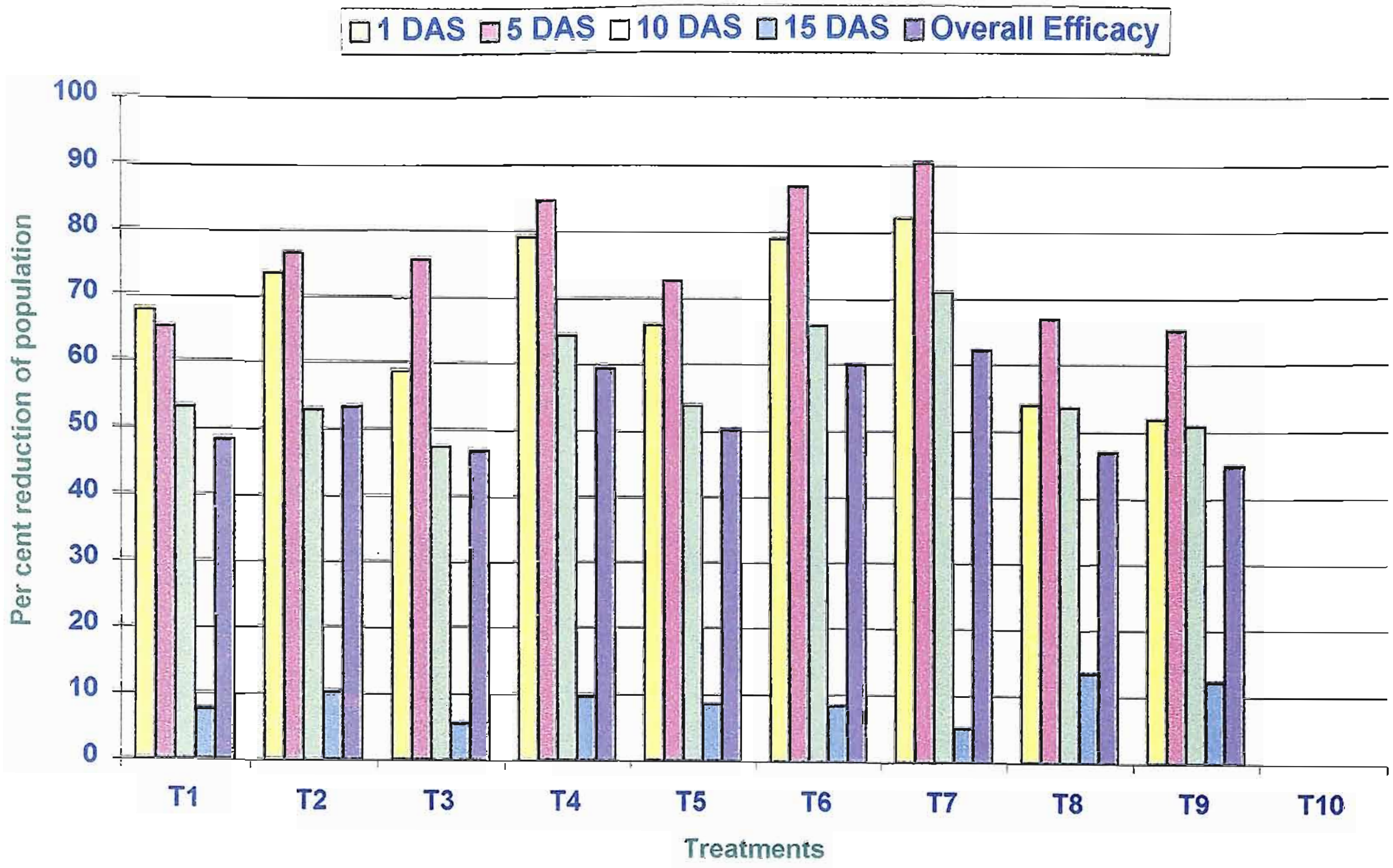

Fig-7 Efficacy of insecticides against tobacco caterpillar after three sprayings at one day after treatment along with thiodicarb and indoxacarb with 79.15 and 78.98 per cent respectively which were on par with each other. Profenofos, endosulfan and cartap hydrochloride were the next best treatments, with 73.57, 67.79 and 66.02 per cent reduction over control. Carbaryl, delfin and neem were less effective when compared to others with 58.77, 53.97 and 51.85 per cent reduction of *S. litura* which are on par with each other.

4.1.3.2 Five days after treatment

Even at 5 DAT spinosad, indoxacarb and thiodicarb were found to be the best treatments in controlling *S. litura* which were on par statistically with 90.45, 86.93 and 84.65 per cent reduction over control. The chemicals next in order were profenofos, carbaryl, cartap hydrochloride, delfin, endosulfan and neem with 76.65, 75.84, 72.73, 67.01, 65.3 and 65.20 per cent reduction, respectively and were on par statistically.

4.1.3.3 Ten days after treatment

Spinosad maintained its supremacy even at 10 DAT with 71.06 per cent reduction followed by indoxacarb and thiodicarb with 65.96 and 64.4 per cent reduction which were on par with each other. Cartap hydrochloride, delfin, endosulfan, profenofos and neem with 53.85, 53.55, 53.25, 52.91 and 50.87 per cent reduction, respectively were moderately effective and on par statistically. Carbaryl was least effective (47.41%) among the treatments.

4.1.3.4 Fifteen days after treatment

No chemical treatment was significantly better while all were significantly superior over control. Spinosad (5.16%) and carbaryl (5.64%) being least effective when compared to other treatments. Neem (12.33%), delfin (13.55%), profenofos (10.35%), thiodicarb (9.72%), indoxacarb (8.40%), cartap hydrochloride (8.46%) and endosulfan (7.57%) were on par statistically.

4.1.3.5 Overall efficacy

Spinosad (0.00005%) exhibited highest efficacy with 62.20 per cent reduction closely followed by indoxacarb (0.02%) and thiodicarb (0.14%) with 60.07 and 59.48 per cent reduction. Profenofos (0.05%) and endosulfan (0.07%) were the next best treatments with 53.37 and 48.48 per cent reduction of *S. litura* without significant difference followed by the cartap hydrochloride (0.4%) with 50.27 per cent reduction. Delfin (0.005%), carbaryl (0.15%), and neem (5%) were the least effective treatments with 47.02, 46.91 and 45.06 per cent reduction and were statistically on par with each other.

4.1.4 Cabbage head borer (*Hellula undalis* Fab.)

4.1.4.1 One day after treatment

Based on the cumulative data it was evident from Table-6 and Fig-8 that spinosad (83.24%) was the best treatment followed by thiodicarb and indoxacarb which resulted in 74.65 and 74.18 per cent reduction of *H. undalis* and were on par

Table-6 Efficacy of insecticides against cabbage head borer after three sprays

Treatments	Reduction in population (%)				Overall mean
	Day 1	Day 5	Day 10	Day 15	
Endosulfan	61.52[c] (51.67)	74.88[b] (59.94)	57.25[b] (49.18)	6.33[a] (13.92)	50.00[c] (45.00)
Profenofos	66.05[c] (54.39)	74.93[b] (60.15)	55.92[b] (48.41)	6.02[a] (13.83)	50.73[c] (45.42)
Carbaryl	60.52[c] (51.10)	72.79[b] (58.57)	49.22[c] (44.55)	2.70[a] (7.71)	46.31[d] (42.88)
Thiodicarb	74.65[b] (59.78)	88.56[a] (70.49)	63.65[a] (52.93)	6.46[a] (14.42)	58.33[b] (49.80)
Cartap hydrochloride	63.02[c] (52.58)	74.06[b] (59.40)	46.86[c] (43.20)	5.86[a] (13.14)	47.45[d] (43.54)
Indoxacarb	74.18[b] (59.49)	88.21[a] (69.95)	59.74[b] (50.62)	7.69[a] (15.92)	57.46[b] (49.29)
Spinosad	83.24[a] (65.88)	83.14[a] (66.14)	71.09a (57.51)	7.59[a] (15.50)	61.26[a] (51.52)
Delfin	54.63[d] (47.67)	61.49[c] (51.65)	58.67[b] (50.02)	8.17[a] (16.54)	45.74[d] (42.55)
Neem	52.80[d] (46.61)	63.61[c] (52.91)	58.58[b] (49.95)	9.15[a] (17.34)	46.04[d] (42.72)
Mean	65.62 (54.35)	75.74 (61.02)	57.89 (49.60)	6.67 (14.25)	51.48 (45.86)
Significance	**	**	**	NS	**
SEm±	0.9194	1.8488	1.6178	2.7702	0.6703
CD (P=0.05)	2.7318	5.4934	4.8068	-	2.0097

Figures in parentheses are angular transformed values

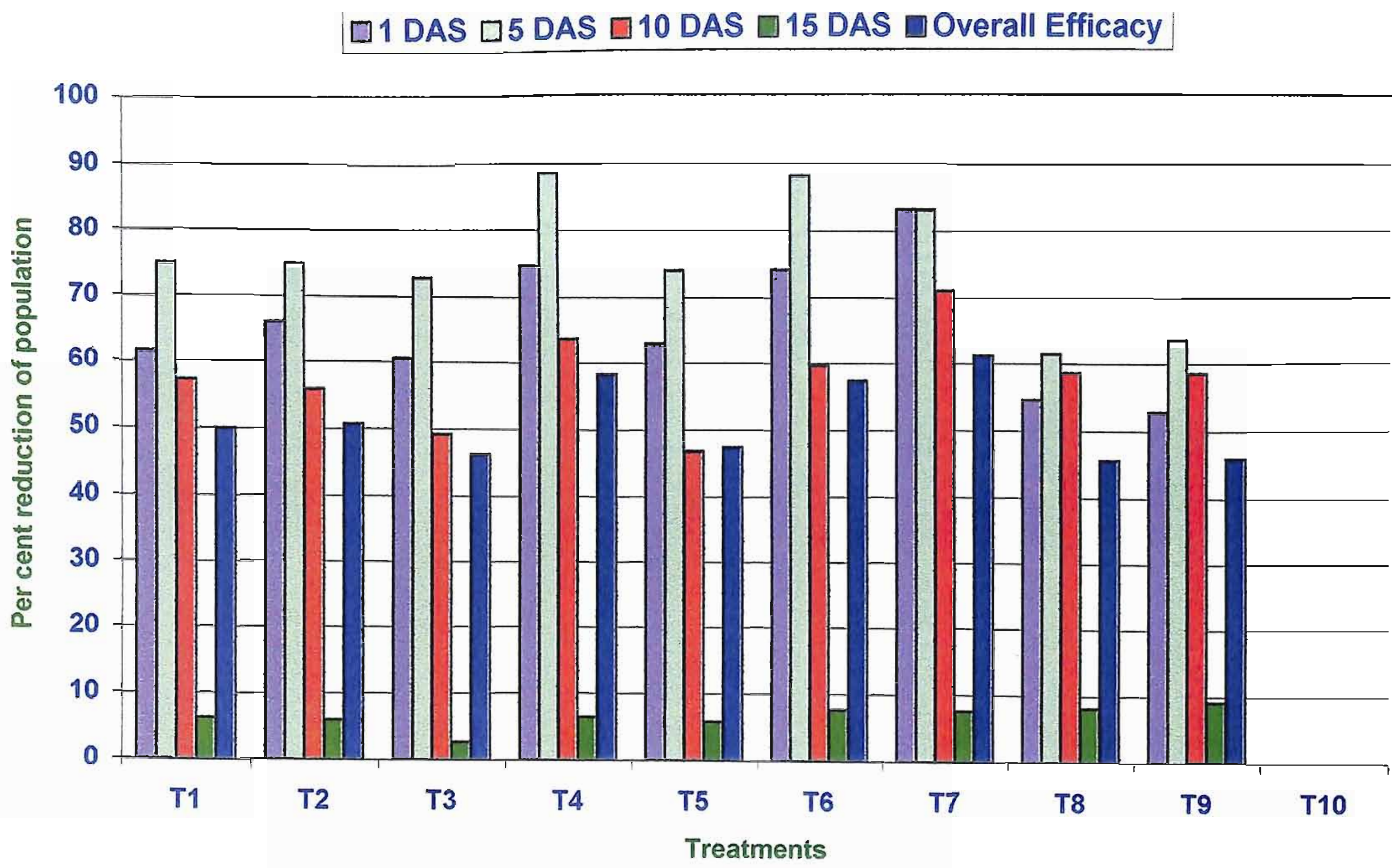

Fig-8 Efficacy of insecticides against cabbage head borer after three sprayings followed by profenofos (66.05%), cartap hydrochloride (63.02%), endosulfan (61.52%) and carbaryl (60.52%) with moderate efficacy and the least effective treatments *viz.*, delfin (54.63%) and neem (52.80%) were on par statistically.

4.1.4.2 Five days after treatment

At 5 DAT, thiodicarb and indoxacarb were the best treatments with 88.56 and 88.21 per cent reduction, respectively which was followed by spinosad (83.14%) were on par statistically. Profenofos (74.93%) closely followed by endosulfan (74.88%), cartap hydrochloride (74.06%) and carbaryl (72.79%) were moderately effective in controlling *H. undalis* and were on par with each other followed by the least efficient treatments, neem (63.61 %) and delfin (61.49%).

4.1.4.3 Ten days after treatment

At 10 DAT spinosad (71.09%) was the best treatment closely followed by thiodicarb (63.65%) which were statistically on par. Indoxacarb (59.74%), delfin (58.67%), neem (58.58%), endosulfan (57.25%) and profenofos (55.92%) were moderately effective without much significant difference, followed by carbaryl and cartap hydrochloride with 49.22 and 46.86 per cent reduction respectively were on par with each other.

4.1.4.4 Fifteen days after treatment

At 15 DAT, neem (9.15%), delfin (8.17%), indoxacarb (7.69%), spinosad (7.59%), thiodicarb (6.46%), endosulfan (6.33%), profenofos (6.02%), cartap hydrochloride (5.86%), carbaryl (2.70%) were on par statistically without much significant difference between the treatments against *H. undalis* population.

4.1.4.5 Overall efficacy

Spinosad (61.26%) was considered as the best treatment closely followed by indoxacarb (57.46%) which were on par statistically. Thiodicarb (58.33%) was highly efficient followed by profenofos (50.73%) and endosulfan (50.00%) with moderate performance were on par statistically followed by the cartap hydrochloride (47.45%), carbaryl (46.31%), neem (46.04%) and delfin (45.74%) which were least efficient and statistically on par with each other in controlling *H. undalis*.

4.1.5 Aphid (*Liphaphis erysimi* Kalt.)

4.1.5.1 One day after treatment

The cumulative data of all the three rounds of treatmental applications (Table-.7 and Fig-9) at 1 DAT revealed that all the insecticidal treatments were significantly superior over the control in bringing down the aphid population. Profenofos (0.05%) recorded highest reduction of 77.71 per cent over control and was found to be the best treatment followed by carbaryl (0.15%) (76.98 %). Indoxacarb (0.14%) which showed 70.77 per cent reduction was followed by endosulfan (0.07%) with 69.62 per cent reduction of pest population. Cartap hydrochloride (0.4%) which recorded 67.66 per cent reduction followed by

Table-7 Efficacy of insecticides against aphids after three sprays

Treatments	Reduction in population (%)				Overall mean
	Day 1	Day 5	Day 10	Day 15	
Endosulfan	69.62[a] (56.70)	89.78[a] (72.42)	93.14[a] (75.03)	37.17[a] (37.57)	72.43[a] (58.33)
Profenofos	77.71[a] (61.85)	94.68[a] (76.72)	93.49[a] (75.33)	37.14[a] (37.55)	75.75[a] (60.50)
Carbaryl	76.98[a] (61.68)	75.50[b] (60.37)	91.09[a] (72.69)	34.10[b] (35.37)	69.42[b] (56.44)
Thiodicarb	65.49[b] (54.08)	45.38[d] (42.33)	80.26[c] (63.64)	36.84[a] (37.34)	56.99[d] (49.02)
Cartap hydrochloride	67.65[a] (55.43)	69.63[b] (56.60)	85.53[b] (67.75)	35.78[a] (36.74)	64.65[c] (53.53)
Indoxacarb	70.77[a] (57.42)	58.67[c] (50.02)	80.19[c] (63.61)	35.91[a] (36.81)	61.39[d] (51.59)
Spinosad	67.52[a] (55.26)	65.95[b] (54.32)	85.57[b] (67.69)	35.96[a] (36.84)	63.75[c] (52.98)
Delfin	49.15[c] (44.52)	67.61[b] (55.43)	83.28[c] (65.87)	36.34[a] (37.07)	59.10[c] (50.25)
Neem	61.97[b] (52.06)	72.29[b] (58.24)	87.19[b] (69.08)	34.79[a] (36.14)	64.06[c] (53.19)
Mean	57.43 (55.44)	71.05 (58.50)	86.64 (68.97)	36.00 (36.86)	65.28 (53.98)
Significance	**	**	**	NS	**
SEm±	2.60	2.1976	1.2922	0.7186	0.8751
CD (P=0.05)	7.80	6.5887	3.8743	-	2.6238

The figures in parentheses are angular transformed values.

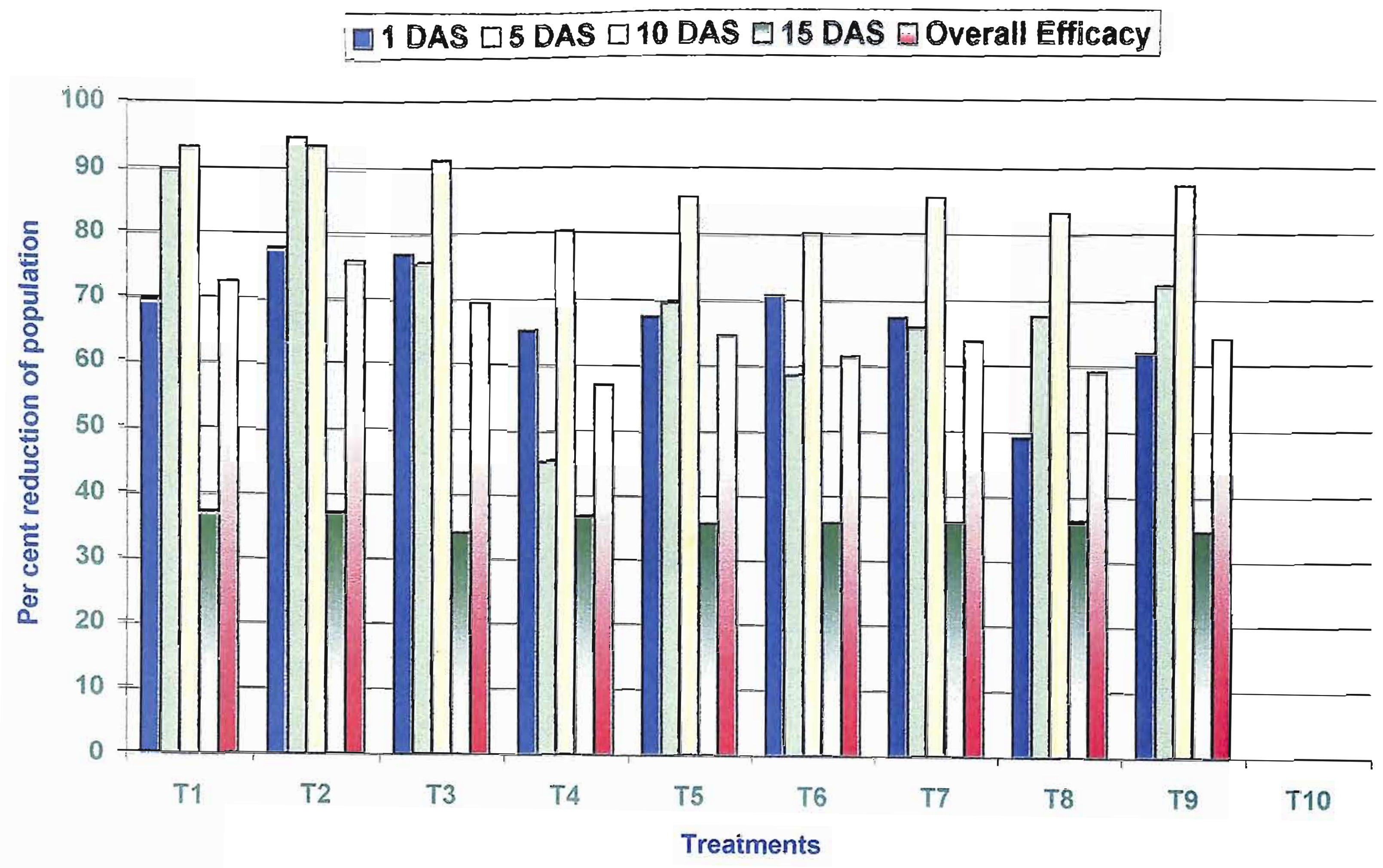

Fig-9 Efficacy of insecticides against aphids after three sprayings

Spinosad(0.00005%) with 67.52 per cent reduction and all the treatments were on par statistically. The other treatments, thiodicarb (0.14%) and neem (5%) were on par with each other which recorded 65.49 and 61.97 per cent reduction respectively. Delfin (0.005%) was significantly effective over check with 49.15 per cent reduction of aphid population.

4.1.5.2 Five days after treatment

A perusal of the cumulative data of the fifth day revealed that profenofos (0.05%) was the best with 94.68 per cent reduction followed by endosulfan (0.07%) which gave 89.78 per cent reduction. Moderate efficacy was shown by carbaryl (0.15%), neem (5%), cartap hydrochloride (0.4%), delfin (0.005%) and spinosad (0.00005%) which gave 75.50, 72.29, 69.63, 67.61 and 65.95 per cent reduction, respectively and were on par with each other statistically. Indoxacarb (0.07%) and thiodicarb (0.14%) were least efficient and were on par statistically in reducing 58.67 and 45.38 per cent population of aphids respectively.

4.1.5.3 Ten Days after treatment

Profenofos (0.05%) and endosulfan (0.07%) which recorded 93.49 and 93.14 percent reduction of aphid population were the best treatments, while carbaryl (0.15%) was the next best chemical with 91.09 per cent reduction and were on par with each other, followed by neem (5%), spinosad (0.00005%) and cartap hydrochloride (0.4%) which gave 87.19, 85.57 and 85.53 per cent reduction of pest population, respectively. Delfin (0.005%), thiodicarb (0.14%) and indoxacarb (0.2%) were significantly effective over control with 83.28, 80.26 and 80.19 per cent reduction in aphid population with statistical parity.

4.1.5.4 Fifteen Days after treatment

At 15 DAT much significant difference was not found between treatments. The data obtained from profenofos (0.05%), endosulfan (0.07%), thiodicarb (0.14%), Delfin (0.005%), spinosad (0.00005%), indoxacarb (0.2%), cartap hydrochloride (0.4%) and neem (5%) were on par with each other and resulted in 37.14, 37.17, 36.84, 36.34, 35.96, 35.91, 35.78 and 34.79 per cent reduction in aphid population, respectively, followed by carbaryl (0.15%) with 34.10 per cent reduction of aphid population.

4.1.5.5 Overall efficacy

Profenofos (0.05%) and endosulfan were adjudged as the best effective treatment in suppressing aphid population with 75.75 and 72.43 per cent reduction of aphid population followed by carbaryl (0.15%) with 69.42 per cent reduction. Cartap hydrochloride (0.4%), neem (5%), spinosad (0.00005%) and Delfin (0.005%) with 64.65, 64.06, 63.75 and 59.10 per cent reduction, respectively were next in the order of efficacy which were on par statistically. Indoxacarb (0.02%) and thiodicarb (0.14%) were observed to be inferior in comparison to the rest of the insecticidal treatments with 61.39 and 56.99 per cent reduction of aphid population, respectively

4.2 DISSIPATION OF INSECTICIDES IN CABBAGE

The results on dissipation patterns of three insecticides *viz.*, endosulfan (0.07%), carbaryl (0.15%) and profenofos (0.05%) in cabbage heads are presented hereunder:

4.2.1 Endosulfan

The residues of endosulfan (0.07%) in cabbage heads detected at periodic intervals of 0, 1, 3, 5, 7, 10 and 15 days after third spray are presented in Table-8 and depicted in Fig-10.

It was evident from the data that initial deposits of endosulfan (3.56 mg/kg) dissipated to an extent of 2.6, 1.64, 0.81, 0.52, 0.42 and 0.17 mg/kg at 1, 3, 5, 7, 10 and 15 days after third spraying with percentage dissipation of 26.97, 53.94, 77.24, 85.39, 88.20 and 95.23, respectively.

The waiting period (T_{tol}) of endosulfan was worked out to be 2.92 days.where as MRL (2 ppm) was given by Codex Alimentarius(2000).

4.2.2 Carbaryl

Carbaryl (0.15%) recorded an initial deposit of 0.45 mg/kg. The dissipation of the insecticides was 0.37, 0.33, 0.29, 0.16, 0.06, 0.01 mg/kg at 1, 3, 5, 7, 10 and 15 days after third spraying, respectively. The dissipation percentages were found to be 17.78, 26.67, 35.56, 64.44, 86.67 and 97.78 at 1, 3, 5, 7, 10 and 15 days, respectively after third spraying.

Table-8 Dissipation of endosulfan, carbaryl and profenofos on cabbage heads

DAT	Endosulfan (0.07%)		Carbaryl (0.15%)		Profenofos (0.05%)	
	Residues (mg/kg)	Dissipation (%)	Residues (mg/kg)	Dissipation (%)	Residues (mg/kg)	Dissipation (%)
0	3.56	-	0.45	-	0.91	-
1	2.6	26.97	0.37	17.77	0.58	36.27
3	1.64	53.94	0.33	26.67	0.42	53.84
5	0.81	77.24	0.29	35.55	0.31	65.93
7	0.52	85.39	0.16	64.44	0.17	81.31
10	0.42	88.2	0.06	86.67	0.06	93.40
15	0.17	95.23	0.01	97.78	0.05	94.50
Reg. Equation	Y = 2.60 + 0.207 X		Y = 0.417 + 0.03 X		Y = 0.657 + 0.0572 X	
T_{tol} (days)	2.92		1		1	
MRL (mg/kg)	2.00		5.00		1.00	

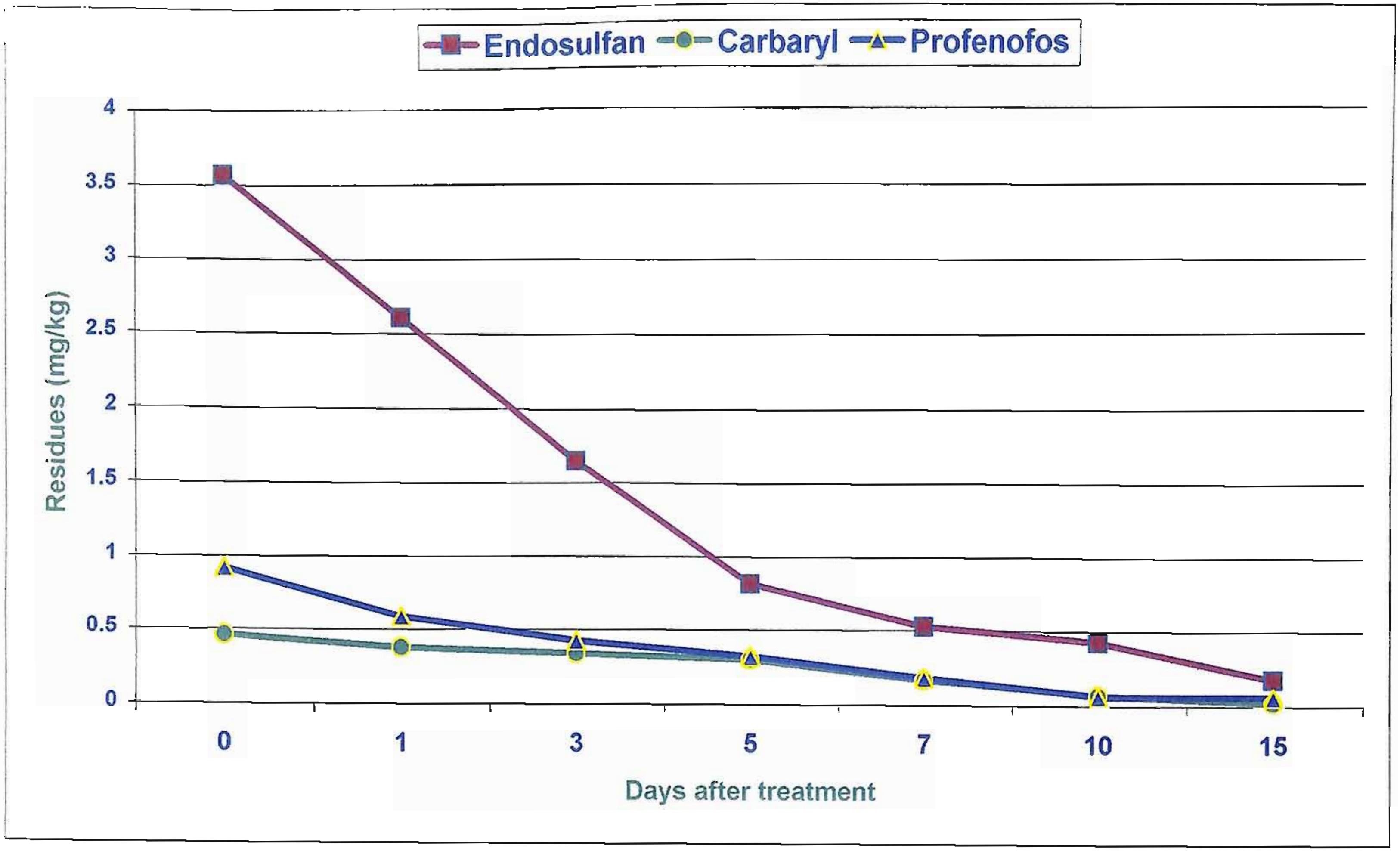

Fig-10 Dissipation of endosulfan, carbaryl and profenofos in cabbage

The waiting period (T_{tol}) for carbaryl was worked out to be 1 day. The initial deposits (0.45 mg/kg) recorded for carbaryl were found to be below MRL (5 ppm) as given by Codex Alimentarius (2000).

4.2.3 Profenofos

It was evident from the data that the initial deposit (0.91 mg/kg) of profenofos (0.05%) dissipated to an extent of 0.58, 0.42, 0.31, 0.17, 0.06 and 0.53 mg/kg in 1, 3, 5, 10 and 15 days after third spraying with per cent dissipation of 36.27, 53.84, 65.93, 81.31, 93.40 and 94.50, respectively.

The waiting period (T_{tol}) of profenofos was worked out to be 1 day. The MRL(1ppm)was given by Codex Alimentarius(2000).

4.3 DECONTAMINATION OF INSECTICIDE RESIDUES FROM CABBAGE

The removal of insecticide residues from the cabbage heads was carried out by using three procedures *viz.*, water washing, dipping of cabbage heads in 2 per cent salt solution for 15 minutes followed by water washing and removal of upper most layer of cabbage heads. The results are presented in Table-9.

4.3.1 Endosulfan

The initial deposit of endosulfan (0.07%) at zero, five and ten days interval of spraying was found to be 3.56, 0.81 and 0.42 mg/kg. The dipping of cabbage

Table-9 Decontamination of endosulfan, carbaryl and profenofos on cabbage heads

Processing procedures	Endosulfan (0.07%)		Carbaryl (0.15%)		Profenofos (0.05%)	
	Residues (mg/kg)	Removal (%)	Residues (mg/kg)	Removal (%)	Residues (mg/kg)	Removal (%)
0 hour	3.56	-	0.45	-	0.91	-
Water wash of cabbage heads	2.79	21.63	0.33	26.67	0.59	35.16
2% salt solution dipping (15 min) followed by water wash	2.53	29.22	0.29	35.55	0.31	65.93
Upper layer removal and washing	0.89	75.0	0.17	62.22	0.08	91.20
5 days	0.81	-	0.29	-	0.31	-
Water wash of cabbage heads	0.71	12.34	0.22	24.13	0.13	58.06
2% salt solution dipping (15 min) followed by water wash	0.68	16.04	0.18	37.93	0.08	74.19
Upper layer removal and washing	0.59	27.16	0.13	55.17	0.03	90.32
10 days	0.42	-	0.06	-	0.06	-
Water wash of cabbage heads	0.01	97.61	0.02	66.67	0.03	50.00
2% salt solution dipping (15 min) followed by water washing	ND	100	0.01	83.33	0.01	83.33
Upper layer removal and washing	ND	100	ND	100	ND	100

heads in 2 per cent salt solution for 15 minutes followed by washing with water reduced the deposits to 2.53 mg/kg (29.22%), 0.68 (16.04%) and 0.001 mg/kg (100%) and by water washing of the cabbage heads, the residual deposits were found to be 2.79 mg/kg (21.63%), 0.71 (12.34%) and 0.01 mg/kg (97.61%) at zero, five and ten days respectively, after third spraying. By upper layer removal method of decontamination, the reduction in residual deposits were 0.89 (75%), 0.59 (27.16%) and 0 mg/kg (100%) at zero, five and ten days respectively after third spraying.

4.3.2 Carbaryl

The initial deposit of carbaryl (0.15%)at zero, five and ten days of spraying was found to be 0.45, 0.29 and 0.06 mg/kg. The simple water wash reduced the deposits to 0.33 mg/kg (26.67%), 0.22 mg/kg (24.13%) and 0.024 mg/kg (66.67%) at zero, five and ten days, respectively after third spraying.

The dipping of cabbage heads in 2 per cent salt solution for 15 minutes followed by washing with water reduced the deposits to 0.29 (35.55%), 0.18 (37.93%) and 0.01 mg/kg (83.33%) at zero, five and ten days, respectively.

The initial deposit (0.45mg/kg) was reduced to 0.17 (62.22%), 0.13 (55.17%) and 0.00 mg/kg (100%) at zero, five and ten days, respectively after third spray by removal of upper most layer and washing of cabbage heads.

4.3.3 Profenofos

The experimental findings in respect of removal of profenofos clearly revealed that the initial deposits of profenofos (0.05 %) at zero, five and ten days of sprayings were found to be 0.91, 0.31 and 0.06 mg/kg. Water washing of cabbage heads reduced the deposits to 0.59, 0.13 and 0.03 mg/kg with per cent reduction of 35.16, 58.06 and 50.00 after third spray.

The dipping of cabbage heads in 2 per cent salt solution for 15 minutes followed by washing with water reduced the deposits to 0.31 (65.93%), 0.08 (74.19%) and 0.01 mg/kg (83.33%) at zero, five and ten days, respectively.

The upper most layer removal and washing of cabbage heads reduced the deposits to 0.08 (91.20%), 0.03 (90.32%) and 0.00 mg/kg (100%) at zero, five and ten days, respectively.

Chapter V

Discussion

CHAPTER V

DISCUSSION

The results obtained during experimentation on "Bioefficacy and dissipation of certain insecticides on cabbage" are discussed with the available pertinent literature in this chapter.

5.1 BIOEFFICACY OF INSECTICIDES AGAINST CABBAGE PESTS

5.1.1 Diamondback moth (*P. xylostella*)

The pooled over all efficacy of three rounds of insecticidal application showed that all the insecticidal treatments were effective in minimizing diamondback moth (Table-3). Spinosad which resulted in 65.78 per cent reduction of pest population was adjudged as the most effective chemical against diamondback moth over the other chemicals. This may be due to different mode of action of spinosad from other conventional insecticides i.e., which has direct contact and ingestion action thus providing greater toxicity than chemicals having ingestion or contact action. Hendrix *et al.* (1997) and Hill and Foster (2000) reported the high efficacy of spinosad in controlling diamondback moth. In the present study, thiodicarb (60.54 %) and indoxicarb (59.88 %) were the next best treatments.

Umeda (2000) recorded less larval population of *P. xylostella* in thiodicarb and spinosad treated plots whereas in this study, their efficacy differ significantly.

Whereas, Adamczyk (1999) reported high toxicity by thiodicarb and low efficacy of spinosad against fall army worm.

Profenofos and cartap hydrochloride were moderately effective against *P. xylostella* with 55.66 and 47.23 per cent reduction. The present findings support the results of Calderson and Hare (1986), Mohan (1987) and Thistation (1987) with respect to profenofos. Whereas Rajavel and Babu (1989), Sannaveerappanavan and Viraktamath (1997) and Singh *et al.* (1993), found the moderate efficacy of cartap hydrochloride against *P. xylostella*. Carbaryl treatment resulted in 48.57 per cent reduction of *P. xylostella* population which was in accordance with the results of Rajamohan and Jayaraj (1978). Whereas Sachin and Srivastava (1977) obtained effective control of *P. xylostella* with carbaryl (0.2 %).

Among nine chemicals tested, delfin and neem were least effective with 44.84 and 42.33 per cent reduction of *P. xylostella*, this may be due to photo degradation of neem and delfin at faster rate resulting in low efficacy. Similar results were obtained by Kirsch and Schmutterer (1988) for delfin and Chandrasekaran *et al.* (1994) for neem. Contradictory results were obtained by Manjunatha (2000) who reported high efficacy of neem against *P. xylostella*, whereas, Sombatsine and Temboonkeat (1987), Fagoonee (1986) and Kadam (1976) who worked with NSKE (Neem Seed Kernel Extract) and neem oil (0.25 %) reported that they are highly effective in controlling *P. xylostella*.

5.1.2 Cabbage leaf webber (*C. binotalis*)

Spinosad, Thiodicarb and Indoxicarb were found to be the most effective insecticides with 60.45, 57.72 and 56.06 per cent reduction of *C. binolalis* over the other insecticides (Table-4). The next best treatment was profenofos and the results obtained in the present investigation are in conformity with the findings of Murthy (1994) and Sreekanth (2000) who obtained nearly 98.14 per cent reduction of pest population with profenofos. Cartap hydrochloride, carbaryl and endosulfan with 43.75, 43.97 and 45.56 per cent reduction respectively were moderately effective against *C. binotalis*.

Sumalatha (1990) and Srinivasan and Moorthy (1991) who reported cartap hydrochloride (0.05 %) to be effective in controlling *C. binotalis*. Krishnaiah and Mohan (1977) and Rabindra and Jayaran (1988) reported endosulfan as effective insecticide in controlling *C. binotalis* whereas Omay (1987) reported the least efficacy of cartap hydrochloride against *C. binotalis*.

Delfin and neem were the least effective chemicals which recorded 40.11 and 39.38 per cent reduction of larval population. Rabindra and Jayaraj (1988) also reported the least efficacy of *B.t.* against *P. xylostella*. Malathi (2000) reported neem gold to be an effective treatment against *P. xylostella*. Whereas, contradictory results were obtained by Krishnaiah *et al.* (1981) who reported efficient control of *P. xylostella* by *B.t.* formulation, Fagoonee and Large (1981), Patnaik *et al.* 1987) and Mani *et al.* (1990) reported effective control of *C. binotalis* by neem products.

5.1.3 Tobacco caterpillar (*S. litura*)

In the present experimentation all the insecticidal treatments offered better control over control in reducing tobacco caterpillar population (Table-5).

Spinosad, indoxicarb and thiodicarb recorded 62.20, 60.07 and 59.48 per cent reduction of tobacco caterpillar population and the results are in accordance with the studies of Hendrix *et al.* (1997) and Adamezyk and Leonard (1999). The next best treatments were profenofos and endosulfan which recorded 53.37 and 48.48 per cent reduction of population respectively. The results confirm the findings of Prasad and Nandinalli (1985). Haratna and Sarjona (1986), Murthy (1994, 1997) and Sreekanth (2000) who reported efficient control of tobacco caterpillar, *S. litura* with profenofos, at 0.05 per cent.

Delfin, carbaryl and neem recorded 47.02, 46.91 and 45.06 per cent reduction of *S. litura*, respectively. These treatments were least effective. Rajamohan and Jayaraj (1978) also noted the least efficacy of carbaryl and Dutta (1997) reported delayed efficacy of *Bt* formulation against *S. litura*.

5.1.4 Head borer (*H. undalis*)

Spinosad was the best treatment against head borer with 61.26 per cent reduction. The next best treatments were the thiodicarb and indoxicarb which gave 58.33 and 57.46 per cent reduction respectively (Table-6). Endosulfan (50.00) and profenofos (50.73) recorded moderate control. Murthy *et al.* (1982) reported high efficacy of endosulfan (0.07 %) against *H. undalis*.

Cartap hydrochloride, carbaryl, neem and delfin were least effective treatments which gave 47.45, 46.31, 46.04 and 45.74 per cent reduction, respectively. The results are contrary to those of Sachin and Srivastava (1977) and Rao (1979) who reported that carbaryl (0.2 % and 0.15 %) was effective against *H. undalis*. Whereas, Drayer (1987) reported the effective control of head borer with neem seed kernel extract (NSKE).

5.1.5 Aphids (*Lipaphis erysimi*)

Profenofos and endosulfan exhibited a supremacy over other chemicals and reduced 75.75 and 72.43 per cent aphid population (Table-7). Shukla *et al.* (1990) and Murthy *et al.* (1982) reported that endosulfan (0.05 % and 0.07 %) was highly effective against aphids on cabbage whereas El-Sayed and El-Ghar (1989) and Mohan (1987) reported that profenofos @ 238-310 a.i./ha and 0.5 kg a.i./ha was effective in controlling cabbage aphids. Carbaryl with 69.42 per cent reduction of population was found to be the next best treatment. Verma (1972) and Sachin and Sreevastava (1979) reported the superiority of carbaryl in reducing the aphid population on cabbage. The results are contrary to Yadav (1988) who found carbaryl @ 0.15% was less effective against aphids. Cartap hydrochloride, neem, spinosad and delfin with 64.65, 64.06, 63.75 and 59.10 per cent reduction, respectively were moderately effective and on par statistically. The results are in accordance with Manjunatha (2000) for neem. Saucke (2000) reported that neem Axal an aqueous NSKE was effective against cabbage aphids.

Indoxicarb and thiodicarb were least effective with 61.39 and 56.99 per cent reduction of aphids compared to other insecticides in the present investigation.

5.2 DISSIPATION OF INSECTICIDES

The results of the disspiation of the three insecticides *viz.*, endosulfan, profenofos and carbaryl when applied at recommended dosages on cabbage, their relative persistence, biodegradation and safe periods are discussed hereunder (Table-8).

Endosulfan (0.15 %) recorded an initial deposit of 3.56 mg/kg and it showed gradual loss of 50 per cent of chemical at 3 DAT. The waiting period was calculated to be 2.92 days which is in accordance with Bordia and Gupta (1992) who reported 50 per cent loss of endosulfan residues in 3 days of application. Whereas, Dethe (1991) reported 5 days of waiting period for endosulfan treatment on cabbage.

According to Balwinder Singh and Chahal (1993), the waiting period of endosulfan was worked out to be 3-5 days when applied @ 500 - 1000 g a.i./ha on cauliflower.

Carbaryl (0.15 %) and profenofos (0.05 %) had very low initial deposits of 0.45 mg/kg and 0.91 mg/kg, respectively in cabbage heads, i.e., less than the MRL value of 5.00 mg/kg and 1.00 mg/kg of carbaryl and profenofos, respectively. The waiting periods worked out to be 1 day for both the chemicals. These results are contradictory with the findings of Gangwar and Singh (1988) who reported cent per cent dissipation of cabbage residues in 22.30 days of application and Bordia and Gupta (1992) in case of carbaryl, reported 50 per cent loss of residues in seven days of application.

Carbaryl showed 64 per cent dissipation from cabbage heads within 7 DAT, whereas profenofos showed 54.02 per cent reduction by 3 DAT. At 15 DAT both carbaryl and profenofos reached below detectable levels (0.01 - 0.05 mg/kg).

5.3 DECONTAMINATION OF INSECTICIDES ON CABBAGE

The results obtained from three processing procedures of decontamination *viz.*, removal of upper most layer of cabbage heads followed by washing with water, dipping of cabbage heads in 2 per cent salt solution for 15 minutes followed by tap water washing and simple water washing methods (Table-9) and the removal per cent of insecticides from the cabbage heads are discussed hereunder:

Among the three methods tested, upper layer removal of cabbage heads followed by water washing was found to be efficient in removing the residues to a greater extent for the three chemicals tested.

The per cent removal of endosulfan residues with upper layer or removal of cabbage heads followed by water washing was maximum i.e., 75 per cent at 0 hour, 27.16 per cent at 5 DAT and 100 per cent at 10 DAT. Moderate removal of endosulfan residues was observed with salt water (2%) dipping for 15 minutes followed by water wash (*viz.*, 29.22 per cent at 0 hour, 16.04 per cent at 5 DAT, and 97.61 per cent at 10 DAT). The removal of residues from cabbage heads with simple water washing was very less *viz.*, 21.62 per cent at 0 hour, 12.34 per cent at 5 DAT and 100 per cent at 15 DAT was established. Senapathi *et al.* (1991) reported that washing of cauliflower heads with table salt (1%) resulted in 60 per cent removal of endosulfan residues.

Upper layer removal of cabbage heads followed by water washing removed 62.22 per cent, 55.17 per cent and 100 per cent residues of carbaryl at 0 hour, 5 days and 10 DAT, respectively. Salt water (2%) dipping for 15 minutes of cabbage heads followed by water washing showed moderate removal of carbaryl residues *viz.*, 35.55 per cent at 0 hour, 37.93 per cent at 5 DAT and 83.33 per cent at 10 DAT. Whereas, simple water washing resulted in very less removal of residues, *viz.*, 26.67 per cent at 0 hour, 24.13 per cent at 5 DAT and 66.67 per cent at 10

DAT. Whereas, Bhatia and Verma (1994) reported 75.40 per cent removal of carbaryl residues with water washing from cabbage heads.

Upper layer removal of cabbage heads followed by water washing removed upto 91.20, 91.32 and 100 per cent of profenofos residues from initial deposit at 0, 5 and 15 DAT, respectively. Salt water (2%) dipping for 15 minutes followed by water washing removed upto 65.93, 75.19 and 83.33 per cent of profenofos residues at 0 hour and 5 and 15 DAT from initial deposit of 0.91 mg/kg. Water washing of cabbage heads removed 35.16, 58.06 and 50.00 per cent of profenofos residues from initial deposit of 0.91 mg/kg at 0 hour and 5 and 15 DAT.

CONCLUSION

Studies on the field evaluation of certain conventional, newer synthetic and botanical insecticides were made against insect pests of cabbage at Agricultural College Farm, Rajendranagar during *rabi*, 2001-02 and dissipation and decontamination of three insecticides was done at AICRP on Pesticide Residues Laboratory.

From the results obtained, the following conclusions can be drawn:

- Spinosad was found to be highly effective against lepidopteran larvae. Thiodicarb and indoxicarb were also found to be effective against the lepidopteran larvae *viz.*, tobacco caterpillar, cabbage leaf webber and head borer while profenofos was found to be effective against aphids. Carbaryl, cartap hydrochloride and endosulfan were moderately effective in controlling aphids and lepidopteran larvae. Both neem and delfin offered less protection against insect pests and were inferior to the other chemicals tested.

Comprehensive performance of insecticides against cabbage pests

Pest	Best insecticide	Next best insecticide
Diamondback moth	Spinosad (0.00005%)	Thiodicarb (0.14%)
Tobacco caterpillar	Spinosad (0.00005%)	Indoxicarb (0.02%)
Cabbage leaf webber	Spinosad (0.00005%)	Thiodicarb (0.14%)
Cabbage head borer	Spinosad (0.00005%)	Thiodicarb (0.14%)
Aphid	Profenofos (0.05%)	Endosulfan (0.07%)

- In view of the above, it is suggested that spraying of spinosad or profenofos at early stage and endosulfan and thiodicarb or indoxicarb at later stage on need basis will help the farmer to keep the cabbage crop free from aphids and lepidopterous insect pests. It is also suggested not to spray same insecticide repeatedly so as to avoid the possible development of resistance to these molecules.

- The initial deposits of carbaryl (0.15%) and profenofos (0.05%) were observed to be less than MRL values. For endosulfan a waiting period of 2.92 days was suggested.

- Removal of the upper layer on cabbage heads and subsequent water washing was recommended as the best method of decontamination of residues, rather than simple washing with water and salt water dipping of cabbage heads and water washing for 15 min, as it resulted in highest removal of residues.

Chapter VI

Summary

CHAPTER VI

SUMMARY

Field experiment on the evaluation of different insecticides *viz.*, endosulfan, profenofos, carbaryl, thiodicarb, cartap hydrochloride, indoxacarb, spinosad. *B.t.* formulation (Delfin) and neem against the pests of cabbage *viz.*, diamondback moth, *P. xylostella*, tobacco caterpillar, *S. litura*, cabbage leaf webber *C. binotalis*, cabbage head borer *H. undalis* and aphid *L. erysimi* was conducted at College Farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi*, 2001-2002. In addition, the dissipation and decontamination of three insecticides *viz.*, endosulfan, carbaryl and profenofos in cabbage heads were also worked out in the AICRP on Pesticide Residues Laboratory, College of Agriculture, Rajendranagar, Hyderabad.

It is evident from the trials that among all the insecticides tested against cabbage pests, spinosad was highly effective in reducing the population of *P. xylostella* (65.78 %) followed by thiodicarb (60.54 %) and indoxacarb (59.88 %). In respect of *S. litura* also spinosad treatment recorded 62.20 per cent reduction in pest population followed by indoxacarb and thiodicarb with 60.07 and 59.48 per cent reduction over control respectively were next in the order of efficacy.

Spinosad was adjudged as the best chemical in reducing cabbage leaf webber and cabbage head borer population with 60.45 and 61.26 per cent reduction over control.

Among the insecticides tested against aphids, profenofos (75.75 %) and endosulfan (72.43 %) were highly effective in reducing the aphid population.

The study indicated that spinosad (0.00005 %) was proved to be highly effective against all four lepidopterous insect pests followed by thiodicarb (0.14%) and indoxacarb (0.02%). While, aphids were best controlled by profenofos (0.05%) and endosulfan (0.07%). Thus, the cabbage pest complex can be very well managed by foliar sprays of profenofos (0.05%) and spinosad (0.00005%) altered with thiodicarb (0.14%) or indoxacarb (0.02%) and endosulfan (0.07%) on need basis.

The initial deposits of endosulfan (0.07%), profenofos (0.05%) and carbaryl (0.15%) in cabbage heads were found to be 3.56, 0.91 and 0.45 mg/kg respectively. The chemicals, profenofos (0.05%), endosulfan (0.07%) and carbaryl (0.15%) had dissipated to an extent of 93.40, 85.2 and 86.7 per cent respectively by tenth day after three sprayings on cabbage.

The waiting period for endosulfan was worked out to be 2.92 days while carbaryl and profenofos had a waiting period of one day each.

Among the three methods of decontamination *viz.*, water washing, salt water dipping (2%) for 15 minutes and washing and upper most layer removal and washing of cabbage heads with water, the third method has removed 91.20, 75.0 and 62.22 per cent of initial residues of profenofos, endosulfan and carbaryl respectively. Hence, removal of upper most layer of cabbage heads and subsequent water washing is suggested before consumption to avoid insecticide residue problems.

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