

**STUDIES ON EFFICACY OF CERTAIN INSECT
CONTROL AGENTS AND RESISTANCE OF RICE
GERMPLASMS AGAINST RICE LEAFFOLDER,
Cnaphalocrocis medinalis (Guenee)**

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**DIVISION OF ENTOMOLOGY
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI- 110 012**

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GERMPLASMS AGAINST RICE LEAFFOLDER,
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By
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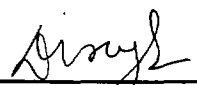
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CERTIFICATE

This is to certify that the thesis entitled "**Studies on efficacy of certain insect control agents and resistance of rice germplasms against rice leaffolder, *Cnaphalocrocis medinalis* (Guenee)**" submitted in partial fulfilment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY** in **ENTOMOLOGY** to the Post-Graduate School, Indian Agricultural Research Institute, New Delhi, is a record of the *bona-fide* research work carried out by **MR. N. CHINNA VENKATESWARLU** under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee.

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

Dated : 26 Dec., 2001


(VIDYA SAGAR SINGH)
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CONTENTS

CHAPTER	TITLE	PAGE NO.
I.	INTRODUCTION	1-4
II.	REVIEW OF LITERATURE	5-45
III.	MATERIALS AND METHODS	46-61
IV.	RESULTS	62-144
V.	DISCUSSION	145-158
VI.	SUMMARY	159-161
	BIBLIOGRAPHY	<i>i-xxvi</i>

LIST OF TABLES

Table No.	Title	Page No.
1.	The details of insecticides used and their source.	49
2.	Dose of the experimental treatments and schedule of their application during <i>kharif</i> 1998-1999.	51
3.	Details of the scale for rice leaffolder resistance studies under field conditions as per <i>standard evaluation system for rice</i> (Anonymous, 1996).	57
4.	Details of the germplasms screened against rice leaffolder, <i>C. medinalis</i> during <i>kharif</i> 1998 and 1999.	58
5.	Effect of different insecticides and biopesticides on rice leaffolder during <i>kharif</i> 1998.	65
6.	Effect of different insecticides and biopesticides on rice leaffolder during <i>kharif</i> 1999.	73
7.	Effect of different insecticides and biopesticides on coccinellids during <i>kharif</i> 1998.	80
8.	Effect of different insecticides and biopesticides on coccinellids during <i>kharif</i> 1999.	85
9.	Effect of different insecticides and biopesticides on ground beetles during <i>kharif</i> 1998.	90
10.	Effect of different insecticides and biopesticides on ground beetles during <i>kharif</i> 1999.	96
11.	Effect of different insecticides and biopesticides on rove beetles during <i>kharif</i> 1998.	101
12.	Effect of different insecticides and biopesticides on rove beetles during <i>kharif</i> 1999.	106
13.	Effect of different insecticides and biopesticides on spiders during <i>kharif</i> 1998.	111

List of Tables contd.....

Table No.	Title	Page No.
14.	Effect of different insecticides and biopesticides on spiders during <i>kharif</i> 1999.	117
15.	Comparative performance of rice germplasms against rice leaffolder, <i>C. medinalis</i> during <i>kharif</i> 1998.	122
16.	Comparative performance of rice germplasms against rice leaffolder, <i>C. medinalis</i> during <i>kharif</i> 1999.	126
17.	Damage rating of rice germplasms for <i>kharif</i> , 1998 and 1999.	130
18.	Studies on correlation between per cent infested leaves and plant height, leaf width, leaf length, texture of leaf during <i>kharif</i> , 1998.	136
19.	Studies on correlation between per cent infested leaves and plant height, leaf width, leaf length, texture of leaf during <i>kharif</i> 1999.	140

LIST OF PLATES

Plate No.	Title	After page
1.	A general view of chemical control experiment.	47
2.	A general view of screening experiment.	47
3.	Larva of rice leaffolder.	62
4.	Adult of rice leaffolder.	62
5.	Leaffolder damaged leaf.	63
6.	Predator, <i>Coccinella septempunctata</i> on rice.	78
7.	Predator, <i>Cheilomenes sexmaculata</i> (F.) on rice.	78
8.	Predator, ground beetle on rice.	88
9.	Predator, rove beetle on rice.	88
10.	Predator, long jawed spider.	109
11.	Predator, <i>Lycosa pseudoannulata</i> on rice.	109
12.	Predator, lynx spider on rice.	109
13.	Predator, spider on rice.	109
14.	Predator, spider on rice.	109
15.	Predator, spider on rice.	109
16.	Adult of <i>Pyrilla perpusilla</i> on rice.	148

1. INTRODUCTION

Rice, *Oryza sativa* L. is most important staple food crop grown in tropical and sub-tropical regions of the world. In India, it is cultivated in all the states in about 45.00 million hectares with estimated annual production of 89.5 million tonnes (Anonymous, 1999-2000).

Though India ranks first in area under rice, its productivity under irrigated ecosystem is 4.2 tonnes/ha as compared to 6.1 and 8.3 tonnes/ha in China and Egypt, respectively (Siddiq, 2000). Insect-pests are major biological constraints in rice production, causing on an average up to 50 per cent loss (Balasubramanian *et al.*, 1973).

Warm humid climate, required for rice cultivation, also favours insect multiplication. Of over 100 species of insects associated with the rice crop, about 15 are economically important (Kalode and Pasalu, 1986). These pests inflict serious damage from seedling stage to maturity and a few acts as vector of virus diseases also. Pradhan (1971) described insect pests as a major bottleneck to a break through in rice production similar to that witnessed in wheat, following the introduction of high yielding varieties.

The rice leaffolder, *Cnaphalocrocis medinalis* (Guenee) as minor or sporadic pest in the past in many Asian countries including India (Alam and Alam, 1964; Alam, 1967; Dale, 1994) has now attained the status of a major pest following cultivation of high yielding cultivars

T-6936

(Khan and Joshi, 1990). Leaffolder outbreaks and consequent damage to the crop have been reported from several states in India (Krishnaiah *et al.*, 1980; Ram, 1986; Chaterjee, 1987; Qadeer, 1988; Sachan, 1992 and Pandey and Sachan, 1992), China, Korea, Srilanka, Bangladesh, Nepal and Malaysia (Khan *et al.*, 1988), Vietnam, South Western Japan (Arida and Shepard, 1990). In India, it now causes moderate to severe damage in most of the rice growing tracts of the country (Sudhakar *et al.*, 1991).

Leaffolder infestation leads to as high as 60 to 70 per cent of leaf damage (Kushwaha and Singh, 1984) inflicting significant yield losses to the extent of 80 per cent (Singh and Dhaliwal, 1983; Murugesan and Chellaiah, 1986; Pandya *et al.*, 1987; Kushwaha, 1988; Srivastava, 1989 and Prabal *et al.*, 1999). Rice leaffolder folds the leaves and scrapes the green matter, reducing the plant photosynthetic ability and consequently the yields. The damage leaves also serve as entry points for fungal and bacterial infections (Pathak, 1975). Higher doses of nitrogenous fertilizers stimulate the leaffolder growth and development, resulting in greater damage (Chantaraprabha *et al.*, 1980; Upadhyay *et al.*, 1981 and Chander, 1999). Expanded rice areas with modern cultivars, new irrigation systems, multiple rice cropping reduced genetic variability of high yielding semi dwarf rice varieties, application of high levels of nitrogenous fertilizers and insecticide induced resurgence have aggravated the leaffolder problem (Khan and Joshi, 1990).

Insecticides have long played a significant role in protecting our crops from ravages of insect-pests and promoting crop yields. At Present, chemical control is the only practical method for a farmer to

respond to an increasing leaffolder infestation. Several insecticides have been found effective against the leaffolder (Garg, 1985 and Raju *et al.*, 1990). Though a lot of work has been done regarding efficacy of conventional insecticides against this pest, the information on potency of plant product based insecticides, microbial insecticides, chitin synthesis inhibitor alone and in combination with conventional insecticides is scanty. Plant products not only act as repellent against insects attacking crop but also provide plant nutrients. Their application is ecologically sound with less harmful effect on natural enemy population. They are also safer to mammals. Hence, there is urgent need to evaluate the efficacy of plant products and biopesticides, alone and in combination with conventional insecticides to ensure effective and environment friendly suppression of the leaffolder.

Natural enemies of pest constitute an important component of its population dynamics, which are being eliminated by indiscriminate use of insecticides in recent times. In view of rich natural enemy complex of the rice leaffolder and also other pests of rice, it is also necessary to select relatively safer insecticides with a view to conserve them.

Exploration of resistance in rice germplasms against the rice leaffolder and its subsequent incorporation in agronomically suitable variety through suitable breeding programme is another important approach to tackle the pest problem especially in low input farming conditions. The cultivation of insect resistant variety provides an ideal way to suppress the insect damage in crops. It involves minimum production cost and leaves no residues in food and environment. Moreover, they are compatible with other methods of pest suppression.

From farmer's point of view, this can be most acceptable form of pest control technique. There is now an ample evidence that varietal resistance against, *C. medinalis* is at a low to moderate level in *Oryza sativa*. The continuous efforts to identify rice varieties with high levels of resistance to this pest are, therefore, needed (Khan and Joshi, 1990).

Keeping all the above background in view, the present studies were carried out at Indian Agricultural Research Institute, New Delhi during *kharif* 1998 and 1999 with the following objectives :

1. Evaluation of the efficacy of synthetic insecticides, biopesticides of plant origin, *Bacillus thuringiensis*, chitin synthesis inhibitor alone and in combination of various treatments for control of rice leaffolder, *C. medinalis*.
2. Evaluation of the effect of insecticidal and non-insecticidal treatments on beneficial organisms under field conditions.
3. Screening of rice germplasms for field resistance against rice leaffolder.

2. REVIEW OF LITERTURE

The rice leaffolder, *Cnaphalocrocis medinalis* (Guenee) has now attained the status of major pest. It causes moderate to severe damage in most of the rice growing tracts of India. The infestation affects the crop plants photosynthetic ability and causes the yield loss. Several insecticidal formulations have been tested against this pest. These formulations have shown their efficiency to control the pest. Insecticides though effective in checking this pest, also kill most of the beneficial natural predators and parasites of rice ecosystem and cause environmental pollution. These adverse effects have necessitated the need for alternate approach to combat the pest problem. Therefore, interest in pesticides of locally available plant products, microbial insecticides and chitin synthesis inhibitor have grown rapidly during recent years. Use of resistant varieties is considered most effective, simple, easy, cheap and ideal method of combating pest problem. Hence, the present investigations were conducted to evaluate the efficiency of few conventional insecticides, plant products, microbial insecticides and chitin synthesis inhibitor alone and in combination with few insecticides and use of resistant varieties for control of leaffolder.

The following is the review on the available literature on different aspects studied in the present investigation in relation to rice leaffolder, *C. medinalis* (Guenee). Wherever, the literature pertaining to leaffolder

control by particular insecticide or its effect on natural enemy was found wanting, literature available on related pests in rice and other lepidopterous insects was also included and have been reviewed in this chapter.

2.1 GRANULAR FORM OF INSECTICIDES

2.1.1 Carbofuran and phorate

Susammamathai *et al.* (1975) conducted a field experiment to evaluate the insecticides against pests of paddy. Carbofuran was found to be the most effective insecticides against stemborer and leaffolder followed by Sevidol and quinalphos.

Based on the field studies, Balasubramanian and Michael (1976) reported that application of quinalphos granules at 1 kg a.i./ha and carbofuran granules at 1 kg a.i./ha were equally effective in controlling green leafhopper, brown planthopper and leaf roller and increased grain yield.

To evaluate the efficiency of certain granular insecticides against rice leaf roller, a field experiment was conducted by Chandramohan *et al.* (1976). They reported that carbofuran 3G at 1.5 kg a.i./ha was effective against the pest and recorded the highest yield of grain followed by diazinon 5 per cent and AC921005 per cent G.

Based on the field studies, Chandramohan and Jayaraj (1976) concluded that application of carbofuran 3 per cent granules at 2.5 kg a.i./ha or carbofuran 1.5 kg a.i./ha on 20th and 50th day after planting or carbofuran 3 G on 20th day after planting at 2.5 kg a.i./ha followed by two rounds of fenthion 0.05 per cent foliar spray on 50th and 65th day after planting were effective in controlling the rice leaf leaf roller.

Jayaraj *et al.* (1976) used four granular insecticides *viz.*, carbofuran, phorate, fenitrothion and endrin each at 3 doses of 0.5, 1.5 and 2.5 kg a.i./ha applied on water surface on 20 and 50 days after transplanting (DAT) for controlling the major pests of rice. Carbofuran and phorate were effective in controlling stemborer and gallfly in higher doses, and carbofuran at all the doses controlled the leaf folder, *C. medinalis* better than the other chemicals.

Chandramohan and Jayaraj (1977) reported the leaf roller damage was found to increase with increasing levels of nitrogen. Among the two granular insecticides *viz.*, carbofuran 3 G and phorate 10 G for its control, carbofuran controlled the pest effectively. Increase in the levels of nitrogen necessitated corresponding increase in dose of carbofuran.

Ramamurthy and Jayaraj (1977) conducted the two different field experiments with foliar application as well as granular insecticides application against rice leaf roller. In the experiment with granular insecticides they concluded that carbofuran recorded lowest incidence of 8.75 per cent as against 26.97 per cent in the untreated control.

Pasalu *et al.* (1980) reported that carbofuran granules @ 1.0 kg a.i./ha, FMC35001, chlorpyrifos and chlorfenvinphos foliar sprays at 0.5kg a.i./ha were effective for the control of leaf folder.

The results of the field experiment conducted by Chaturvedi and Mathur (1981) revealed that among the granular insecticides tested mephosfolan @ 0.75, 1.0, 1.25 kg a.i./ha was the most effective insecticides and was on par with carbofuran against leaf folder.

According to Dhaliwal (1984) seedling root dip in 0.02 per cent chlorpyrifos for 12 hours before transplanting + broadcast of carbofuran twice (15 days and 60 days after transplanting) were quite effective against this pest.

Sasidharan and Nair (1984) used carbofuran, phorate, mephosfolan, disulfoton, quinalphos and chlorodimeform as granules in soil at 21 and 41 days after transplanting for the control of major lepidopteron pests of rice. Among the insecticides tested, carbofuran used @ 0.5 kg and 1.0 kg a.i./ha was not effective for control of leaffolder, *C. medinalis*.

Garg (1985) evaluated the efficiency of 3 selected insecticides viz., chlorpyrifos and monocrotophos @ 0.5 litre a.i./ha and carbofuran granules @ 0.75 kg a.i./ha at specified spray schedule for the control of pink stemborer, *Sesamia inferens* Wlk. and leaffolder, *C. medinalis* in hilly region of Uttar Pradesh. Though all the insecticidal treatments were significantly superior to untreated control, 4 sprays of chlorpyrifos proved to be the most effective in controlling these pests.

Kandasamy and Ravikumar (1986) reported that cartap carbofuran, chlorpyrifos and phosphomidon were most effective against the yellow stemborer, leaffolder and whorl maggot.

Panda and Shi (1989) evaluated 5 insecticides against leaffolder, *C. medinalis* in field conditions. Results indicated that plots treated with carbofuran granules had higher leaf damage than the check plots, perhaps indicating leaffolder resurgence. All other treatments had lower damage. Cartap was most effective against the pest.

Effect of different levels of nitrogen (0, 40, 80 and 120 kg/ha)

and some granular insecticides *viz.*, carbaryl 4G, Sevidol 4:4G, phorate 10G and carbofuran 3G used @ 1.08 kg a.i./ha on the incidence of stemborer, *Scirpophaga incertulas* Wlk. and leaf folder, *C. medinalis* was studied by Thakur and Mishra (1989). Results revealed that increasing levels of nitrogen significantly increased the infestation. But carbofuran 3G and phorate 10G reduced the incidence of the pests.

Murthy *et al.* (1989) carried out the field experiments to determine the effectiveness of 5 granular insecticides against the rice pests *viz.*, *S. incertulas*, *Orseolia oryzae*, *C. medinalis* and *Nilaparvata lugens*. Carbofuran at 1.0 kg a.i./ha was most effective against all 4 pests.

Field experiments were conducted by Biswas and Mandal (1992) against insect pests of paddy *viz.*, *S. incertulas*, *C. medinalis*, *O. oryzae*, *Nephotettix* spp., *Hieroglyphus* spp. and *Chactocnema* spp. in seed bed. Treatment with carbofuran, phorate or quinalphos granules (1 kg a.i./ha) or spraying with methylparathion (0.05%), quinalphos (0.05%) and fenvalerate (0.01%) @ 750 liter/ha controlled *C. medinalis* and *Nephotettix* spp.

Singh (1993) used granular insecticides *viz.*, phorate and quinalphos in furrow and broadcast at 0.5, 1.0 and 2.0 kg a.i./ha against white backed planthopper, leaf folder, grasshopper, gundhi bug and stemborer. Phorate was most effective than quinalphos against these pests.

Satpal *et al.* (1995) reported that carbofuran 0.05 or 1.0 kg a.i./ha was applied at 20, 40 or 60 days after planting (DAT) or various combinations of these dates, against *C. medinalis*. The application of 1 kg a.i./ha carbofuran 20+40+60 DAT produced the highest leaf damage (43.5%) and decreased the grain yield by 8.55 per cent.

Sontakke and Senapathi (1996) evaluated the efficiency of carbofuran used @ 1.0 kg a.i./ha at 3 stages in 2 rice varieties against the major pests of rice under field conditions. Carbofuran applied at 20 DAP controlled early pests, but was not effective against late appearing pests. Application of carbofuran at tillering stage (50 DAP) proved effective on both varieties.

Studies of Singh and Sharma (1998) revealed that three application of phorate 10 G (at 1.0 kg a.i./ha) and carbofuran 3G (at 0.75 kg a.i./ha) either at 30, 50 and 70 or 20, 40 and 60 days after transplanting (DAT) were not effective against rice stemborer, *S. incertulas* and leaf folder, *C. medinalis*.

2.1.2 Foliar sprays

2.1.2.1 Quinalphos

Hussain and Azam (1976) reported that quinalphos granules at 1.5 kg a.i./ha applied at 10 and 30 days after planting and emulsifiable concentrates at 250 ml/ha applied at 55 days after transplanting gave the best control of rice stemborer, gall midge and leaf folder.

Rao *et al.* (1976) reported that BHC, AC92100, endosulfan, mephosfolan, chlorfenviphos, quinalphos, chlorphenamidine, ethyl parathion diazinon, chlorpyrifos, phosphamidon, acephate, fenitrothion, phosalone, dicrotophos, dimethoate and dichlorvos applied as foliar sprays were effective in reducing the damage by leaf folder.

Balasubramanian and Michael (1976) reported quinalphos @ 1 kg a.i./ha to be effective in controlling leaf folder, green leafhopper and brown planthopper.

Thomas and Karunakaran (1977) revealed that teplophos, monocrotophos, ethyl parathion, quinalphos and dicrotophos applied at 0.25 kg a.i./ha were highly effective in checking the incidence of leaffolder.

Godase and Dumbre (1985) conducted a trial with seven insecticides and water spray control and observations were recorded at 24 and 48 hours and a fortnight after the insecticide application to study the mortality and rebuild up of rice leaffolder. Among the insecticides quinalphos (0.02%) and Fenitrothion (0.05%) were the most effective giving 74.48 and 76.54 per cent larval mortality, respectively at 48 hours after application.

Seven insecticides were evaluated for their efficiency against leaffolder by Bhagat (1986). Quinalphos 36EC @ 1.5 kg a.i./ha was found to be most effective and recorded only 1.5 per cent damaged leaves as against 14 per cent in untreated control.

Effectiveness of 15 insecticides as high volume spray and 8 selected insecticides as low volume spray was evaluated against leaffolder, *C. medinalis* by Sain *et al.*, (1987). Results revealed monocrotophos, (@ 0.5 kg a.i./ha), chlorpyriphos (@ 0.5 kg a.i./ha), quinalphos (@ 0.5 kg a.i./ha) and methyl parathion (@ 0.5 kg a.i./ha), effective insecticides.

Quinalphos (@ 0.5 kg a.i./ha), was effective against leaffolder and it gave higher percentage of protections against infestation when compared to control (Venkateswara Rao *et al.*, 1988).

Raju *et al.* (1988) reported on ovicidal action of quinalphos (100

per cent mortality of leaffolder eggs) in their experiments. Out of nine insecticides tested against the rice leaffolder, *C. medinalis*, monocrotophos at 500 ml/ha was most effective followed by quinalphos at 250 g a.i./ha and phasalone at 522 g a.i./ha (Saroja, 1989).

Quinalphos at 0.75 kg a.i./ha was most effective against leaffolder, *C. medinalis* followed by isazophos (0.60 kg a.i./ha), (Singh *et al.*, 1999).

2.1.2.2 Fenvalerate

Nine insecticides were evaluated for their efficacy against green horned caterpillar, *Melanitis leda ismene*. Among them fenvalerate at 50 g a.i./ha, FMC-54800 40 g a.i./ha, chlorpyrifos at 200 g a.i./ha and endosulfan at 350 g a.i./ha were the most effective, causing 100 per cent mortality (Sathiyandam *et al.*, 1986).

Tripathi *et al.* (1984) compared synthetic pyrethroids with more commonly used insecticides for their efficacy against rice pest, *Mythimna separata* in laboratory conditions. Permethrin was most effective followed by cypermethrin, fenvalerate, quinalphos and carbaryl, while carbosulfan was the least effective.

Ovicidal activity of synthetic pyrethroids and diflubenzuron on eggs of rice yellow stemborer, *S. incertulas* was studied under insectary and laboratory conditions by Raju *et al.* (1988). In the insectary synthetic pyrethroids *viz.*, permethrin (0.0125%), cypermethrin (0.01%) and fenvalerate (0.01%) gave higher mortality of eggs (63.9, 62.4 and 59.8%) than diflubenzuron. In the laboratory, cypermethrin (0.01%), deltamethrin (0.00125%) and fenvalerate (0.01%) were equally effective (79.5, 72.7 and 70.9% mortality) followed by permethrin.

Raju *et al.* (1990) repeated the laboratory studies with 9 insecticides against eggs of *C. medinalis* and *S. incertulas*. Cypermethrin and fenvalerate at 0.01 per cent and deltamethrin and permethrin at 0.00125 per cent were most effective, causing more than 90 per cent mortality.

Ramaraju and Natarajan (1997) conducted field experiments against leaffolder, *C. medinalis* on six rice varieties viz., ADT 39, CR1009, CO43, IR20, TRY1 and white ponni. Applying fenvalerate at 100 g a.i./ha to all rice varieties 45 and 60 days after transplanting was most effective on the incidence of leaffolder.

Of 5 insecticides tested against leaffolder, *C. medinalis*, deltamethrin at 0.012 kg a.i./ha was most effective by recording 2.48 per cent leaf damage as compared with 5.65 per cent in the untreated control (Nayak and Panda, 1999).

Rao *et al.* (1984) tested the effectiveness of 3 application of sprays or granules of various insecticides against *S. incertulas*, *O. oryzae* and *C. medinalis*. Isofenphos granules at 1.0 kg a.i./ha against *S. incertulas*, ethoprophos against *O. oryzae* and cypermethrin sprays at 0.10 kg a.i./ha, trizophas sprays at 0.75 kg a.i./ha, permethrin sprays at 0.30 kg a.i./ha and monocrotophos sprays at 0.75 kg a.i./ha were highly effective against *C. medinalis*.

Krishnaiah *et al.* (1994) reported that synthetic pyrethroids cypermethrin (0.05%) and deltamethrin (0.0025%) showed moderate toxicity to BPH and WBPH but were highly effective against GLH in green house conditions. In field studies, cypermethrin (50g a.i./ha) and deltamethrin (25 g a.i./ha) caused BPH resurgence, but when used in

combination with buprofezin (100g a.i./ha) resulted in good control of BPH and rice leaffolder, *C. medinalis*.

Srinivasan and Krishnamurthy (1995) worked on combination of chlorpyrifos 22.5 per cent EC+ cypermethrin 2.5 EC and chlorpyrifos 20 per cent AF against leaffolder and yellow stemborer and found that both were on par with each other as regard to their efficacy. The percentage of dead hearts in chlorpyrifos treated plots was 3 per cent against 18 per cent in control plots. Damage by leaffolder in treated plots was 3.67 per cent while it was as high as 28.3 per cent in control plot.

Effect of insecticidal sprays on rice leaffolder, *C. medinalis* was studied by Bhudhasamai *et al.* (1992) in Thailand. Authors reported that average number of leaffolder damaged leaves at 50 days after transplanting significantly differed among treatments. Plots sprayed with BPMC + fenvalerate, buprofezin + fenvalerate and BPMC + cypermethrin had less leaf damage. Yield were not significantly different among plots, indicating that high leaffolder damage may not decrease yield.

Studies on bioassay of some selected insecticides against the 4th instar larvae of rice leaffolder, *C. medinalis* were conducted under laboratory conditions by Naik *et al.* (1993). Among the effective insecticides, commercial formulations of monocrotophos, quinalphos, phosphamidon and decamethrin were compared by bioassay technique. In the first day the lethal concentration value was in the order of monocrotophos > decamethrin > quinalphos > phosphamidon. While in the subsequent days the order was decamethrin > monocrotophos > quinalphos > phosphamidon which indicated that the decamethrin was the most effective even at lower dose.

2.1.2.3 Diflubenzuron (Dimilin)

Aguda *et al.* (1988) tested dimilin, containing diflubenzuron a chitin synthesis inhibitor and the *Bacillus thuringiensis* product Dipel for selective leaffolder control in the green house. Dimilin was more effective than Dipel, but not always significantly.

Raju *et al.* (1990) observed ovicidal action of diflubenzuron was (200 ppm) 70.7 per cent, (100 ppm) 51.1 per cent and (50 ppm) 48.8 per cent mortality on the eggs of rice leaffolder and stemborer in laboratory condition.

Diflubenzuron at 5 ppm has been reported to cause cent per cent mortality of eggs of *Spodoptera littoralis* (Slamma and El-Din, 1977).

Sharma *et al.* (1994) studied the efficacy of chitin inhibitor, diflubenzuron on the larvae of *Amsacta moorei* Butler by both topical and feeding application methods. The adult inhibition was dose dependent but higher doses were required in feeding methods, as compared to topical, the approximate median adult doses were 1.5 and 0.47 µg per larvae, respectively.

Diflubenzuron 0.025 per cent alone as well as diflubenzuron 0.0125 per cent + 0.075 per cent (*Bacillus thuringiensis* var. *kurstaki*) combination resulted in the highest larval (27.8% and 38.9%) and pre-pupal (38.9% and 44.4%) mortalities of *Spodoptera litura* as reported by Manmadha Rao and Krishnayya (1996).

Sathiyandam *et al.* (1986) evaluated nine insecticides for their toxicity to rice green horned caterpillar, *Melanitis leda ismene* in the laboratory Diflubenzuron at 75 g a.i./ha caused 25 per cent mortality

and 75 per cent larvae became mosaics in larval or larval to pupal moults.

Hazarika and Baishya (1996) tested the topical application of aqueous suspensions of methoprene and diflubenzuron to eggs and adults of *Dicladispa armigera*. Results revealed that with increase in concentration the rate of egg hatch decreased. These compounds were not effective against adults but enhanced their fecundity at low doses.

Sterilant and ovicidal action of diflubenzuron on the rice swarming caterpillar was tested by Beevi (1984) in the laboratory. Ingestion of 100 or 1000 ppm diflubenzuron in honey solution resulted in almost immediate death of some of females, a short life span for all and the deposition of fewer eggs. Ingestion of 10 ppm caused up to 60 per cent sterility and ovicidal action was correlated positively with concentration and negatively with the age of the eggs at treatment.

2.2 EFFICACY OF BIOPESTICIDES

2.2.1 *Bacillus thuringiensis*

Rangaswami and his co-workers (1969) reported an unidentified bacterium attacking larvae and pupae of rice leaffolder at Annamalai nagar, Tamil Nadu.

Two commercial preparations of the *B. thuringiensis* Berliner viz., Dipel (0.5 kg/ha) and Bactospeine (1.5 kg/ha) under laboratory conditions at IRRI recorded 100 per cent mortality of leaffolder larvae (*C. medinalis*) at 5 days after treatment (Anonymous, 1974).

Srivastava and Nayak (1978) conducted studies on comparative laboratory efficacy of four formulations of *B. thuringiensis* Berliner on

rice leaffolder and reported that Thuricide and Dipel were superior to Bactospeine and Cajrab.

Rajamohan and Jayaraj (1978) showed that sprays of *Bacillus thuringiensis* were more effective than the insecticidal sprays of fenitrothion, carbaryl, endosulfan, dichlorvos, phoxim and malathion in reducing the larval population of *S. litura* and *Plutella xylostella*.

Yadava (1979) studied the toxicity of Thuricid HP (*B.t. var. kurstaki*) to larvae of *Sesamia inferens* at different concentrations and found that larvae of both 7 days and 21 days age were equally susceptible and there was positive correlation between mortality rate and concentration used.

Narayanaswamy and Baskaran (1979) reported that neither fungus (*Verticillium lecanii*) alone nor the bacterium (*B.t. var. kurstaki*) alone were able to reduce the incidence of stemborer, whorl maggot or leaf roller under field condition.

Effect of sunlight on the insecticidal activity of *B.t. var. tianmensis* was evaluated against second instar larvae of *C. medinalis* on rice plants. It was observed that four hours after application larval mortality was 23.0-39.6 per cent when treatment was made at 8.00 h and 50.0-72.2 per cent when it was made at 16.00 h (Anonymous, 1981).

Zhu *et al.* (1986) reported that apparent pathological changes in the mid gut tissue of 5th instar of the rice pest, *C. medinalis* infected with *B.t. subsp. kurstaki* occurred from 6 to 22 h after infection.

Seventy two h old culture *B. subtilis* grown on nutrient agar medium was highly pathogenic to the larvae of *Paranara mathias*, *C. medinalis*,

Melanitis leda ismene resulting in 100 per cent mortality (12-18h) when tested on potted rice plants (Srivastava *et al.*, 1987). Aguda *et al.* (1988) tested the diflubenzuron and *B.t.* subsp. *kurstaki* (Dipel) against second and third instar larvae of the pyralid, *C. medinalis* on rice before and after leaf folding in green house condition. Treatment before leaf folding was found to be more effective.

Brownbridge and Onyago (1992) conducted the studies on commercially available *B.t.* formulations based on subsp. *kurstaki* and *aizawi* bioassayed against 2nd, 3rd, 4th and 5th instar larvae of *Chilo partellus* by incorporation into artificial diets. They found that the formulation based on *B.t.* subsp. *kurstaki* was most toxic formulation.

Machenzu *et al.* (1994) selected seventeen strains from 105 strains in a programme for screening highly toxic strains of *B.t.* against larvae of *C. medinalis* at Shanghai, China from field and bioassay tests. Out of 17 strains, strain S-543 (Serotype H5) had shown the greatest toxicity.

Lewis *et al.* (1995) observed that there was increased mortality of *Ostrinia nubilalis* when either *B. thuringiensis* or carbofuran was applied to maize plant treated with granules of *B. bassiana*, with significant effect on yield when applied at pollen shaded stage.

Combined application of Delfin (*B.t.* subsp. *kurstaki*) and chemical insecticide either as a tank mix or at an interval of 72 h were most effective against rice leaffolder. Quinalphos and monocrotophos were on par as also *B.t.* subsp. *kurstaki* at higher doses (1.5 kg/ha) (Sundarbabu and Muthuswami, 1995).

Bentur *et al.* (1999) selected fourteen samples of endotoxins

derived from different strains of *B.t.* (subsp. *kurstaki* and *sphaericus*) tested against rice leaffolder larvae. Out of fourteen samples, five samples viz., BT 29, BT 47, BT 61, BT 70 and HD 1 were effective on larvae. Subsequent testing showed that HD 1 followed by BT 61 and BT 70 were the most effective with mortality being observed after 48 h release of neonate larvae.

Satish *et al.* (1999) conducted the field experiments with three *B.t. kurstaki* formulations viz., Delfin, Dipel and Biobit at the rate of 1.5 kg/ha. These were comparable with insecticides monocrotophos (0.5 kg a.i./ha) and carbofuran (1.0 kg a.i./ha) + monorotophos (0.5 kg a.i./ha) in controlling leaffolder larvae. These formulation showed better performance than the *B.t. thuringiensis* (Biotox) and *B.t. israelensis* (Bactocide).

Rath (1999) evaluated four commercial formulation of *Bacillus thuringiensis* (*B.t.*) Delfin, Biolep, BTKII and Dipel and four neem formulatious (Nimbicidine, Neemax, Achook and Neem gold) against rice yellow stemborer in rainfed low land conditions in West Bengal. All the neem products and two *B.t.* formulation (BTKII and Dipel) could protect the crop from yellow stemborer damage to a limited extent but proved less effective than insecticide chlorpyriphos.

2.2.3 BOTANICALS

2.2.3.1 Neem alone and in combination with insecticides

Neem oil has been found an effective repellent, feeding deterrent, oviposition and embryo inhibitor for leaffolder (Anonymous, 1980).

Saxena *et al.* (1981) conducted studies on rice plants treated with

neem oil 25 or 50 per cent were found to deter oviposition by leaffolder coupled with reduced hatchability on treated plants was 25-50 per cent as against 80 per cent in control, egg hatching was also reduced when eggs were dipped in 12.25 or 50 per cent neem oil.

Schmutterer *et al.* (1983) reported that larvae of rice pests, *Mythina separata* and *C. medinalis*, fed 24 h on rice leaf cuts dipped in various solutions of the four partially purified fractions and two methanolic seed extracts, exhibited pronounced developmental abnormalities and high mortality rates in the succeeding larval instars and in pupal and adult stages.

Dhandapani *et al.* (1985) reported that neem seed kernel extract (NSKE) at 3 per cent reduced the feeding activity of leaffolder.

David (1986) observed that foliar application of 2 per cent neem seed extract and 5 per cent neem cake extract did not control major rice pests during *rabi* season of 1985 in Tamil Nadu.

Neem oil and marvetty oil at 5 per cent was found by Rajasekaran *et al.* (1987) to inhibit the larval feeding of rice leaffolder, *C. medinalis* and they recorded lesser damage as compared to control.

Krishnaiah and Kalode (1990) reported that neem cake incorporated at 150 kg/ha into soil followed by neem oil spray at 3 per cent at 10 days interval effectively checked leaffolder, *C. medinalis* incidence in rice.

Baitha *et al.* (1993) evaluated neem formulation *viz.*, neem cake (NC) (150 kg/ha), neem seed kernel extract (NSKE) (5%), neem oil (3%) along with conventional insecticides like monocrotophos in controlling

rice leaffolder with the result showing the treatment of monocrotophos, NSKE (5%), NC + NSKE 5 per cent + monocrotophos were statistically at par followed by neem oil (3%) in controlling leaffolder.

Sontakke (1993) reported that neem oil 15 kg/ha failed to provide adequate protection against leaffolder, *C. medinalis* as it recorded substantially higher leaffolder damage of 19.3 per cent, but it was found to be significantly superior to untreated control which recorded 28.6 per cent damaged leaves per 10 hills.

The efficacy of different neem products viz., neem cake (200 kg/ha basal application), neem cake (200 kg/ha basal application) + neem seed kernel extract (NSKE) 5 per cent (25 and 32 DAT), NSKE 5 per cent neem leaf decoction (0.5 kg/1 litre of water) and neem oil 3 per cent was compared with chlorpyrifos 20 EC (0.5 kg a.i./ha) and quinalphos 25 EC (0.4 kg a.i./ha) against the leaffolder, *C. medinalis* under field conditions by Ambethgar (1996). Chlorpyrifos proved to be the most effective against the pest, the leaf damage being 11.10 and 10.08 per cent after the first and 2nd spraying, respectively. Neem cake + NSKE 5 per cent was next best treatment followed by quinalphos, neem seed kernel extract and neem oil. Both the application of neem decoction and neem cake proved the least effective in reducing the percentage of damaged leaves due to rice leaffolder.

The neem oil 3 per cent could not effectively check the pest complex viz., BPH, GLH, stemborer and leaffolder on rice when compared to other insecticides like profenofos (0.25%) and monocrotophos (0.11%) as reported by Sunitha and Niachiappan (1997).

Dash *et al.* (1997) observed that treatment with neem derivatives, Repellin 1 per cent and neem seed kernel extract 5 per cent resulted in 7.1 and 8.2 per cent damaged leaves by rice leaffolder as compared to 19.2 per cent damaged leaves in untreated control and were moderately effective against this pest.

Bhatnagar and Pandey (1998) reported that six neem formulations even though superior to control were only moderately effective against rice leaffolder but not comparable to chlorpyrifos (0.05%).

Among the seven neem formulations Rakshak was the most effective followed by chlorpyrifos, Ahook and Neemax in containing the pest damage by rice leaffolder in North Bihar agroclimatic conditions (Sing *et al.*, 1999).

Raut (2000) reported that Neemactin (Azadiractin 1500 ppm) alone failed to provide adequate protection from yellow stemborer and leaffolder but in combination with insecticides gave satisfactory control of these pests.

Nanda *et al.* (2000) reported that neem oil and neem seed extract @ 2 per cent (along with 0.11% Teepal) at 20 and 70 days after transplanting (DAT) and monocrotophos at the rate of 0.4 kg a.i./ha at 40 DAT, proved effective against rice leaffolder giving a moderate pest suppression in between the maximum protection by chemicals only and the neem derivatives alone in the field condition.

Roshan Lal (2000) conducted field studies on the comparative bio-efficacy of neem formulations, Neem gold and Neem Azal with chlorpyrifos 20 EC against *C. medinalis* and found that neem

formulations were moderately effective in managing leaffolder and increasing yield.

Rao (2001) used various insecticides, biopesticides and botanicals against leaffolder, *C. medinalis* under field conditions reported that neem oil was most effective among the botanicals viz., neem oil, *V. negundo*, *C. velutina* and *Datura* species.

2.2.3.2 Chinaberry, *Melia azedarach* L.

Hu *et al.* (1983) conducted a preliminary study on the antifeedant and toxic properties of Chinaberry, *Melia azedarach* L. seed oil against insect pests of rice. Laboratory and field studies in China, showed that the seed oil of Chinaberry, *M. azedarach* had various adverse effects on several important rice pests. At concentration of 0.01-0.04 per cent the seed oil had marked antifeedant and some systemic activity against *Scirpophaga incertulas* (Wlk), *Sogatella furcifera* (How.) and *Nilaparvata lugens* (Stal.). Also sprays of JAP-821 or JAP-822 (both of unstated composition) were more effective than the seed oil in controlling larvae of *Chilo suppressalis* (Wlk) on rice seedlings in pots.

Chiu *et al.* (1985) reported the deterrent effects of seed oil and extract of some meliaceous plants on rice gall midge (GM) oviposition. Seed oil of neem, *A. indica* and seed oil and methanol and petroleum extracts of *M. azedarach* and *M. toosendan* were evaluated as oviposition deterrents against the rice pest, *Orseolia oryzae* in China. Oviposition decreased in choice and no-choice tests when gravid females were caged on rice seedlings sprayed with seed oil or extracts. In no-choice test, 2 per cent methanol extract of *M. toosendan* and *M. azedarach* reduced oviposition by 96 and 71 per cent, respectively,

while in the choice test, 1 per cent methanol extract of *M. toosendan* and *M. azedarach* reduced oviposition by 96 and 83 per cent. The petroleum ether extracts of these plants were also effective. The other oils and extract tested were less effective.

Islam *et al.* (1986) conducted experiment in laboratory and field in Bangladesh to determine the optimal doses and application methods of 4 insecticidal plants and to evaluate their anti-feedent and growth regulating properties against rice hispa, *D. armigera* and pulse beetle, *C. chinensis*. Methyltertiary butyl-ether(MTB) extracts of *Azadirachta indica*, *M. azedarach*, *Amoora rohituka*, *Annona reticulata* and *A. squamosa* were most effective. The addition of sesame or linseed oil to MTB methanolic extracts resulted in higher mortality of *C. chinensis* and the chrysomelid *D. armigera* and increased deterrent effects. *D. armigera* was more susceptible than *C. chinensis* to neem seed kernel extract.

Haque and Islam (1988) studied the effect of methanolic extract of seeds of neem, *A. indica* and Chinaberry, *M. azedarach* on the orientation, feeding behaviour and growth of cicadellid, *Nephotettix nigropictus* in the laboratory. The extracts were shown to be strong repellents and anti-feedants. The nymphal period was prolonged and mortality increased in insects feeding on rice seedlings treated with the extracts. The effectiveness of the extracts increased with increase in concentration.

2.2.3.3 Aak, *Calotropis gigantea*

Rao (1982) reported phagostimulants and antifeedants from *Calotropis gigantea* for *Schistocerca gregaria* Forskal. Chloroform and

methanol extracts prepared from dried powder of leaves, flowers, fruits (without seeds), root bark and latex of *Calotropis gigantea* were tested by painting or spraying green maize leaves for the presence of phagostimulants and anti-feedants against II, III, IV and V instar hoppers and adults of *S. gregaria*. Methanol extracts of leaves, flowers and latex carried phagostimulants while that of fruits and root bark possessed feeding deterrents. On the other hand chloroform extract of different parts of the plant was found to carry antifeedants, though the deterrence was not of a higher order. The antifeedants extracted in methanol from root bark were the most potent as they showed deterrence even at as low concentration as 1 kg dried powder per 100 ml and thus may have some applied value.

2.3 PREDATOR COMPLEX OF RICE LEAFFOLDER

Chen and Chen (1982) reported the predatory two spotted ground beetle to prey upon the rice leaffolder, *C. medinalis*. The beetle larva was found to consume on an average 25.5 larvae of the pest.

Barrion and Listinger (1985) observed several species of *Chlaenius*, including *C. pasticalis* and *C. circumdatus* preying on larvae of *C. medinalis* in upland rice fields in the Philippines. The presence of the carabid did not prevent extensive leaf damage, but it limited damage and population build up.

- Bhardwaj *et al.* (1986) observed that natural enemies including the staphylinid, *Paederus fuscipes*, the coccinellids, *Menochilus sexmaculatus*, *Coccinella septumpunctata* and *Scymnus* sp. and the various species of spiders mainly *Lycosa* sp. were present in large numbers on pests of summer paddy.

Trichogramma confusum, *I. Chilonis*, Odonat spiders and frogs were the predominant natural enemies on the pyroliid rice pest, *C. medinalis* in Henar, China (Shen, 1986). The larval population of *C. medinalis* was significantly negatively correlated with the percentage parasitized eggs by *I. Chilonis* and the abundance of spiders. Gupta *et al.* (1986) reported four species of arachnida as natural enemies in rice agroecosystem around Hyderabad.

Predatory behaviour of *Erigonidium graminicolum* and *L. pseudoannulata* was studied in China (Anonymous, 1987). It was observed that the rate of predation increased with the population density of the prey to a stable high rate. It was suggested that the species of spider and population density and the species of prey should be taken into account in the evaluation of the control of insect pests by spiders.

Joshi *et al.* (1987) while reviewing the literature regarding biological control agents of *C. medinalis* in rice between 1913-1983 reported the formicids such as *Pheidole* sp. *Solenopsis geminata* and *Diacamma*, the carabid *Chlaenius* sp. *Coccinella arcuata* and the spiders *L. pseudoannulata* and *Tetragnatha japonica* as important predators of rice leafhopper. The entomogenous fungi *B. bassiana*, *Syncephalastrum racemosum* and *Penicillium oxalium*, the bacteria, *Bacillus thuringiensis*, *Serratia marcescens* and a granulosis virus were also observed as potential biological agents.

In the survey of Parasuraman (1989) predatory coccinellids were found to feed on BPH, WBPH and leafhoppers, *Menochilus sexmaculatus* accounted for 43% of total natural enemies recorded in rice fields.

Holden *et al.* (1989) found the spiders and mirid bugs as the natural enemies of rice insect pests.

Gu *et al.* (1989) considered that *P. fuscipes* as third most important predator of rice pests, following wolf spiders (*Lycosidae*) and other spiders based on its population and predation efficacy.

Shen and Pang (1989) determined equations for describing the predation of the staphylinid, *P. fuscipes* and the carabid, *Ophionia indica* on the eggs of pyralid, *C. medinalis* and concluded that the staphylinid is an important predator of pyralid egg, but mutual interference became important at high predator density.

Shatrugna Sahu *et al.* (1996) observed *Lycosa pseudoannulata* to prey more on rice pests, green leafhopper (43.3%), leaf folder (3.3%), hispa (6.67%) and stem borer (3.3%).

The population fluctuations of the pyralid, *C. medinalis* were influenced by predatory spiders; particularly *L. pseudoannulata*. Population of the predator increased with the pest population resulting in a decline in pest incidence (Pawan Kumar *et al.*, 1996).

Arida *et al.* (1997) found that the natural enemy population of spiders and Collembolens were heavily affected by insecticide application, whereas mirid bug population was not affected much in paddy fields.

The monthly fluctuations in populations of 12 species of spiders in rice fields in Pakistan between June and November, 1993 showed that the population of all species peaked during July and August and minimum population levels were generally recorded in October and November (Ghafoor, 1998).

Lu *et al.* (1999) found spiders as the dominant predators in rice fields of China (accounting for 38.5-75% of all predator species). Within one month of rice transplantation, a significantly greater number of predators were observed to be moved into rice fields from the neighbouring habitats.

The catches of predators in pitfall traps around an irrigated rice field at IRRI, the Philippines showed that the most common predators were spiders (Araneae), carabids (Carabidae) and ants (Formicidae) (Sigsgaard *et al.*, 1999). The results also indicated that directional movement between the fields and its surroundings, as well as total catches of predators, depend on farm operations and crop age.

2.3.1 SYNTHETIC INSECTICIDES AND SAFETY TO PREDATOR COMPLEX

Tests with six insecticides and 8 acaricides against worker honey bees, 3 pest species and 3 insects used in biological control (*C. undecimpunctata*, *Scymnus* sp. and *Orius* sp.) showed that all insecticides and acaricides including curacron (profenofos) were toxic to one or more predators in cotton (Salman and Ebd El Raof, 1978-79).

Broadley (1983) carried out laboratory studies on the contact toxicity of insecticides to the adults of coccinellids *C. repanda* and *Harmonia octomaculata* and showed that the toxicity in ascending order was endosulfan, Chlorpyrifos, profenofos, methidation, chlorpyrifos, cypermethrin and deltamethrin.

Patnaik (1983) collected adult populations of *C. repanda*, *Micraspis discolor* and *M. vincta* from unsprayed fields and sprayed them in a

Potter's Tower with chlorpyrifos, fenitrothion, formothion, phosphamidon or quinalphos. The phosphamidon proved to be the most toxic to all the 3 predators. Fenitrothion was least toxic to *C. repanda* and chlorpyrifos to *M. discolor*.

Vorley (1985) studied the effect of carbamates and synthetic pyrethroids (cypermethrin and cis-2-cypermethrin) on pests of rice and natural enemies in Malaysia. The carbamates were less toxic to spiders and other natural enemies, while both the pyrethroids were highly toxic to spiders.

Zheng *et al.* (1985) observed that the effects of commonly used pesticides on spiders in rice fields to be related closely to the type, frequency, concentrations, methods and time of applications of the chemicals. The spiders were affected more by the 2nd and 3rd application of pesticides than the 1st especially by organochlorines.

Diflubenzuron was selective having no effect on the larvae of coccinellid, *Scymnus* sp. and other arthropod predator complex, whereas parathion-methyl had adverse effect on them in cotton (Matrangolo *et al.*, 1987).

Fayad and Ibrahim (1988) reported that among the predators, *Coccinella* sp. and *Chrysoperla carnea* were highly susceptible to deltamethrin and a mixture of chlorpyrifos diflubenzuron and profenofos.

- Knaust (1991) studied the non-target effects of two insecticides on nineteen predatory species in the laboratory. Bromophos caused 100 per cent mortality in 7 species and prapoxur in two species.

Wiles (1991) treated the predatory arthropods caged on cereal

plants, with deltamethrin and found that spiders were most susceptible followed by rove beetles (staphylinids), the carabid, *Benbidon lampros* and 7 spotted lady bird, *C. septempunctata*. Field mortality on residual deposits ranged from 9.0 to 63 per cent but toxicity declined markedly over the 5 days after spraying.

Field experiments carried out over three years (1988-1990) in England, showed that seed treatment with fonophos and chlorpyrifos reduced the number of several carabid beetle species caught in pitfall traps (Asterak *et al.*, 1992).

White *et al.* (1992) in field experiments in Brazil found that Lambda-cyhalothrin (3.75 g a.i./ha) and monocrotophos (120 g a.i./ha) had no apparent effect on chrysopids, ants (Formicidae), staphylinids, parasitic wasps (Hymenoptera) or spiders.

Rajendran (1993) reported that all granular insecticides *viz.*, carbofuran (0.75 kg a.i./ha), phorate (1.0 kg a.i./ha) and quinalphos (1.0 kg a.i./ha) were found to be safe to the natural predators like mirid bug, *Cyrtorhinus lividipennis*, spider, *Lycosa pseudoannulata* and coccinellids.

When lambda-cyhalothrin (Karate), fenvalerate (Sumicidin) and primicarb (Pirimor) were applied against aphid vectors of barley yellow dwarf virus, observations on spider populations indicated that the use of insecticides for vector control could lead to serious reduction in population density and activity of these important predators (Krause *et al.*, 1993).

Sontakke (1993) observed that monocrotophos was relatively

safe, whereas chlorpyrifos either alone or in-combination with neem oil was toxic to predators of rice pests in Orissa.

Ganesh Kumar and Velusamy (1996) reported that acephate, BPMC and ethofenprox were safe to *L. pseudoannulata*, *Tetragnatha javana*, *Oxyopes javanus* and acephate and ethofenprox treated prey caused minimum mortality in these three species of spiders in rice.

Patel *et al.* (1997) found in Gujarat that predators and parasitoids of major rice pests were less adversely affected by granular application of carbofuran, phorate and quinalophos.

Panda and Mishra (1999) reported that cartap followed by phorate and carbofuran when applied to control *S. furcifera* in rice fields in Orissa, were safe to spiders, *Cyrtorhinus lividipennis* and *P. fuscipes*.

2.3.2 Biopesticides and safety to predator complex

2.3.2.1 *Bacillus thuringiensis*

The microbial pesticides, Dipel (*B.t.* subsp. *Kurstaki*) was harmless to most of the beneficial arthropods including *C. carnea*, *Cryptolaemus montrouzeri*, *Syrphus uitripennis* and *Trichogramma coccaeiae* and can be recommended for integrated control programme (Franz *et al.*, 1980 and Hassan *et al.*, 1983).

When eighty nine hectares of forest edge in Switzerland infested with *Melolontha melolontha* were treated from a helicopter with a suspension of blastospores of *B. brongniarti* (at 2.6×10^{14} spores/ha) results showed that overall infection rate in beneficial arthropods was only 11 per cent. The infection then rapidly disappeared from them

indicating that the treatment does not endanger the beneficial arthropod fauna of the forest edge (Boltensweiler and Ceruttii, 1986).

Adylov *et al.* (1990) observed that sprays of *B. thuringiensis* had no adverse effect on numbers of immature stages of common lace wing and aphidophagus coccinellids.

Greener and Candy (1994) conducted laboratory experiment with *B.t.* subsp. *tenebrionis* which is used to control *Chrysophtharta bimaculata* in Tasmanian eucalyptus plantations and found that *B.t.* adversely affected the survival of *Chauliognathus lugubris*, a major predator of target insect *C. bimaculata* but survival of two coccinellids and adult *C. bimaculata* was not affected.

Foliar application of neem seed kernel (NSKE) and *B. thuringiensis* were safest to parasites and predators of rice leaffolder (Latha *et al.*, 1994).

2.3.2.2 Botanicals

Saxena *et al.* (1984) reported that the wolf spider, *L. pseudoannulata* a predator of rice hopper, was not adversely affected even at the highest dose of 50 mg of neem oil/spider.

Singh *et al.* (1985) found that most of the botanical pesticides were safe against the predator, *Coccinella septumpunctata*.

Raghuraman (1987) observed the neem seed kernel suspension (5%), neem oil (3%) or aqueous extract of neem cake (10%) treated rice plots to have better recolonization of spider, *L. pseudoannulata* than in monocrotophos (0.07%) treated plots after 7 days. The same

neem products spared the predatory mirid bug, *C. lividipennis* another predator of rice hopper in paddy field (Mohan, 1989).

The populations of *L. pseudoannulata* and *C. lividipennis* were reported to be unaffected by different neem seed kernel extracts in paddy crop (Saxena *et al.*, 1987; Sukla *et al.*, 1988; Saxena, 1989; Jayaraj *et al.*, 1993; Mariappan *et al.*, 1993 and Nanda *et al.*, 1993).

Kareem *et al.* (1988) observed lower population of mirids, and spiders in plots treated with monocrotophos than in plots treated with neem 48 days after treatment.

Schmutter (1990) opined that neem products were relatively weak contact insecticides and the special mode of action in most cases was found to be harmless or only slightly harmful to parasitoids and predators of insects pests.

Mohan *et al.* (1991) observed that though there was initial reduction in population of spiders and mirids in neem treated plots, there was better recolonization of predators, on the other hand population of predators remained at low level in monocrotophos treated plots.

Saleem and Matter (1991) reported that neem oil acted as a temporary repellent on the beetles, *P. alfieri*, *C. undecimpunctata* and lace wing, *C. carnea* in cotton, but otherwise had no detrimental effects on the predators.

Mansour (1993) tested the effect of three commercial neem based insecticides on *Tetranychus cinnabarinus* (Bosd.), predacious mite, *Typhlodromons athiasae* and predacious spider, *Chiracanthium*

mildei in laboratory and none of these products were found to have any detrimental effect on the spiders, *C. mildei*.

Dash *et al.* (1996) observed that there were higher population of natural enemies such as spiders and mirid bugs in rice plots treated with neem derivatives like neem oil spray (3%) and NSKE (5%) than in insecticide treated plots.

Lowest mortality of parasitoid *Cotesia flavipes* occurred after treatment with extracts of *A. indica* and *D. metel* while the extract of *Thevetia nerifolia* caused the greatest mortality (Reddy and Srikanth, 1996).

Schmutter (1996) showed that eggs of coccinellids and chrysopids were not sensitive to neem products and the spiders (juveniles and adults) were also not endangered by neem products.

Srinivasan and Sundarbabu (2000) evaluated the neem seed kernel extract and various commercial neem products against eggs, grubs and adults of predatory green lace wing, *C. carnea stephens* and found that these caused 14.66 to 25.33 per cent egg mortality (as against 8% in control) and 6.66 to 16.6 per cent grub mortality (33% in control). The longevity and fecundity were also slightly affected by all neem products.

2.4 STUDIES ON THE HOST PLANT RESISTANCE

Breeding for leaffolder resistance is a practical means of controlling this pest in rice growing zones. Fields and green house evaluations have identified several traditional rice varieties as resistant to this pest. Even varieties classified as resistant, suffer some damage under high

insect population. In the present review of literature, work done on the aspects relevant to the present study *viz.*, varietal resistance to the rice leaffolder only is presented.

Literature on different plant parameters studies in the present investigations on varietal resistance to the rice leaffolder is presented separately here under.

2.4.1 Varieties and per cent incidence of leaffolder

Soeardjan *et al.* (1968-74) screened 188 varieties of local and foreign origin in the field during the wet season 1970-71 and gave a list of 21 apparently resistant varieties.

Among seven rice varieties tested for reaction to leaffolder, CR 56-17 was least susceptible followed by T141, Ptb21, GEB-24, IR5, T(N)1 and IR8 in increasing order of susceptibility (Yadav *et al.*, 1972).

Velusamy *et al.* (1973) found that varieties like Indrasal, Deval, Myosan, Nagasein, Humwl myotari, Kalagyi, Ngachima were highly susceptible and Gangasalabhata, Japan 37, *O. glaberrima*, Varylava 16, Leavang Rahacng 8, Taichung 65 x T(N)1, IRRI48 were resistant.

Variety N-19 was highly resistant to leaffolder as compared to other varieties like J 280, K118, Jaya and IR8 (Upadhaya *et al.*, 1975).

Veluswamy *et al.* (1975) observed the cross TKM 6 x IR8 and IARI 6579 and Tetep varieties to be resistant to leaffolder incidence.

The cultivars 12713 and 14466 and the varieties T(N)1 and IET528 were highly susceptible and recorded more than 70 per cent incidence of leaffolder, while the varieties ASP 5, cultivar 7711, TKM

6 and IR5 recorded significantly lesser damage (Jayaraj and Chandramohan, 1977).

Mani and Loganathan (1977) observed low incidence of leaffolder (below 11%) in seven varieties out of 30 varieties and the lowest infestation rate of 7.36 per cent was obtained with TNAU 2080.

Shah *et al.* (1977) found that out of 233 cultivars screened none of the cultivars exhibited resistance to *C. medinalis* but 15 were found tolerant to *Pelopidos mathias*.

Pillai *et al.* (1979) assessed the pest damage at the boot leaf stage and found T289, J147, J1-45-7, Kalladachambavu and T1340 to be the most tolerant entries.

Verma *et al.* (1979) evaluated eleven standard rice cultivars and four promising lines for resistance to leaffolder and found that Jaya was the most heavily attacked and Prasad the least attacked.

Gowda *et al.* (1981) found that the per cent leaf damage by leaffolder in various varieties ranged from 10.6 to 100.0 and was lowest in ARC 25, KM 133 and KMP 58.

Upadhyay *et al.* (1981) reported that Bala, CR44-36 and Pusa 2-21 (early maturing), IR-22 (mid late season maturing) had the lowest incidence of *C. medinalis*. IR-20 and Jaya previously reported to be tolerant showed no resistance in these tests.

Out of 140 varieties of rice, three varieties *viz.*, IR 579-92-2-3, RP 1422-2-2-3-5 and IR 1422-2-2-3-2 were found to be resistant (1 to 10% incidence), six moderately resistant (11 to 20% incidence), forty

susceptible (20 to 50% incidence) and ninety one highly susceptible (51 to 100% incidence) to leaffolder as reported by Dani *et al.* (1983).

Jaswant Singh and Dhaliwal (1983) evaluated 384 rice cultivars under field conditions for resistance to leaffolder at two locations in Punjab, 15 proved resistant at Gurdaspur, two at Kapurthala and only one (IET7776) was found resistant at both these locations.

Nadarajan and Nair (1983) screened 31 rice varieties under field conditions for leaffolder resistance and found that GEB24, Ptb33, IR 21937-26-2-3, BG-12-1, BG 367-3, BG 379-2 and BR 1030-51-1-1-2-1 were resistant. All other varieties tested were susceptible or highly susceptible.

Anonymous (1984) found the four breeding lines (2 selections of RP2068 and two nominations of TNAVLR series), 2 donors (TKM6, W1263) and two varieties (IET 5741, IET 6314) to have low damage rating at the trials conducted by AICRIP.

Bautista *et al.* (1984) observed that despite several attempts to develop varieties resistant to rice leaffolder, no resistant variety has so far been released for commercial cultivation.

Of the 39 entries screened under field conditions for resistance to the white backed planthopper and rice leaffolder, IR9224-117-2-3-3 was found to be resistant to both insects (Dhaliwal *et al.*, 1984).

Garg (1984) found none of the 31 entries screened in field during 1982 wet season to be free from leaffolder infestation.

Kushwaha *et al.* (1984) observed an average of 20, 27, 29 and 31% leaffolder damage in rice at Ambala, Karnal, Sirsa and Kurukshetra,

respectively and there were no differences in damage between scented and unscented varieties.

At AICRIP IET7254, IET7613, IET7566, Lalmati A and Lalmati B showed consistently better performance against both stem and leaffolder (Anonymous, 1985).

Rajendran (1985) found that out of 25 entries screened inside nylon net cage, 2 accessions viz., IET 8100 and IET 8105 were resistant (score 1-10% damage).

Uthamasamy (1985) evaluated 49 varieties of rice in *kharif* 1983 and found the varieties Asd 7 and Mahsuri to have less than 10 per cent leaf damage. On the other hand Ptb 33 and Mudgo recorded 13 and 18 per cent leaf damage respectively at 60 days after transplanting.

Heinrich *et al.* (1985) identified 115 accessions from the ten countries in green house screening showing resistant or moderately resistant reactions to leaffolder. Several breeding lines having Ptb 33 or W1263 as donor parent out of 17914 accessions of rice from 62 countries were found to be moderately resistant.

Kalode (1985) found that out of 42 entries screened at AICRIP Hyderabad, the incidence of leaffolder was lowest in Ptb12, Vellai, Yilankalyan, MR1523, ARC 10660, Mudgo and IET 6314.

- The damage caused by two species viz., *C. medinalis* and *Marasmia patnalis* did not differ significantly in various lines and Ptb33, ASD5, TKM6, IR 4707-106-3-2, Darukasail and GEB 24 were possible donors for resistance to these two pests (Joshi *et al.*, 1985).

Medina and Tryon (1986) studied the ovipositional behaviour and food plant preference of *C. medinalis* in 3 resistant wild races and 5 resistant cultivars of rice and found that wild races were more resistant than the cultivated rice. Fewer eggs were laid on them and fewer larvae survived and settled on the leaves. Cultivars with long, broader leaves, showed more damage than those with short narrow leaves.

Kushwaha and Singh (1986b) found that the varieties RP2068-18-3-5, RP2068-17-3-7, RP2068-18-4-5, Co29, IET8817, Vaizhaeppoo, Samba and RP2069-3-4-4-6 were resistant to both *S. furcifera* and *C. medinalis* during 1984 field trials in Haryana.

Rajendran *et al.* (1986) screened 18 rice accessions from AICRIP for resistance to leaffolder at Coimbatore and Pondicherry and found RP2068-18-2-9, TANULFR 832036 and TNAVLFR 831311 to be resistant to this pest.

Sundar babu and Rajendran (1986) presented the resistance/susceptibility grades of 140 varieties to *Nilaparvata lugens* and *C. medinalis* under green house tests and CO19 and PEB33 were found to be resistant to both the pests.

Kushwaha and Raj Singh (1986a) tested 18 scented and 22 unscented varieties for their reaction to leaffolder infestation in Haryana and observed that among scented varieties the cultivar HKP213 had maximum infestation, whereas in non-scented varieties, PAU-12-262 registered greater pest attack.

Saroja *et al.* (1987) screened 64 rice accessions for resistance to *C. medinalis* and observed 13 varieties to be resistant, 14 moderately resistant and 37 susceptible.

Patnaik *et al.* (1987) studied the reaction of 22 medium duration (101-125 days) and 24 medium-late duration (126-140 days) rice cultivars to rice whorl maggot (RWM) and leaffolder (LF) in north-central plateau of Orissa and found that no entry was free of RWM and LF infestation and most of them exhibited moderate resistance.

Uthamasamy (1987) observed that among 128 entries assessed 90 and 119 days after sowing, 10 were free from leaffolder damage. Out of the ten, IET 8675, IET 8698 and IET 8710 were regarded as promising, producing grain yield in excess of 4 t/ha.

Rajendran and Velusamy (1987) screened 32 rice accessions from AICRIP for leaffolder resistance using seedling screening technique and found twelve accessions to be resistant both in the green house and field.

Narayanasamy *et al.* (1988) observed the P834 to be resistant to brown planthopper, leaffolder, rice blast and brown spot.

Hu *et al.* (1988) tested nine cultivars for resistance to leaffolder and only one cultivar Ptb-621 was found to be resistant to the pest.

Sharma *et al.* (1988) reported that variety VLDhan 163, a derivative of IR5904 was resistant to leaffolder, stemborer, leaf and neck blast.

Rajendran (1988) screened 26 rice accessions at the seedling stage in seed boxes for resistance to *C. medinalis* both in the green house and in microplots. The accessions TNAU-LFR 831324, 832024, 842718, 842735 and 842745 all exhibited good resistance to the pest in both tests.

The infestation by *C. medinalis* was significantly and positively correlated with leaf width, plant height and leaf length, thus suggesting that tall, broad and long leaved cultivars of rice should be avoided while selecting varieties for tolerance against this pest (Kushwaha, 1989; Majumdar *et al.*, 1986).

Muthuswami and Gunathilagaraj (1989) screened 24 gall midge resistant genotypes for YSB (*Scirpophaga incertulas*) and LF (*C. medinalis*), BL (*Pyricularia oryzae*) resistance. ARC 10847 and IET 10251 were found to be resistant to LF and only IET 10251 was resistant to both insects and blast.

Balasubramanian *et al.* (1989) screened 26 and 30 rice entries for resistance to *C. medinalis* during 1984 and 1985, respectively, under natural conditions. The entries were interplanted with susceptible IR20 variety. During 1984, damage ranged from 2.7 per cent in TNAU-LFR 831322 to 5.6 per cent (TNAU-LFR83123) at 90 days after transplanting (DAT). During 1985, TNAU-LFR 831323 had the highest level of damage (6.8%) while TNAU-LFR 832042 and TNAU-LF832041 had the lowest level of 5 per cent at 90 DAT.

Tomar *et al.* (1990) screened 81 rice cultivars for resistance to rice leaffolder during 1986-87. In 1986, RP-1714-111-7-3-2 and OR 811-2 had no *C. medinalis* damage while in 1987, RD 2599-150-18-8-5 and RAU 156-56 escaped damage.

Paramasivan *et al.* (1990b) observed that TM6012, a drought resistant selection derived from C22 x BJ1 had field tolerance to leaffolder, gall midge, sheath rot and resistance to blast.

Rajendran and Adiroubance (1990) reported that out of 87 and 71 cultivars screened during 1986 and 1987, KD 14-1-39, RP 2068-18-3, RP 1579-58, RPT 1579-1633 and TN AULFR 831311 showed multiple resistance to *N. lugens* and *C. medinalis* in both seasons.

Paramasivan *et al.* (1990a) found that TM2011 (IET10883) derived from C22/TKM6/IR50 to have high resistance to leaffolder and green leafhopper and moderate resistance to gall midge and stemborer.

Sudhakar *et al.* (1991) studied the reaction of 24 rice varieties for resistance to *C. medinalis*. IE 7564, ES 29-3-3-1, Pusa 2-21 and type 3 were the least susceptible (with 3.80, 4.45, 4.97 and 6.02% infestation, respectively), while Rashi 17-4B-13, Rajashree, Rashi 164 B-11 and UPR 238T were highly susceptible varieties (35.35, 30.08, 30.19 and 28.25% infestation, respectively).

Ray *et al.* (1993) screened 24 cultivars with medium to late maturity from all over India, including the North-Eastern Hill Region (NEHR) and found Sikre, Khonorullo, Krusaro, RCPL3-5 and Dhanse to be moderately resistant, 13 cultivars to be moderately susceptible and 6 cultivars to be susceptible to *C. medinalis*.

Thamrin and Rasmini (1993) studied 22 promising lines for field resistance to leaffolder in the tidal wet lands of Indonesia during the 1991-92 wet season. Line, IR24637-38-2-2 was found to be resistant and other lines were moderately resistant.

Semidwarf variety Pakhal was reported to be resistant to both leaffolder and stemborer (Akram *et al.*, 1994).

Falerio and Patil (1995) evaluated 9 short and 11 medium duration rice varieties for the degree of field tolerance to leaffolder and found the Nela and Co44 exhibited a good degree of tolerance to leaffolder.

Prasad *et al.* (1995) observed that among cultivars screened for resistance against *C. medinalis* RNR-17-49-30, IR-25924-92-1-3, TNAU-LFR 831324, RP 2432-111-1-3 and RP 2151-221-4-2-4 were highly resistant.

Patnaik *et al.* (1995) tested 12 promising medium duration (120-135 days) rice cultivars for resistance against leaffolder and case worm during 1992, 1993 wet seasons. Cultivar RP 2327-318 had high insect damage and low yields in both years. In contrast, cultivar P622-629 (IET 11009) yielded well despite high leaffolder damage in 1992 and cultivars CR712-3-38 and P622-629 had high yields in 1993 despite high levels of case worm damage suggesting that these cultivars may be resistant to damage by defoliating insects.

Mandal *et al.* (1997) evaluated 19 varieties of upland rice for their resistance to leaffolder *C. medinalis* and grasshopper, *Hieroglyphus banian* and *H. nigrorepletus*. Among these variety OR-83-23 proved promising, while varieties OR-377-85-6 and OR 923-2-5 proved susceptible against leaffolder. Pathara, Suphala, Keshari and Anapurna showed resistance, while culture 1 and OR 93-23 were susceptible against grasshoppers.

Ramaraju and Velusamy (1997) found varieties TNAY 90012, TNAU 9004 AND IRSA76 to be resistant to leaffolder and YSB, ASD 16, Co45 and IRSA 69 resistant to YSB and AS90043, ACM93 and TNAU89093 resistant to leaffolder in Tamilnadu.

Nayak and Panda (1998) observed the multiple resistant varieties Bhubana and OR 148-1-44-7 to record significantly lower damage by *C. medinalis* (3.5%) than the susceptible variety T(N)1 (5.9%).

2.4.2 Influence of morphological characters of rice plant on infestation

Kulshreshta *et al.* (1970) reported that the incidence of leaf folder was higher in high yielding dwarf varieties with broader and dark green foliage as compared to tall local varieties.

Lippold (1971) conducted studies on influence of morphological characters of plant on infestation at Bangladesh and found the local varieties with narrow leaves (less than 0.8 cm wide) and introduced varieties with wider leaves (more than 1.5 cm wide) to show resistance (0 to 10% infestation) whereas, those with intermediate leaf width were highly susceptible.

Hanifa and Subramaniam (1973) found the height of plant second internode distance from the top and the length of second leaf to be negatively correlated while the width of second leaf to be positively correlated with infestation of leaf folder. The straight leaves with broader leaf width facilitate easy folding and provide more area of feeding for leaf folder.

Majumdar *et al.* (1984) observed that among plant character studied leaf width had the greatest positive effect on infestation rate followed by plant height and leaf length. They also suggested that in selection for tolerance to the pest, tall plants with broad leaves should be avoided.

Dakshayani *et al.* (1993) observed that larval preferences were positively correlated with leaf width and negatively correlated with trichome density.

Islam and Karim (1997) evaluated 16 rice varieties and breeding lines for the influence of morphological traits on leaffolder (*C. medinalis*, *M. patnalis*, *M. exigua*) incidence during summer 1993 in Bangladesh. Leaffolder resistant variety TKM6, with narrow and long leaves had the lowest level of folded leaves (0.9%) while Purbachi with wide and short leaves recorded the highest level (14.1%). The incidence of folded leaves was negatively correlated with leaf blade length and positively correlated with leaf blade width. There was no correlation between folded leaves and plant height or green leaf numbers.

3. MATERIALS AND METHODS

Field experiments were conducted during *kharif* season 1998 and 1999 at Indian Agricultural Research Institute (I.A.R.I.), New Delhi, to evaluate the bio-efficacy of some insecticides and biopesticides against rice leaffolder, *Cnaphalocrocis medinalis* (Guenee). Studies were also conducted to evaluate the one hundred rice germplasm for their resistance to rice leaffolder, *C. medinalis*.

3.1 TEST VARIETY

The studies were conducted with the rice variety "Pusa-834" which is susceptible to insect pests. The required seed was obtained from Genetics Division, I.A.R.I., New Delhi.

3.2 AGRONOMIC PRACTICES

3.2.1 Raising of paddy nursery

The field for raising nursery bed was brought to a fine tilth and bunds were made around the plot. Seed of the test variety (PUSA-834) was kept in gunny bag and soaked in water for a day to get the sprouted seeds. Sprouted seeds were broadcast uniformly over well prepared nursery seed bed. The seed rate used for nursery raising was 50 kg/ha. Paddy nursery was sown on 20.06.1998 and 07.06.1999 in two *kharif* seasons, respectively. Fertilizers were applied basally as per recommended dose to get good seedlings. The nursery bed was

irrigated once daily. No insecticidal treatment was given to the nursery. In about 30 days after sowing (DAS), the seedlings were ready for transplanting.

3.2.2 Preparation of Main field

The field was ploughed two times with disc plough and tractor drawn cultivator to get fine tilth. All weeds and stubbles were removed from the field, subsequently water was let into the field and puddled twice one day before transplanting and properly levelled.

3.2.3 Layout of the experiment

The field experiment was carried out to evaluate efficacy of insecticides, biopesticides and their combinations against leaffolder and also their effect on its predators during *kharif* 1998 and 1999. The experiment was laid-out in randomised block design. There were nineteen treatments including untreated control, replicated thrice. Small bunds were erected around the plots to impound the prevent loss of water and to insecticides, wherever these were applied. To minimise border effect on crop and pest incidence, one meter buffer space was left-out from the main bunds of the field on all sides. Between replications 50 cm channel was provided to facilitate irrigation, fertilizer and insecticide application uniformly and recording of observations on pest incidence. Following are the details of the experiment.

Design	:	Randomised Block Design (RBD)
Number of replications	:	3
Number of treatment	:	19
Plot size	:	1.5 x 1.5 m

Plate 1. A general view of chemical control experiment

Plate 2. A general view of screening experiment



Plot border	:	0.75 cm
Row to Row spacing	:	15 cm
Plant to Plant spacing	:	15 cm
Date of transplanting	:	27.07.1998 and 09.07.1999

3.2.4 Fertilizer application

Fertilizer was applied at the recommended doses i.e. @ 120 kg nitrogen (N) in the form of urea, 60 kg of P_2O_5 in the form of single super-phosphate and 40 kg of K_2O in the form of murate of potash per hectare. One third of the N and entire amount of P_2O_5 and K_2O were applied as basal dressing at puddling. The remaining N was applied in two equal split doses, once at peak tillering stage and remaining at panicle initiation stage. The fertilizers were applied by broadcasting uniformly. Before urea application excess water was drained and field was irrigated 24 hours later.

3.2.5 Transplanting

Transplanting was done with 30 days old seedlings. Plant to plant and row to row spacing was kept at 15 x 15 cm.

3.2.6 Gap filling

Gap filling was done a week after transplanting to ensure uniform plant population in each treatment.

3.2.7 Irrigation

The experimental field was irrigated daily till the seedlings were established. Further irrigations were given once in two days. Irrigation was completely stopped ten days prior to harvest of the crop.

3.2.8 Weeding

Experimental plots were kept free of weeds and other volunteer plants throughout the crop period manually.

3.2.9 Application of insecticides

Field experiments were carried out to study the relative efficacy of various insecticides including synthetic insecticides, biopesticides of plant origin, *Bacillus thuringiensis*, chitin synthesis inhibitor in various combinations against rice leaffolder and to evaluate the same against its predators. The source, dose and timing of applications of various treatments are presented in Table 1 and 2.

Table 1. The details of insecticides used and their sources

S. No.	Common	Trade name	Group name	Source
1.	Carbofuran	Furadan	Carbamate	Rallis, India Ltd., Rallie House, 21 D.S. marg, P.O. Box 1661, Mumbai-400052
2.	Phorate	Thimet	Organo-phosphorous	Cyanamid Agro Ltd., 16, Maharshi karvy Road, Church gate, Mumbai-400020
3.	Quinalphos	Ekalux	Organo-phosphorous	Sandoz (India) Ltd., Sandoz House, Dr. Annebisent Road, Varly, Mumbai-400016
4.	Fenvalerate	Triumphcard	Synthetic pyrethroid	Northern Minerals Ltd., Daultabad, Gurgaon, Haryana

5.	Diflubenzuron	Dimilin	Insect growth regulator	Coromandal Indag Products, Pvt. Ltd., Coromandal House, 62, Spur Tank Road, Chetput, Chennai-600031
6.	<i>Bacillus thuringiensis</i>	Dipel	-	Lupin Agro Chemical Ltd., 159, C.S.T Road, Kalina, Santacruz East, Mumbai-400098
7.	Neem-A	-	Botanical	IARI, Campus, New Delhi
8.	Neem-B (Refined)	-	Botanical	-do-
9.	Chinaberry	-	Botanical	-do-
10.	Aak	-	Botanical	-do-

The insecticides were applied as foliar sprays as well as granular application. The dose of insecticides expressed in terms of active ingredient (a.i.)/ha were applied after duly mixing with water. The spray volume used was 300, 500 and 800 lit/ha at 20, 40 and 60 days after transplanting, respectively. A high volume knap sack sprayer of 10 liters capacity was used for spraying and the plants were thoroughly covered with spray solution. During spraying, care was taken to prevent drift among the different treatments. Spraying at each time was completed on the same day in all the treatments. Spraying was done in the morning time except microbial insecticide, *Bacillus thuringiensis* (B.t.), which was sprayed in the evening time on the same day to avoid degradation of spore activity during the sunny day. Granular insecticides were applied by broadcasting in the field over a thin film of standing water and water was retained for 48 hours after application. In untreated control plot, only water was sprayed.

Table 2. Dose of the experimental treatments and schedule of their application during kharif 1998-99

	Treatment	Dose	Time of application						
			Kharif 1998			Kharif 1999			
			DAT			DAT			
			20	40	60	20	40	60	
T ₁	Carbofuran 3G	0.50 kg a.i./ha	√	-	√	√	√	√	√
T ₂	Carbofuran 3G	0.75 kg a.i./ha	√	-	√	√	√	√	√
T ₃	Carbofuran 3G + Dipel 8 L	0.75 kg a.i./ha + 900 ml/ha	√	-	√	√	√	√	√
T ₄	Phorate 10G	0.50 kg a.i./ha	√	-	√	√	√	√	√
T ₅	Phorate 10G	0.75 kg a.i./ha	√	-	√	√	√	√	√
T ₆	Phorate 10G + Dipel 8L	0.75 kg a.i./ha + 900 ml/ha	√	-	√	√	√	√	√
T ₇	Quinalphos 25 EC (3 sprays)	150, 250 and 400 g a.i./ha	√	√	√	√	√	√	√
T ₈	Quinalphos 25 EC (2 sprays)	-, 250 and 400 g a.i./ha	-	√	√	-	√	√	√
T ₉	Fenvalerate 20 EC (3 sprays)	22.5, 37.5 and 60 g a.i./ha	√	√	√	√	√	√	√
T ₁₀	Fenvalerate 20 EC (2 sprays)	-, 37.5 and 60 g a.i./ha	-	√	√	-	√	√	√
T ₁₁	Dipel 8 L (3 sprays)	900, 900 and 900 ml/ha	√	√	√	√	√	√	√
T ₁₂	Diflubenzuron 25% WP (3 sprays)	75, 125 and 200 g a.i./ha	√	√	√	√	√	√	√
T ₁₃	Dipel 8L (2 sprays) + diflubenzuron 25% WP (1 spray)	900, 900 ml/ha and 200 g a.i./ha	√	√	√	√	√	√	√
T ₁₄	Neem-A (3 sprays)	5%	√	√	√	√	√	√	√
T ₁₅	Neem-B (Refined) (3 sprays)	5%	√	√	√	√	√	√	√
T ₁₆	Chinaberry (3 sprays)	5%	√	√	√	√	√	√	√
T ₁₇	Aak (3 sprays)	5%	√	√	√	√	√	√	√
T ₁₈	Solvent + emulsifier (3 sprays)	-	√	√	√	√	√	√	√
T ₁₉	Control (untreated)	-	-	-	-	-	-	-	-

Note :

- : Treatment not applied
 √ : Treatment applied
 DAT : Days after transplanting

T 1001

Studies were also conducted with various combinations of treatments by alteration of sprays of synthetic insecticides and biopesticides with a view to study their efficacy in controlling rice leaffolder and feasibility of reducing synthetic insecticide dose to achieve economic control coupled with conservation of rich arthropod fauna of rice ecosystem.

3.2.10 COLLECTION AND EXTRACTION OF BOTANICAL INSECTICIDES

3.2.10.1 Collection of plant material

3.2.10.1.1 Neem (*Azadirachta indica* A. Juss) seeds

Yellow ripened fruits were collected from IARI campus, New Delhi. They were depulped, washed thoroughly in a stream of water and shade dried. They were decorticated to separate seed coats from kernels (NSK). The NSK were then ground to a powder in a mixer.

3.2.10.1.2 Chinaberry (*Meda azedarach* L.) fruits

Chinaberry fruits were collected from IARI Campus, New Delhi. The berries were shade dried and ground to a powder in a wiley type mill.

3.2.10.1.3 Aak (*Calotropis gigantea*)

Whole plants (the plants endemic in IARI, Campus were used) were uprooted with the help of a spade. The roots were cleaned free of soil and dirt. Later bark was removed from the root and dried in the shade for few days. They were milled to powder form.

3.2.10.2 Preparation of hexane-extracted neem oil

Neem seed kernels (NSK) (1 kg) were soaked with freshly distilled n-hexane overnight and n-hexane extract was decanted through a cotton wool filter. Light golden neem oil (300 g) was obtained after removal of solvent under vacuum evaporation. The neem oil thus obtained was partially cooled and the waxes were scooped off to furnish neem oil which we have named here in after as refined neem oil.

3.2.10.3 Methanolic extraction of neem seed kernels (NSK)

The defatted kernels (2.8 kg) were further ground to a powder and extracted with methanol using soxhlet apparatus. The methanolic extract on evaporation under reduced pressure yielded dark brown solid (250 g).

3.2.10.4 Preparation of chinaberry extract

Chinaberry powder (2.0 kg) was soxhlet-extracted with freshly distilled methanol. The methanolic extract was evaporated under reduced pressure to yield a dark viscous extract (450 g).

3.2.10.5 Preparation of Aak

Aak powder (2.5 kg) was soxhlet-extracted with freshly distilled methanol. The methanolic extract was evaporated under reduced pressure using rotary evaporator. The cold extraction was repeated with fresh lots of methanol four times and extract was pooled and processed as before. The total extraction was sprayed in the petriplate and left aside for 2 to 3 days to allow evaporation of traces of solvent and a thin layer of solvent-free residue (71.05 g) was formed in the

petriplate. The extract was formulated by adding ethyl methyl ketone toluene and Tween-80 as emulsifier. The emulsion thus obtained was sprayed immediately after its formulation in the experimental field.

3.3 RECORDING OF DATA ON THE LEAF DAMAGE

3.3.1 Observation on leaf damage

The incidence of leaffolder was recorded periodically in the experimental field. A total of three insecticide sprays were given in the evaluation trials. Five hills were selected at random in each plot and the number of leaves damaged by leaffolder and total leaves were counted in each hill. The observations on leaf damage were recorded one day before spraying and at ten days interval after spraying. The treatment in which more than one spray was given, the leaf damage on 20th day of the previous spray became pre-treatment count for the following spray. The percentage leaffolder damaged was calculated by using the following formula and expressed in percentage.

$$\text{Leaffolder damage (\%)} = \frac{\text{Number of damaged leaves/5 hills}}{\text{Total number of leaves/5 hills}} \times 100$$

3.3.2 Observation on natural enemies

Observations were recorded on the natural enemies to know the effect of different insecticide treatments on the natural enemy population. The population of both immature and mature stages of predators viz., coccinellids, rove beetle, ground beetle and spiders was recorded simultaneously along with leaffolder damage on five randomly selected hills in each plot.

3.3.3 Harvesting and threshing

Harvesting and threshing were done manually for all treatments. Threshing was done individually for each plot. While threshing, care was taken to avoid mixing of the grains.

3.3.4 Recording yield data

Finally grain yield was recorded for each treatment in kg/plot.

3.3.5 Statistical analysis

The per cent leaffolder damage was transformed into angular values, while population of its predators was transformed by square root transformation after adding 0.5 to each original count. The transformed data were then subjected to statistical analysis. The yield per plot was subjected to statistical analysis directly.

3.4 IDENTIFICATION OF SOURCE OF RESISTANCE TO RICE LEAFFOLDER

Field studies were conducted to identify the source of resistance to leaffolder *C. medinalis* (Guenee) during *kharif* 1998 and 1999. One hundred lines of rice germplasm obtained from the Genetics Division, IARI, New Delhi were evaluated against the leaffolder under natural infestation conditions at the institute farm.

The experimental field was thoroughly prepared and during last ploughing entire quantity of phosphorus (60 kg) and potash (40 kg) and one third quantity of nitrogen (40 kg) in the form of urea, super-phosphate and murate of potash, respectively, was applied as basal dose. The rest of nitrogen (80 kg) was applied in two split doses, one at peak tillering stage and remaining at panicle initiation stage.

One hundred lines of rice germplasm were sown in a single row plot for each line. Direct sowing was done in a row length of 150 cm for each line. Eleven hills were sown in the row with five seeds placed at each hills.

A susceptible check (Pusa 169) was also included in the study. Sowings were done on 18.7.98 and 19.06.99 during two years. Row to row spacing was 30 cm. There were two replications during 1998 and three replications in 1999. The experimental field were irrigated immediately after sowing. Thinning and gap filling was done after germination to ensure uniform plant population in each variety. All recommended package of practices were adopted, but without any insecticide application (Plate 1).

3.4.1 Evaluation of rice germplasm

The observations were recorded on :

1. per cent infested leaves by rice leaffolder, *C. medinalis*.
2. Morphological basis of resistance to leaffolder.

3.4.1.1 Per cent infested leaves

For evaluation of rice germplasms against leaffolder, total number of infested leaves and total number of leaves per 5 hills in every replication of each line was recorded and mean per cent damage worked out. Observations were recorded at two stages of crop growth viz., panicle emergence and physiological maturity.

The per cent leaffolder damage was scored according to the standard evaluation system for rice (Anonymous, 1996). The detailed description of rating scale 0-9 is given in Table 3.

Table 3. Details of the scale for rice leaffolder resistance studies under field conditions as per standard evaluation system for rice (Anonymous, 1996)

Scale	Damage rating	Damaged plants (% infested leaves)
0	Highly resistance	No damage
1	Resistance	1-10
3	Moderately resistant	11-20
5	Moderately susceptible	21-35
7	Susceptible	36-50
9	Highly susceptible	51-100

3.4.1.2 Morphological characters

To explore the morphological factors contributing towards resistance, different plant characters like plant height, leaf width, leaf length and texture of flag leaf (determined by touch and feel method) were recorded in five tillers selecting one from each hill per replication at the time of maximum growth period of the crop when infestation of *C. medinalis* was found to be maximum. The mean values were then obtained for plant height, leaf length and leaf width.

3.5 STATISTICAL ANALYSIS

Simple correlation coefficients were worked out between per cent leaffolder damage and various morphological characters *viz.*, plant height, leaf width, leaf length and texture of the leaf.

Table 4. Details of the germplasms screened against rice leaffolder, *C. medinalis* during *kharif* 1998 and 1999

S. No.	Germplasm	1998	1999
0.	Pusa-169 (S)	√	√
1.	IET-4141	√	√
2.	Kolumbo mutant	√	√
3.	IR-52813-C3-150-1	√	√
4.	PTB-10	√	√
5.	IR-52813-C2-27-3	√	√
6.	IET-6155-399-a	√	√
7.	Dwarf Mashuri	√	√
8.	Pusa-677	√	√
9.	IR-64-273	√	√
10.	IR-52813-C3-73-3	√	√
11.	Pusa-150-21-1	√	√
12.	IRAT-109	√	√
13.	Pant Dhan-10	√	√
14.	PAU-1628-23a	√	√
15.	Improved Sabarmati	√	√
16.	Pavizham	√	√
17.	Basmati-370	√	√
18.	Pusa-744-85-1240	√	√
19.	IR-52813-C3-75-3	√	√
20.	R-24-1	√	√
21.	Indrasan	√	√
22.	Karnal Local	√	√
23.	HKR-120	√	√
24.	Pusa-598-17	√	√
25.	Adt-34	√	√
26.	Lalnakanda	√	√
27.	Makam	√	√
28.	Bali-1	√	√
29.	IR-52813-C3-124-3	√	√

Table contd.....

S. No.	Germplasm	1998	1999
30.	Aruna	√	√
31.	Ratna	√	√
32.	IR-19761-305	√	√
33.	IET-12604-4R	√	√
34.	IR-19761-282a	√	√
35.	IR-64	√	√
36.	Pusa-1021-5	√	√
37.	Pusa-33-2-77	√	√
38.	IR-52813-C4-111-1-2-2	√	√
39.	IRAT-144	√	√
40.	Mahsuri	√	√
41.	Pusa-150-21-1	√	√
42.	Pusa-1008-2-1-1-2	√	√
43.	Pusa-745	√	√
44.	Pusa-570	√	√
45.	Chan-Xiang Xian	√	√
46.	IR-28	√	√
47.	Rasi	√	√
48.	IR-52813-C3-99-3-3-3	√	√
49.	IR-54718-Co-104-2-2 (HB-6)	√	√
50.	Pusa-169 (S)	√	√
51.	Pusa-44-33	√	√
52.	Kanakam	√	√
53.	IR-52813-C3-62-3	√	√
54.	TCN-8-IET-13554 (HKR-90-414)	√	√
55.	Ranjani	√	√
56.	Pusa-1117-14-3	√	√
57.	HKR-119	√	√
58.	TCN-9-IET-13845 (BH-834-2)	√	√
59.	Jaya	√	√
60.	IR-72	√	√
61.	Dular	√	√

Table contd.....

S. No.	Germplasm	1998	1999
62.	Giza-171	√	√
63.	Pusa-1022-97	√	√
64.	Pusa-702	√	√
65.	Pusa-743-1-1-23	√	√
66.	Pusa-836-202-208-207-2	√	√
67.	Basmati Dwarf	√	√
68.	Pusa-150-21-1-1-2-1	√	√
69.	IET-10649-1	√	√
70.	IET-10649-1 (early)	√	√
71.	Gharbharam	√	√
72.	Pattambi-29	√	√
73.	Vikramarya	√	√
74.	IR-36	√	√
75.	Pusa-702-1	√	√
76.	Pusa-560	√	√
77.	Pusa-703	√	√
78.	Pusa-835-203-213-102	√	√
79.	PAU-1126	√	√
80.	P-107792-157-1	√	√
81.	IR-52813-C3-146-2	√	√
82.	Pusa-205-6-4	√	√
83.	Ramya	√	√
84.	Pusa-588-13	√	√
85.	PAU-1628	√	√
86.	IR-50	√	√
87.	Tainan-3	√	√
88.	Pusa-205-275	√	√
89.	Pusa-835-203-2-103-33	√	√
90.	Pusa-598-12-5-844-303	√	√
91.	IRAT-141	√	√
92.	IR-19761-283a	√	√
93.	Kartika	√	√

Table contd.....

S. No.	Germplasm	1998	1999
94.	Usha Barabanki	√	√
95.	Pusa-615	√	√
96.	Pusa-1187-72-1	√	√
97.	Pusa-1007-24	√	√
98.	Pusa-1120-7-3	√	√
99.	IET-12604-3r	√	√
100.	Pusa-834-204-207-202-2-1	√	√
101.	Asha	√	√
102.	Pusa-169 (S)	√	√

√ : germination present

S : **Susceptible check**

4. RESULTS

The field experiments were conducted to study the efficacy of various synthetic insecticides and bio-pesticides for the control of rice leaffolder, *Cnaphalocrocis medinalis*, effect of these treatments on the predator complex of leaffolder and screening of rice germplasms for resistance against leaffolder. The experimental findings are presented in this chapter. The data are presented in Tables 5 to 19.

4.1 Influence of various insecticides and biopesticides on rice leaffolder

A total of ten insecticides were evaluated against leaffolder during the present investigations. There were nineteen treatments which included three alternations treatments, solvent + emulsifier and untreated control (Table 2). Among the three alternation treatments two alternations were those of granular formulation with biopesticides (i.e. carbofuran 0.75 kg + Dipel and phorate 0.75 kg + Dipel) with Dipel being applied at time of third spraying. The other alternation treatment was that of Dipel + diflubenzuron (Diflubenzuron comprised third spray). The above alternations were done with an idea to investigate feasibility studies regarding profitable leaffolder control whereby, further granular application can be reduced. In *kharif* 1998 second dose (at 40 DAT) of granular formulation was not applied. While *kharif* 1999 all three doses (at 20, 40 and 60 DAT) were applied.

Plate 3. Larva of rice leaffolder

Plate 4. Adult of rice leaffolder



4.1.1 Effect of various insecticides and biopesticides on rice leaffolder, *C. medinalis* during kharif 1998

For assessing the efficacy of the various treatments on the damage caused to the crop, counts were taken on damaged leaves and the total number of leaves per hill for five hills at random for each treatment. The percentage damage caused to the leaves was calculated. The counts were taken at one day before spraying and ten days interval after insecticidal application.

One day before first spray leaffolder infestation ranged from 0.0 per cent to 1.08 per cent with no significant differences among treatments.

4.1.1.1 First spray

The data recorded ten days after first spraying showed that the leaffolder infestation ranged from 0.76 per cent to 2.88 per cent folded leaves. Minimum infestation was recorded in fenvalerate 3 sprays (T_9) which recorded only 0.76 per cent folded leaves. Carbofuran 0.75 kg (T_2) was next best treatment and recorded 0.88 per cent damaged leaves, followed by quinalphos 3 sprays (T_7) carbofuran 0.5 kg (T_1), carbofuran 0.75 kg + Dipel (T_3), phorate 0.75 kg + Dipel (T_6), phorate 0.5 kg (T_4), phorate 0.75 kg (T_5) and diflubenzuron (T_{12}) which recorded 0.90, 0.96, 1.00, 1.14, 1.19, 1.26 and 1.52 per cent folded leaves, respectively and were found to be statistically on par with the best treatment, fenvalerate (T_9). The highest infestation of 2.88 per cent folded leaves was recorded in untreated control (T_{19}). Next highest infestation of 2.58 per cent folded leaves was recorded in fenvalerate

Plate 5. Leaffolder damaged leaf



2 sprays (T₁₀) where the first spray was not applied. Diflubenzuron (T₁₂) was found to be significantly superior over untreated control. Dipel (T₁₁) was better than botanicals and untreated control (T₁₉). All other treatments viz., Dipel + diflubenzuron (T₁₃), Neem-A (T₁₄), Aak (T₁₇), chinaberry (T₁₆), quinalphos 2 sprays (T₈), Neem-B (Refined, T₁₅), solvent + emulsifier (T₁₈), fenvalerate 2 sprays (T₁₀) recorded infestation ranging from 1.84 to 2.58 per cent and were found to be on par with untreated control (T₁₉).

Twenty days after first spray, results showed that all the synthetic insecticidal treatments were significantly superior over untreated control (T₁₉). Fenvalerate 3 sprays (T₉) was the most effective with minimum damage of 1.67 per cent folded leaves as compared to a maximum of 5.62 per cent in untreated control (T₁₉). The next best treatments were quinalphos 3 sprays (T₇) followed by carbofuran 0.75 kg (T₂), carbofuran 0.75 kg + Dipel (T₃), carbofuran 0.5 kg (T₁), phorate 0.75 kg + Dipel (T₆), diflubenzuron (T₁₂) and phorate 0.75 kg (T₅) which recorded leaf folder ranging from 1.93 to 2.59 per cent and were on par with each other and also with best treatment fenvalerate (T₉). Among synthetic insecticidal treatments only phorate 0.5 kg (T₄) recorded 3.14 per cent folded leaves and significantly differed with fenvalerate 3 sprays (T₉). Among the biopesticides Dipel (T₁₁) was on par with insecticidal treatments. Untreated control (T₁₉) had the highest infestation of 5.62 per cent followed by solvent + emulsifier (T₁₈) with 5.27 and fenvalerate 2 sprays (T₁₀), quinalphos 2 sprays (T₈) (where first spray was not applied) with 5.22 and 4.97 per cent infestation, respectively and were on par with untreated control (T₁₉). The efficacy of other treatments can be seen from Table 5.

Table 5. Effect of different insecticides and biopesticides on rice leafhopper during kharif 1998

Treatment	Pre-treat. count	Percentage of folded leaves/5 hills							Grain yield/plot (kg)
		I st spraying			II nd spraying			III rd spraying	
		10 DAS 2	20 DAS 3	10 DAS 4	20 DAS 5	10 DAS 6	7		
T ₁ Carbofuran 0.50 kg a.i./ha	0.57 (3.52)	0.96 (5.51)	2.38 (8.72)	3.23 (10.19)	6.24 (14.33)	7.33 (15.64)	2.40		
T ₂ Carbofuran 0.75 kg a.i./ha	0.65 (4.52)	0.88 (5.12)	1.94 (7.89)	2.48 (9.01)	5.76 (13.82)	6.22 (14.38)	2.45		
T ₃ Carbofuran 0.75 kg a.i./ha + Dipel 8 L	0.72 (4.65)	1.00 (5.70)	2.10 (8.30)	2.27 (8.65)	6.83 (15.08)	7.94 (16.36)	2.36		
T ₄ Phorate 0.50 kg a.i./ha	0.23 (1.58)	1.26 (6.45)	3.14 (10.14)	3.85 (11.28)	7.45 (15.81)	8.27 (16.71)	2.30		
T ₅ Phorate 0.75 a.i./ha	0.61 (4.05)	1.19 (6.24)	2.59 (9.22)	2.94 (9.81)	6.11 (14.28)	6.89 (15.19)	2.42		
T ₆ Phorate 0.75 kg a.i./ha+Dipel 8L	0.94 (4.40)	1.14 (5.93)	2.46 (8.94)	3.02 (9.99)	6.97 (15.24)	8.56 (16.98)	2.33		
T ₇ Quinalphos 0.05% (3 sprays)	0.46 (3.11)	0.91 (5.42)	1.93 (7.87)	2.12 (8.29)	4.02 (11.44)	4.93 (12.72)	2.56		
T ₈ Quinalphos 0.05% (2 sprays)	0.25 (1.66)	2.34 (8.76)	4.97 (12.75)	4.92 (12.70)	5.72 (13.73)	6.88 (15.15)	2.50		
T ₉ Fenvalerate 0.007% (3 sprays)	0.55 (4.15)	0.76 (4.85)	1.67 (7.34)	1.99 (7.96)	3.58 (10.86)	4.20 (11.77)	2.62		
T ₁₀ Fenvalerate 0.007% (2 sprays)	0.72 (3.84)	2.58 (9.07)	5.22 (13.17)	4.83 (12.66)	4.99 (12.88)	5.33 (13.28)	2.52		
T ₁₁ Dipel 8 L 0.024% (3 sprays)	0.18 (1.40)	1.78 (7.45)	2.74 (9.46)	3.86 (11.31)	8.10 (16.49)	9.75 (18.15)	2.06		
T ₁₂ Diflubenzuron 25% WP 0.025% (3 sprays)	0.00 (0.00)	1.52 (6.90)	2.51 (8.97)	3.24 (10.29)	7.36 (15.62)	8.46 (16.83)	2.18		

Table contd.....

Treatment	Pre-treat. count	Percentage of folded leaves/5 hills									Grain yield/ plot (kg)
		I st spraying			II nd spraying			III rd spraying			
		10 DAS 2	20 DAS 3	10 DAS 4	20 DAS 5	10 DAS 6	20 DAS 7	10 DAS 8	20 DAS 9	10 DAS 10	
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	0.23 (1.59)	1.84 (7.75)	3.19 (10.27)	3.52 (10.79)	9.79 (18.21)	9.27 (17.67)	2.10				
T ₁₄ Neem-A 5% (3 sprays)	0.34 (1.93)	1.94 (7.91)	4.10 (11.55)	5.06 (12.92)	9.45 (17.89)	10.14 (18.55)	1.98				
T ₁₅ Neem-B 5% (Refined, 3 sprays)	1.07 (4.84)	2.41 (8.87)	4.32 (11.97)	5.62 (13.64)	10.12 (18.53)	10.55 (18.94)	1.96				
T ₁₆ Chinaberry 5% (3 sprays)	1.08 (5.78)	2.33 (8.76)	4.68 (12.47)	5.90 (13.96)	10.88 (19.19)	12.38 (20.59)	1.78				
T ₁₇ Aak 5% (3 sprays)	0.90 (3.15)	2.24 (8.57)	4.43 (12.12)	5.73 (13.83)	10.57 (18.93)	11.25 (19.58)	1.84				
T ₁₈ Solvent + emulsifier	0.88 (4.39)	2.48 (9.02)	5.27 (13.24)	6.88 (15.16)	13.98 (21.93)	14.16 (22.08)	1.58				
T ₁₉ Control (untreated)	0.54 (3.17)	2.88 (9.77)	5.62 (13.67)	8.25 (16.63)	15.23 (22.92)	16.65 (24.03)	1.52				
F Test	Non Sig	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**
SEM±	-	(0.80)	(0.76)	(0.73)	(0.98)	(0.86)	(0.14)				
CD (0.05)	-	(2.29)	(2.16)	(2.09)	(2.82)	(2.46)	(0.42)				
CD (0.01)	-	(3.08)	(2.91)	(2.81)	(3.79)	(3.31)	(0.56)				

Note :

- (i) = DAS-Days after spraying
- (ii) = Values in parenthesis are arc sin transformed
- (iii) = **Significant at 1% level
- (iv) = Transplanting date 27.7.1998
- (v) = Pre-treatment count was taken one day before spraying

- (vi) = Ist spraying -20 DAT
- (vii) = IInd spraying -40 DAT
- (viii) = IIIrd spraying -60 DAT
- (ix) = Dose of the treatments are mentioned in Table 2, Page 51

4.1.1.2 Second spray

The influence of insecticides and biopesticides on the damage by leaffolder after second round of insecticidal application is presented below.

The data recorded ten days after second spraying showed that, there was no significant increase in leaffolder infestation in all treatments, except for solvent + emulsifier (T₁₈) and untreated control (T₁₉) which had 6.88 and 8.25 per cent folded leaves, respectively. All the insecticidal treatments were significantly superior over untreated control (T₁₉). Fenvalerate 3 sprays (T₉) was the best treatment among the insecticidal treatments and recorded lowest damage of 1.99 per cent infested leaves and significantly differed with carbofuran 0.5 kg (T₁) and phorate 0.5 kg (T₄) which had recorded 3.23 and 3.85 per cent leaffolder infestation, respectively. After fenvalerate 3 sprays (T₉), next best treatment was quinalphos 3 sprays (T₇) which recorded 2.12 per cent folded leaves followed by carbofuran 0.75 kg + Dipel (T₃), carbofuran 0.75 kg (T₂), phorate 0.75 kg (T₅) and phorate 0.75 kg + Dipel (T₆) which recorded 2.27 to 3.02 per cent leaffolder infestation and were on par with each other. In treatments of quinalphos 2 sprays (T₈) and fenvalerate 2 sprays (T₁₀) where spray was applied only at the beginning of 40 days after transplanting (DAT), ten days after second spray no increased infestation of leaffolder was observed in these treatments. Diflubenzuron (T₁₂) followed by Dipel (T₁₁) were inferior than fenvalerate 3 sprays (T₉) but better than botanicals and untreated control (T₁₉). Among the botanicals Neem-A (T₁₄) was the best followed by Neem-B (Refined, T₁₅), Aak (T₁₇) and chinaberry (T₁₆) with all of them differing significantly from untreated control (T₁₉).

Twenty days after second spray, leaffolder infestation ranged from 3.58 to 15.23 per cent with all insecticidal treatments being significantly superior over untreated control (15.23% folded leaves). Fenvalerate 3 sprays (T_9) maintained its supremacy in reducing leaffolder infestation by recording only 3.58 per cent infested leaves and was on par with quinalphos 3 sprays (T_7) and fenvalerate 2 sprays (T_{10}) which had 4.02 and 4.99 per cent folded leaves, respectively. All other insecticidal and biopesticidal treatments had leaffolder infestation varying from 5.72 to 10.88 per cent as shown in Table 5.

4.1.1.3 Third spray

A perusal of data on the per cent leaffolder infestation ten days after third spray revealed that all the treatments were significantly superior to untreated control (T_{19}) which had maximum infestation of 16.65 per cent folded leaves. Fenvalerate 3 sprays (T_9) still continued to be the most effective treatment with only 4.20 per cent infestation. The next best treatment was quinalphos 3 sprays (T_7) which had recorded 4.93 per cent leaffolder infestation followed by fenvalerate 2 sprays (T_{10}) with no significant difference among them. All the alternation treatments of insecticides viz., carbofuran 0.75 kg + Dipel (T_3), phorate 0.75 kg Dipel (T_6) and Dipel + diflubenzuron (T_{13}) had infestation ranging from 7.94 to 9.27 per cent and were on par with each other. These all are on par with granular application of insecticides viz., carbofuran 0.50 kg (T_1), phorate 0.50 kg (T_4) and phorate 0.75 kg (T_5) except with treatment carbofuran 0.75 kg (T_2). Among botanical Neem-A (T_{14}) was best (10.14 per cent infestation) followed by Neem-B (Refined, T_{15}), Aak (T_{17}) and chinaberry (T_{16}). Botanicals were superior than untreated control (T_{19}).

The overall picture regarding the effect of different insecticides and biopesticides on leaffolder during *kharif* 1998 revealed that fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇) were the most effective treatments throughout the spray period. Diflubenzuron (T₁₂) was more effective than Dipel (T₁₁). In alternation treatments, application of carbofuran 0.75 kg+Dipel (T₃) was most effective. Among botanicals Neem-A 5 per cent (T₁₄) was the most effective and all synthetic insecticides contained leaffolder damage more effectively than Dipel and botanicals.

4.1.1.4 Effect of insecticides on grain yield during *kharif* 1998

The yield data revealed that, all treatments except Aak (T₁₇), chinaberry (T₁₆) and solvent + emulsifier (T₁₈) yielded significantly more than untreated control (T₁₉). It is evident from Table 5 that fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇), the two best treatments yielded more (2.62 and 2.56 kg/plot, respectively). Other insecticidal treatments which were statistically on par with these two treatments were fenvalerate 2 sprays (T₁₀), quinalphos 2 sprays (T₈), carbofuran 0.75 kg (T₂), phorate 0.75 kg (T₅), carbofuran 0.50 kg (T₁), carbofuran 0.75 kg+Dipel (T₃), phorate 0.75 kg + Dipel (T₆) and phorate 0.50 kg (T₄) with yields ranging from 2.52 to 2.30 kg/plot. Among botanicals Neem-A (T₁₄) gave the highest yield (1.98 kg/plot) while chinaberry (T₁₆) yielded lowest (1.78 kg/plot). The yields of chinaberry (T₁₆), Aak (T₁₇) and solvent + emulsifier (T₁₈) were 1.84, 1.78 and 1.58 kg/plot, respectively and were on par with untreated control (T₁₉) which recorded the lowest yield of 1.52 kg/plot.

4.1.2 Influence of various insecticides and biopesticides on rice leaffolder during *kharif* 1999

One day before (*i.e.*, pre-treatment count) first spraying, observations on leaffolder infestation ranged from 0.06 to 0.86 per cent with no significant differences among the treatments.

4.1.2.1 First spray

The data obtained ten days after first spraying showed that all the synthetic insecticidal treatments were significantly superior to untreated control (T_{19}). The leaffolder infestation ranged from 0.72 to 2.48 per cent. Minimum infestation was recorded in quinalphos 3 sprays (T_7) with 0.72 per cent. It was on par with fenvalerate 3 sprays (T_9), carbofuran 0.75 kg + Dipel (T_3), carbofuran 0.75 kg (T_2), phorate 0.75 kg (T_5) and phorate 0.50 kg (T_4) had recorded 0.96, 1.03, 1.14, 1.23 and 1.23 per cent folded leaves, respectively. The best treatments quinalphos (T_7) significantly differed with phorate 0.75 kg + Dipel (T_6) and carbofuran 0.50 kg (T_1) which had recorded 1.34 and 1.54 per cent leaffolder infestation. All the bio-pesticidal treatments including Dipel and botanicals were on par with each other but inferior to quinalphos (T_7). Diflubenzuron (T_{12}) recording 1.46 per cent folded leaves was inferior to quinalphos (T_7) but better than biopesticides *viz.*, Dipel (T_{11}), Neem-A (T_{14}), Aak (T_{17}), Neem-B (Refined, T_{15}) and chinaberry (T_{18}).

Twenty days after first spray, leaffolder infestation varied from 1.54 to 7.28 per cent. Fenvalerate 3 sprays (T_9) had minimum infestation of 1.54 per cent and was on par with quinalphos 3 sprays (T_7). The next best treatment was carbofuran 0.75 kg (T_2) which recorded 3.15

per cent folded leaves followed by treatments of carbofuran 0.75 kg + Dipel (T₃), phorate 0.75 kg (T₅) and phorate 0.75 kg + Dipel (T₆) which had recorded 3.64, 3.76 and 4.03 per cent folded leaves, respectively and were found to be on par with each other. Diflubenzuron (T₁₂) had 5.16 per cent folded leaves and was on par with phorate 0.50 kg (T₄), carbofuran 0.50 kg (T₁) and phorate 0.75 kg + Dipel (T₆) which had recorded 4.87, 4.32 and 4.03 per cent folded leaves, respectively. Neem-A (T₁₄) is best among botanical followed by Neem-B (Refined, T₁₅), Aak (T₁₇) and chinaberry (T₁₆) which had ranging from 5.97 to 6.54 per cent leaffolder damage. Highest infestation of 7.28 per cent folded leaves was recorded in untreated control (T₁₉) followed by quinalphos 2 sprays (T₈), fenvalerate 2 sprays (T₁₀) (where first spray was not applied) and solvent + emulsifier which had infestation ranging from 7.06 to 6.92 per cent folded leaves and were on par with each other.

4.1.2.2 Second spray

Observations taken ten days after second spray, showed that all insecticides and biopesticides were found to be significantly superior to untreated control (T₁₉), which had highest per cent of folded leaves. Fenvalerate 3 sprays (T₈), quinalphos 3 sprays (T₇), carbofuran 0.75 kg (T₂) and carbofuran 0.75 kg + Dipel (T₃) were the most effective by recording 3.07, 3.50, 3.96 and 4.20 per cent folded leaves, respectively. The treatments fenvalerate 2 sprays (T₁₀) and quinalphos 2 sprays (T₈) where the second dose was applied, the infestation did not show much increase and these treatments had shown 4.82 and 5.13 per cent damaged leaves and were on par with carbofuran 0.5

kg (T₁), phorate 0.75 kg + Dipel (T₆), diflubenzuron (T₁₂) and phorate 0.75 kg (T₅) which recorded 5.73, 5.86, 5.89 and 5.97 per cent folded leaves, respectively. Among the botanicals Neem-A (T₁₄) was most effective followed by Neem-B (Refined, T₁₅), Aak (T₁₇) and chinaberry (T₁₆). Infestation in these treatments ranged from 11.34 to 13.74 per cent. Highest infestation of 16.92 per cent folded leaves was recorded in untreated control (T₁₉) followed by solvent + emulsifier (T₁₈) which had 16.85 per cent infestation and were statistically on par with each other.

The data recorded, twenty days after second spray, indicated that there was no change in trend in order of efficacy of the treatments. A steady increase of damage was noticed in the untreated control (T₁₉). All the treatments were significantly superior over untreated control (T₁₉). The most effective treatments were fenvalerate 3 sprays (T₉), quinalphos 3 sprays (T₇), carbofuran 0.75 kg + Dipel (T₃) and carbofuran 0.75 kg (T₂) which recorded 3.48, 4.28, 4.97 and 5.14 per cent folded leaves, respectively and were on par with each other. Diflubenzuron (T₁₂) was on par with phorate 0.50 kg (T₄), phorate 0.75 kg (T₅), phorate 0.75 kg Dipel (T₈), quinalphos 2 sprays (T₈) and fenvalerate 2 sprays (T₁₀), Dipel (T₁₁) and Dipel + diflubenzuron (T₁₃) were inferior to insecticidal sprays but at par with neem (T₁₄). Among botanicals Neem-A (T₁₄) was best treatment and was found to be on par with other botanicals *viz.*, Aak (T₁₇), Neem-B (Refined, T₁₅) and chinaberry (T₁₆). High infestation of 23.83 per cent folded leaves was observed in untreated control (T₁₉) followed by solvent + emulsifier (T₁₈) with 21.74 per cent and these were on par with each other. Efficacy of the treatments have been shown in the Table 6.

Table 6. Effect of different insecticides and biopesticides on rice leafhopper during *kharif* 1999

Treatment	Pre-treat. count	Percentage of folded leaves/5 hills										Grain yield/ plot (kg)
		I st spraying			II nd spraying			III rd spraying				
		10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS		
T ₁ Carbofuran 0.50 kg a.i./ha	0.63 (4.48)	1.54 (7.11)	4.32 (11.93)	5.73 (13.79)	7.49 (15.86)	8.29 (16.71)	8.66 (17.05)	2.47				
T ₂ Carbofuran 0.75 kg a.i./ha	0.48 (3.89)	1.14 (6.07)	3.15 (10.18)	3.96 (11.47)	5.14 (13.05)	5.00 (12.81)	7.10 (15.43)	2.62				
T ₃ Carbofuran 0.75 kg a.i./ha + Dipel 8 L	0.35 (3.28)	1.03 (5.79)	3.64 (10.96)	4.20 (11.71)	4.97 (12.86)	8.76 (17.17)	10.14 (18.48)	2.56				
T ₄ Phorate 0.50 kg a.i./ha	0.23 (1.59)	1.23 (6.35)	4.87 (12.73)	7.49 (15.87)	9.37 (17.78)	11.68 (19.89)	11.38 (19.70)	2.43				
T ₅ Phorate 0.75 a.i./ha	0.86 (5.30)	1.23 (6.35)	3.76 (11.10)	5.97 (14.13)	8.93 (17.36)	9.84 (18.25)	10.77 (19.14)	2.57				
T ₆ Phorate 0.75 kg a.i./ha+Dipel 8 L	0.44 (3.01)	1.34 (6.57)	4.03 (11.55)	5.86 (13.99)	8.56 (17.00)	11.75 (20.03)	12.35 (20.57)	2.45				
T ₇ Quinalphos 0.05% (3 sprays)	0.63 (4.54)	0.72 (4.74)	1.95 (8.05)	3.50 (10.71)	4.28 (11.83)	5.98 (14.14)	7.00 (15.34)	2.69				
T ₈ Quinalphos 0.05% (2 sprays)	0.54 (4.09)	2.01 (8.07)	7.06 (15.44)	5.13 (13.01)	8.56 (16.90)	8.42 (16.79)	8.66 (17.04)	2.58				
T ₉ Fenvalerate 0.007% (3 sprays)	0.32 (3.21)	0.96 (5.54)	1.54 (7.05)	3.07 (10.05)	3.48 (10.68)	5.13 (13.09)	6.32 (14.56)	2.76				
T ₁₀ Fenvalerate 0.007% (2 sprays)	0.16 (1.90)	2.06 (8.19)	6.95 (15.24)	4.82 (12.66)	7.65 (15.99)	7.97 (16.35)	7.94 (16.31)	2.64				
T ₁₁ Dipel 8 L 0.024% (3 sprays)	0.36 (3.40)	1.82 (7.72)	5.73 (13.73)	8.25 (16.67)	13.23 (21.24)	13.49 (21.46)	14.36 (22.21)	2.25				
T ₁₂ Diflubenzuron 25% WP 0.025% (3 sprays)	0.06 (1.20)	1.46 (6.92)	5.16 (13.08)	5.89 (14.00)	10.07 (18.44)	11.82 (20.05)	11.41 (19.71)	2.34				

Table contd.....

Treatment	Pre-treat. count	Percentage of folded leaves/5 hills										Grain yield/ plot (kg)
		I st spraying			II nd spraying			III rd spraying			8	
		10 DAS	20 DAS	3	10 DAS	20 DAS	5	10 DAS	20 DAS	7		
1	2	3	4	5	6	7	8					
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	0.61 (3.66)	1.66 (7.40)	5.48 (13.55)	7.69 (16.09)	14.03 (21.97)	13.77 (21.77)	14.86 (22.67)	2.24				
T ₁₄ Neem-A 5% (3 sprays)	0.47 (3.89)	1.83 (7.76)	5.97 (14.13)	11.34 (19.65)	15.34 (23.06)	18.04 (25.12)	17.57 (24.78)	2.20				
T ₁₅ Neem-B 5% (Refined, 3 sprays)	0.55 (4.21)	1.97 (8.02)	6.13 (14.36)	12.68 (20.81)	17.82 (24.94)	19.23 (25.99)	19.64 (26.28)	2.16				
T ₁₆ Chinaberry 5% (3 sprays)	0.28 (3.00)	2.00 (8.07)	6.54 (14.79)	13.74 (21.75)	18.25 (25.27)	19.56 (26.22)	19.82 (26.43)	1.93				
T ₁₇ Aak 5% (3 sprays)	0.54 (4.20)	1.86 (7.81)	6.37 (14.60)	12.83 (20.97)	17.70 (24.87)	18.60 (25.54)	18.97 (25.81)	2.00				
T ₁₈ Solvent + emulsifier	0.45 (3.13)	2.10 (8.19)	6.92 (15.26)	16.85 (24.22)	21.74 (27.75)	23.14 (28.72)	26.04 (30.67)	1.83				
T ₁₉ Control (untreated)	0.23 (2.64)	2.48 (9.01)	7.28 (15.62)	16.92 (24.29)	23.83 (29.21)	27.33 (31.48)	28.75 (32.39)	1.65				
F Test	Non Sig	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**				
SEm±	-	{0.63}	{0.66}	{0.66}	{0.90}	{0.90}	{0.72}	{0.16}				
CD (0.05)	-	{1.82}	{1.91}	{1.91}	{2.57}	{2.58}	{2.05}	{0.46}				
CD (0.01)	-	{2.44}	{2.56}	{2.56}	{3.45}	{3.46}	{2.76}	{0.61}				

Note :

- (i) = DAS-Days after spraying
(ii) = Values in parenthesis are arc sin transformed
(iii) = **Significant at 1% level
(iv) = Transplanting date 9.7.1999
(v) = Pre-treatment count was taken one day before spraying

- (vi) = Ist spraying -20 DAT
(vii) = IInd spraying -40 DAT
(viii) = IIIrd spraying - 60 DAT
(ix) = Dose of the treatments are mentioned in Table 2, Page 51

4.1.2.3 Third spray

The data on efficacy of the insecticides and biopesticides after third round of spraying, taken 60 days after transplanting, are presented here under (Table 6).

The damage recorded ten days after third spraying indicated that all the insecticidal treatments were significantly superior over untreated control (T₁₉). A persual of data, revealed that carbofuran 0.75 kg (T₂) was the most effective treatment with only 5.0 per cent folded leaves. It was followed by fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇) which had 5.13 and 5.98 per cent leaffolder damage, respectively and were statistically on par with carbofuran 0.75 (T₂). Fenvalerate 2 sprays (T₁₀), carbofuran 0.50 kg (T₁), quinalphos 2 sprays (T₈) and phorate 0.75 kg (T₅) recorded 7.97, 8.29, 8.42 and 9.84 per cent folded leaves were found to be next best treatments and were on par with each other. In alternation treatments, carbofuran 0.75 kg + Dipel (T₃), phorate + Dipel (T₆) and Dipel + diflubenzuron (T₁₃) had 8.76, 11.75 and 13.77 per cent folded leaves, respectively. Furthermore carbofuran 0.75 kg + Dipel (T₃) significantly differed from phorate 0.75 kg + Dipel (T₆) and Dipel + diflubenzuron (T₁₃). All botanical treatments viz., Neem-A (T₁₄), Aak (T₁₇), Neem-B (Refined, T₁₅) and chinaberry (T₁₆) had leaffolder infestation ranging from 18.04 to 19.56 per cent and were statistically on par with each other. However, these were inferior to insecticidal, Dipel and diflubenzuron treatments.

Twenty days after third spray, all the insecticidal and biopesticidal treatments were found to be superior to untreated control (T₁₉). Highest infestation of 28.75 per cent leaffolder infestation was recorded in

untreated control (T₁₉) followed by solvent + emulsifier (T₁₈) which had 26.04 per cent folded leaves and were on par with each other. Fenvalerate 3 sprays (T₉) was the most effective treatment with 6.32 per cent folded leaves followed by quinalphos 3 sprays (T₇), carbofuran 0.75 kg (T₂) and fenvalerate 2 sprays (T₁₀) which had recorded 7.00, 7.10 and 7.93 per cent folded leaves, respectively and were statistically on par. Carbofuran 0.50 kg (T₁) and carbofuran 0.75 kg (T₂) were better than phorate 0.50 kg (T₄) and phorate 0.75 kg (T₅). Alternation treatments of carbofuran 0.75 + Dipel (T₃) was better than phorate 0.75 kg + Dipel (T₆). Diflubenzuron (T₁₂, 3 sprays) was at par with carbofuran 0.75 + Dipel (T₃). Dipel (T₁₁, 3 sprays) was on par with Dipel + diflubenzuron (T₁₃). Similar efficacy of alternation treatments continued even 20 days after third spray. These alternation treatments were significantly superior over botanical treatments. Among the botanicals Neem-A (T₁₄) was the best treatment and was on par with other botanical treatments (Table 6).

The overall effect of different insecticides on leaffolder during *kharif* 1999, showed that fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇) were the most effective treatments throughout the spray period. The next best treatments were carbofuran 0.75 kg (T₂), fenvalerate 2 sprays (T₁₀) and quinalphos 2 sprays (T₈). Among alternation treatments, carbofuran 0.75 kg + Dipel (T₃) was the most effective followed by phorate 0.75 kg + Dipel (T₆) and Dipel + diflubenzuron (T₁₃). Among four botanicals used, Neem-A (T₁₄) proved to be the most effective. All synthetic insecticides were better than biopesticides in minimising leaffolder damage. Diflubenzuron was better than Dipel and four botanicals used during the study period.

4.1.2.4 Effect of insecticides on grain yield during *kharif* 1999

The yield data revealed that, all treatments except chinaberry (T₁₆), Aak (T₁₇) and solvent + emulsifier (T₁₈) recorded significantly more yield than untreated control (T₁₉) (Table 6). It is evident from Table 6 that fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇) the best two treatments yielded more (2.76 and 2.69 kg/plot, respectively). Other insecticidal treatments which were statistically on par with these two treatments were fenvalerate 2 sprays (T₁₀), carbofuran 0.75 kg (T₂), quinalphos 2 sprays (T₈), phorate 0.75 kg (T₅), carbofuran 0.75 kg + Dipel (T₃), carbofuran 0.5 kg (T₁), phorate 0.75 kg + Dipel (T₆), phorate 0.50 kg (T₄) and diflubenzuron (T₁₂) had yield ranging from 2.64 to 2.34 kg/plot. Among botanicals only Neem-A (T₁₄) and Neem-B (Refined, T₁₅) gave the highest yield (2.20 and 2.16 kg/plot) while Aak (T₁₇), chinaberry (T₁₆) and solvent + emulsifier (T₁₈) recorded yields ranging from 2.00 to 1.83 kg/plot and were on par with untreated control (T₁₉) which recorded lowest yield of 1.65 kg/plot.

4.2 Effect of different insecticides on predator complex of rice leaffolder, *C. medinalis*

Natural enemies for a long time before the advent of synthetics played a prominent role in regulating pest population. Now a days it has been recognized that pesticides usage besides causing environmental pollution, also effects natural fauna mainly parasites and predators in any ecosystem. Hence, it is very much important to investigate the effect of various insecticides on these natural enemies so as to screen relatively safer insecticides. Keeping this inview the present investigations regarding effect of different insecticides on

predators of rice leaffolder, *C. medinalis*, viz., coccinellids, rove beetles ground beetles and spiders was undertaken. Coccinellids observed during the present study comprised of *Coccinella septempunctata*, *Cheilomenes sexmaculata* (F.), *Brumus suturalis* and some other species (Plate 6-7). Spider fauna included wolf spider, *Lycosa pseudoannulata*, long jawed spider, *Tetragnatha* sp., orb spider, *Neoscona* sp. and some other species (Plate 10-15) while rove beetles comprised of *Paederus* sp. (Plate 9) and ground beetles included, *Casnoidea* sp. and *Ophinea* sp. (Plate 8). Population counts of these predators (both immature and mature stages) was taken simultaneously along with leaffolder damage.

4.2.1 Effect of different insecticides and biopesticides on coccinellids during kharif 1998

Observations were recorded to find out the adverse effect of insecticides and biopesticides on coccinellids at 10 and 20 days interval after treatment were imposed.

4.2.1.1 First spray

Ten days after first spray, the population of coccinellids ranged from 0.00 to 1.67/5 hills. Maximum population of coccinellids was observed in untreated control (T_{19}) and quinalphos 2 sprays (T_8) (where first spray was not applied) and minimum population was recorded in quinalphos 3 sprays (T_7), fenvalerate 3 sprays (T_9) and carbofuran (T_2). Treatments of carbofuran + Dipel (T_3) and phorate (T_5), both recorded 0.67 coccinellids/5 hills. These treatments were statistically on par with treatments recording lowest coccinellid population viz., quinalphos 3 sprays (T_7), fenvalerate 3 sprays (T_9) and carbofuran 0.75 kg a.i./ha

Plate 6. Predator, *Coccinella septempunctata* on rice

Plate 7. Predator, *Cheilomenes sexmaculata* (F.) on rice



(T₂). Population of coccinellids in treatments viz., Neem-A (T₁₄), phorate + Dipel (T₆), Aak (T₁₇), diflubenzuron (T₁₂), phorate (T₄), Dipel + diflubenzuron (T₁₃), chinaberry (T₁₆), carbofuran (T₃), Neem-B (Refined, T₁₅) solvent + emulsifier (T₁₈), Dipel (T₁₁) and fenvalerate 2 sprays (T₁₀) ranged from 1.00 to 1.33/5 hills and these treatments were on par with untreated control (Table 7).

Twenty days after first spray, coccinellids population varied from 0.33 to 2.67/5 hills, with highest population being observed in fenvalerate 2 sprays (T₁₀) (where the first spray was not given), untreated control (T₁₉) and solvent + emulsifier (T₁₈) (2.67 coccinellids/5 hills each) and lowest in quinalphos 3 sprays (T₇) and fenvalerate 3 sprays (T₉) (0.33 coccinellids/5 hills each). Treatment of carbofuran (T₂) (1.00 coccinellid/5 hills) was on par with treatments recording lowest coccinellids population viz., T₇ and T₉. Aak (T₁₇) had 2.33 beetles/5 hills and was followed by treatments of quinalphos 2 sprays (T₈), Dipel (T₁₁), Neem-B (Refined, T₁₅), Chinaberry (T₁₆), Dipel + diflubenzuron (T₁₃), carbofuran (T₁), Neem-A (T₁₄), phorate (T₄), phorate (T₅) and diflubenzuron (T₁₂), which recorded coccinellid population ranging from 2.33 to 1.33/5 hills in decreasing order and these were on par with untreated control (T₁₉), T₁₈ and T₁₀.

4.2.1.2 Second spray

Ten days after second spray, the population of coccinellids ranged from 0.33 to 3.67/5 hills. Maximum population of 3.67/5 hills was recorded in untreated control (T₁₉) and minimum of 0.33/5 hills in quinalphos (T₇). In treatments of quinalphos (T₈) and fenvalerate 2 sprays (T₁₀) (where the second spray was applied) the population of

Table 7. Effect of different insecticides and biopesticides on coccinellids during kharif 1998

Treatment	Coccinellid population/5 hills								
	I st spraying			II nd spraying			III rd spraying		
	10 DAS	20 DAS	10 DAS	20 DAS	10 DAS	20 DAS	10 DAS	20 DAS	10 DAS
T ₁ Carbofuran 3G	1.33 (1.34)	2.00 (1.56)	2.67 (1.76)	4.00 (2.11)	2.67 (1.76)	4.00 (2.11)	2.67 (1.76)	4.00 (2.11)	2.00 (1.56)
T ₂ Carbofuran 3G	0.00 (0.71)	1.00 (1.22)	2.33 (1.68)	3.00 (1.86)	2.33 (1.68)	3.00 (1.86)	2.33 (1.68)	3.00 (1.86)	1.33 (1.27)
T ₃ Carbofuran 3G + Dipel 8 L	0.67 (1.05)	1.33 (1.34)	2.33 (1.68)	3.67 (2.01)	2.33 (1.68)	3.67 (2.01)	2.33 (1.68)	3.67 (2.01)	2.67 (1.77)
T ₄ Phorate 10G	1.00 (1.22)	1.67 (1.46)	3.00 (1.86)	4.33 (2.19)	3.00 (1.86)	4.33 (2.19)	3.00 (1.86)	4.33 (2.19)	2.33 (1.68)
T ₅ Phorate 10G	0.67 (1.05)	1.67 (1.46)	2.67 (1.76)	3.67 (2.03)	2.67 (1.76)	3.67 (2.03)	2.67 (1.76)	3.67 (2.03)	2.00 (1.56)
T ₆ Phorate 10G + Dipel 8 L	1.00 (1.22)	1.33 (1.34)	2.33 (1.68)	4.00 (2.11)	2.33 (1.68)	4.00 (2.11)	2.33 (1.68)	4.00 (2.11)	2.67 (1.77)
T ₇ Quinalphos 25 EC (3 sprays)	0.00 (0.71)	0.33 (0.88)	0.33 (0.88)	1.33 (1.34)	0.33 (0.88)	1.33 (1.34)	0.33 (0.88)	1.33 (1.34)	1.00 (1.22)
T ₈ Quinalphos 25 EC (2 sprays)	1.67 (1.46)	2.33 (1.68)	0.67 (1.05)	1.33 (1.34)	0.67 (1.05)	1.33 (1.34)	0.67 (1.05)	1.33 (1.34)	1.67 (1.46)
T ₉ Fenvalerate 20 EC (3 sprays)	0.00 (0.71)	0.33 (0.88)	0.67 (1.05)	1.00 (1.22)	0.67 (1.05)	1.00 (1.22)	0.67 (1.05)	1.00 (1.22)	1.00 (1.22)
T ₁₀ Fenvalerate 20 EC (2 sprays)	1.33 (1.34)	2.67 (1.77)	1.00 (1.22)	1.67 (1.46)	1.00 (1.22)	1.67 (1.46)	1.00 (1.22)	1.67 (1.46)	1.33 (1.34)
T ₁₁ Dipel 8 L (3 sprays)	1.33 (1.34)	2.33 (1.68)	3.00 (1.86)	4.67 (2.26)	3.00 (1.86)	4.67 (2.26)	3.00 (1.86)	4.67 (2.26)	2.33 (1.64)
T ₁₂ Diflubenzuron 25% WP (3 sprays)	1.00 (1.22)	1.67 (1.44)	2.33 (1.68)	4.00 (2.11)	2.33 (1.68)	4.00 (2.11)	2.33 (1.68)	4.00 (2.11)	2.00 (1.56)

Table contd.....

Treatment	Coccinellid population/5 hills									
	I st spraying			II nd spraying			III rd spraying			Non-Sig
	10 DAS 1	20 DAS 2	10 DAS 3	10 DAS 3	20 DAS 4	10 DAS 5	20 DAS 4	10 DAS 5	20 DAS 4	
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	1.00 (1.22)	2.00 (1.58)	2.67 (1.77)	2.67 (1.77)	4.33 (2.18)	2.67 (1.77)	4.33 (2.18)	2.67 (1.77)	4.33 (2.18)	2.67 (1.77)
T ₁₄ Neem-A (3 sprays)	1.00 (1.17)	2.00 (1.56)	3.00 (1.86)	3.00 (1.86)	5.00 (2.32)	3.00 (1.86)	5.00 (2.32)	3.00 (1.86)	5.00 (2.32)	2.67 (1.71)
T ₁₅ Neem-B (Refined, 3 sprays)	1.33 (1.34)	2.33 (1.68)	3.33 (1.93)	3.33 (1.93)	5.33 (2.37)	3.33 (1.93)	5.33 (2.37)	3.33 (1.93)	5.33 (2.37)	2.00 (1.56)
T ₁₆ Chinaberry (3 sprays)	1.33 (1.29)	2.00 (1.58)	3.33 (1.95)	3.33 (1.95)	5.67 (2.47)	3.33 (1.95)	5.67 (2.47)	3.33 (1.95)	5.67 (2.47)	2.67 (1.76)
T ₁₇ Aak (3 sprays)	1.00 (1.22)	2.33 (1.68)	3.00 (1.86)	3.00 (1.86)	5.67 (2.47)	3.00 (1.86)	5.67 (2.47)	3.00 (1.86)	5.67 (2.47)	2.33 (1.64)
T ₁₈ Solvent + emulsifier (3 sprays)	1.33 (1.34)	2.67 (1.76)	3.33 (1.95)	3.33 (1.95)	6.33 (2.60)	3.33 (1.95)	6.33 (2.60)	3.33 (1.95)	6.33 (2.60)	3.00 (1.86)
T ₁₉ Control (untreated)	1.67 (1.46)	2.67 (1.76)	3.67 (2.04)	3.67 (2.04)	6.00 (2.53)	3.67 (2.04)	6.00 (2.53)	3.67 (2.04)	6.00 (2.53)	3.33 (1.93)
F Test	Sig*	Sig*	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Non-Sig
SEm±	(0.12)	(0.13)	(0.13)	(0.13)	(0.16)	(0.13)	(0.16)	(0.13)	(0.16)	-
CD (0.05)	(0.39)	(0.42)	(0.43)	(0.43)	(0.52)	(0.43)	(0.52)	(0.43)	(0.52)	-
CD (0.01)	(NS)	(NS)	(0.62)	(0.62)	(0.73)	(0.62)	(0.73)	(0.62)	(0.73)	-

Note :

- (i) = DAS-Days after spraying
- (ii) = Values in parenthesis are square root transformed
- (iii) = **Significant at 1% level
- (iv) = *Significant at 5% level
- (v) = Transplanting date 27.7.1998
- (vi) = Ist spraying -20 DAT
- (vii) = IInd spraying -40 DAT
- (viii) = IIIrd spraying - 60 DAT
- (ix) = Dose of the treatments are mentioned in Table 2, Page 51

coccinellids decreased (0.67 and 1.00/5 hills, respectively). These treatments were on par with lowest population treatment (T₇). Population of coccinellids in treatments viz., Chinaberry (T₁₆), solvent + emulsifier (T₁₈), Neem-B (Refined T₁₅), phorate (T₄), Dipel (T₁₁), Neem-A (T₁₄), Aak (T₁₇), Dipel + diflubenzuron (T₁₃), carbofuran (T₁), phorae (T₅), carbofuran + Dipel (T₃), carbofuran (T₂), diflubenzuron (T₁₂) and phorate + Dipel (T₆) ranged from 2.33/5 to 3.33 hills in declining order and these treatments were on par with untreated control (T₁₉), thus proving safe to this natural enemy.

Twenty days after second spray, the population of coccinellids ranged from 1.00 to 6.33 beetles/5 hills with highest population in solvent + emulsifier (T₁₈) and lowest population in fenvalerate 3 sprays (T₉). Other insecticidal treatments which recorded low coccinellids population in comparison with control included quinalphos 2 sprays (T₈), quinalphos 3 sprays (T₇) and fenvalerate 2 sprays (T₁₀) which had coccinellids in range of 1.33 to 1.67/5hills and were on par with fenvalerate 3 sprays (T₉). Treatments of Aak (T₁₇), Chinaberry (T₁₆), Neem-B (Refined, T₁₅), Neem-A (T₁₄), Dipel (T₁₁), phorate (T₄), Dipel + diflubenzuron (T₁₃), carbofuran (T₁), diflubenzuron (T₁₂) and phorate + Dipel (T₆) ranged from 5.67 to 4.00/5 hills and these treatments were on par with untreated control (T₁₉) which had coccinellid population of 6.00/5 hills.

4.2.1.3 Third spray

Ten days after third spray, coccinellid population varied from 1.00/5 hills in fenvalerate 3 sprays (T₉) to 3.33/5 hills in untreated control (T₁₉). No significant differences among the treatments were observed.

The overall effect of different insecticides and biopesticides on coccinellids during *kharif* 1998 revealed that throughout spray period, both untreated control (T_{19}) and solvent + emulsifier (T_{18}) followed by Chinaberry (T_{16}), Aak (T_{17}), Neem-B (Refined, T_{15}) and Neem-A (T_{14}) had higher coccinellid population. Among the alternation treatments Dipel + diflubenzuron (T_{13}) followed by carbofuran + Dipel (T_3) and phorate + Dipel (T_6) showed relatively more coccinellid population. Synthetic insecticidal treatments *viz.*, quinalphos 3 sprays (T_7) fenvalerate 3 sprays (T_9), quinalphos 2 sprays (T_8) and fenvalerate 2 sprays (T_{10}) showed very low coccinellid population throughout the spray period.

4.2.2 Effect of different insecticides and biopesticides on coccinellids during *kharif* 1999

4.2.2.1 First spray

Ten days after first spray, the range of coccinellids varied from 0.00 to 3.00/5 hills. Maximum population of 3.00/5 hills were observed in three treatments *viz.*, fenvalerate 2 sprays (T_{10}) (where the first spray was not applied), untreated control (T_{19}) and solvent + emulsifier (T_{18}). No population of coccinellids was recorded in quinalphos 3 sprays (T_7). Treatments of fenvalerate 3 sprays (T_9), carbofuran + dipel (T_3), phorate (T_4) and carbofuran (T_2) also recorded very low population of 0.33 to 1.00/5 hills. All the botanicals *viz.*, chinaberry (T_{16}), Neem-B (Refined, T_{15}), Neem-A (T_{14}) and Aak (T_{17}) recorded high population ranging from 2.67 to 2.33/5 hills and these treatments were on par with both untreated control (T_{19}) and solvent + emulsifier (T_{18}). The effect of other insecticidal treatments can be seen from Table 8.

Twenty days after first spray, the population of coccinellids varied from 1.00 to 5.00/5 hills, with highest population of 5.00/5 hills observed in untreated control (T_{19}) and lowest 1.00/5 hills in fenvalerate 3 sprays (T_9). Treatments of quinalphos (T_8) and fenvalerate 2 sprays (T_{10}) (in which first spray was not applied), the population of coccinellids was recorded as 4.67 and 4.33/5 hills, respectively and were on par with untreated control (T_{19}). Treatments of Chinaberry (T_{16}), Aak (T_{17}), Neem-B (Refined, T_{15}), Neem-A (T_{14}), Dipel + diflubenzuron (T_{13}), Dipel (T_{11}), diflubenzuron (T_{12}), carbofuran (T_1), phorate (T_5), carbofuran (T_2) and phorate (T_4) recorded coccinellid population ranging from 4.67 to 3.00/5 hills and these were on par with untreated control (T_{19}). Only the treatment of quinalphos 3 sprays (T_7) recorded 1.67 beetles/5 hills which was on par with lowest coccinellid population treatment fenvalerate 3 sprays (T_9).

4.2.2.2 Second spray

Ten days after second spray, the population of coccinellids varied from 1.67 to 6.67/5 hills in various treatments. Maximum population of 6.67/5 hills was observed in untreated control (T_{19}). Minimum populations of 1.67/5 hills was recorded in fenvalerate 3 sprays (T_9). In treatments of fenvalerate 2 sprays (T_{10}) and quinalphos 2 sprays (T_8) (where second spray was applied), population of coccinellid decreased to 2.00 and 2.33/5 hills, respectively. Other insecticidal treatments viz., quinalphos 3 sprays (T_7), phorate + Dipel (T_6), carbofuran (T_2) and phorate (T_5) had 2.00 to 3.33 beetles/5 hills and were statistically on par with lowest treatment fenvalerate 3 sprays (T_9). Treatments of solvent + emulsifier (T_{18}), Aak (T_{17}), Neem-B (Refined,

Table 8. Effect of different insecticides and biopesticides on coccinellids during *kharif* 1999

Treatment	Coccinellid population/5 hills											
	I st spraying			II nd spraying			III rd spraying					
	10 DAS 1	20 DAS 2	10 DAS 3	20 DAS 4	10 DAS 5	20 DAS 6	10 DAS 1	20 DAS 2	10 DAS 3	20 DAS 4	10 DAS 5	20 DAS 6
T ₁ Carbofuran 3G	1.67 (1.46)	3.33 (1.95)	4.00 (2.11)	4.67 (2.27)	3.33 (1.93)	2.00 (1.55)						
T ₂ Carbofuran 3G	1.00 (1.17)	3.00 (1.85)	3.00 (1.85)	3.67 (2.03)	3.00 (1.87)	1.00 (1.17)						
T ₃ Carbofuran 3G + Dipel 8 L	0.33 (0.88)	2.67 (1.76)	3.67 (2.03)	4.00 (2.11)	3.00 (1.83)	1.67 (1.44)						
T ₄ Phorate 10G	0.67 (1.05)	3.00 (1.85)	3.67 (2.02)	4.67 (2.25)	3.33 (1.94)	1.67 (1.46)						
T ₅ Phorate 10G	1.67 (1.46)	3.00 (1.85)	3.33 (1.94)	4.33 (2.18)	3.00 (1.85)	1.33 (1.29)						
T ₆ Phorate 10G + Dipel 8 L	1.00 (1.22)	2.67 (1.73)	3.00 (1.85)	3.67 (2.03)	3.67 (2.03)	1.67 (1.46)						
T ₇ Quinalphos 25 EC (3 sprays)	0.00 (0.70)	1.67 (1.44)	2.00 (1.55)	2.33 (1.67)	1.33 (1.34)	1.00 (1.17)						
T ₈ Quinalphos 25 EC (2 sprays)	2.67 (1.76)	4.67 (2.25)	2.33 (1.67)	2.67 (1.77)	2.33 (1.67)	1.33 (1.34)						
T ₉ Fenvalerate 20 EC (3 sprays)	0.33 (0.88)	1.00 (1.25)	1.67 (1.46)	2.00 (1.55)	1.67 (1.46)	1.33 (1.29)						
T ₁₀ Fenvalerate 20 EC (2 sprays)	3.00 (1.85)	4.33 (2.18)	2.00 (1.55)	2.67 (1.77)	2.00 (1.55)	1.33 (1.27)						
T ₁₁ Dipel 8 L (3 sprays)	2.00 (1.55)	3.67 (2.01)	5.00 (2.33)	5.67 (2.47)	4.00 (2.11)	1.67 (1.46)						
T ₁₂ Diflubenzuron 25% WP (3 sprays)	1.67 (1.46)	3.33 (1.95)	4.33 (2.18)	5.00 (2.34)	3.00 (1.85)	1.67 (1.46)						

T₁₅), chinaberry (T₁₆), Dipel (T₁₁), Neem-A (T₁₄), Dipel + diflubenzuron (T₁₃) and diflubenzuron (T₁₂) had recorded 6.00 to 4.33/5 hills and were on par to untreated control (T₁₉).

Twenty days after second spray, the population of coccinellids varied from 2.00 to 7.67/5 hills with highest population in solvent + emulsifier (T₁₈) and lowest 2.00/5 hills in fenvalerate 3 sprays (T₉). Only treatments of diflubenzuron (T₁₂), Dipel + diflubenzuron (T₁₃), Dipel (T₁₁), Neem-A (T₁₄), Aak (T₁₇), Neem-B (Refined, T₁₅) and chinaberry (T₁₆) with 5.00 to 6.67 coccinellids/5hills, were found to be on par with untreated control (T₁₉). Treatments of quinalphos (T₇), fenvalerate 2 sprays (T₁₀), quinalphos 2 sprays (T₈), phorate + Dipal (T₆) and carbofuran (T₂) had recorded 2.33 to 3.67/5 hills and were found to be on par with fenvalerate 3 sprays (T₉) which recorded lowest coccinellid population.

4.2.2.3 Third spray

Ten days after third spray, the coccinellid population ranged from 1.33 to 5.67/5 hills. Maximum population of 5.67/5 hills was recorded in untreated control (T₁₉). Minimum population of 1.33/5 hills was recorded in quinalphos 3 sprays (T₇). Among the alternation treatments, Dipel + diflubenzuron (T₁₃) and phorate + Dipel (T₆) recorded 3.67/5 hills each and were found to be on par with untreated control (T₁₉), while carbofuran + Dipel (T₃) recorded 3.00/5 hills and did not significantly differ with lowest population treatment T₇. Only treatments of Neem-A (T₁₄), Dipel (T₁₁), Neem-B (Refined T₁₅), Chinaberry (T₁₆), Aak (T₁₇) and solvent + emulsifier (T₁₈) with 4.00 to 5.33 coccinellids/ 5 hills, were found to be on par with untreated control (T₁₉). All other

insecticidal treatments showed significantly lower population of coccinellids in comparison with untreated control (T_{19}). Treatments of fenvalerate 3 sprays (T_9), fenvalerate 2 sprays (T_{10}) and quinalphos 2 sprays (T_8) had coccinellid population ranging from 1.67 to 2.33/5 hills and were found to be statistically on par with lowest coccinellid population treatment quinalphos 3 sprays (T_7).

Twenty days after third spray, there was a general decrease in this natural enemy's population and population ranged from 1.00 to 2.67/5 hills. Maximum population of 2.67/5 hills was recorded in solvent + emulsifier (T_{18}) while minimum population 1.00/5 hills was observed in carbofuran (T_2) and quinalphos 3 sprays (T_7). No significant differences in coccinellid population among the treatments were observed.

The overall effect of different insecticides and biopesticides on coccinellids during *kharif* 1999 revealed that throughout spray period both untreated control (T_{19}) and solvent + emulsifier (T_{18}) followed by botanicals and biopesticides had high coccinellid population. The alternation treatments phorate + Dipel (T_6), Dipel + diflubenzuron (T_{13}) followed by carbofuran + Dipel (T_3) also showed higher population. Synthetic insecticidal treatments *viz.*, fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) fenvalerate 2 sprays (T_{10}) and quinalphos 2 sprays (T_8) showed a very low coccinellid population throughout the spray period in comparison to untreated control (T_{19}).

4.2.3 Effect of different insecticides and biopesticides on ground beetle during *kharif* 1998

Observations were recorded to find out the effect of insecticides

Plate 8. Predator, ground beetle on rice

Plate 9. Predator, rove beetle on rice



and biopesticides on ground beetle at 10 and 20 days interval after the treatments were imposed.

4.2.3.1 First spray

Ten days after first spray, the population of ground beetle ranged from 0.00 to 1.67/5 hills. Maximum population of 1.67/5 hills was found in quinalphos 2 sprays (T_8) (in which first spray was not applied), while nil population was recorded in fenvalerate 3 sprays (T_9) and phorate (T_5). No significant differences among the treatments were observed.

Twenty days after first spray, ground beetle population varied from 0.33 to 2.00/5 hills in different treatments. Maximum population of 2.00/5 hills was observed in solvent + emulsifier (T_{18}), whereas minimum population of 0.33/5 hills was observed in fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) and phorate (T_5). Treatments which were statistically on par with untreated control (T_{19}) and solvent + emulsifier (T_{18}) included quinalphos 2 sprays (T_8) (in which first spray was not applied), Dipel + diflubenzuron (T_{13}), phorate (T_4), Neem-A (T_{14}), fenvalerate 2 sprays (T_{10}) (in which first spray was not applied), Aak (T_{17}), Chinaberry (T_{16}) and Dipel (T_{11}) which had ground beetle population ranging from 1.33 to 1.67/5 hills. Treatments of carbofuran + Dipel (T_3), carbofuran (T_1), Neem-B (Refined, T_{15}), carbofuran (T_2), diflubenzuron (T_{12}) and phorate + Dipel (T_6) were other insecticidal treatments in which ground beetle population varied between 0.67 to 1.00/5 hills and were statistically on par with lowest population treatments of fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) and phorate (T_5).

Table 9. Effect of different insecticides and biopesticides on ground beetles during *kharif* 1998

Treatment	Ground beetle population/5 hills									
	I st spraying			II nd spraying			III rd spraying			
	10 DAS 1	20 DAS 2	10 DAS 3	20 DAS 4	10 DAS 5					
T ₁ Carbofuran 3G	0.33 (0.88)	1.00 (1.22)	2.67 (1.77)	4.00 (2.11)	1.33 (1.34)					
T ₂ Carbofuran 3G	0.67 (1.05)	1.00 (1.22)	1.67 (1.46)	3.00 (1.87)	1.00 (1.22)					
T ₃ Carbofuran 3G + Dipel 8 L	0.33 (0.88)	0.67 (1.05)	1.33 (1.34)	3.33 (1.95)	1.67 (1.46)					
T ₄ Phorate 10G	1.00 (1.17)	1.33 (1.34)	2.33 (1.68)	4.00 (2.11)	1.33 (1.34)					
T ₅ Phorate 10G	0.00 (0.71)	0.33 (0.88)	1.00 (1.22)	3.67 (2.04)	1.33 (1.29)					
T ₆ Phorate 10G + Dipel 8 L	0.33 (0.88)	1.00 (1.22)	1.67 (1.46)	3.00 (1.86)	1.67 (1.46)					
T ₇ Quinalphos 25 EC (3 sprays)	0.33 (0.88)	0.33 (0.88)	0.67 (1.05)	1.00 (1.22)	0.33 (0.88)					
T ₈ Quinalphos 25 EC (2 sprays)	1.67 (1.46)	1.33 (1.34)	1.00 (1.22)	1.33 (1.34)	0.33 (0.88)					
T ₉ Fenvalerate 20 EC (3 sprays)	0.00 (0.71)	0.33 (0.88)	0.67 (1.05)	1.33 (1.34)	0.33 (0.88)					
T ₁₀ Fenvalerate 20 EC (2 sprays)	0.67 (1.05)	1.33 (1.34)	0.33 (0.88)	0.67 (1.05)	0.67 (1.05)					
T ₁₁ Dipel 8 L (3 sprays)	1.00 (1.17)	1.67 (1.46)	2.67 (1.77)	4.67 (2.27)	1.67 (1.46)					
T ₁₂ Diflubenzuron 25% WP (3 sprays)	0.67 (1.05)	1.00 (1.22)	2.00 (1.58)	3.67 (2.02)	1.33 (1.34)					

Table contd.....

Treatment	Ground beetle population/5 hills									
	I st spraying		II nd spraying		III rd spraying					
	10 DAS 1	20 DAS 2	10 DAS 3	20 DAS 4	10 DAS 5	20 DAS 6	10 DAS 7	20 DAS 8	10 DAS 9	20 DAS 10
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	1.00 (1.17)	1.33 (1.34)	2.33 (1.64)	4.33 (2.18)	2.00 (1.56)					
T ₁₄ Neem-A (3 sprays)	1.00 (1.22)	1.33 (1.34)	2.67 (1.77)	4.67 (2.27)	2.00 (1.56)					
T ₁₅ Neem-B (Refined, 3 sprays)	1.33 (1.34)	1.00 (1.22)	2.67 (1.77)	4.00 (2.11)	1.67 (1.46)					
T ₁₆ Chinaberry (3 sprays)	1.33 (1.34)	1.67 (1.46)	3.00 (1.86)	4.33 (2.18)	2.00 (1.56)					
T ₁₇ Aak (3 sprays)	1.00 (1.22)	1.67 (1.46)	3.00 (1.86)	4.67 (2.25)	2.00 (1.52)					
T ₁₈ Solvent + emulsifier (3 sprays)	1.33 (1.34)	2.00 (1.58)	3.33 (1.95)	4.67 (2.27)	2.33 (1.68)					
T ₁₉ Control (untreated)	1.33 (1.34)	1.67 (1.46)	3.67 (2.03)	4.67 (2.27)	3.00 (1.86)					
F Test	Non-sig	Sig*	Sig**	Sig**	Sig*					
SEm±		{ 0.11 }	{ 0.12 }	{ 0.13 }	{ 0.16 }					
CD (0.05)	-	{ 0.35 }	{ 0.38 }	{ 0.42 }	{ 0.52 }					
CD (0.01)	-	{ NS }	{ 0.54 }	{ 0.59 }	{ NS }					

Note :

- (i) = DAS-Days after spraying
- (ii) = Values in parenthesis are square root transformed
- (iii) = **Significant at 1% level
- (iv) = *Significant at 5% level
- (v) = Transplanting date 27.7.1998
- (vi) = Ist spraying -20 DAT
- (vii) = IInd spraying -40 DAT
- (viii) = IIIrd spraying -60 DAT
- (ix) = Dose of the treatments are mentioned in Table 2, Page 51

4.2.3.2 Second spray

Ten days after second spray, ground beetle population varied from 0.33 to 3.67/5 hills. Highest population of 3.67/5 hills was observed in untreated control (T_{19}) and lowest population of 0.33/5 hills in fenvalerate 2 sprays (T_{10}) (in which second spray was applied). Treatments of Dipel + diflubenzuron (T_{13}), phorate (T_4), carbofuran (T_1), Neem-A (T_{14}), Neem-B (Refined T_{15}), Dipel (T_{11}), chinaberry (T_{16}), Aak (T_{17}) and solvent + emulsifier (T_{18}) recorded 2.33 to 3.33 beetles/5 hills and were found to be on par with the highest ground beetle population treatment viz., untreated control (T_{19}). Treatments of fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) (with 0.67/5 hill each), quinalphos 2 sprays (T_8) and phorate (T_5) (with 1.00/5 hills each) were on par with lowest population treatment of fenvalerate 2 sprays (T_{10}). The effect of other insecticidal treatments can be seen from Table 9.

Twenty days after second spray, ground beetle population varied from 0.67 to 4.67/5 hills in various treatment. Maximum population of 4.67/5 hills was recorded in untreated control (T_{19}). While lowest population of 0.67/5 hills was recorded in fenvalerate 2 sprays (T_{10}). Treatments of quinalphos 3 sprays (T_7), quinalphos 2 sprays (T_8) and fenvalerate 3 sprays (T_9) had 1.00 to 1.33 beetles/5 hills and were found to be statistically on par with lowest population treatment of fenvalerate 2 sprays (T_{10}). All other insecticidal treatments had ground beetle population varying from 3.00 to 4.67/5 hills and were on par with untreated control (T_{19}) (Table 9).

4.2.3.3 Third spray

Ten days after third spray, population of ground beetle ranged from

0.33 to 3.00 beetles/5 hills. Highest population of 3.00 beetles/5 hills was observed in untreated control (T_{19}) and lowest population was recorded (0.33/5 hills) in fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) and quinalphos 2 sprays (T_8). Among alternation treatments, Dipel + diflubenzuron (T_{13}) recorded 2.00 ground beetles/5 hills while other alternation treatments viz., carbofuran + Dipel (T_3) and phorate + Dipel (T_6) had population of 1.67 beetles/5 hills each. Treatments of fenvalerate 2 sprays (T_{10}), carbofuran (T_2), phorate (T_5), phorate (T_4), carbofuran (T_1) and diflubenzuron (T_{12}) recorded ground beetle population ranging from 0.67 to 1.33/5 hills and were found to be on par with lowest population treatments fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) and quinalphos 2 sprays (T_8). Other insecticidal treatments viz., Dipel (T_{11}), Neem-B (Refined, T_{15}), Aak (T_{17}), chinaberry (T_{16}), Neem-A (T_{14}) and solvent + emulsifier (T_{18}) had ground beetle population ranging from 1.67 to 2.33/5 hills and were statistically on par with highest ground beetle population (3.00/5 hills) in untreated control (T_{19}).

Overall picture showed that untreated control (T_{19}), solvent + emulsifier (T_{18}), botanicals and biopesticide showed higher ground beetle population than synthetic insecticidal treatments. All alternation treatments had ground beetle population statistically on par with untreated control. Fenvalerate 3 sprays (T_9) and fenvalerate 2 sprays (T_{10}) among synthetic insecticides showed lowest ground beetle population.

4.2.4 Effect of different insecticides and biopesticides on ground beetle during *kharif* 1999

Observations were recorded to find out the adverse effect of

insecticides and biopesticides on ground beetle at ten days and twenty days intervals after the treatments were imposed.

4.2.4.1 First spray

Ten days after first spray, the population of ground beetle ranged from 0.00 to 2.33/5 hills. Highest population of 2.33 ground beetles/5 hills was recorded in untreated control (T_{19}). Treatments of Dipel + diflubenzuron (T_{13}), Aak (T_{17}), Neem-B (Refind, T_{15}), Neem-A (T_{14}), Dipel (T_{11}), fenvalerate 2 sprays (T_{10}), solvent + emulsifier (T_{18}), chinaberry (T_{16}) and quinalphos 2 sprays (T_8) recorded ground beetle population ranging from 1.33 to 2.00/5hills and were found to be on par with highest ground beetle population treatment (T_{19}). Treatments of quinalphos 3 sprays (T_7), phorate (T_5) and carbofuran + Dipel (T_3) had no ground beetles, while fenvalerate 3 spray (T_9), carbofuran (T_2), phorate + Dipel (T_6), phorate (T_4) and carbofuran (T_1) populations varied from 0.33 to 0.67/5 hills and were found to be on par with lowest ground beetle population treatments (T_7 , T_5 and T_3).

Twenty days after first spray, ground beetle population varied from 0.33 to 3.00/5 hills with highest population in untreated control (T_{19}) and lowest in quinalphos 3 sprays (T_7). Treatments of quinalphos 2 sprays (T_8), solvent + emulsifier (T_{18}), fenvalerate 2 sprays (T_{10}), Neem-A (T_{14}), Dipel (T_{11}), Aak (T_{17}), phorate (T_4) carbofuran (T_1), Neem-B (Refined, T_{15}), diflubenzuron (T_{12}), phorate (T_5) and chinaberry (T_{16}) recorded population ranging from 2.67 to 2.00/5 hills and were found to be on par with untreated control (T_{19}). The treatments of fenvalerate 3 sprays (T_9) and carbofuran (T_2) had a low ground beetle population of 0.67 and 1.00/5 hills and were found to be statistically on par with lowest population treatment (T_7).

4.2.4.2 Second spray

Ten days after second spray, there was a general increase in this natural enemy population, which ranged from 1.00 to 5.67/5 hills. Treatments of Aak (T_{17}), Neem-B (Refined, T_{15}), chinaberry (T_{16}) and solvent + emulsifier (T_{18}) recorded population varying from 4.33 to 5.00/5 hills and were on par with untreated control (T_{19}), which had highest population of 5.67/5 hills. The population in all other treatments was significantly lower than untreated control and ranged from 2.33 to 4.00/5 hills. Only three treatments viz., quinalphos 3 sprays (T_7), fenvalerate (T_{10}) 2 sprays and quinalphos 2 sprays (T_8) with 1.33 to 1.67 ground beetles/5 hills and were statistically on par with lowest ground beetle population treatment of fenvalerate 3 sprays (T_9) (1.00/5 hills).

Twenty days after second spray, the increasing trend was observed in ground beetle population and population ranged from 2.00 to 7.67/5 hills. Highest population of 7.67 beetles/5 hills was recorded in untreated control (T_{19}), while fenvalerate 3 sprays (T_9) had lowest population of 2.00/5 hills. Treatments of Dipel (T_{11}), Neem-A (T_{14}), Aak (T_{17}), Neem-B (Refined, T_{15}), chinaberry (T_{16}) and solvent + emulsifier (T_{18}) had ground beetle population ranging from 5.67 to 7.33/5 hills and were on par with untreated control (T_{19}). Treatment of fenvalerate 3 sprays (T_9) recorded the lowest ground beetle population of 2.00 beetles/5 hills. Treatments of fenvalerate 2 sprays (T_{10}) and quinalphos 2 sprays (T_8), where the second spray was applied, the population of ground beetle varied from 2.67 to 3.00/5 hills and were found to be on par with lowest population treatment (T_9) and quinalphos 3 sprays (T_7) (2.33 beetles/5 hills). The population in all other insecticidal

Table 10. Effect of different insecticides and biopesticides on ground beetles during *Kharif* 1999

Treatment	Ground beetle population/5 hills														
	I st spraying			II nd spraying			III rd spraying								
	10 DAS	20 DAS	2	10 DAS	20 DAS	4	10 DAS	20 DAS	5	10 DAS	20 DAS				
T ₁ Carbofuran 3G	0.67 (1.05)	2.00 (1.58)	2.67 (1.77)	4.67 (2.27)	3.00 (1.85)	1.33 (1.27)	0.67 (1.05)	1.00 (1.58)	2.00 (1.55)	2.67 (1.77)	3.00 (1.85)	3.33 (2.01)	4.67 (2.27)	5.00 (2.31)	5.67 (2.48)
T ₂ Carbofuran 3G	0.33 (0.88)	1.00 (1.22)	2.33 (1.67)	3.67 (2.02)	2.67 (1.77)	3.00 (1.87)	4.67 (2.26)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₃ Carbofuran 3G + Dipel 8 L	0.00 (0.70)	1.67 (1.46)	2.67 (1.77)	3.33 (1.95)	3.67 (2.01)	3.33 (1.95)	4.67 (2.26)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₄ Phorate 10G	0.67 (1.05)	2.00 (1.58)	2.67 (1.77)	4.67 (2.26)	3.00 (1.85)	1.00 (1.17)	0.67 (1.05)	1.00 (1.58)	2.00 (1.55)	2.67 (1.77)	3.00 (1.85)	3.33 (2.01)	4.67 (2.26)	5.00 (2.31)	5.67 (2.48)
T ₅ Phorate 10G	0.00 (0.70)	2.00 (1.58)	2.67 (1.77)	4.67 (2.26)	3.00 (1.85)	1.00 (1.17)	0.67 (1.05)	1.00 (1.58)	2.00 (1.55)	2.67 (1.77)	3.00 (1.85)	3.33 (2.01)	4.67 (2.26)	5.00 (2.31)	5.67 (2.48)
T ₆ Phorate 10G + Dipel 8 L	0.33 (0.88)	1.67 (1.46)	2.33 (1.67)	3.67 (2.03)	2.67 (1.77)	3.00 (1.87)	4.67 (2.26)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₇ Quinalphos 25 EC (3 sprays)	0.00 (0.70)	0.33 (0.88)	1.33 (1.34)	2.33 (1.67)	1.33 (1.29)	1.67 (1.46)	2.67 (1.77)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₈ Quinalphos 25 EC (2 sprays)	2.00 (1.58)	2.67 (1.77)	1.67 (1.46)	3.00 (1.85)	1.67 (1.46)	3.00 (1.87)	4.67 (2.26)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₉ Fenvalerate 20 EC (3 sprays)	0.33 (0.88)	0.67 (1.05)	1.00 (1.22)	2.00 (1.55)	1.00 (1.22)	1.67 (1.46)	2.67 (1.77)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₁₀ Fenvalerate 20 EC (2 sprays)	2.00 (1.55)	2.33 (1.67)	1.67 (1.46)	2.67 (1.77)	1.67 (1.46)	3.00 (1.87)	4.67 (2.26)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₁₁ Dipel 8 L (3 sprays)	1.67 (1.46)	2.33 (1.67)	4.00 (2.11)	5.67 (2.48)	4.00 (2.11)	3.00 (1.85)	4.67 (2.26)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)
T ₁₂ Diflubenzuron 25% WP (3 sprays)	1.00 (1.17)	2.00 (1.55)	3.00 (1.85)	5.00 (2.31)	3.00 (1.85)	3.00 (1.85)	4.67 (2.26)	3.00 (1.85)	4.33 (2.18)	1.33 (1.29)	1.67 (1.46)	1.33 (1.34)	1.67 (1.46)	1.67 (1.46)	1.67 (1.46)

Table contd.....

Treatment	Ground beetle population/5 hills											
	I st spraying			II nd spraying			III rd spraying					
	10 DAS	20 DAS	2	10 DAS	20 DAS	4	10 DAS	20 DAS	5	10 DAS	20 DAS	6
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	1.33 (1.34)	1.67 (1.46)		3.67 (2.03)	5.33 (2.40)		4.33 (2.19)		4.33 (2.19)		1.67 (1.46)	
T ₁₄ Neem-A (3 sprays)	1.67 (1.46)	2.33 (1.67)		4.00 (2.11)	6.00 (2.55)		4.00 (2.11)		4.00 (2.11)		1.33 (1.17)	
T ₁₅ Neem-B (Refined, 3 sprays)	1.67 (1.46)	2.00 (1.58)		4.33 (2.18)	6.67 (2.67)		4.67 (2.27)		4.67 (2.27)		1.00 (1.34)	
T ₁₆ Chinaberry (3 sprays)	2.00 (1.58)	2.00 (1.55)		4.67 (2.27)	7.00 (2.73)		4.67 (2.27)		4.67 (2.27)		1.33 (1.34)	
T ₁₇ Aak (3 sprays)	1.67 (1.46)	2.33 (1.67)		4.33 (2.18)	6.67 (2.67)		4.33 (2.19)		4.33 (2.19)		1.00 (1.17)	
T ₁₈ Solvent + emulsifier (3 sprays)	2.00 (1.58)	2.67 (1.77)		5.00 (2.33)	7.33 (2.79)		5.00 (2.33)		5.00 (2.33)		1.67 (1.46)	
T ₁₉ Control (untreated)	2.33 (1.64)	3.00 (1.85)		5.67 (2.48)	7.67 (2.85)		5.33 (2.40)		5.33 (2.40)		2.00 (1.58)	
F Test	Sig**	Sig**		Sig**	Sig**		Sig**		Sig**		Non sig	
SEm±	{0.14}	{0.11}		{0.09}	{0.12}		{0.14}		{0.14}		-	
CD (0.05)	{0.45}	{0.37}		{0.30}	{0.38}		{0.46}		{0.46}		-	
CD (0.01)	{0.64}	{0.53}		{0.43}	{0.55}		{0.66}		{0.66}		-	

Note :

- (i) = DAS-Days after spraying
- (ii) = Values in parenthesis are square root transformed
- (iii) = **Significant at 1% level
- (iv) = Transplanting date 9.7.1999
- (v) = Ist spraying -20 DAT
- (vi) = IInd spraying -40 DAT
- (vii) = IIIrd spraying - 60 DAT
- (viii) = Dose of the treatments are mentioned in Table 2, Page 51

treatments had ground beetle ranging from 3.33 to 5.33/5 hills which was significantly lower than untreated control (T_{19}).

4.2.4.3 Third spray

Ten days after third spray, ground beetle population ranged from 1.33 to 5.33/5 hills. Maximum population (5.33/5 hills) was recorded in untreated control (T_{19}) while minimum population (1.33/5 hills) in quinalphos 3 sprays (T_7) and fenvalerate 3 sprays (T_9). Among alternation treatments, Dipel + diflubenzuron (T_{13}) and phorate + Dipel (T_8) recorded 4.33 beetles/5 hills each while treatment of carbofuran + Dipel (T_3) recorded 3.67 beetles/5 hills. Treatments of quinalphos 2 sprays (T_8) and fenvalerate 2 sprays (T_{10}) had population ranging from 1.67 to 2.00 beetles/5 hills and were found to be statistically on par with lowest ground beetle population treatments viz., quinalphos 3 sprays (T_7) and fenvalerate 3 sprays (T_9). Except treatments of phorate (T_4), carbofuran (T_1), phorate (T_5) and carbofuran (T_2) all other treatments were on par with untreated control (T_{19}) which had highest population of 5.33/5 hills. The effect of other insecticidal treatments is shown in Table 10.

Twenty days after third spray, there was a general decrease in this natural enemy population and population ranged from 0.67 to 2.00/5 hills. No significant difference among the treatments was observed.

The overall effect of different insecticides, botanical and biopesticide on ground beetles during *kharif* 1999 revealed that throughout the spray period both untreated control (T_{19}) and solvent + emulsifier (T_{18}) followed

by botanicals and biopesticides had high ground beetle population. Alternation treatments showed an increase in ground beetle population in comparison to synthetic insecticidal treatments. Synthetic insecticides viz., quinalphos 3 sprays (T₇) and fenvalerate 3 sprays (T₉) showed a very low ground beetle population throughout the spray period in comparison to untreated control (T₁₉). All botanicals and biopesticide proved much safer than synthetic insecticides during *kharif*, 1999 to this predator.

4.2.5 Effect of different insecticides and biopesticides on rove beetles during *kharif*, 1998

4.2.5.1 First spray

Ten days after first spray, the population of rove beetle ranged from 0.00 to 1.67/5 hills. Maximum population of 1.67 beetles/5 hills was recorded in untreated control (T₁₉) followed by quinalphos 2 sprays (T₈) (in which first spray was not applied). No population was observed in both fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇). Treatments of phorate + Dipel (T₆), carbofuran (T₁) and carbofuran (T₂) recorded 0.67 beetles/5 hills each and were found to be on par with lowest population treatments T₉ and T₇. Treatments of Dipel (T₁₁), carbofuran + Dipel (T₃), Aak (T₁₇), phorate (T₅), Neem-A (T₁₄) and diflubenzuron (T₁₂) recorded 1.00/5 hills each while treatments of phorate (T₄), Dipel + diflubenzuron (T₁₃), fenvalerate 2 sprays (T₁₀), solvent + emulsifier (T₁₈), Neem-B (Refined, T₁₅) and chinaberry (T₁₆) had recorded 1.33/5 hills each and were found to be statistically on par with both untreated control (T₁₉) and quinalphos 2 sprays (T₈).

Twenty days after first spray, rove beetle population varied from 0.33 to 3.00/5 hills, with highest population of 3.00/5 hills was observed untreated control (T_{19}) and lowest population of 0.33/5 hills in fenvalerate 3 sprays (T_9). Treatments of quinalphos 3 sprays (T_7), carbofuran + Dipel (T_3), carbofuran (T_2) and phorate (T_5) recorded population ranging from 0.67 to 1.00/5 hills and were on par with the lowest rove beetles populations treatment T_9 . Other treatments viz., T_{15} , T_4 , T_{17} , T_8 , T_{14} , T_{11} , T_{18} and T_{10} had rove beetle population varying from 2.00 to 2.67/5 hills and were on par with untreated control (T_{19}) (Table 11).

4.2.5.2 Second spray

Ten days after second spray, the population of rove beetle ranged from 0.33 to 4.00/5 hills. Maximum, population of 4.00/5 hills was observed in untreated control (T_{19}). The population of rove beetle decreased in treatments of fenvalerate 2 sprays (T_{10}) and quinalphos 2 sprays (T_8) (in which second spray was applied) to 0.67/5 hills and 1.00/5 hills, respectively and were found to be statistically on par with lowest rove beetle population treatments fenvalerate 3 sprays T_9) and quinalphos 3 sprays (T_7). Treatments of carbofuran + Dipel (T_3), phorate + Dipel (T_6) and carbofuran (T_2) recorded 1.67, 2.00 and 2.00/5 hills, respectively and were found to have significantly lower rove beetle population than the untreated control (T_{19}). Other insecticidal treatments had rove beetle population varying from 2.33 to 3.67/5 hills and were on par with untreated control (T_{19}).

Twenty days after second spray, rove beetle population varied from 1.00 to 5.67/5 hills. Highest population of 5.67/5 hills was observed in both untreated control (T_{19}) and solvent + emulsifier (T_{18}). Minimum

Table 11. Effect of different insecticides and biopesticides on rove beetles during kharif 1998

Treatment	Rove beetle population/5 hills									
	I st spraying			II nd spraying			III rd spraying			10 DAS
	10 DAS	20 DAS	2	10 DAS	20 DAS	3	10 DAS	20 DAS	4	
T ₁ Carbofuran 3G	0.67 (1.05)	1.67 (1.46)	2.67 (1.76)	2.67 (1.76)	4.33 (2.19)	2.67 (1.76)	4.33 (2.19)	2.67 (1.76)	4.33 (2.19)	2.67 (1.77)
T ₂ Carbofuran 3G	0.67 (1.05)	1.00 (1.22)	2.00 (1.58)	2.00 (1.58)	3.33 (1.93)	2.00 (1.58)	3.33 (1.93)	2.00 (1.58)	3.33 (1.93)	2.67 (1.77)
T ₃ Carbofuran 3G + Dipel 8 L	1.00 (1.17)	1.00 (1.17)	1.67 (1.38)	1.67 (1.38)	3.00 (1.87)	1.67 (1.38)	3.00 (1.87)	1.67 (1.38)	3.00 (1.87)	3.00 (1.86)
T ₄ Phorate 10G	1.33 (1.34)	2.00 (1.56)	3.00 (1.85)	3.00 (1.85)	4.33 (2.18)	3.00 (1.85)	4.33 (2.18)	3.00 (1.85)	4.33 (2.18)	2.33 (1.68)
T ₅ Phorate 10G	1.00 (1.22)	1.00 (1.22)	2.33 (1.67)	2.33 (1.67)	3.00 (1.86)	2.33 (1.67)	3.00 (1.86)	2.33 (1.67)	3.00 (1.86)	2.00 (1.56)
T ₆ Phorate 10G + Dipel 8 L	0.67 (0.99)	1.67 (1.46)	2.00 (1.56)	2.00 (1.56)	3.67 (2.02)	2.00 (1.56)	3.67 (2.02)	2.00 (1.56)	3.67 (2.02)	2.67 (1.77)
T ₇ Quinalphos 25 EC (3 sprays)	0.00 (0.70)	0.67 (1.05)	0.33 (0.88)	0.33 (0.88)	1.33 (1.34)	0.33 (0.88)	1.33 (1.34)	0.33 (0.88)	1.33 (1.34)	0.67 (1.05)
T ₈ Quinalphos 25 EC (2 sprays)	1.67 (1.46)	2.00 (1.58)	1.00 (1.22)	1.00 (1.22)	1.33 (1.34)	1.00 (1.22)	1.33 (1.34)	1.00 (1.22)	1.33 (1.34)	1.00 (1.22)
T ₉ Fenvalerate 20 EC (3 sprays)	0.00 (0.70)	0.33 (0.88)	0.33 (0.88)	0.33 (0.88)	1.00 (1.22)	0.33 (0.88)	1.00 (1.22)	0.33 (0.88)	1.00 (1.22)	0.67 (0.99)
T ₁₀ Fenvalerate 20 EC (2 sprays)	1.33 (1.34)	2.67 (1.76)	0.67 (1.05)	0.67 (1.05)	1.33 (1.34)	0.67 (1.05)	1.33 (1.34)	0.67 (1.05)	1.33 (1.34)	0.33 (0.88)
T ₁₁ Dipel 8 L (3 sprays)	1.00 (1.17)	2.33 (1.68)	3.33 (1.95)	3.33 (1.95)	5.00 (2.34)	3.33 (1.95)	5.00 (2.34)	3.33 (1.95)	5.00 (2.34)	2.33 (1.68)
T ₁₂ Diflubenzuron 25% WP (3 sprays)	1.00 (1.22)	1.67 (1.46)	2.67 (1.77)	2.67 (1.77)	4.33 (2.18)	2.67 (1.77)	4.33 (2.18)	2.67 (1.77)	4.33 (2.18)	2.00 (1.56)

Table contd.....

Treatment	Rove beetle population/5 hills											
	I st spraying			II nd spraying			III rd spraying					
	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	1.33 (1.34)	1.67 (1.46)	3.00 (1.86)	3.00 (1.86)	4.67 (2.26)	3.00 (1.86)	3.00 (1.86)	4.67 (2.26)	3.00 (1.86)	4.67 (2.26)	3.00 (1.86)	3.00 (1.86)
T ₁₄ Neem-A (3 sprays)	1.00 (1.22)	2.00 (1.58)	3.33 (1.93)	3.33 (1.93)	5.00 (2.34)	3.33 (1.93)	3.33 (1.93)	5.00 (2.34)	3.33 (1.93)	5.00 (2.34)	3.33 (1.93)	3.33 (1.68)
T ₁₅ Neem-B (Refined, 3 sprays)	1.33 (1.34)	2.00 (1.56)	3.33 (1.95)	3.33 (1.95)	5.33 (2.39)	3.33 (1.95)	3.33 (1.95)	5.33 (2.39)	3.33 (1.95)	5.33 (2.39)	3.33 (1.95)	2.67 (1.77)
T ₁₆ Chinaberry (3 sprays)	1.33 (1.34)	1.67 (1.46)	3.67 (2.03)	3.67 (2.03)	5.00 (2.34)	3.67 (2.03)	3.67 (2.03)	5.00 (2.34)	3.67 (2.03)	5.00 (2.34)	3.67 (2.03)	3.00 (1.86)
T ₁₇ Aak (3 sprays)	1.00 (1.22)	2.00 (1.58)	3.00 (1.86)	3.00 (1.86)	5.33 (2.41)	3.00 (1.86)	3.00 (1.86)	5.33 (2.41)	3.00 (1.86)	5.33 (2.41)	3.00 (1.86)	2.67 (1.77)
T ₁₈ Solvent + emulsifier (3 sprays)	1.33 (1.34)	2.33 (1.68)	3.67 (2.04)	3.67 (2.04)	5.67 (2.46)	3.67 (2.04)	3.67 (2.04)	5.67 (2.46)	3.67 (2.04)	5.67 (2.46)	3.67 (2.04)	3.33 (1.95)
T ₁₉ Control (untreated)	1.67 (1.46)	3.00 (1.87)	4.00 (2.11)	4.00 (2.11)	5.67 (2.47)	4.00 (2.11)	4.00 (2.11)	5.67 (2.47)	4.00 (2.11)	5.67 (2.47)	4.00 (2.11)	3.67 (2.03)
F Test	Sig*	Sig*	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig*
SEm±	{0.14}	{0.13}	{0.15}	{0.15}	{0.15}	{0.15}	{0.15}	{0.15}	{0.15}	{0.15}	{0.15}	{0.14}
CD (0.05)	{0.44}	{0.40}	{0.49}	{0.49}	{0.47}	{0.49}	{0.49}	{0.47}	{0.49}	{0.47}	{0.49}	{0.45}
CD (0.01)	{NS}	{NS}	{0.70}	{0.70}	{0.67}	{0.70}	{0.70}	{0.67}	{0.70}	{0.67}	{0.70}	{NS}

Note :

- (i) = DAS-Days after spraying
(ii) = Values in parenthesis are square root transformed
(iii) = **Significant at 1% level
(iv) = *Significant at 5% level
(v) = Transplanting date 27.7.1998

- (vi) = Ist spraying -20 DAT
(vii) = IInd spraying -40 DAT
(viii) = IIIrd spraying -60 DAT
(ix) = Dose of the treatments are mentioned in Table 2, Page 51

population of 1.00/5 hills was recorded in fenvalerate 3 sprays (T_9). Treatments of fenvalerate 2 sprays (T_{10}), quinalphos 3 sprays (T_8) and quinalphos 3 sprays (T_7) recorded 1.33/5 hills each and were found to be statistically on par with lowest rove beetle population treatment T_9 . Treatments of phorate + Dipel (T_6), phorate (T_4), carbofuran (T_1), diflubenzuron (T_{12}), Dipel + diflubenzuron (T_{13}), Neem-A (T_{14}), Dipel (T_{11}), chinaberry (T_{16}), Neem-B (Refined, T_{15}) and Aak (T_{17}) recorded population ranging from 3.67 to 5.33/5 hills and were found to be on par with both untreated control (T_{19}) and solvent + emulsifier (T_{18}). The effect of other insecticidal treatments can be seen from Table 11.

4.2.5.3 Third spray

Ten days after third spray, rove beetle population varied from 0.33 to 3.67/5 hills, with untreated control (T_{19}) recording highest (3.67/5 hills) while fenvalerate 2 sprays (T_{10}) recording lowest (0.33/5 hills). Only treatments of fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) and quinalphos 2 sprays (T_8) had rove beetle ranging from 0.67 to 1.00/5 hills and were found to be on par with treatment T_{10} . Among alternation treatments, Dipel + diflubenzuron (T_{13}), carbofuran + Dipel (T_3) and phorate + Dipel (T_6) had rove beetle population ranging from 3.00 to 2.67/5 hills and were found to be on par with untreated control (T_{19}). The population of rove beetle in all other treatments were found on par with untreated control (T_{19}), excepting the treatments of phorate (T_5) and diflubenzuron (T_{12}) (Table 11).

Overall picture regarding effect of various insecticides and biopesticides on rove beetle during *kharif* 1998 showed that in comparison with untreated control, botanicals and biopesticidal treatments,

synthetic insecticides recorded relatively low predator population throughout the spray period. Alternation treatments did not cause a significant difference in rove beetle population.

4.2.6 Effect of different insecticides and biopesticides on rove beetles during *kharif* 1999

4.2.6.1 First spray

Ten days after first spray, rove beetle population varied from 0.00 to 2.33/5 hills. Maximum population of 2.33/5 hills was observed in untreated control (T_{19}), quinalphos 2 sprays (T_8), (in which first spray was not applied) chinaberry (T_{16}) and solvent + emulsifier (T_{18}). Treatments of phorate (T_4), phorate + Dipel (T_6), diflubenzuron (T_{12}) (with 1.33/5 hills each), Neem-A (T_{14}), Dipel (T_{11}), carbofuran (T_1) (with 1.67/5 hills each), Dipel + diflubenzuron (T_{13}), Aak (T_{17}), fenvalerate 2 sprays (T_{10}) and Neem-B (Refined, T_{15}) (with 2.00/5 hills each) were found to be on par with highest rove beetle population treatments T_{19} , T_8 , T_{16} and T_{18} . Treatments of phorate (T_5) and carbofuran + Dipel (T_3) recorded 0.67/5 hills each and were found to be on par with fenvalerate 3 sprays (T_9) and quinalphos 3 sprays (T_7) which recorded nil population of the rove beetle.

Twenty days after first spray, rove beetle population ranged from 0.67 to 4.33/5 hills. Highest population of 4.33/5 hills was recorded in untreated control (T_{19}) while only 0.67/5 hills (lowest) was observed in fenvalerate 3 sprays (T_9). Treatments of phorate + Dipel (T_6), carbofuran (T_2), carbofuran + Dipel (T_3) (with 2.33/5 hills each), phorate (T_4), carbofuran (T_1) (with 2.67/5 hills), diflubenzuron (T_{12}) (with 3.00/

5 hills), Dipel + diflubenzuron (T_{13}) (3.33/5 hills), Dipel (T_{11}), Neem-A (T_{14}), quinalphos 2 sprays (T_8), chinaberry (T_{16}) (with 3.67/5 hills each), fenvalerate 2 sprays (T_{10}), Aak (T_{17}), solvent + emulsifier (T_{18}) and Neem-B (Refined, T_{15}) (with 4.00/5 hills each) were found to be on par with highest rove beetle population treatment viz., untreated control (T_{19}). Only one treatment, quinalphos 3 sprays (T_7) with 1.00/5 hills was on par with fenvalerate 3 sprays (T_9), which had lowest rove beetle population (Table 12).

4.2.6.2 Second spray

Ten days after second spray, rove beetle population varied from 1.00 to 6.33/5 hills. Highest population was recorded in untreated control (T_{19}) whereas lowest population was observed in quinalphos 3 sprays (T_7). Treatments of fenvalerate 3 sprays (T_9) (with 1.33/5 hills), fenvalerate 2 sprays (T_{10}), quinalphos 2 sprays (T_8) (with 1.67/5 hills each) were at par with T_7 . The rove beetle population decreased in treatments where second spray (which comprised first dose) was applied and were found to statistically on par with lowest population treatment quinalphos 3 sprays (T_7). Treatments of Dipel (T_{11}), Dipel + diflubenzuron (T_{13}), Neem-A (T_{14}), Neem-B (Refined, T_{15}), Aak (T_{17}), chinaberry (T_{16}) and solvent + emulsifier (T_{18}) recorded 4.33 to 6.00/5 hills and were found to be on par with untreated control (T_{19}). In all other insecticidal treatments recorded significantly lower population were recorded in comparison with untreated control (T_{19}).

Twenty days after second spray, there was a general increase in the population of rove beetle which ranged from 2.33 to 8.00/5 hills, with highest population of 8.00/5 hills being recorded in solvent +

Table 12. Effect of different insecticides and biopesticides on rove beetles during kharif 1999

Treatment	Rove beetle population/5 hills											
	I st spraying			II nd spraying			III rd spraying					
	10 DAS	20 DAS	2	10 DAS	20 DAS	4	10 DAS	20 DAS	5	10 DAS	20 DAS	6
T ₁ Carbofuran 3G	1.67 (1.46)	2.67 (1.77)	3.00 (1.85)	4.33 (2.19)	3.67 (2.02)	3.00 (1.77)	3.67 (2.03)	4.00 (2.11)	3.33 (1.93)	3.67 (2.00)	2.33 (1.67)	2.33 (1.67)
T ₂ Carbofuran 3G	1.00 (1.17)	2.33 (1.67)	2.67 (1.77)	3.67 (2.02)	3.00 (1.77)	3.67 (2.03)	4.00 (2.11)	3.33 (1.95)	3.67 (2.00)	3.00 (1.85)	1.33 (1.34)	1.33 (1.34)
T ₃ Carbofuran 3G + Dipel 8 L	0.67 (1.05)	2.33 (1.67)	3.33 (1.95)	4.00 (2.11)	4.00 (2.11)	3.33 (1.95)	4.00 (2.11)	3.33 (1.95)	4.00 (2.11)	4.00 (2.11)	2.00 (1.55)	2.00 (1.55)
T ₄ Phorate 10G	1.33 (1.34)	2.67 (1.76)	3.67 (2.03)	4.67 (2.25)	3.67 (2.03)	3.67 (2.03)	4.67 (2.25)	4.00 (2.11)	3.33 (1.93)	3.33 (1.93)	1.67 (1.44)	1.67 (1.44)
T ₅ Phorate 10G	0.67 (1.05)	2.00 (1.55)	3.33 (1.93)	4.00 (2.11)	4.00 (2.11)	3.33 (1.93)	4.00 (2.11)	3.33 (1.93)	2.67 (1.77)	2.67 (1.77)	1.00 (1.17)	1.00 (1.17)
T ₆ Phorate 10G + Dipel 8 L	1.33 (1.34)	2.33 (1.67)	3.33 (1.95)	4.33 (2.19)	3.33 (1.95)	3.33 (1.95)	4.33 (2.19)	4.00 (2.11)	3.67 (2.02)	3.67 (2.02)	1.67 (1.46)	1.67 (1.46)
T ₇ Quinalphos 25 EC (3 sprays)	0.00 (0.70)	1.00 (1.22)	1.00 (1.22)	2.33 (1.67)	1.00 (1.46)	1.00 (1.22)	2.33 (1.67)	2.33 (1.67)	1.67 (1.46)	1.67 (1.46)	0.67 (1.05)	0.67 (1.05)
T ₈ Quinalphos 25 EC (2 sprays)	2.33 (1.67)	3.67 (2.03)	1.67 (1.46)	2.67 (1.77)	1.67 (1.46)	1.67 (1.46)	2.67 (1.77)	2.33 (1.67)	2.33 (1.67)	2.33 (1.67)	1.33 (1.34)	1.33 (1.34)
T ₉ Fenvalerate 20 EC (3 sprays)	0.00 (0.70)	0.67 (1.05)	1.33 (1.34)	2.33 (1.67)	1.33 (1.34)	1.33 (1.34)	2.33 (1.67)	3.00 (1.85)	1.67 (1.46)	1.67 (1.46)	1.00 (1.17)	1.00 (1.17)
T ₁₀ Fenvalerate 20 EC (2 sprays)	2.00 (1.55)	4.00 (2.11)	1.67 (1.46)	3.00 (1.85)	1.67 (1.46)	1.67 (1.46)	3.00 (1.85)	3.00 (1.85)	2.33 (1.67)	2.33 (1.67)	1.00 (1.17)	1.00 (1.17)
T ₁₁ Dipel 8 L (3 sprays)	1.67 (1.46)	3.67 (2.00)	4.33 (2.18)	5.67 (2.46)	4.33 (2.18)	4.33 (2.18)	5.67 (2.46)	4.67 (2.24)	4.67 (2.24)	4.67 (2.24)	2.33 (1.67)	2.33 (1.67)
T ₁₂ Diflubenzuron 25% WP (3 sprays)	1.33 (1.34)	3.00 (1.85)	3.67 (2.03)	5.67 (2.47)	3.67 (2.03)	3.67 (2.03)	5.67 (2.47)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	1.67 (1.38)	1.67 (1.38)

Table contd.....

Treatment		Rove beetle population/5 hills												F Test	Non-Sig		
		I st spraying			II nd spraying			III rd spraying			Sig**	Sig*	Non-Sig				
		10 DAS	20 DAS	2	10 DAS	20 DAS	3	10 DAS	20 DAS	4						10 DAS	20 DAS
T ₁₃	Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	2.00 (1.55)	3.33 (1.95)	4.67 (2.25)	6.00 (2.51)	4.33 (2.18)	2.00 (1.58)										
T ₁₄	Neem-A (3 sprays)	1.67 (1.46)	3.67 (2.01)	5.00 (2.31)	6.67 (2.66)	5.33 (2.40)	2.00 (1.55)										
T ₁₅	Neem-B (Refined, 3 sprays)	2.00 (1.55)	4.00 (2.11)	5.33 (2.40)	6.00 (2.52)	5.00 (2.30)	2.33 (1.67)										
T ₁₆	Chinaberry (3 sprays)	2.33 (1.67)	3.67 (2.03)	5.67 (2.46)	6.33 (2.59)	4.67 (2.26)	2.33 (1.67)										
T ₁₇	Aak (3 sprays)	2.00 (1.55)	4.00 (2.11)	5.67 (2.44)	7.00 (2.72)	5.00 (2.33)	2.00 (1.55)										
T ₁₈	Solvent + emulsifier (3 sprays)	2.33 (1.67)	4.00 (2.11)	6.00 (2.54)	8.00 (2.90)	5.67 (2.47)	2.33 (1.67)										
T ₁₉	Control (untreated)	2.33 (1.67)	4.33 (2.15)	6.33 (2.60)	7.33 (2.79)	6.00 (2.53)	2.67 (1.77)										
		Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**
		(0.14)	(0.15)	(0.16)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)
		(0.44)	(0.49)	(0.51)	(0.55)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)	(0.56)
		(0.63)	(0.69)	(0.72)	(0.78)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)

Note :

- (i) = DAS-Days after spraying
(ii) = Values in parenthesis are square root transformed
(iii) = **Significant at 1% level
(iv) = *Significant at 5% level
(v) = Transplanting date 9.7.1999
(vi) = Ist spraying -20 DAT
(vii) = IInd spraying -40 DAT
(viii) = IIIrd spraying -60 DAT
(ix) = Dose of the treatments are mentioned in Table 2, Page 51

emulsifier (T₁₈) followed by untreated control (T₁₉) which recorded 7.33/5 hills while lowest population of 2.33/5 hills was observed in both fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇). Only treatments of quinalphos 2 sprays (T₈), fenvalerate 2 sprays (T₁₀), carbofuran (T₂), phorate (T₅), Dipel + diflubenzuron (T₁₃), phorate + Dipel (T₆) and carbofuran (T₁) recorded population ranging from 2.67 to 4.33/5 hills and were found to be on par with lowest population treatments (T₉ and T₇). Treatments of Dipel (T₁₁), diflubenzuron (T₁₂), Dipel + diflubenzuron (T₁₃), Neem-B (Refined, T₁₅), chinaberry (T₁₆), Neem-A (T₁₄) and Aak (T₁₇) had rove beetle population ranging from 5.67 to 7.00/5 hills and were on par with both untreated control (T₁₉) and solvent + emulsifier (T₁₈).

4.2.6.3 Third spray

Ten days after third spray, rove beetle population varied from 1.67 to 6.00/5 hills, with untreated control (T₁₉) recording highest and fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇) recording lowest population of 1.67/5 hills each. Among alternation treatments, Dipel + diflubenzuron (T₁₃) had highest population (4.33/5 hills) followed by carbofuran + Dipel (T₃) and phorate + Dipel (T₆) with 4.00 and 3.67 rove beetles/5 hills, respectively. Treatments of fenvalerate (T₁₀) 2 sprays, quinalphos 2 sprays (T₈) with 2.33/5 hills each, phorate (T₅) with 2.67/5 hills, carbofuran (T₂) with 3.00/5 hills, phorate (T₄) with 3.33/5 hills and carbofuran (T₁) with 3.67/5 hills were found to be on par with lowest rove beetle population treatments fenvalerate 3 sprays (T₉) and quinalphos 3 sprays (T₇). All other insecticidal treatment, which had rove beetle population ranging from 4.00 to 5.67/5 hills, were found to be on par with untreated control (T₁₉) (Table 12).

Twenty days after third spray, there was a general decrease in rove beetle population ranging from 0.67 to 2.67/5 hills with lowest population of 0.67/5 hills being observed in both fenvalerate 3 sprays (T_9) and quinalphos 3 sprays (T_7), while highest population of 2.67/5 hills was recorded in untreated control (T_{19}) with no significant differences among them.

Overall picture showed that untreated control, solvent + emulsifier, botanicals and biopesticide showed higher rove beetle population than synthetic insecticidal treatments. Alternation treatments did not result in a significant increase in this predator population even though they resulted in a slight increase in comparison with synthetic insecticides. Fenvalerate 3 sprays (T_9) and quinalphos 3 sprays (T_7) among synthetic insecticides showed lowest rove beetle population.

4.2.7 Effect of different insecticides and biopesticides on spiders during *kharif* 1998

4.2.7.1 First spray

Ten days after first spray, the population of spiders varied from 0.33 to 2.00/5 hills. Maximum population of 2.00/5 hills was recorded in each treatment *viz.*, fenvalerate 2 sprays (T_{10}) (in which first spray was not applied), untreated control (T_{19}), solvent + emulsifier (T_{18}) and quinalphos 2 sprays (T_8) (in which first spray was not applied), while minimum of 0.33/5 hills was observed in quinalphos 3 sprays (T_7). Treatments of fenvalerate 3 sprays (T_9), phorate + Dipel (T_6) (with 0.67/5 hills), carbofuran + Dipel (T_3), carbofuran (T_4), diflubenzuron (T_{12}) and phorate (T_5) (with 1.00/5 hills each) were found to be on par with lowest

Plate 10. Predator, long jawed spider on rice

Plate 11. Predator, *Lycosa pseudoannulata* on rice



Plate 12. Predator, Lynx spider on rice

Plate 13. Predator, spider on rice



Plate 14. Predator, spider on rice

Plate 15. Predator, spider on rice



spider population treatment quinalphos 3 sprays (T_7). All other treatments had spider population ranging from 1.33 to 1.67/5 hills and were on par with untreated control (T_{19}).

Twenty days after first spray, the population of spiders ranged from 0.67 to 3.67/5 hills, with highest population of 3.67/5 hills in both untreated control (T_{19}) and fenvalerate 2 sprays (T_{10}) (in which first spray was not applied) and lowest population of 0.67/5 hills in both fenvalerate 3 sprays (T_9) and quinalphos 3 sprays (T_7). Only one treatment viz., phorate (T_5) had recorded 1.67 spiders/5 hills and was found to be statistically on par with treatments T_9 and T_7 . All other treatments viz., carbofuran (T_2), phorate (T_4), phorate + Dipel (T_6), carbofuran + Dipel (T_3), carbofuran (T_1), diflubenzuron (T_{12}), Dipel + diflubenzuron (T_{13}), Aak (T_{17}), Neem-B (Refined, T_{15}), Neem-A (T_{14}), Dipel (T_{11}), chinaberry (T_{16}), quinalphos 2 sprays (T_8) and solvent + emulsifier (T_{18}) had spider population ranging from 2.00 to 3.33/5 hills and were found to statistically on par with both untreated control (T_{19}) and fenvalerate 2 sprays (T_{10}).

4.2.7.2 Second spray

Ten days after second spray, spider population ranged from 1.00 to 6.33/5 hills. Maximum population of 6.33/5 hills being recorded in untreated control (T_{19}) and minimum of 1.00/5 hills was observed in fenvalerate 3 sprays (T_9), fenvalerate 2 spray (T_{10}) and quinalphos 3 sprays (T_7). Treatments of quinalphos 2 sprays (T_8) and fenvalerate 2 sprays (T_{10}) in which second spray was applied, the spider population drastically decreased to 1.00/5 to 1.33/5 hills and was found to be on par with lowest population treatments T_9 and T_7 . Treatments which were

Table 13. Effect of different insecticides and biopesticides on spiders during kharif 1998

Treatment	Spider population/5 hills									
	I st spraying			II nd spraying			III rd spraying			
	10 DAS 1	20 DAS 2	10 DAS 3	20 DAS 4	10 DAS 5	20 DAS 6	10 DAS 7	20 DAS 8	10 DAS 9	
T ₁ Carbofuran 3G	1.00 (1.22)	2.67 (1.76)	4.00 (2.11)	5.33 (2.37)	3.00 (1.86)					
T ₂ Carbofuran 3G	1.33 (1.34)	2.00 (1.56)	3.33 (1.95)	4.00 (2.11)	2.33 (1.68)					
T ₃ Carbofuran 3G + Dipel 8 L	1.00 (1.17)	2.33 (1.68)	2.67 (1.77)	4.33 (2.18)	3.67 (2.04)					
T ₄ Phorate 10G	1.67 (1.46)	2.00 (1.58)	4.00 (2.11)	5.67 (2.46)	3.00 (1.86)					
T ₅ Phorate 10G	1.00 (1.22)	1.67 (1.46)	3.00 (1.84)	4.33 (2.18)	2.67 (1.76)					
T ₆ Phorate 10G + Dipel 8 L	0.67 (1.05)	2.33 (1.68)	3.33 (1.95)	5.00 (2.34)	3.33 (1.95)					
T ₇ Quinalphos 25 EC (3 sprays)	0.33 (0.88)	0.67 (1.05)	1.00 (1.22)	1.00 (1.22)	1.67 (1.46)					
T ₈ Quinalphos 25 EC (2 sprays)	2.00 (1.58)	3.33 (1.94)	1.33 (1.34)	1.33 (1.34)	2.33 (1.68)					
T ₉ Fenvalerate 20 EC (3 sprays)	0.67 (1.05)	0.67 (1.05)	1.00 (1.17)	1.33 (1.34)	1.67 (1.46)					
T ₁₀ Fenvalerate 20 EC (2 sprays)	2.00 (1.58)	3.67 (2.01)	1.00 (1.22)	1.67 (1.46)	2.00 (1.56)					
T ₁₁ Dipel 8 L (3 sprays)	1.67 (1.46)	3.00 (1.87)	4.67 (2.24)	6.33 (2.59)	3.67 (2.04)					
T ₁₂ Diflubenzuron 25% WP (3 sprays)	1.00 (1.22)	2.67 (1.76)	4.00 (2.11)	5.00 (2.32)	3.00 (1.86)					

Table contd.....

Treatment	Spider population/5 hills										
	I st spraying			II nd spraying			III rd spraying			Sig**	
	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS		
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	1.33 (1.34)	2.67 (1.76)	4.33 (2.18)	5.67 (2.47)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	
T ₁₄ Neem-A (3 sprays)	1.67 (1.46)	3.00 (1.86)	5.00 (2.33)	6.33 (2.60)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	
T ₁₅ Neem-B (Refined, 3 sprays)	1.33 (1.34)	3.00 (1.86)	5.33 (2.41)	6.33 (2.60)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	
T ₁₆ Chinaberry (3 sprays)	1.33 (1.34)	3.33 (1.93)	5.00 (2.34)	6.67 (2.66)	4.00 (2.12)	4.00 (2.12)	4.00 (2.12)	4.00 (2.12)	4.00 (2.12)	4.00 (2.12)	
T ₁₇ Aak (3 sprays)	1.67 (1.46)	3.00 (1.86)	5.67 (2.47)	6.00 (2.54)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	3.67 (2.04)	
T ₁₈ Solvent + emulsifier (3 sprays)	2.00 (1.58)	3.33 (1.95)	6.00 (2.54)	6.33 (2.60)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	4.33 (2.20)	
T ₁₉ Control (untreated)	2.00 (1.58)	3.67 (2.04)	6.33 (2.60)	7.00 (2.72)	5.00 (2.34)	5.00 (2.34)	5.00 (2.34)	5.00 (2.34)	5.00 (2.34)	5.00 (2.34)	
F Test	Sig*	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	Sig**	
SEM±	{0.11}	{0.15}	{0.15}	{0.18}	{0.12}	{0.12}	{0.12}	{0.12}	{0.12}	{0.12}	
CD (0.05)	{0.35}	{0.48}	{0.46}	{0.57}	{0.37}	{0.37}	{0.37}	{0.37}	{0.37}	{0.37}	
CD (0.01)	{NS}	{0.68}	{0.65}	{0.81}	{0.52}	{0.52}	{0.52}	{0.52}	{0.52}	{0.52}	

Note :

- (i) = DAS-Days after spraying
- (ii) = Values in parenthesis are square root transformed
- (iii) = **Significant at 1% level
- (iv) = *Significant at 5% level
- (v) = Transplanting date 27.7.1998

- (vi) = Ist spraying -20 DAT
- (vii) = IInd spraying -40 DAT
- (viii) = IIIrd spraying -60 DAT
- (ix) = Dose of the treatments are mentioned in Table 2, Page 51

on par with the highest spider population untreated control (T_{19}) included Dipel + diflubenzuron (T_{13}), Dipel (T_{11}), Neem-A (T_{14}) chinaberry (T_{16}), Neem-B (Refined, T_{15}), Aak (T_{17}) and solvent + emulsifier (T_{18}) which had spider population ranging from 4.33 to 6.00/5 hills. All other insecticidal treatments which had the spider population varying from 2.67 to 4.00/5 hills were observed to be significantly differing with untreated control (T_{19}) (Table 13).

Twenty days after second spray, spider population varied from 1.00 to 7.00/5 hills. Highest population of 7.00/5 hills was recorded in untreated control (T_{19}) followed by chinaberry (T_{16}) with 6.67/5 hills. Treatments of phorate (T_5), carbofuran + Dipel (T_3) with 4.33/5 hills, diflubenzuron (T_{12}), phorate + Dipel (T_6) with 5.00/5 hills each, carbofuran (T_1) with 5.33/5 hills, phorate (T_4), Dipel + diflubenzuron (T_{13}) with 5.67/5 hills, Aak (T_{17}) with 6.00/5 hills, Dipel (T_{11}), Neem-A (T_{14}), Neem-B (Refined, T_{15}) and solvent + emulsifier (T_{18}) with 6.33/5 hills each were found to be on par with highest population treatment T_{19} . Treatments of quinalphos 2 sprays (T_8), fenvalerate 3 sprays (T_9) 1.33/5 hills each, fenvalerate 2 sprays (T_{10}) with 1.67/5 hills were found to be statistically on par with lowest population treatment quinalphos 3 sprays (T_7) (1.00/5 hills).

4.2.7.3 Third spray

Ten days after third spray, spider population varied from 1.67 to 5.00/5 hills. Lowest spider population treatments were fenvalerate (T_9) 3 sprays and quinalphos 3 sprays (T_7) which had 1.67 spiders/5 hills each. Treatment which were on par with the lowest spider population treatments T_9 and T_7 included fenvalerate 2 sprays (T_{10}), quinalphos

2 sprays (T_8), carbofuran (T_2) and phorate (T_9) which had spider population ranging from 2.00 to 2.67/5 hills. Among alternation treatments two treatments *viz.*, Dipel + diflubenzuron (T_{13}) and carbofuran + Dipel (T_3) which had recorded 3.67 spiders/5 hills each were found to be on par with untreated control (T_{19}). Treatments of Aak (T_{17}), Dipel (T_{11}) with 3.67 spiders/5 hills, Neem-B (Refined, T_{15}), chinaberry (T_{16}) with 4.00/5 hills each, solvent + emulsifier (T_{18}) and Neem-A (T_{14}) with 4.33/5 hills each were on par with untreated control (T_{19}) which had highest spider population (5.00/5 hills). Other treatments *viz.*, phorate (T_4), diflubenzuron (T_{12}) and carbofuran (T_1) which had spider population of 3.00/5 hills each significantly differed from highest population treatment T_{19} .

The overall picture regarding the effect of insecticides and biopesticides on spider population during *kharif* 1998 showed that throughout the spray period, high spider population was recorded in untreated control and solvent + emulsifier. Treatments of fenvalerate 2 sprays (T_{10}) and quinalphos 2 sprays (T_8) in which first spray was not applied recorded high spider population initially. All botanicals and biopesticide registered higher spider population than synthetic insecticidal treatments. Alternation of treatments had no significant effect on increase in spider population. All synthetic insecticidal treatments showed low spider population in comparison with untreated control and botanical treatments.

4.2.8 Effect of different insecticides and biopesticides on spiders during *kharif*, 1999

4.2.8.1 First spray

Ten days after first spray, the population of spiders ranged from 0.33 to 3.67/5 hills. Maximum population of 3.67 spiders/5 hills was recorded in untreated control (T_{19}), quinalphos 2 sprays (T_8) (in which first spray was not applied) and solvent + emulsifier (T_{18}), while minimum population of 0.33/5 hills was recorded in fenvalerate 3 sprays (T_9). Treatments of diflubenzuron (T_{12}), Dipel + diflubenzuron (T_{13}), Dipel (T_{11}), Neem-B (Refined, T_{15}), Neem-A (T_{14}), fenvalerate 2 sprays (T_{10}) (in which first was not applied) and chinaberry (T_{16}) were found to be on par with highest spider population treatments (T_{19} , T_8 and T_{18}) by recording population ranging from 2.00 to 3.33 spiders/5 hills. Treatments which were on par with the lowest spider population treatment (T_9) (with 0.33/5 hills) included quinalphos 3 sprays (T_7), phorate (T_4) with 1.00/5 hills, phorate + Dipel (T_6) and carbofuran (T_2) with 1.33/5 hills each. Other insecticidal treatments viz., carbofuran (T_1), phorate (T_5) and carbofuran + Dipel (T_3) had spider population of 1.67/5 hills each and were significantly lower than untreated control (T_{19}).

Twenty days after first spray, spider population varied from a low of 1.67/5 hills in both fenvalerate 3 sprays (T_9) and quinalphos 3 sprays (T_7) to a high of 5.33/5 hills in untreated control (T_{19}). Only treatments of phorate + Dipel (T_6), carbofuran (T_2) (with 2.67/5 hills), carbofuran (T_1), phorate (T_5) and carbofuran + Dipel (T_3) (with 3.00/5 hills each) were on par with lowest population treatments fenvalerate 3 sprays (T_9)

and quinalphos 3 sprays (T_7). All other treatments had spider population ranging from 3.33 to 5.00/5 hills and were statistically on par with untreated control (T_{19}).

4.2.8.2 Second spray

Ten days after second spray, spider population ranged from 2.00 to 7.33/5 hills, with untreated control (T_{19}) recording highest and fenvalerate 3 sprays (T_9) recording lowest. Treatments of quinalphos 2 sprays (T_8) and fenvalerate 2 sprays (T_{10}) (where the second spray was applied) the spider population showed a high decrease and recorded 2.33 and 2.67 spiders/5 hills, respectively. These two treatments were now found to be statistically on par with lowest spider population treatment (T_9). Other treatments which were on par with fenvalerate 3 sprays (T_9), included quinalphos 3 sprays (T_7), carbofuran + Dipel (T_3), carbofuran (T_2), phorate (T_5), phorate (T_4) and phorate + Dipel (T_6) by recording from 2.67 to 3.67/5 hills. Treatments of Dipel (T_{11}), Dipel + diflubenzuron (T_{13}), Neem-A (T_{14}), Aak (T_{17}), Neem-B (Refined, T_{15}), chinaberry (T_{16}) and solvent + emulsifier (T_{18}) recorded the spider population ranging from 5.33 to 7.00/5 hills and were found to on par with untreated control (T_{19}) which showed highest spider population.

Twenty days after second spray, there was a general increase in spider population, which varied from 2.67 to 9.33/5 hills. All botanicals viz., Aak (T_{17}), Neem-B (Refined, T_{15}), chinaberry (T_{16}), Neem-A (T_{14}), biopesticidal treatment of Dipel (T_{11}) and Dipel + diflubenzuron (T_{13}) along with solvent + emulsifier (T_{18}) had 6.33 to 9.00 spiders/5 hills and were on par with untreated control (T_{19}) which has highest spider

Table 14. Effect of different insecticides and biopesticides on spiders during *kharif* 1999

Treatment	Spider population/5 hills											
	I st spraying			II nd spraying			III rd spraying					
	10 DAS	20 DAS	2	10 DAS	20 DAS	4	10 DAS	20 DAS	5	10 DAS	20 DAS	6
T ₁ Carbofuran 3G	1.67 (1.44)	3.00 (1.85)	4.00 (2.11)	4.67 (2.26)	3.00 (1.85)	3.00 (1.85)	3.00 (1.85)	3.00 (1.85)	3.00 (1.85)	3.00 (1.85)	2.33 (1.67)	2.33 (1.67)
T ₂ Carbofuran 3G	1.33 (1.34)	2.67 (1.77)	3.33 (1.93)	3.67 (2.03)	2.67 (1.77)	2.67 (1.77)	3.00 (1.85)	3.00 (1.85)	3.00 (1.85)	3.00 (1.85)	2.00 (1.55)	2.00 (1.55)
T ₃ Carbofuran 3G + Dipel 8 L	1.67 (1.46)	3.00 (1.85)	3.00 (1.85)	4.00 (2.09)	3.00 (1.85)	3.00 (1.85)	3.00 (1.85)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	3.00 (1.85)	3.00 (1.85)
T ₄ Phorate 10G	1.00 (1.17)	3.33 (1.95)	3.67 (2.02)	5.00 (2.33)	3.33 (1.95)	3.67 (2.02)	3.67 (2.02)	3.67 (2.02)	3.67 (2.02)	3.67 (2.02)	1.67 (1.44)	1.67 (1.44)
T ₅ Phorate 10G	1.67 (1.46)	3.00 (1.85)	3.33 (1.93)	4.67 (2.25)	3.00 (1.85)	3.33 (1.93)	3.67 (2.03)	3.00 (1.85)	3.00 (1.85)	4.00 (2.11)	2.67 (1.77)	2.67 (1.77)
T ₆ Phorate 10G + Dipel 8 L	1.33 (1.34)	2.67 (1.77)	3.67 (2.03)	4.33 (2.18)	2.67 (1.77)	3.67 (2.03)	3.67 (2.03)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	3.00 (1.85)	3.00 (1.85)
T ₇ Quinalphos 25 EC (3 sprays)	1.00 (1.17)	1.67 (1.46)	2.67 (1.76)	3.00 (1.85)	1.67 (1.46)	2.67 (1.76)	2.67 (1.76)	2.33 (1.67)	2.33 (1.67)	1.67 (1.44)	1.33 (1.29)	1.33 (1.29)
T ₈ Quinalphos 25 EC (2 sprays)	3.67 (2.02)	5.00 (2.33)	2.33 (1.67)	3.33 (1.95)	5.00 (2.33)	2.33 (1.67)	2.33 (1.67)	2.67 (1.77)	2.67 (1.77)	1.67 (1.44)	1.67 (1.44)	1.67 (1.44)
T ₉ Fenvalerate 20 EC (3 sprays)	0.33 (0.88)	1.67 (1.46)	2.00 (1.58)	2.67 (1.76)	1.67 (1.46)	2.00 (1.58)	2.00 (1.58)	1.67 (1.44)	1.67 (1.44)	1.67 (1.44)	1.00 (1.17)	1.00 (1.17)
T ₁₀ Fenvalerate 20 EC (2 sprays)	3.00 (1.85)	4.67 (2.26)	2.67 (1.76)	3.33 (1.95)	4.67 (2.26)	2.67 (1.76)	2.67 (1.76)	2.33 (1.67)	2.33 (1.67)	2.00 (1.55)	2.00 (1.55)	2.00 (1.55)
T ₁₁ Dipel 8 L (3 sprays)	2.67 (1.76)	4.00 (2.11)	5.33 (2.40)	6.67 (2.66)	4.00 (2.11)	5.33 (2.40)	5.33 (2.40)	4.00 (2.11)	4.00 (2.11)	4.00 (2.11)	3.00 (1.85)	3.00 (1.85)
T ₁₂ Diflubenzuron 25% WP (3 sprays)	2.00 (1.55)	3.67 (2.01)	4.67 (2.25)	6.00 (2.53)	3.67 (2.01)	4.67 (2.25)	4.67 (2.25)	3.67 (2.01)	3.67 (2.01)	3.67 (2.01)	2.33 (1.67)	2.33 (1.67)

Table contd.....

Treatment	Spider population/5 hills												F Test	Sig*	Sig**	Non sig
	I st spraying			II nd spraying			III rd spraying									
	10 DAS	20 DAS	2	10 DAS	20 DAS	4	10 DAS	20 DAS	5	20 DAS	6					
T ₁₃ Dipel 8 L (2 sprays) + diflubenzuron 25% WP (1 spray)	2.33 (1.67)	4.33 (2.18)	4.33 (2.18)	5.67 (2.47)	6.33 (2.60)	6.33 (2.60)	3.67 (2.03)	3.67 (2.03)	3.67 (2.03)	3.67 (2.03)	3.67 (2.03)	3.67 (2.03)	3.67 (2.03)			
T ₁₄ Neem-A (3 sprays)	3.00 (1.85)	4.33 (2.19)	4.33 (2.19)	6.00 (2.54)	7.00 (2.72)	7.00 (2.72)	4.33 (2.18)	4.33 (2.18)	4.33 (2.18)	4.33 (2.18)	4.33 (2.18)	4.33 (2.18)	4.33 (2.18)	3.00 (1.85)		
T ₁₅ Neem-B (Refined, 3 sprays)	3.00 (1.85)	4.67 (2.25)	4.67 (2.25)	6.33 (2.60)	7.33 (2.79)	7.33 (2.79)	4.67 (2.25)	4.67 (2.25)	4.67 (2.25)	4.67 (2.25)	4.67 (2.25)	4.67 (2.25)	4.67 (2.25)	3.67 (2.03)		
T ₁₆ Chinaberry (3 sprays)	3.33 (1.95)	4.33 (2.18)	4.33 (2.18)	6.67 (2.66)	7.33 (2.79)	7.33 (2.79)	5.00 (2.33)	5.00 (2.33)	5.00 (2.33)	5.00 (2.33)	5.00 (2.33)	5.00 (2.33)	5.00 (2.33)	3.00 (1.85)		
T ₁₇ Aak (3 sprays)	3.33 (1.95)	4.67 (2.26)	4.67 (2.26)	6.33 (2.60)	7.67 (2.84)	7.67 (2.84)	6.00 (2.54)	6.00 (2.54)	6.00 (2.54)	6.00 (2.54)	6.00 (2.54)	6.00 (2.54)	6.00 (2.54)	3.67 (2.03)		
T ₁₈ Solvent + emulsifier (3 sprays)	3.67 (2.01)	5.00 (2.31)	5.00 (2.31)	7.00 (2.72)	9.00 (3.07)	9.00 (3.07)	7.33 (2.78)	7.33 (2.78)	7.33 (2.78)	7.33 (2.78)	7.33 (2.78)	7.33 (2.78)	7.33 (2.78)	4.00 (2.08)		
T ₁₉ Control (untreated)	3.67 (2.03)	5.33 (2.40)	5.33 (2.40)	7.33 (2.79)	9.33 (3.13)	9.33 (3.13)	7.67 (2.84)	7.67 (2.84)	7.67 (2.84)	7.67 (2.84)	7.67 (2.84)	7.67 (2.84)	7.67 (2.84)	4.33 (2.18)		
SEm±	(0.16)	(0.15)	(0.15)	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	-		
CD (0.05)	(0.51)	(0.48)	(0.48)	(0.51)	(0.48)	(0.48)	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)	-		
CD (0.01)	(NS)	(NS)	(NS)	(0.72)	(0.69)	(0.69)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	-		

Note :

- (i) = DAS-Days after spraying
- (ii) = Values in parenthesis are square root transformed
- (iii) = **Significant at 1% level
- (iv) = *Significant at 5% level
- (v) = Transplanting date 9.7. 1999
- (vi) = Ist spraying - 20 DAT
- (vii) = IInd spraying - 40 DAT
- (viii) = IIIrd spraying - 60 DAT
- (ix) = Dose of the treatments are mentioned in Table 2, Page 51

population. Lowest population of 2.67/5 hills was observed in fenvalerate 3 sprays (T_9). Treatments of quinalphos 3 sprays (T_7) (with 3.00/5 hills), fenvalerate 2 sprays (T_{10}), quinalphos 2 sprays (T_8) (with 3.33/5 hills each), carbofuran (T_2) (with 3.67/5 hills), carbofuran + Dipel (T_3) (with 4.00/5 hills) and phorate + Dipel (T_6) (with 4.33/5 hills) were statistically on par with low spider population treatment T_9 . The effect of other insecticides on spiders can be seen from Table 14.

4.2.8.3 Third spray

Ten days after third spray, spider population ranged from 1.67 to 7.67/5 hills. Only two treatments *viz*, solvent + emulsifier (T_{18}) and Aak (T_{17}) (with 7.33 and 6.00 spiders/5 hills, respectively) were on par with highest spider population treatment *i.e.* untreated control (T_{19}) which recorded 7.67/5 hills. Among alternation treatments, both carbofuran + Dipel (T_3) and phorate + Dipel (T_6) recorded a high population with 4.00/5 hills followed by Dipel + diflubenzuron (T_{13}) with 3.67/5 hills. Treatments of fenvalerate 2 sprays (T_{10}), quinalphos 3 sprays (T_7) (with 2.33/5 hills), quinalphos 2 sprays (T_8) (with 2.67/5 hills), carbofuran (T_2), phorate (T_5) and carbofuran (T_1) (with 3.00/5 hills each) were on par with lowest population treatment fenvalerate 3 sprays (T_9) which had 1.67 spiders/5 hills. Other treatments recorded significantly higher population than (T_9) but at the same time population in these treatments was significantly lower than highest spiders population treatment (T_{19}). The effect of these treatments has been shown in Table 14.

Twenty days after third spray, there was general decrease in this natural enemy population which ranged from 1.00 to 4.33/5 hills with lowest population of 1.00/5 hills observed in fenvalerate 3 sprays (T_9),

while highest population of 4.33/5 hills recorded in untreated control (T_{19}) with no significant differences among them.

The overall effect of various insecticides and biopesticides on spiders during *kharif* 1999 showed that throughout the spray period, high spider population was recorded in untreated control (T_{19}) and solvent + emulsifier (T_{18}). All synthetic insecticidal treatments showed low spider population in comparison with untreated control, botanicals and biopesticidal treatment. Alternation treatments had no significant effect on increase in spider population.

4.3 IDENTIFICATION OF SOURCES OF RESISTANCE IN RICE AGAINST RICE LEAFFOLDER, *C. MEDINALIS*

The objective of this study was to evaluate 100 rice germplasms for their resistance to leaffoler, *Cnaphalocrocis medinalis* and also to find the correlation between morphological parameters *viz.*, leaf width, leaf length, plant height and texture of the leaf with leaffolder infestation.

The experiments were conducted during *kharif* 1998 and 1999 season, respectively for their performance against leaffolder, *C. medinalis* under natural infestation conditions. The investigations also included one susceptible variety (Pusa-169) which was used as check. Observations showed that there was considerable variation in the leaffolder incidence among the varieties. The leaffolder incidence was less during *kharif* 1998, in comparison with *kharif* 1999 season. The results of the present investigations are presented below.

4.3.1 Evaluation of rice germplasms for resistance to leafroller, *C. medinalis* during *kharif*, 1998

The incidence of rice leafroller was studied by recording the number of infested leaves and total number of leaves at two stages during crop period. Observations taken, one at panicle initiation and the other at physiological maturity. Mean of the two observations was calculated and per cent folded leaves were rated according to the *standard evaluation system for rice, IRRI* (Anonymous, 1996) (Table 3). The results obtained are presented in Table 15.

A total of 33 germplasms showed damage rating of 1, 56 germplasms showed damage rating of 3 while 12 germplasms exhibited damage rating of 5. Among the germplasms screened, highest infestation of 23.40 per cent folded leaves was recorded in Pusa 745.

4.3.2 Evaluation of rice germplasms for resistance to leafroller, *C. medinalis* during *kharif*, 1999

During 1999 also observation on infested leaves and total number of leaves were recorded in the same manner as was done during 1998. It may be seen from the data that there was considerable variation in the leafroller incidence during *kharif*, 1999. A total of 23 germplasms showed damage rating of 1, 45 germplasms showed damage rating of 3, 29 germplasms showed damage rating of 5 and 5 germplasms showed damage rating of 7. Maximum infestation of 39.65 per cent folded leaves was recorded in Pusa 745 (Table 16).

4.3.3 Damage rating for the two *kharif* seasons, 1998 and 1999

During both the years, twenty two germplasms *viz.*, IR-64-273, IR-

Table 15. Comparative performance of rice germplasms against rice leaffolder, *C. medinalis* during kharif 1998

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
0.	Pusa-169 (S)	12.72	18.64	15.68	3
1.	IET-4141	13.36	16.62	14.99	3
2.	Kolumbo mutant	8.11	14.29	11.20	3
3.	IR-52813-C3-150-1	12.67	13.81	13.24	3
4.	PTB-10	4.54	13.10	8.82	1
5.	IR-52813-C2-27-3	12.74	16.96	14.85	3
6.	IET-6155-399a	6.92	7.70	7.31	1
7.	Dwarf Mashuri	13.64	14.90	14.27	3
8.	Pusa-677	14.92	21.47	18.20	3
9.	IR-64-273	3.45	5.23	4.34	1
10.	IR-52813-C3-73-3	1.98	3.20	2.59	1
11.	Pusa-150-21-1	14.26	17.36	15.81	3
12.	IRAT-109	2.72	5.10	3.91	1
13.	Pant Dhan-10	10.65	14.15	12.40	3
14.	PAU-1628-23a	12.84	15.80	14.14	3
15.	Improved Sabarmati	4.55	6.79	5.60	1
16.	Pavizham	11.38	13.23	12.30	3
17.	Basmati-370	8.25	13.07	10.66	3
18.	Pusa-744-85-1240	3.29	4.27	3.78	1
19.	IR-52813-C3-75-3	2.58	3.20	2.89	1
20.	R-24-1	8.67	11.61	10.14	1
21.	Indrasan	6.10	11.16	8.63	1
22.	Karnal Local	10.79	15.17	12.98	3
23.	HKR-120	19.86	23.00	21.43	5
24.	Pusa-598-17	15.67	17.43	16.55	3
25.	Adt-34	5.46	6.52	5.99	1
26.	Lalnakanda	10.64	14.77	12.00	3
27.	Makam	12.43	16.65	14.54	3
28.	Bali-1	6.80	8.40	7.60	1

Table contd.....

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
29.	IR-52813-C3-124-3	6.25	7.21	6.73	1
30.	Aruna	11.74	14.20	12.97	3
31.	Ratna	8.65	13.25	10.95	3
32.	IR-19761-305	13.58	19.26	16.42	3
33.	IET-12604-4R	17.65	23.89	20.76	5
34.	IR-19761-282a	13.68	16.90	15.29	3
35.	IR-64	9.35	15.55	12.45	3
36.	Pusa-1021-5	6.27	9.37	7.82	1
37.	Pusa-33-2-77	12.86	18.60	15.73	3
38.	IR-52813-C4-111-1-2-2	13.59	21.71	17.65	3
39.	IRAT-144	7.20	9.68	8.44	1
40.	Mahsuri	10.82	18.76	14.79	3
41.	Pusa-150-21-1	20.78	22.34	21.56	5
42.	Pusa-1008-2-1-1-2	8.37	12.17	10.27	1
43.	Pusa-745	18.94	27.86	23.40	5
44.	Pusa-570	10.98	11.52	11.25	3
45.	Chan-Xiang Xian	2.48	3.57	2.98	1
46.	IR-28	1.64	2.72	2.18	1
47.	Rasi	11.73	13.33	12.53	3
48.	IR-52813-C3-99-3-3-3	3.14	2.96	3.05	1
49.	IR-54718-CO-104-2-2 (HB-6)	13.26	16.10	15.68	3
50.	Pusa-169 (S)	12.34	17.10	14.72	3
51.	Pusa-44-33	21.82	24.14	22.98	5
52.	Kanakam	8.96	13.74	11.35	3
53.	IR-52813-C3-62-3	18.65	24.21	21.43	5
54.	TCN-8-IET-13554 (HKR-90-414)	14.87	15.21	15.04	3
55.	Ranjani	19.80	22.32	21.06	5
56.	Pusa-1117-14-3	18.87	20.49	19.68	3
57.	HKR-119	16.39	23.81	20.10	5
58.	TCN-9-IET-13845 (BH-834-2)	2.14	3.34	2.74	1
59.	Jaya	14.45	20.85	17.47	3

Table contd.....

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
60.	IR-72	12.68	18.05	15.36	3
61.	Dular	1.98	2.18	2.08	1
62.	Giza-171	4.83	6.47	5.65	1
63.	Pusa-1022-97	9.82	14.10	11.96	3
64.	Pusa-702	13.85	20.07	16.96	3
65.	Pusa-743-1-1-23	8.37	14.39	11.38	3
66.	Pusa-836-202-208-207-2	12.92	12.38	12.65	3
67.	Basmati Dwarf	1.87	3.61	2.74	1
68.	Pusa-150-21-1-1-2-1	4.43	6.25	5.34	1
69.	IET-10649-1	13.00	10.24	11.62	3
70.	IET-10649-1 (early)	12.40	14.68	13.54	3
71.	Gharbharam	4.67	6.21	5.44	1
72.	Pattambi-29	1.22	2.62	1.92	1
73.	Vikramarya	16.36	23.30	19.83	3
74.	IR-36	18.58	26.22	22.40	5
75.	Pusa-702-1	12.49	16.23	14.36	3
76.	Pusa-560	5.26	7.28	6.27	1
77.	Pusa-703	11.42	13.66	12.54	3
78.	Pusa-835-203-213-102	17.82	24.22	21.02	5
79.	PAU-1126	13.57	15.39	14.48	3
80.	P-107792-157-1	17.32	25.72	21.52	5
81.	IR-52813-C3-146-2	8.73	10.57	9.65	1
82.	Pusa-205-6-4	6.54	8.24	7.39	1
83.	Ramya	7.88	14.63	11.25	3
84.	Pusa-588-13	11.67	15.49	13.58	3
85.	PAU-1628	15.25	17.61	16.43	3
86.	IR-50	1.84	2.50	2.17	1
87.	Tainan-3	4.72	7.58	6.15	1
88.	Pusa-205-275	12.36	17.30	14.83	3
89.	Pusa-835-203-2-103-33	10.86	14.58	12.72	3

Table contd.....

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
90.	Pusa-598-12-5-844-303	8.72	15.96	12.35	3
91.	IRAT-141	14.58	21.96	18.27	3
92.	IR-19761-283a	7.28	8.30	7.79	1
93.	Kartika	10.95	12.35	11.65	3
94.	Usha Barabanki	6.55	10.17	8.36	1
95.	Pusa-615	15.25	21.15	18.20	3
96.	Pusa-1187-72-1	14.97	17.96	16.48	3
97.	Pusa-1007-24	10.52	17.40	13.96	3
98.	Pusa-1120-7-3	4.76	8.94	6.85	1
99.	IET-12604-3r	12.67	16.59	14.53	3
100.	Pusa-834-204-207-202-2-1	19.43	23.85	21.64	5
101.	Asha	6.92	11.76	9.34	1
102.	Pusa-169 (S)	15.56	23.88	19.72	3

Note :

- (i) : Date of sowing 18.7.1998
(ii) : ^a : By standard evaluation system for rice
(iii) : **S** : Susceptible

Table 16. Comparative performance of rice germplasms against rice leaffolder, *C. medinalis* during kharif 1999

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
0.	Pusa-169 (S)	16.79	22.64	19.71	3
1.	IET-4141	22.53	26.95	24.74	5
2.	Kolumbo mutant	10.80	13.92	12.36	3
3.	IR-52813-C3-150-1	14.65	21.83	18.24	3
4.	PTB-10	11.65	17.76	14.72	3
5.	IR-52813-C2-27-3	14.23	19.25	16.74	3
6.	IET-6155-399a	17.29	19.33	18.31	3
7.	Dwarf Mashuri	19.78	22.96	21.37	5
8.	Pusa-677	20.43	24.85	22.64	5
9.	IR-64-273	6.52	5.88	6.20	1
10.	IR-52813-C3-73-3	2.87	3.67	3.27	1
11.	Pusa-150-21-1	21.75	22.89	22.32	5
12.	IRAT-109	4.69	3.85	4.27	1
13.	Pant Dhan-10	12.35	18.51	15.43	3
14.	PAU-1628-23a	22.72	25.00	23.86	5
15.	Improved Sabarmati	10.82	13.48	12.15	3
16.	Pavizham	13.87	14.77	14.32	3
17.	Basmati-370	8.79	14.89	11.84	3
18.	Pusa-744-85-1240	4.64	6.60	5.62	1
19.	IR-52813-C3-75-3	1.89	4.21	3.05	1
20.	R-24-1	16.24	19.02	17.63	3
21.	Indrasan	12.38	17.10	14.74	3
22.	Karnal Local	17.34	19.16	18.25	3
23.	HKR-120	21.54	25.68	23.61	5
24.	Pusa-598-17	21.83	24.65	23.24	5
25.	Adt-34	5.57	8.59	7.08	1
26.	Lalnakanda	13.70	23.05	18.38	3
27.	Makam	12.48	18.84	15.66	3
28.	Bali-1	8.57	14.99	11.78	3

Table contd.....

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
29.	IR-52813-C3-124-3	9.21	7.43	8.32	1
30.	Aruna	19.26	25.10	22.18	5
31.	Ratna	13.63	10.49	12.06	3
32.	IR-19761-305	21.72	23.78	22.75	5
33.	IET-12604-4R	23.63	29.23	26.43	5
34.	IR-19761-282a	23.05	24.12	23.59	5
35.	IR-64	14.42	16.20	15.31	3
36.	Pusa-1021-5	11.83	13.29	12.56	3
37.	Pusa-33-2-77	17.58	18.44	18.36	3
38.	IR-52813-C4-111-1-2-2	23.76	24.94	24.35	5
39.	IRAT-144	10.10	12.36	11.23	3
40.	Mahsuri	17.82	20.30	19.06	3
41.	Pusa-150-21-1	36.49	39.39	37.94	7
42.	Pusa-1008-2-1-1-2	16.37	20.17	18.27	3
43.	Pusa-745	36.94	42.36	39.65	7
44.	Pusa-570	12.48	14.62	13.55	3
45.	Chan-Xiang Xian	3.74	4.50	4.12	1
46.	IR-28	2.23	4.79	3.51	1
47.	Rasi	21.42	22.36	21.89	5
48.	IR-52813-C3-99-3-3-3	4.95	6.79	5.87	1
49.	IR-54718-CO-104-2-2 (HB-6)	9.89	8.95	9.42	1
50.	Pusa-169 (S)	17.86	25.00	21.43	5
51.	Pusa-44-33	27.65	28.82	28.24	5
52.	Kanakam	13.52	20.28	16.90	3
53.	IR-52813-C3-62-3	35.67	38.81	37.24	7
54.	TCN-8-IET-13554 (HKR-90-414)	17.27	22.45	19.86	3
55.	Ranjani	26.94	32.30	29.62	5
56.	Pusa-1117-14-3	27.83	31.61	29.72	5
57.	HKR-119	34.23	32.65	33.44	5
58.	TCN-9-IET-13845 (BH-834-2)	2.31	4.87	3.59	1
59.	Jaya	18.82	25.94	22.38	5

Table contd.....

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
60.	IR-72	20.97	27.35	24.16	5
61.	Dular	2.76	6.10	4.43	1
62.	Giza-171	6.43	9.23	7.83	1
63.	Pusa-1022-97	10.39	12.15	11.27	3
64.	Pusa-702	24.63	31.37	28.00	5
65.	Pusa-743-1-1-23	11.67	12.87	12.27	3
66.	Pusa-836-202-208-207-2	16.82	20.30	18.56	3
67.	Basmati Dwarf	5.44	6.52	5.98	1
68.	Pusa-150-21-1-1-2-1	4.84	8.68	6.76	1
69.	IET-10649-1	13.25	12.49	12.87	3
70.	IET-10649-1 (early)	12.34	16.39	14.36	3
71.	Gharbharam	8.34	10.04	9.19	1
72.	Pattambi-29	2.18	4.62	3.40	1
73.	Vikramarya	24.73	27.65	26.19	5
74.	IR-36	34.85	36.31	35.58	7
75.	Pusa-702-1	15.64	18.40	17.02	3
76.	Pusa-560	12.95	15.73	14.34	3
77.	Pusa-703	6.54	9.90	8.22	1
78.	Pusa-835-203-213-102	24.42	22.66	23.54	5
79.	PAU-1126	14.97	21.55	18.26	3
80.	P-107792-157-1	23.58	27.28	25.43	5
81.	IR-52813-C3-146-2	12.65	19.95	16.30	3
82.	Pusa-205-6-4	12.74	19.90	16.32	3
83.	Ramya	14.64	19.22	16.93	3
84.	Pusa-588-13	17.95	21.81	19.88	3
85.	PAU-1628	20.76	21.73	21.24	5
86.	IR-50	3.84	5.80	4.82	1
87.	Tainan-3	4.65	8.83	6.74	1
88.	Pusa-205-275	20.97	26.15	23.56	5
89.	Pusa-835-203-2-103-33	10.68	17.39	14.03	3

Table contd.....

S. No.	Germplasm	Per cent folded leaves		Mean	Rating ^a
		I st observation panicle initiation	II nd observation physio- logical maturity		
90.	Pusa-598-12-5-844-303	16.78	18.47	17.63	3
91.	IRAT-141	18.34	20.42	26.38	5
92.	IR-19761-283a	9.85	10.19	10.02	1
93.	Kartika	16.28	19.40	17.84	3
94.	Usha Barabanki	7.31	8.53	7.92	1
95.	Pusa-615	21.74	26.40	24.07	5
96.	Pusa-1187-72-1	21.69	23.37	22.53	5
97.	Pusa-1007-24	16.45	19.63	18.04	3
98.	Pusa-1120-7-3	5.89	14.93	10.41	1
99.	IET-12604-3r	16.44	23.34	19.89	3
100.	Pusa-834-204-207-202-2-1	32.48	38.00	35.24	5
101.	Asha	16.18	19.03	17.61	3
102.	Pusa-169 (S)	21.37	27.81	24.59	5

Note :

(i) : Date of sowing 19.6.1999

(ii) : ^a : By standard evaluation system for rice(iii) : **S : Susceptible**

Table 17. Damage rating of rice germplasms for *kharif*, 1998 and 1999

S. No.	Germplasm	Damage rating ^a (1998)	Damage rating ^a (1999)
0.	Pusa-169 (S)	3	3
1.	IET-4141	3	5
2.	Kolumbo mutant	3	3
3.	IR-52813-C3-150-1	3	3
4.	PTB-10	1	3
5.	IR-52813-C2-27-3	3	3
6.	IET-6155-399a	1	3
7.	Dwarf Mashuri	3	5
8.	Pusa-677	3	5
9.	IR-64-273	1	1
10.	IR-52813-C3-73-3	1	1
11.	Pusa-150-21-1	3	5
12.	IRAT-109	1	1
13.	Pant Dhan-10	3	3
14.	PAU-1628-23a	3	5
15.	Improved Sabarmati	1	3
16.	Pavizham	3	3
17.	Basmati-370	3	3
18.	Pusa-744-85-1240	1	1
19.	IR-52813-C3-75-3	1	1
20.	R-24-1	1	3
21.	Indrasan	1	3
22.	Karnal Local	3	3
23.	HKR-120	5	5
24.	Pusa-598-17	3	5
25.	Adt-34	1	1
26.	Lalnakanda	3	3
27.	Makam	3	3
28.	Bali-1	1	3
29.	IR-52813-C3-124-3	1	1

Table contd.....

S. No.	Germplasm	Damage rating ^a (1998)	Damage rating ^a (1999)
30.	Aruna	3	5
31.	Ratna	3	3
32.	IR-19761-305	3	5
33.	IET-12604-4R	5	5
34.	IR-19761-282a	3	5
35.	IR-64	3	3
36.	Pusa-1021-5	1	3
37.	Pusa-33-2-77	3	3
38.	IR-52813-C4-111-1-2-2	3	5
39.	IRAT-144	1	3
40.	Mahsuri	3	3
41.	Pusa-150-21-1	5	7
42.	Pusa-1008-2-1-1-2	1	3
43.	Pusa-745	5	7
44.	Pusa-570	3	3
45.	Chan-Xiang Xian	1	1
46.	IR-28	1	1
47.	Rasi	3	5
48.	IR-52813-C3-99-3-3-3	1	1
49.	IR-54718-CO-104-2-2 (HB-6)	3	1
50.	Pusa-169 (S)	3	5
51.	Pusa-44-33	5	5
52.	Kanakam	3	3
53.	IR-52813-C3-62-3	5	7
54.	TCN-8-IET-13554 (HKR-90-414)	3	3
55.	Ranjani	5	5
56.	Pusa-1117-14-3	3	5
57.	HKR-119	5	5
58.	TCN-9-IET-13845 (BH-834-2)	1	1
59.	Jaya	3	5
60.	IR-72	3	5
61.	Dular	1	1

Table contd.....

S. No.	Germplasm	Damage rating ^a (1998)	Damage rating ^a (1999)
62.	Giza-171	1	1
63.	Pusa-1022-97	3	3
64.	Pusa-702	3	5
65.	Pusa-743-1-1-23	3	3
66.	Pusa-836-202-208-207-2	3	3
67.	Basmati Dwarf	1	1
68.	Pusa-150-21-1-1-2-1	1	1
69.	IET-10649-1	3	3
70.	IET-10649-1 (early)	3	3
71.	Gharbharam	1	1
72.	Pattambi-29	1	1
73.	Vikramarya	3	5
74.	IR-36	5	7
75.	Pusa-702-1	3	3
76.	Pusa-560	1	3
77.	Pusa-703	3	1
78.	Pusa-835-203-213-102	5	5
79.	PAU-1126	3	3
80.	P-107792-157-1	5	5
81.	IR-52813-C3-146-2	1	3
82.	Pusa-205-6-4	1	3
83.	Ramya	3	3
84.	Pusa-588-13	3	3
85.	PAU-1628	3	5
86.	IR-50	1	1
87.	Tainan-3	1	1
88.	Pusa-205-275	3	5
89.	Pusa-835-203-2-103-33	3	3
90.	Pusa-598-12-5-844-303	3	3
91.	IRAT-141	3	5
92.	IR-19761-283a	1	1
93.	Kartika	3	3

Table contd.....

S. No.	Germplasm	Damage rating ^a (1998)	Damage rating ^a (1999)
94.	Usha Barabanki	1	1
95.	Pusa-615	3	5
96.	Pusa-1187-72-1	3	5
97.	Pusa-1007-24	3	3
98.	Pusa-1120-7-3	1	1
99.	IET-12604-3r	3	3
100.	Pusa-834-204-207-202-2-1	5	5
101.	Asha	1	3
102.	Pusa-169 (S)	3	5

Note :(i) **S : Susceptible**(ii) ^a : By the standard evaluation system for rice

52813-C3-73-3, IRAT-109, Pusa-744-85-1240, IR-52813-C3-75-3, Adt-34, IR-52813-C3-124-3, Chan-xiang xian, IR-28, IR-52813-C3-99-3-3-3, TCN-9 IET-13845 (BH-834-2), Dular, Giza 171, Basmati Dwarf, Pusa-150-21-1-1-2-1, Gharbharam, Pattambi-29, IR-50, Tainan-3, IR-19761-283a, Usha Barabanki and Pusa-1120-7-3 recorded consistent damage rating of 1. Thirty germplasms *viz.*, Kolumbo mutant, IR-52813-C3-150-1, IR-52813-C2-27-3, Pant Dhan-10, Pavizham, Basmati-370, Karnal Local, Lalnakanda, Makam, Ratna, IR-64, Pusa-33-2-77, Mahsuri, Pusa-570, Kanakam, TCN-8 IET-13554 (HKR-90-414), Pusa-1022-97, Pusa-743-1-1-23, Pusa-836-202-208-207-2, IET-10649-1, IET-10649-1 (early), Pusa-702-1, PAU-1126, Ramya, Pusa-588-13, Pusa-835-203-2-103-33, Pusa-598-12-5-844-303, Kartika, Pusa-1007-24 and IET-12604-3r recorded consistent damage rating of 3. Eight germplasms *viz.*, HKR-120, IET-12604-4R, Pusa-44-33, Ranjani, HKR-119, Pusa-835-203-213-102, P-107792-157-1 and Pusa-834-204-207-202-2-1 showed consistent damage rating of 5 during both the years, while Pusa-150-21-1, Pusa-745, IR-52813-C3-62-3 and IR-36 exhibited damage rating of 5 in *kharif*, 1998 and 7 in *kharif*, 1999 (Table 17).

4.3.4 Correlation studies between infested leaves and leaf width, leaf length, texture of the leaf and plant height during 1998 and 1999

The present investigations revealed that among morphological characters of rice plant like plant height, leaf width, leaf length and texture of the leaf, only leaf width played a prominent role in deciding the resistance of the germplasms to leaf folder incidence.

Results revealed that during both the years, there was significant correlation between leaf width and per cent infested leaves ($r = 0.251^{**}$ and 0.326^{**}), but no significant correlation was observed between per cent infested leaves and leaf length, plant height ($r = -0.015$ and 0.043 ; -0.088 and 0.061 , respectively).

4.3.4.1 Leaf width, texture of leaf and per cent infested leaves

Significant correlation was observed between leaf width and infested leaves. The germplasms viz., IR-64-273, IR-52813-C3-73-3, Pusa-744-85-1240, IR-52813-C3-75-3, IR-52813-C3-124-3, IR-28, IR-52813-C3-99-3-3-3, TCN-9 IET-13845 (HB-834-2), Giza-171, Basmati Dwarf, IR-50 and Pusa-1120-7-3 recorded damage rating 1 (resistant) with minimum leaf width *i.e.* had narrow leaves (0.98 to 1.10 cm). All the above mentioned germplasms, except IR-52813-C3-73-3, Pusa-744-85-1240, IR-52813-C3-99-3-3-3 and Giza-171 had rough leaf texture. Exceptionally lowest infestation was recorded in Pattambi-29 germplasm, even though it has high leaf width (1.35 cm). During both the years eight germplasms which had a common damage rating of 5 (moderately susceptible) had leaf width which was 1.34 cm or more. Except HKR-120 and Pusa-835-203-213-102 which had rough texture all other germplasms had smooth leaf texture. During 1999, twenty one germplasms viz., IET-4141, Dwarf Mashuri, Pusa-677, Pusa-150-21-1, IR-52813-C3-73-3, PAU-1628-23a, Pusa-598-17, Aruna, IR-19761-305, IR-19761-282a, IR-52813-C4-111-1-2-2, Rasi, Pusa-1117-14-3, Jaya, IR-72, Pusa-702, Vikramarya, PAU-1628, Pusa-205-275, IRAT-141, Pusa-615 and Pusa-1187-72-1 recorded damage rating of 5 (moderately susceptible) with the same leaf width *i.e.* 1.34 cm or more. All the above

Table 18. Studies on correlation between per cent infested leaves and plant height, leaf width, leaf length, texture of leaf during *kharif* 1998

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Texture of leaf
0.	Pusa-169 (S)	15.68	85.85	1.38	26.71	R
1.	IET-4141	14.99	79.30	1.62	30.87	S
2.	Kolumbo mutant	11.20	87.90	1.32	30.50	R
3.	IR-52813-C3-150-1	13.24	77.60	1.41	34.55	R
4.	PTB-10	8.82	120.05	1.23	39.32	R
5.	IR-52813-C2-27-3	14.85	88.70	1.42	37.83	S
6.	IET-6155-399a	7.31	73.85	1.47	36.02	R
7.	Dwarf Mashuri	14.27	77.80	1.40	25.79	S
8.	Pusa-677	18.20	75.90	1.36	25.58	S
9.	IR-64-273	4.34	72.90	1.04	24.02	R
10.	IR-52813-C3-73-3	2.59	84.30	0.98	27.35	S
11.	Pusa-150-21-1	15.81	92.50	1.62	29.69	S
12.	IRAT-109	3.91	108.80	1.67	30.57	R
13.	Pant Dhan-10	12.40	89.95	1.40	31.08	R
14.	PAU-1628-23a	14.14	86.40	1.45	29.57	S
15.	Improved Sabarmati	5.60	91.55	1.69	33.83	R
16.	Pavizham	12.30	88.10	1.55	32.18	R
17.	Basmati-370	10.66	128.30	1.35	44.58	R
18.	Pusa-744-85-1240	3.78	93.80	1.08	32.58	S
19.	IR-52813-C3-75-3	2.89	80.90	1.00	31.72	R
20.	R-24-1	10.14	99.60	1.68	37.91	R
21.	Indrasan	8.63	110.65	1.78	31.36	S
22.	Karnal Local	12.98	105.95	1.73	39.14	S
23.	HKR-120	21.43	92.90	1.53	25.21	R
24.	Pusa-598-17	16.55	91.90	1.35	33.31	S
25.	Adt-34	5.99	106.15	1.30	29.41	R
26.	Lalnakanda	12.00	102.80	1.31	33.05	S
27.	Makam	14.54	79.80	1.35	28.85	R
28.	Bali-1	7.60	140.05	2.15	39.55	R
29.	IR-52813-C3-124-3	6.73	78.90	1.06	31.11	R

Table contd.....

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Text-ure of leaf
30.	Aruna	12.97	92.30	1.43	30.19	R
31.	Ratna	10.95	86.60	1.30	32.83	R
32.	IR-19761-305	16.42	89.00	1.42	31.45	R
33.	IET-12604-4R	20.76	111.22	1.59	39.96	S
34.	IR-19761-282a	15.29	99.10	1.47	43.48	S
35.	IR-64	12.45	85.90	1.29	27.52	S
36.	Pusa-1021-5	7.82	110.50	2.30	31.72	R
37.	Pusa-33-2-77	15.73	84.00	1.37	32.95	R
38.	IR-52813-C4-111-1-2-2	17.65	100.60	1.58	42.37	R
39.	IRAT-144	8.44	110.20	1.79	46.58	S
40.	Mahsuri	14.79	114.00	1.60	38.61	R
41.	Pusa-150-21-1	21.56	80.20	1.62	30.41	S
42.	Pusa-1008-2-1-1-2	10.27	110.85	2.04	39.45	R
43.	Pusa-745	23.40	95.40	1.60	28.22	S
44.	Pusa-570	11.25	145.80	1.77	36.40	S
45.	Chan-Xiang Xian	2.98	106.60	1.62	24.69	R
46.	IR-28	2.18	84.60	1.00	30.53	R
47.	Rasi	12.53	92.00	1.43	29.78	S
48.	IR-52813-C3-99-3-3-3	3.05	76.30	1.05	27.92	S
49.	IR-54718-CO-104-2-2 (HB-6)	15.68	94.70	1.25	30.30	R
50.	Pusa-169 (S)	14.72	78.50	1.42	26.35	R
51.	Pusa-44-33	22.98	80.20	1.55	35.73	S
52.	Kanakam	11.35	93.00	1.54	32.32	R
53.	IR-52813-C3-62-3	21.43	86.80	1.45	30.83	S
54.	TCN-8-IET-13554 (HKR-90-414)	15.04	111.70	1.67	37.86	R
55.	Ranjani	21.06	84.30	1.68	34.13	S
56.	Pusa-1117-14-3	19.68	97.70	1.65	38.36	S
57.	HKR-119	20.10	86.40	1.52	36.89	S
58.	TCN-9-IET-13845 (BH-834-2)	2.74	103.80	1.06	34.07	R
59.	Jaya	17.47	97.10	1.65	29.79	S
60.	IR-72	15.36	72.90	1.55	33.80	S
61.	Dular	2.08	140.40	1.78	38.33	R

Table contd.....

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Text-ure of leaf
62.	Giza-171	5.65	94.00	1.00	28.75	S
63.	Pusa-1022-97	11.96	85.90	1.20	29.05	R
64.	Pusa-702	16.96	100.00	1.55	43.20	S
65.	Pusa-743-1-1-23	11.38	85.10	1.65	28.53	S
66.	Pusa-836-202-208-207-2	12.65	88.10	1.33	28.22	S
67.	Basmati Dwarf	2.74	94.40	1.09	32.48	R
68.	Pusa-150-21-1-1-2-1	5.34	83.00	1.29	32.15	R
69.	IET-10649-1	11.62	89.00	1.31	28.59	R
70.	IET-10649-1 (early)	13.54	92.50	1.34	35.24	R
71.	Gharbharam	5.44	137.20	1.70	47.90	R
72.	Pattambi-29	1.92	131.50	1.35	36.50	R
73.	Vikramarya	19.83	83.70	1.47	29.69	S
74.	IR-36	22.40	76.80	1.40	30.97	S
75.	Pusa-702-1	14.36	93.10	1.35	32.54	S
76.	Pusa-560	6.27	106.50	1.66	35.29	R
77.	Pusa-703	12.54	89.30	1.20	34.34	R
78.	Pusa-835-203-213-102	21.02	91.60	1.38	27.62	R
79.	PAU-1126	14.48	83.10	1.60	30.60	R
80.	P-107792-157-1	21.52	100.40	1.63	35.09	S
81.	IR-52813-C3-146-2	9.65	90.70	1.55	31.69	R
82.	Pusa-205-6-4	7.39	81.80	1.49	34.41	R
83.	Ramya	11.25	85.00	1.50	31.29	R
84.	Pusa-588-13	13.58	88.40	1.90	38.51	R
85.	PAU-1628	16.43	81.10	1.41	30.47	R
86.	IR-50	2.17	73.90	0.99	28.47	R
87.	Tainan-3	6.15	106.30	1.43	35.97	S
88.	Pusa-205-275	14.83	90.80	1.75	33.50	S
89.	Pusa-835-203-2-103-33	12.72	91.30	1.19	30.40	R
90.	Pusa-598-12-5-844-303	12.35	97.00	1.45	31.70	R
91.	IRAT-141	18.27	89.80	1.53	27.71	S
92.	IR-19761-283a	7.79	79.60	1.26	34.39	R
93.	Kartika	11.65	70.50	1.52	26.39	R

Table contd.....

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Text-ure of leaf
94.	Usha Barabanki	8.36	117.60	1.60	37.57	R
95.	Pusa-615	18.20	78.60	1.20	31.17	S
96.	Pusa-1187-72-1	16.48	91.90	1.49	38.48	S
97.	Pusa-1007-24	13.96	95.60	2.05	33.30	R
98.	Pusa-1120-7-3	6.85	94.70	1.00	26.64	R
99.	IET-12604-3r	14.53	81.90	1.35	27.29	S
100.	Pusa-834-204-207-202-2-1	21.64	87.80	1.48	30.24	S
101.	Asha	9.34	77.00	1.73	29.80	R
102.	Pusa-169 (S)	19.72	71.70	1.42	25.72	R
r value			0.043	0.251**	-0.015	

Note :**(S) = Susceptible**

R = Rough

S = Smooth

** = Significant at 1% level

Table 19. Studies on correlation between per cent infested leaves and plant height, leaf width, leaf length, texture of leaf during *kharif* 1999

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Texture of leaf
0.	Pusa-169 (S)	19.71	88.07	1.40	26.65	R
1.	IET-4141	24.74	86.87	1.65	34.88	S
2.	Kolumbo mutant	12.36	83.20	1.30	26.74	R
3.	IR-52813-C3-150-1	18.24	79.60	1.38	28.72	R
4.	PTB-10	14.72	119.00	1.27	36.07	R
5.	IR-52813-C2-27-3	16.74	93.00	1.43	36.08	S
6.	IET-6155-399a	18.31	82.53	1.49	34.96	R
7.	Dwarf Mashuri	21.37	80.00	1.45	26.52	S
8.	Pusa-677	22.64	80.07	1.34	23.97	S
9.	IR-64-273	6.20	69.80	1.07	26.69	R
10.	IR-52813-C3-73-3	3.27	86.13	1.02	25.00	S
11.	Pusa-150-21-1	22.32	95.00	1.59	25.67	S
12.	IRAT-109	4.27	105.20	1.68	30.03	R
13.	Pant Dhan-10	15.43	90.53	1.43	29.27	R
14.	PAU-1628-23a	23.86	92.00	1.40	31.96	S
15.	Improved Sabarmati	12.15	93.00	1.73	36.11	R
16.	Pavizham	14.32	92.80	1.52	31.50	R
17.	Basmati-370	11.84	127.90	1.25	44.17	R
18.	Pusa-744-85-1240	5.62	94.07	1.04	29.49	S
19.	IR-52813-C3-75-3	3.05	81.07	1.06	32.78	R
20.	R-24-1	17.63	94.87	1.71	31.11	R
21.	Indrasan	14.74	115.70	1.72	31.74	S
22.	Karnal Local	18.25	112.90	1.70	40.50	S
23.	HKR-120	23.61	93.60	1.56	26.46	R
24.	Pusa-598-17	23.24	93.87	1.35	30.36	S
25.	Adt-34	7.08	105.60	1.32	26.92	R
26.	Lalnakanda	18.38	103.20	1.29	31.29	S
27.	Makam	15.66	85.33	1.35	26.19	R
28.	Bali-1	11.78	142.10	2.12	33.57	R
29.	IR-52813-C3-124-3	8.32	76.13	1.10	27.79	R

Table contd.....

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Text-ure of leaf
30.	Aruna	22.18	94.73	1.46	29.81	R
31.	Ratna	12.06	85.53	1.34	31.84	R
32.	IR-19761-305	22.75	90.87	1.37	34.93	R
33.	IET-12604-4R	26.43	112.80	1.55	35.89	S
34.	IR-19761-282a	23.59	102.73	1.50	39.69	S
35.	IR-64	15.31	86.50	1.31	26.53	S
36.	Pusa-1021-5	12.56	105.40	2.15	30.28	R
37.	Pusa-33-2-77	18.36	88.60	1.38	34.00	R
38.	IR-52813-C4-111-1-2-2	24.35	95.20	1.63	39.62	R
39.	IRAT-144	11.23	115.30	1.73	47.67	S
40.	Mahsuri	19.06	110.90	1.58	39.95	R
41.	Pusa-150-21-1	37.94	85.33	1.65	28.91	S
42.	Pusa-1008-2-1-1-2	18.27	106.13	2.08	33.68	R
43.	Pusa-745	39.65	92.53	1.60	27.96	S
44.	Pusa-570	13.55	148.40	1.79	36.25	S
45.	Chan-Xiang Xian	4.12	101.87	1.56	21.92	R
46.	IR-28	3.51	83.67	1.02	28.27	R
47.	Rasi	21.89	96.53	1.43	30.38	S
48.	IR-52813-C3-99-3-3-3	5.87	78.33	1.10	25.46	S
49.	IR-54718-CO-104-2-2 (HB-6)	9.42	90.20	1.25	27.23	R
50.	Pusa-169 (S)	21.43	83.52	1.38	26.24	R
51.	Pusa-44-33	28.24	82.70	1.55	34.21	S
52.	Kanakam	16.90	94.00	1.59	32.32	R
53.	IR-52813-C3-62-3	37.24	88.40	1.45	26.82	S
54.	TCN-8-IET-13554 (HKR-90-414)	19.86	114.93	1.71	37.87	R
55.	Ranjani	29.62	80.40	1.67	32.86	S
56.	Pusa-1117-14-3	29.72	93.53	1.69	38.24	S
57.	HKR-119	33.44	87.60	1.56	34.07	S
58.	TCN-9-IET-13845 (BH-834-2)	3.59	106.90	1.00	30.74	R
59.	Jaya	22.38	98.70	1.69	32.52	S
60.	IR-72	24.16	75.50	1.60	36.92	S
61.	Dular	4.43	138.00	1.82	41.47	R

Table contd.....

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Texture of leaf
62.	Giza-171	7.83	98.50	1.10	23.08	S
63.	Pusa-1022-97	11.27	82.53	1.23	29.14	R
64.	Pusa-702	28.00	94.00	1.58	37.58	S
65.	Pusa-743-1-1-23	12.27	91.80	1.71	30.61	S
66.	Pusa-836-202-208-207-2	18.56	90.20	1.35	25.93	S
67.	Basmati Dwarf	5.98	95.70	1.04	30.48	R
68.	Pusa-150-21-1-1-2-1	6.76	86.90	1.35	28.48	R
69.	IET-10649-1	12.87	91.30	1.31	27.10	R
70.	IET-10649-1 (early)	14.36	95.70	1.30	30.31	R
71.	Gharbharam	9.19	134.67	1.75	41.22	R
72.	Pattambi-29	3.40	134.50	1.38	34.91	R
73.	Vikramarya	26.19	82.07	1.47	29.14	S
74.	IR-36	35.58	78.20	1.40	29.21	S
75.	Pusa-702-1	17.02	96.10	1.32	35.65	S
76.	Pusa-560	14.34	102.73	1.68	31.56	R
77.	Pusa-703	8.22	88.27	1.40	30.37	R
78.	Pusa-835-203-213-102	23.54	95.40	1.40	27.67	R
79.	PAU-1126	18.26	83.53	1.68	31.46	R
80.	P-107792-157-1	25.43	105.70	1.59	31.70	S
81.	IR-52813-C3-146-2	16.30	91.43	1.55	31.83	R
82.	Pusa-205-6-4	16.32	88.60	1.45	35.68	R
83.	Ramya	16.93	89.27	1.53	27.59	R
84.	Pusa-588-13	19.88	93.87	1.86	40.12	R
85.	PAU-1628	21.24	83.40	1.45	32.46	R
86.	IR-50	4.82	70.67	1.04	23.82	R
87.	Tainan-3	6.74	103.97	1.41	36.03	S
88.	Pusa-205-275	23.56	96.87	1.73	34.39	S
89.	Pusa-835-203-2-103-33	14.03	94.40	1.20	31.43	R
90.	Pusa-598-12-5-844-303	17.63	102.50	1.43	31.00	R
91.	IRAT-141	26.38	90.97	1.55	25.27	S
92.	IR-19761-283a	10.02	85.53	1.30	29.64	R
93.	Kartika	17.84	72.41	1.55	29.72	R

Table contd.....

S. No.	Germplasm	Folded leaf (%)	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	Text-ure of leaf
94.	Usha Barabanki	7.92	122.87	1.67	37.42	R
95.	Pusa-615	24.07	96.40	1.25	29.06	S
96.	Pusa-1187-72-1	22.53	90.53	1.53	36.86	S
97.	Pusa-1007-24	18.04	99.00	1.97	33.78	R
98.	Pusa-1120-7-3	10.41	97.20	1.04	21.66	R
99.	IET-12604-3r	19.89	80.47	1.32	26.75	S
100.	Pusa-834-204-207-202-2-1	35.24	87.00	1.34	24.30	S
101.	Asha	17.61	81.40	1.75	26.54	R
102.	Pusa-169 (S)	24.59	72.90	1.36	25.70	R
r value			0.061	0.326**	-0.088	

Note :

(S) = Susceptible

R = Rough

S = Smooth

** = Significant at 1% level

germplasms were having smooth leaf texture except IR-19761-305, IR-52813-C4-111-1-2-2 and PAU-1628 which had rough texture. Germplasms viz., Pusa-150-21-1, Pusa-745, IR-52813-C3-62-3 and IR-36 which had highest damage rating of 7 (susceptible) in 1999 along with smooth texture, had higher leaf width of 1.40 cm or more (Table 19).

4.3.4.2 Plant height and per cent infested leaves

Data on the plant height indicated that there was no significant correlation between the plant height and infestation among the germplasms during both the years ($r = 0.043$ and 0.061).

4.3.4.3 Leaf length and per cent infested leaves

There was no significant correlation between leaf length and per cent infested leaves revealing that leaf length has no effect on per cent incidence, irrespective of tall and dwarf varieties ($r = -0.015$ and -0.088).

5. DISCUSSION

The results obtained during the present investigations have been thoroughly examined and discussed with pertinent literature in support of the results at appropriate places.

5.1 EFFICACY OF DIFFERENT INSECTICIDES AND BIOPESTICIDES AGAINST RICE LEAFFOLDER, *C. MEDINALIS*

Observations recorded during both the years of study *i.e.*, *kharif* 1998 and 1999 (Table 5 and 6) showed that in general during *kharif* 1998, infestation increased 20 days after second spraying, while in *kharif* 1999 infestation showed appreciable increase in 10 days after second spraying.

During both years fenvalerate 3 sprays (T_9) followed by quinalphos 3 sprays (T_7) were the most effective treatments by recording very low infestation of leaffolder. During the entire spray period fenvalerate 3 sprays (T_9) showed a maximum of 4.20 and 6.32 per cent folded leaves, while quinalphos 3 sprays (T_7) showed only infestation of 4.93 and 7.00 per cent folded leaves in comparison to untreated control (T_{19}), which had maximum of 16.65 and 28.75 per cent folded leaves during *kharif* 1998 and 1999, respectively. Earlier studies by Raju *et al.* (1990), Ramaraju and Natarajan (1997) proved fenvalerate to be highly effective against leaffolder which is in congruence with the present finding.

Basides, Sathiyandam *et al.* (1986), Tripathi *et al.* (1984) Raju *et al.* (1988) also observed fenvalerate to be highly effective against other pyralid pests of rice. The efficacy of quinalphos obtained during the present study is in agreement with the findings of Rao *et al.* (1976), Balasubramanian and Micheal (1976), Thomas and Karunakaran (1977), Krishnaiah *et al.* (1980), Bhagat (1986), Sain *et al.* (1987) Godase and Dumbre (1985), Venkateswara Rao *et al.* (1988), Raju *et al.* (1988), Saroja (1989) and Singh *et al.* (1999).

In the present investigations two more treatments, one each of fenvalerate and quinalphos were taken up, but here instead of three sprays only two sprays were applied starting from 40 days after transplanting (sprayings were done at 40 and 60 DAT and first spray at 20 DAT was avoided). Results obtained during both the years of study revealed that the two spray application treatments of fenvalerate (T_{10}) and quinalphos (T_8) were found to be nearly as effective as fenvalerate (T_9) and quinalphos (T_7) applied at 3 different intervals. Further T_{10} and T_8 though showed, slightly higher infestation initially (comparable to untreated control T_{19}), however, later on effectively contained leaffolder damage when sprayings were applied (starting at 40 DAT). Hence, it would be profitable if one spray each of fenvalerate and quinalphos are avoided or deferred to a later date if needed.

Carbofuran and phorate applied at both doses 0.50 kg and 0.75 kg a.i./ha also provided effective control of leaffolder. However both the granular applications at higher dose i.e. 0.75 kg a.i./ha recorded slightly lower infestation when compared to lower dose of 0.50 kg a.i./ha. During *kharif* 1998 only two doses of granular application (one at

20 DAT and second at 60 DAT) was given skipping the application at 40 DAT. This was done as initial leaffolder infestation was quite less. However, during *kharif* 1999 all the three doses were applied. Carbofuran at 0.75 kg a.i./ha recorded a maximum of 6.22 and 7.10 per cent folded leaves, while phorate at 0.75 kg a.i./ha had shown a high of 6.89 and 10.77 per cent folded leaves during both the years of study. At lower dose of 0.50 kg a.i./ha carbofuran showed a high of 7.33 and 8.66 per cent folded leaves while phorate showed a high of 8.29 and 11.38 per cent folded leaves during *kharif* 1998 and 1999, respectively. Effectiveness of both carbofuran and phorate against leaffolder obtained during the present studies was in agreement with the findings of Jayaraj (1976); Chandramohan and Jayaraj (1977); Thakur and Mishra (1989). Effectiveness of carbofuran against rice leaffolder was also reported by Susammamathai *et al.* (1975); Balasubramanian and Micheal (1976); Chandramohan *et al.* 1976); Chandramohan and Jayaraj (1976); Ramamurthy and Jayaraj (1977); Pasalu *et al.* (1980) and Murthy *et al.* (1989). However, Sasidharan and Nair (1984); Singh and Sharma (1998) opined that carbofuran and phorate applied at different stages proved ineffective in controlling leaffolder.

Dimilin (diflubenzuron) also provided effective leaffolder control and it followed synthetic insecticidal treatments in the order of efficacy during both the years of study. Efficacy of Dimilin against leaffolder was earlier reported by Aguda *et al.* (1988) and Raju *et al.* (1990). Among the various biopesticides, *B.t.* based product Dipel and botanical pesticides, Neem-A (T₁₄) proved to be superior over other botanical treatments *viz.*, Neem-B (Refined, T₁₅), Aak (T₁₇) and Chinaberry (T₁₆). During *kharif*

1998 Dipel recorded a maximum of 9.75 per cent folded leaves while Neem-A recorded a maximum of 10.14 per cent folded leaves. Similarly in *kharif* 1999 Dipel and Neem-A had a maximum of 14.36 and 18.04 per cent folded leaves, respectively. Superiority of Dipel in controlling leaffolder was also reported by Zhu *et al.* (1986); Srivastava *et al.* (1987); Sundarbabu and Muthusami (1995) and Satish *et al.* (1999).

In the present studies neem formulations provided only moderate control of leaffolder. The present findings are in agreement with that of David (1986); Dash *et al.* (1997); Sunita and Niachiappan (1997); Bhatnagar and Pandey (1998). Roshan Lal (2000); Raut (2000) and Rao (2001) who also observed that neem formulations are moderately effective against rice leaffolder.

In the present investigations three alternation treatments *viz.*, Dipel + diflubenzuron (T_{13}), carbofuran + Dipel (T_3) and phorate + Dipel (T_6) were included. During both the years of study carbofuran + Dipel (T_3) was the best alternation treatment. The alternation treatments of carbofuran + Dipel (T_3) and phorate + Dipel (T_6) also provided as effective control as carbofuran and phorate applied at 3 stages. Hence, it would be profitable if one granular application of these systemic insecticide is substituted with the biopesticide. Studies conducted by Sundarbabu and Muthusami (1995) and Rao (2001) with alternations of synthetic insecticides and biopesticides against rice leaffolder also yielded similar results.

5.2 OUTBREAK OF *PYRILLA PERPUSILLA* ON RICE DURING *KHARIF* 1999

In *kharif* 1999 during first week of August there was a severe

Plate 16. Adult of *Pyrilla perpusilla* on rice



outbreak of *P. perpusilla* on rice. Even after maturity of the crop high population of this new pest was maintained. Earlier Sukhani (1971) also observed breeding and egg laying by *P. perpusilla* on paddy during Sept.-Oct. 1970. Pawar (1981) and Garg and Sethi (1983) also recorded severe outbreak of this pest on rice. *P. perpusilla* was also reported as new pest of rice in India by Pathak and Khan (1994). In addition Karnataka and Kanaujia (1998) reported that out of 20 alternate food plants of *P. perpusilla* 11 belonged to graminiae family and comprised cereal crops, grasses and sugarcane.

5.3 EFFECT OF DIFFERENT INSECTICIDES AND BIOPESTICIDES ON GRAIN YIELD DURING KHARIF 1998 AND 1999

During both the years fenvalerate 3 sprays (T_9) followed by quinalphos 3 sprays (T_7) which had minimal leaffolder infestation, gave the highest yield (Table 5 and 6). The next best treatments during both the years were fenvalerate, quinalphos (with 2 sprays), carbofuran and phorate at higher dose (0.75 kg a.i./ha). Among alternation treatments the decreasing order of yield was : carbofuran + Dipel > phorate + Dipel > Dipel + diflubenzuron. The treatments of Aak (T_{17}), Chinaberry (T_{16}) along with solvent + emulsifier (T_{18}) resulted in yields which were statistically on par with untreated control (T_{19}). Even though leaffolder infestation was less in *kharif* 1998 than in *kharif* 1999, a low yield was realized in all treatments including untreated control in *kharif* 1998. This might be due to the fact that crop was raised for the first time on this piece of land and also partly due to climatic factors unfavourable for crop growth.

5.4 EVALUATION OF EFFECT OF VARIOUS INSECTICIDAL AND BIOPESTICIDAL TREATMENTS ON PREDATORS OF RICE LEAFFOLDER, *C. MEDINALIS*

In the present studies, spiders, coccinellids rove beetle and ground beetles were conspicuous predators observed in the field. A very good predator population was witnessed during both the years, but the initial build up of these important predators was more in *kharif* 1999 than in *kharif* 1998. During long history of rice cultivation throughout the world, a stable relationship between rice insect pests and their natural enemies has been observed (Ooi and Shepard, 1994). Even though the number and relative abundance of natural enemies may vary from year to year, from locality to locality or from season to season (Yasumatu *et al.*, 1981) but the outbreak of *P. perpusilla* might have had a definite influence in the initial build up and sustenance of these predators in *kharif* 1999. Yasumatu *et al.* (1981) observed that coccinellids (*Micraspis discolor*, *M. vincta*, *Harmonia octomaculata*), ground beetles (*Ophionea indica*, *O. ishii*), rove beetle (*Paederus fuscipes*) and some spiders are common for rice, grain and sugarcane fields and actively feed on eggs, nymphs and adults of leaf and planthoppers, defoliators and stemborers on these crops. Spiders particularly lycosids (Zhang, 1989 and Conlong, 1995), *Tetragnathea* sp., salticids, jumping spider (Liu *et al.*, 1996) are also important predators in sugarcane ecosystem where *P. perpusilla* is a major pest. Garg and Sethi (1983) observed that eggs and newly hatched nymph of sugarcane leafhopper, *P. perpusilla* on paddy were attacked by coccinellids, *Brumoides suturalis*. Since population build up of natural

enemies is density dependent, abundant availability of the prey might have resulted in an increase in numbers of these predators in *kharif* 1999.

5.5 EFFECT OF INSECTICIDAL AND BIOPESTICIDAL TREATMENTS ON COCCINELLIDS DURING *KHARIF* 1998 AND 1999

Even though a high population of these predators was observed during both the years yet a better initial population build up was observed in *kharif* 1999. All synthetic insecticidal treatments recorded lower population of this predator in comparison with biopesticidal treatments and untreated control. Treatments of fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7), fenvalerate 2 sprays (T_{10}) and quinalphos 2 sprays (T_8) had a maximum of 1.00 to 1.67 and 2.00 to 2.67 coccinellids/5 hills in comparison with untreated control (T_{19}) which had 6.00 and 7.33 coccinellids/5 hills during *kharif* 1998 and 1999, respectively (Table 7 and 8). In treatments of T_{10} (fenvalerate 2 sprays) and T_8 (quinalphos 2 sprays) where first spray was not given (at 20 DAT), coccinellids' population comparable to that of untreated control (T_{19}) was recorded, but after application of these treatments, these predators' population was reduced considerably. Toxicity of profenophos, cypermethrin, deltamethrin (Broadley, 1983), quinalphos (Patnaik, 1983), deltamethrin (Fayad and Ibrahim, 1988 and Wiles, 1991) to coccinellids has earlier been reported, which corroborates present findings. In comparison with the above insecticidal treatments, granular formulations of carbofuran 0.50 kg, carbofuran 0.75 kg, phorate 0.50 kg and phorate 0.75 kg had maximum of 4.00, 3.00, 4.33 and 3.67 coccinellids during *kharif* 1998 and 4.67, 3.67, 4.67 and 4.33 coccinellids/5 hills during

kharif 1999, which was statistically on par with coccinellids population in untreated control (T_{19}) during both years, thus proving to be comparatively safe to this predator. Rajendran (1993), Patel (1997) also observed that predators of rice pest were not adversely affected by granular application of phorate, carbofuran and quinalphos. The safety of diflubenzuron, Dipel and Neem to coccinellids observed during the present study was in agreement with the findings of Matrangolo *et al.* (1987), Franz *et al.* (1980), Hassan *et al.* (1983), Greener and Candy (1994), Latha *et al.* (1994), Saleem and Matter (1991) and Schmutter (1996).

Alternation of treatments did not result in any significant change in these predators' population during both the years. It was observed that a general decrease in predator population occurred after 60 DAT (even in the untreated control this trend was observed).

5.6 EFFECT OF INSECTICIDAL AND BIOPESTICIDAL TREATMENTS ON ROVE BEETLE AND GROUND BEETLES DURING KHARIF 1998 AND 1999

In comparison to *kharif* 1998, 1999 had a higher population of both these predators in various treatments as well as in untreated control. During both the years synthetic insecticidal treatments of fenvalerate 3 sprays (T_9), fenvalerate 2 sprays (T_{10}), quinalphos 3 sprays (T_7) and quinalphos 2 sprays (T_8) recorded low population of these two predators in comparison with untreated control (T_{19}). Similar observations were recorded by Wiles (1991) who found rove beetles and carabid, *Bembidion lampros* to be susceptible to deltamethrin on caged cereal plants. Asterak *et al.* (1992) observed that seed treatment with fenophos

and chlorpyrifos reduced several carabid beetle species caught in pitfall traps from which it may be concluded that synthetic pyrethroids and organophosphorus compounds do affect these natural enemies.

During *kharif* 1998, carbofuran and phorate (at both doses) recorded population of these two predators comparable to the population in the untreated control. While in *kharif* 1999, these granular formulations at both doses had population which was much higher than synthetic insecticidal treatments. All biopesticidal treatments had good numbers of both these predators during the two years of study. No parallel could be drawn due to lack of pertinent literature regarding effect of various biopesticides on these two natural enemies. However, Saleem and Matter (1991) found that neem oil acted as a temporary repellent on beetles of *P. affierii*, but otherwise had no detrimental effect on this predator.

Alternation treatments did not significantly increase population of these predators, but alternation did result in stabilization of population when compared to synthetic insecticidal treatments.

5.7 EFFECT OF INSECTICIDAL AND BIOPESTICIDAL TREATMENTS ON SPIDERS DURING *KHARIF* 1998 AND 1999

During both the years of study a high population of spiders was recorded but initial build up of this predator was more in *kharif* 1999 than in *kharif* 1998 (Table 13 and 14).

All biopesticidal treatments *viz.* Dipel (T_{11}), Neem-A (T_{14}), Neem-B (Refined, T_{15}), Aak (T_{17}) and chinaberry (T_{16}) consistently recorded higher spider population during both the years of study. The safety of

neem products to spiders was earlier reported by Saxena *et al.* (1984), Raghuraman (1987), Kareem *et al.* (1988), Saxena *et al.* (1987), Sukla *et al.* (1988), Saxena (1981), Mohan *et al.* (1991), Jayaraj *et al.* (1993), Mariappan *et al.* (1993), Nanda *et al.* (1993), Dash *et al.* (1996) and Schmutter (1996).

Granular formulations of carbofuran and phorate at both doses *i.e.* at 0.50 kg a.i./ha and 0.75 kg a.i./ha registered a higher spider population in relation with synthetic insecticidal treatments during the entire study period. The population in the above treatments was comparable to the population in biopesticide treated plots, thus proving safe to this natural enemy. These findings are conformity with results of Rajendran (1993), Patel (1997) and Panda and Mishra (1999).

Synthetic insecticidal treatments of fenvalerate 3 sprays (T_9), quinalphos 3 sprays (T_7) and fenvalerate 2 sprays (T_{10}), quinalphos 2 sprays (T_8) (after application at 40 DAT) showed a consistent low population of this predator in both the years of study, hence, proving detrimental for their build up in rice ecosystem. Similar findings with pyrethroids, cypermethrin and cis-2-cypermethrin on spiders in rice was reported by Vorley (1985), with deltamethrin by Wiles (1991), with lambda-cyhalothrin and fenvalerate on spiders in barley by Krause *et al.* (1993).

Alternation of treatments *i.e.* carbofuran + Dipel (T_3), phorate + Dipel (T_6) and Dipel + diflubenzuron (T_{13}) did not result in any significant change in spider population, during *kharif* 1998 and 1999.

Even though ecological approach and chemical control does not go hand in hand, pesticides still remain the first line of defence against

many rice pests and are used freely when insect outbreak occurs (Pathak and Khan, 1994). From the above results obtained it is evident that natural enemy fauna in rice was severely affected by synthetic insecticidal sprays even though their use resulted in realizing better leaffolder control and thereby higher yields. The above statement can be made much more clear by observing the natural enemy population before and after sprays of fenvalerate (T_{10}) and quinalphos (T_8) where 2 sprays were applied. A higher population which was realized before spraying never recovered from its low numbers after sprayings were applied. On the other hand, granular formulations alone and in alternation with Dipel had not only resulted in yields comparable of that of synthetic insecticidal treatments but also conserved the valuable natural enemy fauna in rice. Therefore, promoting integrated pest management strategy, it is desirable to utilize and conserve natural enemies of rice pests through need-based application of selective pesticides for suppression of rice pests.

5.8 SCREENING OF RICE GERmplasm FOR LEAFFOLDER RESISTANCE

The observations during both the years of study period revealed that during *kharif* 1999 a higher leaffolder infestation was noticed in comparison to *kharif* 1998.

During *kharif* 1998, out of 100 germplasms screened, 33 germplasms had damage rating of 1 (resistant), 56 germplasms had damage rating of 3 (moderately resistant), 12 germplasms had damage rating of 5 (moderately susceptible) and no germplasm showed highest damage rating of 7 (susceptible). While in *kharif* 1999, 23 germplasms showed

damage rating of 1, 45 showed 3, 29 showed 5, 4 showed damage rating of 7. During both the years no germplasm showed highest rating of 9 (highly susceptible). During *kharif* 1998, susceptible check Pusa-169 showed damage rating of 3 while in *kharif* 1999 it showed a damage rating of 5.

Twenty two germplasms which showed consistent damage rating of 1 during both the years were IR-64-273, IR-52813-C3-73-3, IRAT-109, Pusa-744-85-1240, IR-52813-C3-75-3, Adt-34, IR-52813-C3-124-3, Chan-Xiang Xian, IR-28, IR-52813-C3-99-3-3-3, TCN-9-IET-13845 (BH-834-2), Dular, Giza-171, Basmati Dwarf, Pusa-150-21-1-1-2-1, Gharbharam, Pattambi-29, IR-50, Tainan-3, IR-19761-283a, Usha Barabanki and Pusa-1120-7-3. The thirty germplasms *viz.*, Kolumbo mutant, IR-52813-C3-150-1, IR-52813-C2-27-3, Pant Dhan-10, Pavizham, Basmati-370, Karnal Local, Lalnakanda, Makam, Ratna, IR-64, Pusa-33-2-77, Mahsuri, Pusa-570, Kanakam, TCN-8-IET-13554 (HKR-90-414), Pusa-1022-97, Pusa-743-1-1-23, Pusa-836-202-208-207-2, IET-10649-1, IET-10649-1 (early), Pusa-702-1, PAU-1126, Ramya, Pusa-588-13, Pusa-835-203-2-103-33, Pusa-598-12-5-844-303, Kartika, Pusa-1007-24 and IET-12604-3r showed consistent damage rating of 3. Eight germplasms *viz.*, HKR-120, IET-12604-4R, Pusa-44-33, Ranjani, HKR-119, Pusa-835-203-213-102, P-107792-157-1 and Pusa-834-204-207-202-2-1 showed consistent damage rating of 5 during both the years, while Pusa-150-21-1, Pusa-745, IR-52813-C3-62-3 and IR-36 showed damage rating of 5 in *kharif* 1998 and 7 in *kharif* 1999 (Table 17). Earlier Upadhyay *et al.* (1975) and Verma (1979) reported that Jaya variety of rice was attacked by leaf folder. Similar observations with Jaya

(damage rating of 3 in 1998 and 5 in 1999) obtained during the present investigations was in congruence with their findings.

Correlation studies carried out during the present investigations between per cent leaffolder infestation and leaf width, leaf length, plant height and texture of the leaf each (Table 18 and 19) showed that among these morphological characters only leaf width had significant positive correlation with leaffolder infestation ($r=0.251^{**}$ and 0.326^{**}).

All the germplasms which showed damage rating of 1 during both years had narrow leaves with leaf width ranging from 0.98 to 1.10 cm. The germplasms which showed consistent damage rating of 3 and 5 during both the years had leaf width ranging from 1.20 to 2.05 cm and 1.40 to 1.63 cm, respectively.

Germplasms viz., Pusa-150-21-1, Pusa-745, IR-52813-C3-62-3 and IR-36 which showed highest damage rating of 7 in *kharif* 1999 showed leaf width of 1.65, 1.65, 1.45 and 1.40 cm, respectively. Similar observations regarding wider leaf width favouring leaf folder infestation was recorded by Hanifa and Subramanian (1973), Majumdar *et al.* (1984), Dakshayani (1993) and Islam and Karim (1997). During both the years of study no significant correlation between plant height, leaf length and leaffolder infestation was observed ($r=0.043$, -0.015 and 0.064 , -0.088). Islam and Karim also reported that plant height has no significant correlation with leaffolder infestation. Similarly, Hanifa and Subramanian (1973) reported that leaf length of second leaf from the top to be negatively correlated, with leaffolder infestation.

Observations regarding correlation between texture of leaf and per cent infestation showed that in general smooth textured leaves had high

infestation, while rough textured leaves had low infestation. However, the following germplasms viz., IR-52813-C3-73-3, Pusa-744-85-1240, IR-52813-C3-99-3-3-3 and Giza-171 had smooth textured leaves with low infestation, while HKR-120 and Pusa-835-203-213-102 inspite of having rough textured leaves showed a higher infestation of leaffolder. It was also observed that some of the germplasms inspite of having wider leaf width showed less leaffolder infestation viz., IRAT-109 (1.68 cm), Adt-34 (1.32 cm), Chan-Xiang-Xian (1.56 cm), Dular (1.82 cm), Pusa-150-21-1-1-2-1 (1.35 cm), Gharbharam (1.75 cm), Pattambi-29 (1.38 cm), Tainan-3 (1.41 cm), IR-19761-283a (1.30 cm) and Usha Barabanki (1.67 cm). These were some of the exceptions observed. Such exceptions might be due to the fact that in addition to various morphological parameters, biochemical constituents of plants also do influence resistance against various pests. Hence, in general selection of rice germplasms with narrow-leaves may help in breeding a resistant variety against rice leaffolder, *C. medinalis*.

6. SUMMARY

The investigation entitled "Studies on efficacy of certain insect control agents and resistance of rice germplasms against leaffolder, *Cnaphalocrocis medinalis* (Guenee)" were carried out during *kharif* 1998 and 1999 at the Experimental Farm, Indian Agricultural Research Institute, New Delhi. The findings of these investigations have been summarized below :

1. More leaffolder infestation was recorded in *kharif* 1999 as compared to *kharif* 1998.
2. There was a severe outbreak of *Pyrilla perpusilla* on rice during *kharif* 1999.
3. During both years of the study, a very good natural enemy population was observed but initial build up of these natural enemies was much higher in *kharif* 1999 possibly due to *P. perpusilla* outbreak.
4. Among the various treatments applied for control of leaffolder during both the years of study, fenvalerate 3 sprays followed by quinalphos 3 sprays proved very effective and were followed by treatments of fenvalerate 2 sprays and quinalphos 2 sprays.
5. Among the granular formulation both carbofuran and phorate at higher doses (0.75 kg a.i./ha) proved to be more effective in comparison with their lower doses (0.50 kg a.i./ha).

6. Diflubenzuron was found to be as effective as granular formulations against leaffolder.
7. Biopesticide i.e. Dipel and all botanicals viz., Neem-A, Neem-B (Refined), Chinaberry and Aak were moderately effective against leaffolder.
8. Among the alternation treatments carbofuran + Dipel and phorate + Dipel proved to be more effective than biopesticide and botanicals, while other alternation treatment Dipel + diflubenzuron was as effective as Dipel.
9. All synthetic insecticidal treatments (sprays) adversely effected natural enemy population.
10. All alternation, granular and botanical treatments proved to be safe to natural enemies.
11. In screening experiment, out of the one hundred germplasms during *kharif* 1998 and 1999, twenty two germplasms showed a consistent damage rating of 1 during both the years.
12. A significant correlation between per cent infested leaves and leaf width was obtained during both the years.
13. No significant correlation between per cent infested leaves and plant height and leaf length was observed.
14. Except a few germplasms, majority of the germplasms which had a damage rating of 5 and 7 had smooth texture.

Synthetic insecticidal treatments provided very effective control of leaffolder but also adversely affected its natural enemy population. On

the other hand granular formulations and alternation treatments, besides providing effective control of leaffolder also conserved natural enemies and hence can be recommended for leaffolder control.

The germplasms found promising for leaffolder resistance during present investigations should be further explored for their biochemical basis of resistance and thus be utilised in future breeding programmes.

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*Original not seen

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