EVALUATION OF SOME INDIGENOUS PLANTS FOR THEIR INSECTICIDAL PROPERTIES AGAINST RICE LEAFFOLDER, *CNAPHALOCROCIS MEDINALIS* (GUENEE), A SERIOUS PEST OF RICE IN NAGALAND.

BY

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NAGALAND UNIVERSITY

HEADQUARTER: LUMAMI

Dedicated
to my
Beloved Parents

Nagaland University

School of Agricultural Sciences and Rural Development

Medziphema Campus

April 2007

DECLARATION

I, Moanaro hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/institute.

This is being submitted to the Nagaland University for the degree of Doctor of Philosophy in Entomology.

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This is to certify that the Thesis entitled **"Evaluation of some indigenous plants for their insecticidal properties against rice leaffolder, *Cnaphalocrocis medinalis* (Guenee), a serious pest of rice in Nagaland"** submitted to the **School of Agricultural Sciences and Rural Development, Nagaland University,** in partial fulfilment of the requirement for the degree of **Doctor of Philosophy in Entomology,** is a record of bonafide research carried out by **Ms. Moanaro**, under our personal guidance and supervision. The findings of the investigation have not been submitted for award of any other degree in this or any other university or institute of learning.

The assistance of all kind received by her has been duly acknowledged.

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LIST OF ABBREVIATIONS

(A)	-	Acetone extract
@	-	At a rate of
cm	-	Centimeter
CV	-	Co-efficient variation
$CV_{(a)}$	-	Co-efficient variation for main plot analysis
$CV_{(b)}$	-	Co-efficient variation for sub plot analysis
CRD	-	Complete Randomised Design
Conc.	-	Concentration
DAT	-	Days after transplanting
DATr	-	Days after treatment
°C	-	Degree Celsius
dia.	-	Diameter
DMRT	-	Duncan's Multiple Range Test
E	-	East
et al.	-	Et allia (and others / co-workers)
Fig.	-	Figure
F-test	-	Fisher's test
ha	-	Hectare
kg	-	Kilogram
LSD	-	Least significant test.
l	-	Litre
MSL	-	Mean sea level
MSS	-	Mean sum square
m	-	meter
mm	-	millimeter
(M)	-	Methanol extract
viz.	-	Namely
NS	-	Non significant
N	-	North
P	-	Page
ppm	-	Parts per million
%	-	Percent
/	-	Per
q	-	Quintal
RCBD	-	Randomised Complete Block Design
SASRD	-	School of Agricultural Sciences and Rural Development
sq m	-	Square meter
S	-	South
ss	-	Sum square
t	-	Tonne

INTRODUCTION

1. INTRODUCTION

Almost half of the world depends on rice as a major source of food. Although most rice producers and consumers live in Asia, rice is also an essential, stable and a source of income for millions of others in Africa and South America. In India, the total area under rice is about 43.4 million hectares and the annual production is approximately 89.5 million tonnes. After China, India is the largest producer of rice in the world (Atwal and Dhaliwal 2002). In Nagaland, it is cultivated in an area of 1.51 lakh hectares with a production of 1.23 lakh tonnes under rainfed and upland condition (Anonymous, 2004). The crop is attacked by a number of insect pests causing substantial loss in yield. More than hundred insect pests attack rice crop, of these 20 are major pests . The crop suffers on an average 10-30% yield loss depending on the severity of incidence of insect pests and diseases (DRR, 1990) and on an average, the yield loss due to insect pests amounts to at least 20% in India (Pathak *et al.*, 1982). Insect pests are one of the major constraints in rice production as it is evident from multi location trials conducted under All India Coordinated Rice Improvement Project (AICRIP) where protected crop yielded 28.8% more than unprotected (Kalode, 1985). Rice leaffolder *Cnaphalocrocis medinalis* (Guenee) is an important pest in almost all the rice growing countries of Asia (Khan *et al.*, 1988). Being one of the minor pests of rice it had gained the major pest status ever since the introduction of high yielding and fertilizer responsive varieties cultivated to bring the green revolution (Reissing *et al.*, 1985). Pangtey *et al.*, (1982) has reported the outbreak of rice leaffolder in Kohima district of Nagaland.

The symptoms of leaffolder damage are characterized by the presence of a large number of leaf rolls. The caterpillars after hatching, move about on the rice leaf for a few minutes, secrete a silken thread and fasten the edges of leaves and one larva is found in one leaf roll or fold. It scraps the green portion on the upper surface of leaf. Scraping is done initially in the middle portion of the leaf blade and subsequently extends to either end. The presence of caterpillar inside the leaf roll is indicated by the green excretory matter left behind the caterpillar during its progress of feeding. Scrapping is done only lengthwise on the leaf surface. They exhibit four types of leaf rolling. In the first type, the edges of leaf area are fastened together in the middle region. In the second type, the tip of the leaf is fastened to the middle portion of the leaf blade.The third type is almost similar to the second type except that the leaf is fastened in a twisted manner and in the fourth type the adjacent leaves are fastened together after rolling each leaf. First type is more common and the second type of folding is normally seen in the earlier stages of the crop growth.

Reports show that severe infestation of rice leaffolder *C. medinalis* (Guenee) leads to as high as 60-70 % leaf damage (Kushwaha and Singh, 1984) causing significant yield loss (Murugesan and Chelliah 1986, Shrivastava 1989). Pandya *et al.* (1987) estimated yield loss caused by the pests and concluded that every unit of increase in infestation by *C. medinalis* alone, yield decreased by 1.40 percent during summer and 1.46 % during *kharif* (wet) season. Pandya *et al.* (1994) noted that every unit per cent increase in the leaffolder incidence at tillering, early earing and milky seed stage led to 1.98, 2.22 and 1.23 % yield loss during wet season.

Intensive crop production system still rely heavily on chemicals for insect pest control and the role of insecticides in rice is almost significant as it acts as protective umbrella for other inputs. Although the use of insecticides is not directly compatible with the ecological approach to pest management, their use becomes inevitable during infestation above economic threshold levels. Singh *et al.*, (1994) reported that spraying of monocrotophos, carbaryl, phosalone, phosphamiton, fenitrotion and phosalone @ 0.5 kg a.i/ha or application of cartap @ 1.0 kg a.i/ha were effective in controlling rice leaffolder. Chemical insecticides widely used for pest control are valued for the effectiveness, relatively long shelf life and the ease with which they can be transported, stored and applied, but most of these chemicals have broad spectrum biological activity which leads insect pest to develop resistance, pest resurgence, destruction of their natural enemies turned formally innocuous species into pest and harms the non-target species. They also cause serious problems like pollution of soil, water and long term consequences for man and wild life environment. It has been reported that due to excessive use of pesticides, at least 447 species of insects and mites, 200 species of plant pathogens and 48 species of weeds are now resistant to chemical pesticides (Verma and Dubey, 1999). There is a growing awareness of toxicological and environmental problems involved in the use of chemical pesticides in developed and also in developing countries. This awareness has led to a steadily increasing movement towards more environmental-oriented, sustainable agriculture with low or no input of toxic chemical pesticides and other agricultural chemicals in an attempt to preserve and protect the environment as well as health. One of theseveral tactics is the exploitation of natural products of plant origin that effects the pest population through metabolic and developmental disorders.

The plant world is a rich store house of bio-chemicals that could be trapped for their use as pesticides. The toxic constituents present in the plants represent the secondary metabolites

whose major roles in the plants are reportedly defensive. These pesticides of plant origin have many advantages over synthetic pesticides as they possesses least or no health hazards, no environmental pollution and minimum risk of development of insect resistance, no risk of pest resurgence, surface persistence, no adverse effect on crop viability, less expensive and easily available (Singh and Dhaliwal, 1993).

The use of botanicals for the control of insect pests has a long history. Use of pyrethrum was already known during the time of the Persian king Darius The Great (521-486BC). Nicotine have been used in the last centuries and insecticides formulated from herbs and oils were used for the protection of seeds and stored grains by the Egyptians and Chinese during pre-biblical times (Pedigo, 1999). Centuries before synthetic insecticides became available, farmers in India protected crops with natural repellents found in neem seeds and leaves (Pruthi and Singh, 1950). The use of botanicals for pest control declined with the advert of DDT and the whole array of distinctively toxic, broad spectrum insecticides. The value of botanicals that affect the behaviour and physiology of pests, rather killing them outright, has been recognized. They are desirable in integrated pest management programme and plant species screened for insecticidal properties exceeded 6000 by 1971, of these nearly 2400 species belonging to 235 plant families are reported to exhibit considerable pest control activity (Grainge and Ahmed, 1988).

Keeping the above points in mind, the present study was undertaken to explore five locally available plants, ***Asang*** (*Amphineuron apulentum* Kaulf. Holtum.); ***Akawa*** (*Clerodendrum viscosum* Vent.); ***Ongret*** (*Litsea citrata* Bl. Bijdr.); Suli (*Millettia auriculata* Baker ex Brand) and ***Alinengba*** (*Mimusops hexandra* Roxb.Cor.) known with toxic property were selected for testing their insecticidal property against rice leaffolder which is emerging as the number one pest of rice, in Nagaland with the following objectives:

- Evaluation of crude plant extracts for their antifeedant property in laboratory/net house.
- Effect of crude plant extracts on ovipositional activity in laboratory/net house.
- Effect of crude plant extracts on the developmental stage in laboratory/net house.
- Field evaluation of crude plant extracts for management of the pest population.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The research work conducted and published by the workers in the past on botanical insecticides/plant products in the field of present investigations on rice leaffolder, insect pests of rice and other crops are reviewed in this chapter by categorizing in the following manner.

2.1 Laboratory/ net house studies.

2.2 Field evaluation.

2.1. Laboratory / net house studies.

2.1.1. Plant products as antifeedant / repellent property.

Crude oil, expelled from decorticated seeds at 3, 6, 13, 25 and 50 % v/v formulations in water containing 0.1 % to 1.66 % Teepol, repelled first instar larvae of *C. medinalis* when choice was given between treated and control leaf cuts. The percentage of larvae settled for feeding after 24 hours on treated leaves were significantly lower than control. Feeding of *C. medinalis* were also reduced and the weight of the excreta was significantly less as compared to the control and higher conc. of neem oil give greater reduction in feeding. (IRRI 1979).

Saxena *et al*., 1980 reported that when neem oil treated leaves with 12 % were offered to leaffolder in a Choice test it significantly lowered the number of larvae arrived on treated leaves and antifeedant activity of neem oil was higher with an increase in conc. of neem oil spray on plants, as measured by quantum of excreta.

In laboratory and green house test, suspensions containing low concentrations of azadirachtin and solannin, compounds isolated from ethanol extracts of neem seeds, *A. indica* A. Juss., possessed activity as feeding deterrents against the striped cucumber beetle, *Acalymma vittatum* (F), and spotted cucumber beetle, *Diabrotica undecimpunctata howardii* Barber. The chemicals were particularly active against the striped cucumber beetle, the more serious pest of muskmelons. (Reed *et. al*., 1982).

Krishniah and Kalode, (1984) reported that neem oil discouraged settling of brown planthopper, *Nilaparvata lugens* (stal) and white backed planthopper; *Sogatella furcifera* (Horvath) on treated plants and considerably reduced their intake.

Alford and Bentley, (1986), examined citrus limonoids limonin, deoxylimonin and citrolin for activity as antifeedants and growth disruptors against larvae of the spruce budworm, *Choristoneura fumiferana* (Clemens). Diet consumption assays indicated no significant depression of feeding by these compounds incorporated at 1000 ppm in short-term (48 h) no-choice and choice tests. Long term feeding studies (fourth instar to pupa) showed that high concentration of citrolin (500 ppm) extended larval development time by 40% over that of control; limonin and deoxylimonin had no significant effect on development. Pupal weights of individuals fed with limonoids were not affected.

Tripathi *et al*., (1987) evaluated acetone extracts of 26 plants for antifeedant activity against Bihar hairy caterpillar *Spilosoma obliqua.* Among 26 plant extracts tested, antifeedant activity was highest in *Lindenbergia grandiflora* Benth followed by *Passiflora mollissima* HBK which gave 82.75 and 71.84 % protection over control respectively. While moderate antifeedant activity was found in *Schima khosiana* Dyer and *Ehretia canarensis* Miq. which gave 61.11 and 60.70 % protection over control respectively.

In laboratory experiments, concentrations of 0.4, 0.8 and 1.2 % (w/v) neem-seed extract inhibited feeding of adult and larvae of Colorado potato beetle, *Leptinotarsa decemlineata* (Say) on treated potato foliage, *Solanum tuberosum* L. Adult mortality did not exceed 25 % in any neem treatment ; however, 73 % of larvae were dead 72 h after feeding on foliage treated with 1.2 % neem extract. Toxicity of neem extract to larvae was enhanced, and feeding of larvae and adults was inhibited to a greater extent by addition of the synergist piperonyl butaoxide (PBO) at a ratio of 10:1 (PBO/azadirachtin). In field experiments, spray application of neem extract significantly reduced numbers of *L. decemlineata* larvae and adults in treated plots on all sample dates. The effectiveness of neem extract against *L. decemlineata* was significantly improved on two days by addition of PBO (Zehnder and Warthen, 1988).

Semi-solid crude plant extractives isolated by soxhlet extraction with solvents were tested against 3rd instar larvae of castor semi-looper *Achaea janata* L. at 1000 and 500 ppm conc. (w/v) by Purohit et al.,(1989). Among them, products from *A. indica* seeds, vemidin, Neemol, Nemidin, *Annona squamosa* and *Diaspyrous chloroxylon* exhibited absolute antifeedant activity.

Rao *et al.*, (1990) reported that Petroleum ether extracts of *A. squamosa* L., *Argemone mexicana* L., *calotropis gigantean* R.Br., *Datura stramonium* L., *Eucalyptus globules* Labill, *Pongamia glabra* vent., *Ricinus communis* L. at 0.5 % conc. offered cent per cent protection indicating their high antifeedant effect on *Henosepilachna vigintioctopunctata*, while petroleum ether extract at 1 % conc. gave more than 85 % protection except *Leucaemea leucophyla* which offered only 60.44 % protection over control. Among the aqueous extract 1 and 5 % concentration of *A. Squamosa, A. mexicana, C. gigantea* and *R. communis* showed higher antifeedant activity and aqueous extracts of *L. leucophyla, P. Srosophils juliflora, Sapindus emerginatus* gave very poor protection at 1 % conc. against 2nd instar larvae indicating very little antifeedant activity.

Seven plant extracts viz. *A. indica* A.Juss, *Pongamia glabra* vent., *Annona squamosa* L., *Lawsoina alba* L. and *Datura suaveoleus* were determined for antifeedant activity against *Spodoptera litura* (Fab) on groundnut leaves. The results indicated that leaf and seed extracts of *A. indica* A.Juss and the extract of *P. glabra* Vent. were highly effective and offered 75.55, 88.96 and 66.41 % protection respectively at 15 % conc. and it was also concluded that the antifeedants are dose dependent. (Koshuya and Ghelani, 1990)

Dubey *et al.*, (1991) studied antifeeding property of nine naturally occurring plant products against the larvae of *Helicoverpa armigera* Hb. Neem seed kernel extract 5 % and Neem rind extract 1 % provided maximum protection to chickpea resulting in higher yields. Garlic (0.5 %), Shikekai pod (1 %), Ritha pod (1 %) and Onion extracts (2.5 %) proved to be the least effective.

Chloroform extract of flowers of *Rhododendron molle* was found to be very effective as antifeedant against 5th instar larvae of *M. seperata* and *N. lugens* and a very potent contact poison against 3rd instar larvae of rice borer, *C. supperessalis* (Chin, 1993).

Methanolic extracts of 37 plants were evaluated by Tripathi and Singh, (1994), as feeding deterrent against *S. obliqua* Walker by using leaf disc method as bioassay, antifeedant activity has been confirmed in eight plants. Highest protection was shown by *Robus ellipticus* (100 %) which was followed by *Saraca indica* (99.57 %), neem extract (99.00 %) and *Uritica parviflora* (83.61 %). All these plants were at par with each other and equally effective.

Jacob and Sheila, (1994), investigated aqueous extracts of *Datura alba* Nees., *A. indica* (Adr). Juss, *C. procera* Br. and *Chromolaena odoratum* L. for antifeedant property against *Selepa docilis* Butl and *Pericallia ricini* F. Leaf disc bioassay method showed that only *Azadirachta indica* extract (5 %) exhibited high antifeedant property against both *P. ricini* and *S. docilis* with feeding ratio 17.78 % and medium antifeedant property with 37.98 % feeding ratio towards *P. ricini*.

According to Rao *et. al.*, (1996), neem and custard apple acts as effective Phagodeterrents at 0.1 % conc. but without significant mortality on *Achoea janata* Linn larvae when compared to endosulfan 0.05 % and botanical formulations when sprayed on castor plants retained their antifeedancy upto 7 days in field.

Bisen and Kumar, (1997), evaluated that petroleum ether extract 1 % conc. of *Artimisia vulgaris, Urtica dioica, Polygonum runcinetum* and *Eupatorium glandulosum* for their antifeedant action against 3rd instar larvae of bunch caterpillar on tea in the laboratory. All the plant extracts showed varying degree of antifeedant effects and offered 77.52 to 87.19 % protection to tea leaves over control against feeding by bunch caterpillar. The maximum antifeedant action was exhibited by the extract of *A. vulgaris* followed by *P. runcinetum, U. dioica* and *E. glandulosum* at 1.0 % concentration each. Each of the four plant extracts at 0.5 % and 0.25 % conc. has been found effective as antifeedant but to a lesser degree as compared to 1.0 % conc.

Mayabeni (1997) compared the efficacy of neem bark decoction, neem based chemicals and neem derivatives (neem oil, leaf extract and leaf decoction) against 4th instar larvae of *C. medinalis*. Leaf area fed by the larvae recorded after 48 hours proved that neem bark was the most effective botanical in reducing the rate of feeding and pupation.

Rao *et al.*, (1999) reported annona concentrate @ 0.025 % to be effective antifeedant against *H. armigera* Hub. with 92.39 % reduction in feeding till 48 hours after application. Mixture of annona oil and neem oil (annona oil 36 EC + neem oil 36 EC) also showed efficacy with 41.08 per cent reduction in feeding over control. Neem formulation azadirachtin 1500 ppm was the effective among other neem formulations with a reduction of 87.31 % feeding.

Patel and Jhala, (1999) tested antifeedant activity of different neem formulations viz. Repelin @ 1.0 %, Margocide CK @ 0.1 %, Neemark @ 1 %, Gronim @ 0.6 %, Nimbecidine @ 0.2 %, Parasmaru @ 0.3 %, Neem oil @ 0.5 % and Achook @ 1.0 % against *Athalia lugens proxima* which showed antifeedant action with highest % reduction in leaf area consumption (72.72 %) on Margocide CK.

Antifeedant property of two commercial neem formulations viz. Neem Azal – T/S (1 % azadirachtin) and Neem Azal – F (5 % azadirachtin) in comparison with a standard insecticide endosulfan 35 EC tested by leaf disc dipping method against *Acherontia styx*, *Henosepilachna vigintioctopunctata* and *Mylloceros subfasciatus* adults revealed that, though endosulfan recorded the lowest leaf damage owing to its lethal action, Neem Azal – F 1ml/l was most potent antifeedant against *Acherontia styx* and *Mylloceros subfasciatus* adults with 97.40 and 98.24 % protection. Neem Azal – T/S 5ml/l exhibited the highest level of feeding deterrency (92.34 %) against *Henosepilachna vigintioctopunctata* and the antifeedant effect was in general dose dependent. (Kumar and Babu,1999)

Saikia and Parameswaran, (2000) evaluated EC and dust formulation of neem (*Azadirachta indica*) and pungam (*pongamia glabra*) oil for its repellant and antifeedant properties against rice leaffolder, *cnaphalocrocis medinalis* (Guenee). They found Neem oil 60 EC (A) at 3 %, Neem oil + Pungam oil 60 EC (C) at 3 % and Neem seed kernel dust 20D at 25 kg/ha to be most effective and potent repellent as well as antifeedant against rice leaffolder. The neem based EC and dust formulations at higher concentrations found to retain antifeedant property for six days.

Acetone extracts of 17 plant species screened for the presence of antifeedant property against *spodoptera litura* indicated that the extracts of *Azadirachta indica, Holarrhena antidysenterica, Glyricidia maculate and Acorus calamus* were found to possess strong antifeedant activity on the basis of minimum per cent feeding and maximum protection over control. The former plant species recorded lowest PC_{95} (protection over control) value of 0.048 per cent which was 16.25, 43.52 and 60.40 times lower than extracts of *A. calamus*, *G. maculate* and *H. antidysenterica* respectively. (Desai and Patil, 2000)

Bansal *et al*. (2001) screened *Ajuga parviflora* and *Ajuga bracteosa* for antifeedant activity against *spilosoma* obliqua Walker. Methanol extract of *A. parviflora* has been found to exhibit significant antifeedant activity at all tested conc. viz. 200 ppm, 100 ppm, 50 ppm and 25 ppm. There was significant decrease in activity with decrease in conc. While *A. bracteosa* exhibited significant activity at 200 ppm conc. only. At lower concentrations ie. 100 ppm, 50 ppm and 25 ppm antifeedant activity was insignificant.

Leaf disc choice method was adopted by Ramarethinam *et al*., (2002) to determine the antifeedant activity of nimbecidine in the laboratory. Study revealed significant influence on *Achoea janata* and a positive dose dependent on antifeedant activity with highest on dose 6 ml/l.

Metha *et al*., (2002) reported that petroleum ether extracts of *Artemisia brevifolia* Wall, *Eupatorium adenophorum* Spreng, *Lantana camera* L, *Melia azadarach* L and *Rumex nepalensis* exhibited complete cessation of feeding on third instar caterpillar of cabbage butterfly *Pieris brassicae* at 5 % concentration. Moderate to high level of reductions in feeding were resulted varying from 89.43 – 95.83 %, 75.50 – 88.90 % and 52.97 – 75.17 % at lower concentrations of 2.1, 1.25 and 0.625 % respectively.

Extracts of *Pogostemon parviflorus*, *Pongamia glabra* and *A. squamosa* showed antifeedant activity against tea mosquito bug, *Helopeltis theivora* Waterhouse. The extract of *P. parviflorus* possesses highest antifeedant property. The antifeedant activity with petroleum ether and methanol extracts were less as compared to chloroform extract. (Gogoi *et al*., 2003).

Belina *et al*., (2005) has reported a low to moderate effectof cow-five (*Purchgavya*) on *C. medinalis* in combination with soapnut solution. In the screen house when mixed with 0.5 % soapnut solution it was effective in reducing feeding significantly as compared to untreated control but was inferior to entosulfan (0.07 %).

2.1.2. Plant products as ovicides / oviposition deterrents.

In laboratory trials conducted by Saxena *et al*., (1981), females of the rice leaffolder, *Cnaphalocrocis medinalis* (Guenee) laid only one third of the number of eggs on neem oil treated rice plants (25 % and 50 %) as compared to control.

According to Singh and Srivastava, (1985) alcohol extract of neem seed oil at 5% completely deterred ovipositional activity of *Dacus cucurbitae* and even 2.5% concentration was effective in preventing oviposition.

Saxena and Barrion, (1987) reported that treatment of rice plants with neem seed kernel extract affected reproductive maturation of *Nilaparvata lugens* (Stal.) of males and frequencies of meiotic cells were significantly less in male progenies.

Velusamy *et al*., (1987) evaluated three neem products, neem oil at 1 %, 2 %, 5% neem seed kernel extract and 5% neem cake extract on brown planthopper oviposition. Treatments with all three products significantly reduced oviposition with maximum reduction on 2% neem oil product.

Karem *et al*., (1988 b) reported that oviposition by *Nephotettix viresceus* (Distant) and hatchability of eggs decreased on rice seedlings systemically treated with neem seed kernel extract.

Petroleum ether extracts of six plants viz. *Annona squamosa*, *Sapindus tryoliatus*, *Acacia concinna*, *Gyrandropis pentaphylla*, *Hyuocarpus alpine* and *Ocimum gratissimum* was evaluated by Reddy and Urs, (1988) for ovipositional reduction on brown planthopper at 5 % and 2 % conc. The result indicated significant reduction in all six extracts with maximum reduction in *Annona squamosa*.

Saxena *et al*., (1989) reported that topical application of neem oil on *Nilaparvata lugens* (Stal.) females at 2.5 or 5 mg/individual or caging on plants sprayed with > 3% neem oil disrupted the production of normal courtship signals and mating behaviour. At higher conc. Of neem oil, most females did not call, consequently males could not locate the females.

Different neem based formulations viz. Repelin 1.0%, Margocide CK 0.6%, Nimbecidine 0.2%, Parasmani 0.3%, Neem oil 0.5% and Achook 1.0% were tested in the laboratory by Patel and Jhala, (1999), for oviposition deterrent against sawfly, *Athalia lugens proxima* (Klug). The result showed that Repelin was the most effective oviposition deterrent.

Dwivedi and Mathur, (2000), designed a laboratory trial to find potentiality of five plant extracts viz., *Lawsonia inermis* (Lythraceae), *Acacia nilotica* (Mimosaceae), *Tagetes indica* (Compositae), *Thevetia nerrifolia* (Apocyanaceae) in acetone and pet ether as ovicide against pulse beetle, *Callosobruchus chinensis*. Out of these plants evaluated, *Lawsonia* leaf extract in both the solvents was found to be most effective, however, other screened plants also exhibit significant egg mortality, 85% in acetone and 71.67 % in petroleum ether has been observed in 100 % concentration of *Lawsonia* leaf extract. Experiments were conducted at optimum conditions of temperature and relative humidity viz., 25 ± 5° and 70 ± RH respectively.

Sundararaju and Babu, (2000) evaluated tender and hardened (matured) shoots of cashew along with tender and hardened shoots of neem for oviposition preference on neem mosquito bug, *Helopeltis antonii* sign. under choice test. In spite of relatively high moisture

content, total sugar and protein, and low phenol and tannin estimated in the tender and hardened shoots of cashew than neem, the matured shoots of cashew were very much less preferred for oviposition which indicates the presence of strong deterrency factor to be exploited as a botanical insecticide.

Patil and Goud, (2003) evaluated ten methanolic plant extracts viz.- *Acorus calamus* L., *Annona squamosa* L., *Azadirachta indica* A. Juss, *Clerodendron inerme* Garten, *Lycopersicon esculentum* Mill, *Melia azadarach* L., *Ocimum sanctum* L., *Ricinus communis* L., *Vinca rosea* L., *Vitex negundo* L., and two commercial botanicals (Honge oil and Neemark) for their ovipositional / repellent properties against *plutella xylostella* under laboratory conditions. Among the plant product tested, *Azadirachta indica* at 0.5% conc. recorded maximum reduction in egg laying both under no choice (50.33%) and free choice (64.43%) followed by *Acorus calamus* with 40.55% and 40.87% reduction respectively in no choice and free choice conditions. Whereas, least repellency was noticed with castor, *Ricinus communis* extract.

2.1.3. Plant products as growth and development inhibitors.

Binder and Waiss, (1984) reported that extracts of dried soyabean, *Glycine max* (L) and Merrill leaves from the insect resistant line PI 229358 with solvents of increasing polarity when incorporated in artificial diet of bollworm, *Heliothis Zea* (Boddie), larvae caused increased larval mortality. Larval deaths were associated with failure to complete larval-to-pupal metamorphosis.

Prabhaker *et al.*, (1986) reported that neem-seed extract, incorporated into an artificial diet at 0.02, 0.2 and 2.0 % (wt / vol) prolonged development and induced mortality in all larval stages of *Trichoplusia ni* (Hubner) and *Spodoptera exigua* (Hubner). Only one non-reproductive *T. ni* adult female was produced at the lowest concentration (0.02 %) when fifth instars were exposed to the diet. No pupae were formed by *S. exigua* larvae, regardless of stage treated with or extract concentrationtested. Larval mortality of both species was more pronounced during ecdysis, indicating activity similar to that of other insect growth regulators.

Saxena (1987) reported that larvae of rice leaffolders caged on neem oil or extract treated plants suffered from ecdysial failures and developmental deformities.

In a greenhouse study, oils extracted from seeds of Karanj, (*Pongamia pinnata* Pierre); mahua, (*Madhuca longifolia* Koen. Macbr) and pinnai, (*Colophyllum inophyllum* L.), trees were more effective than the oil of neem, *Azadirachta indica* A. Juss, in reducing the survival of the rice green leafhopper, *Nephotettia virescens* (Distant) and transmission of the rice tungro virus (RTV) and were as effective as oil of custard-apple, *Annona squamosa* L. Insect mortality was 100 % after 4 d on rice plants sprayed with oils at 5 % concentration in contrasts to 69 % insect survival on control plants (Mariappan *et al.*, 1988).

Milled seed of *Limuanthes alba* var. versicolar (Greene) when incorporated into artificial diet at 3 % (wet weight), caused 100 % mortality in newly hatched fall armyworm larvae, *Spodoptera frugiperda* (Smith) within 8 days. An ether extract and subsequent ethanol extract at dose equivalent to 3 % powdered meal caused no mortality. European corn borer larvae, *Ostrinia nubilalis* (Hubner), were less sensitive to the materials derived from L. alba. The seed meal did not cause significant mortality, although weights of the surviving larvae were only 4 % of the weight of the control larvae after 8 days (Bartelt and Mikolajezak, 1989)

Effects of azadirachtin on the metamorphosis, longevity and reproduction of Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann); oriental fruit fly, *Dacus dorsalis* (Hendel) and melon fly, *D. cucurbitae* (Coquillett), exposed as late third instars and pupae to treated sand were determined by John *et. al.*, (1990). Formation of puparia was not affected by Azadirachtin at the concentrations tested. Adult emergence was completely inhibited at concentrations of 14 ppm for *D. cucurbitae*. *D. cucurbitae* was significantly more susceptible to azadirachtin than *C.capitata* and *D. dorsalis*. Even though adult emergence was inhibited, approximately 95 % of treated puparia contained living adults. Adults that emerged from treatments appeared normal but significantly mortality was noticed when compared with control. Ten days after emergence 75 % *D. dorsalis* and 64 % *C. capitata* died after treatment exposure as larvae and pupae to 4.66 ppm azadirachtin. Whereas approximately 24 % of *D. cucurbitae* exposed to 2.77 ppm azadirachtin died within 10d after emergence. Azadirachtin had no significant effect on the number of eggs laid by adult *D. dorsalis* and *C. capitata* that had survived larval-pupal treatments with 1.85 ppm. Azadirachtin had no significant effect on egg hatching growth and development of F_1 progeny.

Krishnaiah and Kalode, (1990) showed that the oils of mahua (*Bassica datifolia*) and pinnai (*Calophyllum inophyllum*) were highly toxic to brown planthopper (BPH) nymphs and were superior to maravetty (*Hydnocarpus wightiana*). Oil of pinnai and neem affected orientation and settling of BPH. Pinnai was superior to neem and Mahua in antifeedant effects against BHP. They also disrupted the growth of BPH and green leafhopper (GLH). Neem seed kernel water extract (NSKWE) spray adversely affected the growth of BPH (at 500 ppm) and GLH (at 25000 ppm). NSKWE as seedling root dip was more efficient than spray. Neem seed kernel suspension (NSKS) 3 % level inhibited the growth of GLH nymphs. Field studies revealed that neem cake (150 kg / ha) incorporated in soil and followed by neem oil (3 %) spray at 10 days interval effectively checked leaf folder incidence. However 3 % sprays of neem oil, mahua oil, pinnai oil and neem seed kernel suspension did not show consistant effectiveness against stem borer (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae)* and whorl maggot (*Hydrellia Philippines*).

Harvey *et al*., (1994) evaluated effects of selected natural insecticides on the tobacco budworm, *Heliothis virescens* (F). Compounds evaluated were azadirachtin, Kryocide, Pyrerthrum, rotenone, ryania and sabadilla. Survivorship within the rotenone (87.3 %) treatment was highest and was at par with the control (83.3 %); larvae exposed to ryania and azadirachtin rarely survived beyond the first instar. Survivorships among the Kryocide, pyrethrum and sabadilla treatments were 56.7, 40.0 and 35.0 % respectively. With the exception of rotenone, developmental time was significantly longer for all treatments compared with the control. Larvae maintained on the diet required 20 additional days to reach the pupal stage. Similarly, development among larvae reared on Kryocide and sabadilla was lengthened to 9 and 13 days respectively. Neem seed extract inhibited growth and development of gypsy moth, Lymantria dispar (L) larvae was reported by Martin *et al*., 1994. Untreated control larvae increased their weight by 40 fold by day 14, whereas insects treated with 0.0-10 % neem and 1.0 % neem weighed 30 % and 40 % respectively, of the average weight of the untreated larvae. By day 14, 99 % of the controls were in the fifth stage and 1 % were prepupae. After treatment with 0.10 % neem almost one – third of those larvae were still in the fourth stage, whereas larvae treated with 1.0 % neem were still in the second and third stages.

Alice *et al*., (2000) reported that in the seed treatment method, neem seed kernel extract (NSKE) (5 %) and palmarosa oil (0.05 %) was found to have 46.6 % survival of

brown planthopper, *Nilaparvata lugens* (Stal.) as against 86.6 % in control. Mean developmental period was more in NSKE (16.33 days) and growth index was minimum in Neem seed kernel extract (2.85 %). In seedling root dip method, a similar trend as in seed treatment method was observed, in foliar application method also Neem seed kernel extract was found to be superior among the other plant products. The area of the honeydew by BPH absorbed in the filter paper was maximum in Neem seed kernel extract 5 % which showed an increase number of feeding probes yeast like symbiotes (YLS) was found to be minimum in neem product.

Morale *et. al.*, (2000) reported that neem oil 1 %, Karanj oil 1 %, cotton seed oil 1 % and NSE (methanolic) 1 % significantly affected the larval period, larval mortality and fecundity of *Helicoverpa armigera* (Hubner). Neem oil 1 % and Neem seed extract (NSE) (aqueous) 5 % caused malformation of pupae while adults were found malformed due to NSE (methanolic) 1%, Neem oil 1% and NSE (aqueous)5 %.

Methanolic extract of NSKE was evaluated by Joseph, (2000) for its antifeedant and growth inhibitory effects against last instar larvae of Ailanthus defoliator, *Eligma narcissus indica*. The result indicates feeding deterrence and growth inhibition. Larval feeding on NSKE treated food resulted in various degrees of growth disruption in pupal and adult morphogenesis in a dose-dependent manner.

2.2. Field evaluation.

Rajasekaran *et al.*, (1988) evaluated 5 % Neem seed kernel extract (NSKE) and neem coated urea (NCV) @ 100 kg + 150 kg neem cake/40m^2 plot against rice stem borer, *Scirpophaga incertulas* (Walker); leaffolder, *Cnaphalocrocis medinalis* (Gunee) and ear head bug, *Leptocorisa oratorius* (Fabricus). NSKE significantly reduced damage by leaffolder. The efficacy was comparable to monocrotophos while NSKE had no effect on stem borer and earhead bug.

Neem oil at 4 % conc. was recorded to be very effective against white back planthopper (WBPH), *Sogatella furcifera* (Horvath) and green leafhopper (GLH),*Nephotettix* spp. The treatment was at par with monocrotophos and chlorpyriphos (Shukla *et al.*, 1988).

Neem oil at 4 conc. 1 %, 2 %, 3 % and 4 % mixed with teepol 0.4 % was evaluated by Singh et al., (1993) against rice leaffolder, *C. medinalis* (Gunee) on PR 160. Observations on all treatments were significantly better with 20.56 to 26.91 percent damage leaves than untreated control with 33.32% leaf damage with minimum infestation of 20.56 % on 2 % neem oil treatment. The difference with respect to yield in various treatments (4678 to 5048 kg/ha) and untreated control (4360 kg/ha) were non significant and higher conc. (4 %) of neem oil treatment exhibited less effectiveness against rice leaffolder.

Dilawari *et al.*, (1991) reported that application of Neemark at 0.25 kg a.i./ha at white head stage was effective against rice stem borer, *Scirpophaga incertulas* (Walk.) and found to at par with chlorpyrifos (0.5 kg a.i./ha) and yield was also significantly better than control and was at par with carbofuran, phorate, phosphamidon and chlorpyrifos.

According to Jayaraj, (1991) neem seed kernel extract (3-5 %) was effective against rice leaffolder, Marasmia patnalis (Bradly).

Neemark, Repelin, Neemrich I and II alone or in combination with synthetic insecticide monocrotophos (Nuvacron) were evaluated against the rice leaffolder, *C. medinalis* (Guenee) in the field by Singh *et al.*, (1994). Repelin recorded minimum percentage of folded leaves (10.08 %) as compared with control (21.04 %). The combine treatments (Neemark-monocrotophos) significantly reduced the leaffolder damage, which were found to be at par with monocrotophos alone.

Dhaliwal *et al.*, (1993) reported that Repelin and Neemrich II were effective in reducing rice leaffolder incidence with leaf damage 18.91 % and 20.64 % respectively as compared to untreated control with 32.15 % damaged leaves.

Muralibaskaran *et al.*, (1993) evaluated six plant products for their efficacy against sesame shoot Webber and pod borer during 1987 and 1988 rainy season by spraying them twice at 30 and 50 days after sowing. Among them neem oil (2 %) reduced shoot Webber damage even upto 7 days after each treatment and also registered lower pod borer damage (4 %). In addition neem oil yielded highest cost benefit ratio of 3:67 followed by endosulfan (0.07 %) neem kernel extract (2 %) and tobacco decoction (1 %). Neem leaf extract, karanj oil (2 %) and Mahuwa oil (2 %) were not profitable treatments and recorded cost benefit ratio less than one.

Ambethgar (1996) evaluated 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 %, neem leaf decoction (0.5 kg/one litre of water), and neem oil 3 % was compared with chlorphyriphos (0.5 kg a.i/ha) and quinalphos (0.4 kg a.i/ha) against rice leaffolder, *C. medinalis* Guenee under field conditions. The treatments were applied at two times at 7 day interval, the first at 25 DAT. Chlopyriphos proved to be the most effective exhibiting the leaf damage 11.10 % and 10.08 % followed by Neem cake + NSKE 5 % with 12.11 % and 12.29 %, Quinalphos 15.80 % and 14.57 %, neem seed kernel extract 16.02 % and 16.08 % and neem oil 16.47 % and 16.84 % leaf damage after the first and second sprayings respectively. Both the applications of neem leaf decoction and neem cake proved least effective in reducing the percentage of damaged leaves due to rice leaffolder.

Kaul and Sharma, (1999) evaluated efficacy of six neem products, viz., Nimbicidine, Neemark, Neemgold, Econeem, Neemazal and Fortune in the field against major insect pests of rice. All neem formulations were at par with the insecticide chloropyriphos for the control of stem borer, *Scirpophaga innotata* (Walk.); rice hispa, *Dicladispa armigera* (Olivier); and leaf folder, *C. medinalis* (Guenee), damaging rice variety *Kasturi Basmati*. Significantly higher yields (30–31 Q/ha) were obtained in treated plots as compared to (28 Q/ha) in the untreated plot.

Krishnamurthi *et al*., (1999) evaluated locally available botanicals, viz., *Lantana camera*, *Euphorbia hirta*, *Andrographis paniculata*, *Bougainvillae prosopis* in comparison with proven botanicals neem and pungam derivatives and an insecticide chlorpyriphos against rice leaffolder, *C. medinalis*. Results revealed that the application of plant extracts for controlling rice leaffolder incidence was as effective as that of NSKE and these two were found to be equally effective as that of chlorpyriphos in reducing the population of rice leaffolder.

Field evaluation of custard apple (*Annona squamosa*.L) and neem (Azadirachta *indica* A. Juss.) based formulations against castor semi-looper (*Achaea janata* L.) indicated that reduction in the larval population at 24 and 72 hrs after treatment respectively was 58.89 % to 66.70 % by Annona oil concentrate 2.5 EC; 46.45 % to 58.52 % by NSKE 1500 ppm, 48.28 % to 56.80 % by Annona oil 36 EC + neem oil 36 EC and 45.96 % to 55.10 % by Annona oil 72 EC respectively. The activity of botanicals decreased to some extent 3 days after treatment (Raman *et al*., 2000).

Studies on bioefficacy of neem derivatives integrated with conventional pesticides like monocrotophos, phorate and chloropyriphos sprayed on rice varieties *Jaya* and *Lalat* against rice leaffolder, *C. medinalis* (Guenee) revealed that neem oil and neem seed extract @ 2 % (along with 0.1 % Teepol) at 20 and 70 days after transplanting and monocrotophos @ 0.4 kg a.i. at 40 days of the transplanting, proved effective against rice leaffolder with a moderate suppression in between the maximum protection by chemicals only and the neem derivatives (Nanda *et al*., 2000).

A field experiment on the efficacy of different plant products along with seed dresser and chemical insecticides against *Liriomyza trifolii* on ridge gourd indicated that NSKE 5 % conc. found promising in control of leaf miner (28.35 %) and recorded highest yield (32.71 q/ ha) whereas karanji oil (29.68 %) and Monocrotophos failed to offer satisfactory control of leaf miner (Rosaiah, 2001).

Belina *et al*., (2005) has reported that endosulfan (0.07 %) was as effective as twice to cow-five (3 %) with or without soapnut solution (0.5 %). The injury to the flag leaves indicated no difference in treatment effects. There was no significant difference among the treatments in terms of certain plant characters and grain yield.

MATERIALS AND METHODS

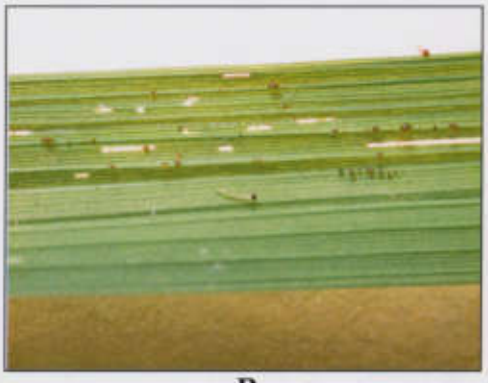
3. MATERIALS AND METHOD

The materials used and the methods adopted in the present investigation are classified and described in detail as per the need of the experiments.

3.1. Test insect – *Cnaphalocrocis medinalis* (Guenee)

Adult moths are golden yellow in colour with black wing margins in the apical region. Males are brighter than the females. There are three dark brown zig-zag horizontal lines on each forewing (Plate 1E). The anterior one is longer and extended from the coastal margin to the anal margin. The middle one is short and comma-like, curved outwards and the inner one is shorter than the outer one and do not reach the anal margin. In the hind wing, there are two brown lines, outer being much longer than the inner. Abdominal terminal of male is pointed whereas it is blunt in females. The males have a tuft of black adrocorial scales on the coastal margin and a thick black hair tuff on the fore tibiae. Wing span of male is 15.0 to 16.0 mm whereas in females it is 15.0 to 17.0 mm. Adult males and females live for 3.0 to 4.0 and 5.0 to 7.0 days respectively. The moths are nocturnal in habit and during daytime they remain hidden under the leaf canopy. Mating occurs during the night. Copulation lasts for 10 to 20 minutes and oviposition starts 2 to 3 days after mating. The female lays eggs singly or in groups of 2 to 6 in a single line on either surface of the leaves but very often on the upper surface, parallel to the midrib, often concentrated on the tips of long drooping leaves or on the culms, especially near the soil level. Freshly laid eggs are hexagonal, jelly like, translucent with a reticulate upper surface but turn to ovoid in shape and yellowish white in colour when mature and measure 0.73 to 0.92 mm in length and 0.31 to 0.42 mm in breadth (Plate 1A). The incubation period varies from 3 to 4 days. A female lays 68 to 182 eggs in her lifetime. The newly hatched first instar larvae are whitish with black head and measure about 1.50 mm in length and 0.30 mm in breadth. In this instar the larvae are gregarious and do not fold the leaves. They scrape chlorophyll on the youngest unfurled leaves in group of 2 to 4 and as they feed (Plate 2A & 2B), their body colour turns greenish and the larvae becomes solitary and folding of the leaves starts during the second instar (Plate 1B). There are five larval instars and a full grown larva is yellowish green with an orange tinge on the dorsal side. It measures 17.0 to 18.0 mm long and 2.50 mm wide (Plate 1C). Before pupation the larvae turn sluggish and cease to feed and measure 12.0 to

A



B

C

D

E

Plate 1. Different stages of rice leaffolder, *C. medinalis* (Guenee).
A. Egg mass. **B**. Newly hatched larva. **C**. Full grown larva. **D**. Pupa. **E**. Female moth.

A

B

Plate 2. Rice leaves infested by rice leaffolder.
A. Leaf rolls as damage symptoms. **B**. Folded leaves as damage symptoms.

13.0 mm in length and 2.50 mm in width and this stage lasts for 1 to 2 days. Newly formed pupae are yellowish brown but turn reddish brown later and measure 8.0 to 10.0 mm in length and 1.0 to 2.0 mm in breadth (Plate 1D). Pupal stage lasts for 6.0 to 7.0 days. Total life span from egg to adult is 33.0 to 48.0 days in male and it is 36.0 to 52.0 days in female.

3.2. Plants used for the experiments:

Poisonous plants growing widely in Nagaland have been selected and are described below:

3.2.1. Botanical name : ***Amhineuron apulentum*** **(Kaulf) Holtum.**

Family : **Thelypteridaceae**

Vernacular name : ***Asang*** **(Ao),** ***Ma-a-chai*** **(Assamese)**

It grows as wild fern all over Nagaland in fallow land and in degraded forest. Fronds are light green in colour and hispides emit a strong pungent smell when disturbed (Plate 3A).

Leaf paste mixed with a herb *Hypericum japanicum* (Ao-Chani) are applied to relief tooth ache. Crushed leaves are kept in poultry houses to repel the mites from the birds.

Fresh leaves collected from fallow and degraded forest area in and around Medziphema were dried in shade. The leaves were spread on bamboo mat for about 10-15 days. Dried leaves were grinded in a grinder into fine powder (Plate 3B).

3.2.2. Botanical name :***Clerodendrum viscosum*** **Vent.**

Family : **Verbanaceae.**

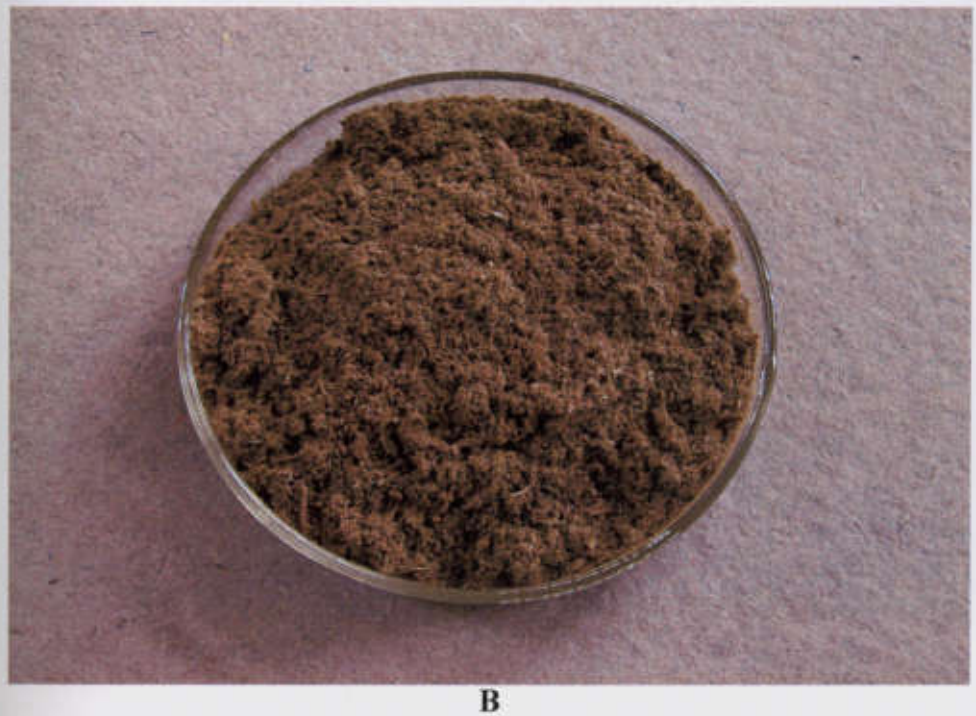
Vernacular name : ***Akawa*** **(Ao)**

The plant is a shrub and grows up to 3 m height. It is a common shrub in secondary forest and fallow land. Leaves are ovate to lanceolate, acute or acuminate, dentate. Flowers are white or tinged with pink and reddish bracts, drubes bluish black. Flowering takes place during the month of February-August (Plate 4A).

Young shoots crushed in the form of a paste are applied on the hair to kill head lice and it softens the hair.

Leaves collected from the fallow land and secondary forest was dried in shade. The dried leaves were grinded into powder and used for the extraction (Plate 4B).

A



B

Plate 3. ***Asang***, *A. apulentum* (Kauf) Holtum.
A. Wild growing fern. **B**. Dry leaf powder.

A

B

Plate 4. ***Akawa***, *C. viscosum* Vent.
A. Wild shrub in full bloom. **B**. Dry leaf powder.

3.2.3. Botanical name : ***Litsea citrata*** **Bl. Bijdr.**

Family : **Lauraceae**

Vernacular name : ***Ongret*** **(Ao)**

It is a small tree and grows wild in fallow land and secondary forest areas. Leaves are alternate, buds naked or scaly, leaves somewhat in equilateral, lanceolate or narrow ovate lanceolate and dark green in colour. Flowers are dioecious, umbellate or capitate. Fruits are inserted in small calyx tube, copular and enlarged (Plate 5A).

Bark and leaves are used as carminative, expectorant and stimulant. Paste of leaves and fruits are used as acaricide and fruits are used as spices. Crushed berries mixed with finely grinded meat of "for" (kind of rat which lives under the culms of bamboos) and fermented bamboo shoots of *Bambussa* sp. is boiled and taken by patients suffering from dysentery and diarrhea. Twigs are crushed and used as insecticide and the plant is smoked inside the house to kill the larvae which eats away the roof made of palm leaves (*Levistomia jinkemsia* and *Caryota* sp.).

Ripe fruits were collected and dried in shade by spreading on bamboo mat (Plate 5B).

3.2.4. Botanical name : ***Millettia auriculata*** **Baker ex. Brand.**

Family : **Fabaceae.**

Vernicular name : ***Suli*** **(Ao)**

A large robust, woody climber found in secondary forest and fallow land. Leaves are petiolate, leaflets green, glabrous above, pale below and obovate. Flowers in dense axillary racemes near the end of the branches, pods are straight and very hard (Plate 6A).

Pastes of roots are applied to sores in cattle to kill the worms and the plants are crushed and washed into the streams to kill the fishes. The birds collect and keep small twigs of this plant in their nests and it is said that the twigs are kept as medicine for their young ones.

Roots of the plants were chopped into small pieces and dried under shade on a bamboo mat and were grinded into powdered form (Plate 6B).

A

B

C

Plate 5. ***Ongret***, *L. citrata* Bl. Bijdr.
A. Tree growing wild in the forest of Nagaland. **B**. Leaves and fruits. C. Dry fruits.

A

B

Plate 6. ***Suli***, *M. auriculata* Baker ex. Brand.
A. Woody climber growing wild in the secondary forest of Nagaland.
B. Dry root powder.

3.2.5. Botanical name : ***Mimusops hexandra* Roxb. Cor.**

Family : **Sapotaceae.**

Vernicular name : ***Alinengba* (Ao)**

It is a large woody climber; sometimes a shrub, often gregarious. Leaves are wholly glabrous, shinning, generally crowded at the ends of branchlets. Leaves are obovate-oblong in shape, obtuse or emarginated with 2-4 blade, petiole ¼ inch. Flowers ½ inch across, pale yellow in colour, pedicels ¼ inch, calyx segments-6, stamens 6-8, staminods glabrous, frequently bifid. Berry ½ inch long, 1 seeded (sometimes 2), flowering from November to February. It grows in ecotone belt (Plate 7A).

Crushed roots are washed into the stream to poison the fish. (All the performances are carried out with ritual and handlings of roots are done against the wind direction to avoid body contact with the gas which causes serious body inflammation and swelling).

Roots collected from the forest are chopped into small pieces and dried in shade by spreading on bamboo mats. Dried roots are grinded into fine powder with the help of a grinder (Plate 7B).

3.2.6. Neem oil:

Neem oil is a product of seed extract of Neem tree, *Azadirachta indica* (A.Juss). It is tropical/sub-tropical tree where fruits usually appear 3-6 years after planting but sometimes it is produced after 2 years in high salinity soil and fruiting generally takes place during the month of June/July. Neem oil is extracted form crushed seeds by steam pressure or solvents. Neem oil is a thick, dark brown fluid with bitter taste and pungent garlic odour. Azadirachtin is the primary toxin in neem oil which contains mainly triglycerides and triterpenoids. Neem oil is effective against a wide range of pests at several stages of the life because of its feeding and oviposition deterrent, repellent and growth inhibiting properties. Further more, it disturbs a number of physiological processes in insects and their activities are strongly affected. Neem oil has been selected as a standard from insecticide of plant origin to compare the effectiveness of plant extracts in the experiment.

A

B

Plate 7. ***Alinengba***, *M. hexandra* Roxb. Cor.
A. Woody climber growing wild in the secondary forest of nagaland.
B. Dry root powder.

3.2.7. Fenvalerate:

Technical name of Fenvalerate is (R.S)-Cyno-3-phenoxybenzyl (R,S)-2-(4-chlorophenyl)-3-methylbutyrate. It is a pyrethrin derivative insecticide and it exhibits broad spectrum activities against a number of insects such as orthoptera, hemiptera and Lepidoptera. Its low toxicity and wide range of effectiveness make this an effective insecticide for field crops especially for leaf eating and sucking pests. Its LD_{50} for rat is 451mg/kg. Chronic problems have not been demonstrated for this class of chemicals, except for dermatitis that occurs as an allergic response in individuals sensitive to the pyrethrum extract. Fenvalerate has been selected as a standard from scientific insecticide for comparing the effectiveness of plant extracts in the experiment.

3.3. The rice cultivar – *Jaya.*

It is a high yielding variety of rice being a selection from the cross IN-1 and I41. The male parent is a tall, photosensitive variety.

The plant is dwarfing having erect leaves and short and stiff culms. The variety does not lodge with high dose of nitrogenous fertilizers. The yield of the variety keeps on increasing progressively even at 200 to 250 kg/ha. The variety is non-sensitive to photoperiod but sensitive to temperature and matures within 130-140 days. The kernels are long and medium and grains are fine. At vegetative stage it is difficult to distinguish *Jaya* from IR 8 but at flowering stage it can be identified by full erection of panicle unlike IR 8 and IN-1.

Evidence indicates that at a particular nitrogen level the spacing can be increased from effect on the yield. It has a yield potential of about 10 to 15% more than that of IR 8 which ranges from 9,000 to 10,000 kg/ha. This variety is grown in comparatively lowlands as the plants require about 5 to 8 cm standing water in the plot during its active growth period.

Jaya is susceptible to most of the important pest of rice.

3.4. Mass rearing of rice leaffolder:

In order to get a continuous supply of test insect in a particular stage in sufficient number for the experiments the insect was reared in the net house by

adopting the methods developed by Waldbauer and Marciano (1979). The steps are mentioned below.

- Moths collected from the field in the morning hour with the help of insect net were released in the potted rice plants (var. *Jaya*) kept under nylon net. The net was supported on bamboo structure outside the laboratory (Plate 8A).

- Moths were allowed to lay eggs on the leaves of the potted plants. The eggs were collected from the leaves 24 hrs. after release of the moth.

- Leaves were examined for the presence of eggs and the leaves with eggs were cut with the help of scissors. The cut ends of the leaves were wrapped with moist cotton and 2-3 leaves were kept in glass tubes. The opening ends of the glass tubes were plugged with a cotton cork. After labeling, the tubes were kept in a desiccator having water for hatching.

- Newly hatched larvae were carefully transferred to the fresh leaves with the help of a wet camel brush.

- Larvae were reared in the glass tubes plugged with cotton cork (Plate 8B). The tubes were kept in a desiccator with water for normal growth.

- Fresh leaves wrapped with moist cotton were supplied daily. The tubes were cleaned every alternate day to remove the fecal matter and to dry the glass tubes which used to receive water due to condensation.

- The pupae formed were taken out from the glass tubes and kept in glass jars for emergence of moth. The moths thus emerged were released on the potted plants covered with nylon net. The process was continued through out the experimental period.

3.5. Laboratory/net house experiments:

In the Laboratory/ Net House experiments, the plant extracts were evaluated for their actions as antifeedant effect on oviposition and larval development of

A

B

Plate 8. Mass rearing of rice leaffolder, *C. medinalis* (Guenee).
A. Potted plants inside the nylon net cover. **B**. Glass tubes used for larval rearing.

3.5.1. Plant extraction process:

The details of plant parts used for extraction are tabulated in Table 1. Dry Plant materials of 300 gms were used for each extraction in soxhlet apparatus (Plate 9A) using acetone and methanol as solvents. The solvents in the boiling flask were filled up to ¾ capacity and the extraction was done at 45°C for 6 hours. After extraction the solvents were recovered in the extractor by filtering process and the crude extract left behind in the boiling flask were collected in bottles and kept for use during the experiments (Plate 9B).

Table 1. Details of plant parts used for extraction in different solvents.

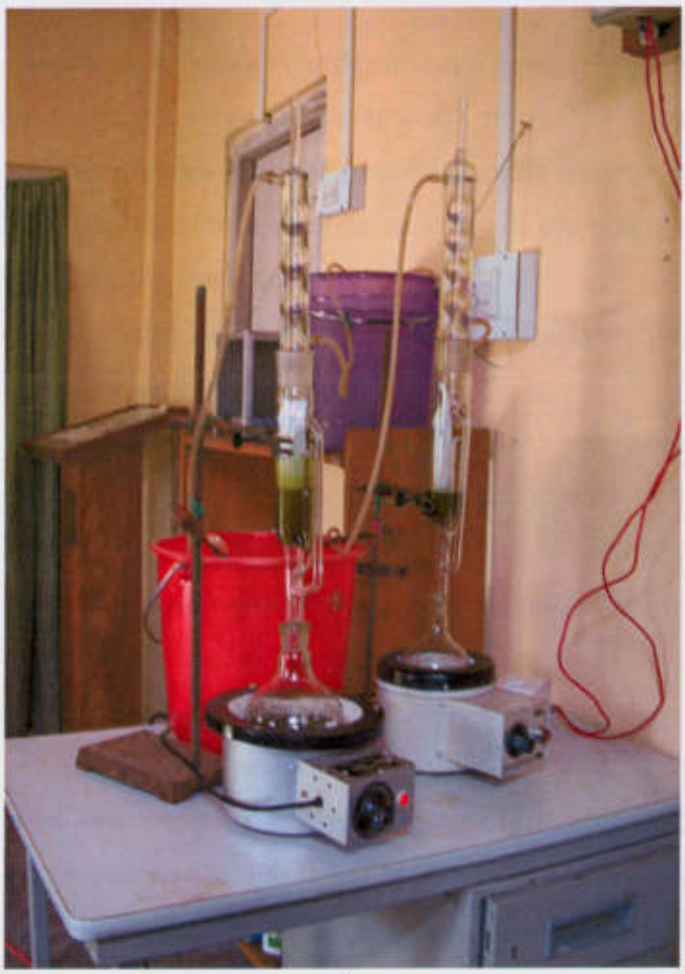
Sl. No.	Scientific name	Vernacular/Common name	Family	Plant parts used	Solvent
1.	*Amphineuron apulentum* (kaulf) Holtum	*Asang* (Ao) *Ma-a-chai* (Assamese)	Thelypteridaceae	Leaves	Acetone / Methanol
2.	*Clerodendrum viscosum* Vent.	*Akawa* (Ao)	Verbanaceae	Leaves	Acetone
3.	*Litsea citrata* Bl. Bejdr.	*Ongret* (Ao)	Lauraceae	Fruits	Acetone / Methanol
4.	*Millettia auriculata* Baker ex. Brand.	*Suli* (Ao)	Fabaceae	Roots	Acetone / Methanol
5.	*Mimusops hexandra* Roxb.Cor.	*Alinengba* (Ao)	Sapotaceae	Roots	Acetone / Methanol

3.5.2. Preparation of plant extract emulsions:

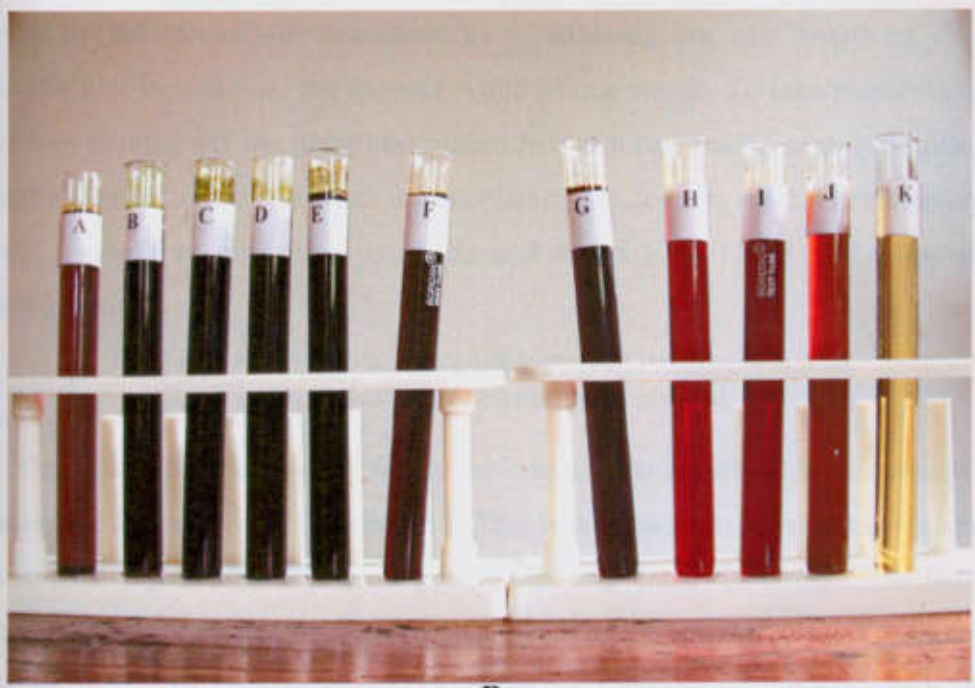
For preparation of plant extracts emulsion, 20 ml of plant extract and 1 ml of tritonX 100 at 0.1 % conc. were taken in measuring cylinder of 1 lt capacity. The water was added up to the mark and the mixture was shaken well so that the extract could disperse well and uniform emulsion was obtained. The neem oil and fenvalerate emulsions were prepared from commercially available formulations.

3.5.3. Planting of rice plants in earthen pots:

Soil mixed thoroughly with rotten FYM at the ratio 2:1 was filled up to ¾ capacity of the earthen pots (16 cm dia.). Healthy rice plants of *Jaya* variety at tillering stage were uprooted from the fields and planted in the pots. Plants were watered periodically and the potted plants were used for the experiments after a week of planting.



A



B

Plate 9. Extraction from various plant parts.
A. Soxhlet apparatus . **B**. Plant extracts processed from different plants.

3.5.4. Spraying of emulsions:

The potted plants were sprayed with emulsion prepared for the purpose with the help of pneumatic hand spray up to run-off stage. The sprayer was rinsed thoroughly with water before changing the emulsions and a separate sprayer was used for spraying water to maintain the control treatment. All the plants were allowed to dry before the experiments were set up.

3.5.5. Evaluation of plant extracts for the antifeedant property against *Cnaphalocrocis medinalis* (Guenee):

The test on rice leaffolder *C. medinalis* (Guenee) was carried out in a net house at SASRD. Plants were sprayed to the runoff stage with 2 % conc. of plant extract emulsion. Emulsions prepared from Neem oil (1.5 %) and fenvalerate (0.1 %) were used as standard check and plants sprayed with plain water were kept as control for comparison. Healthy larvae of 6 day old were preconditioned for 3 hours and released @ 5 larvae/treatment on potted plants. The plants were covered separately with nylon net cover supported by bamboo sticks (Plate10A). All the treatments were replicated three times and were arranged in completely randomized design (CRD) (Fig. 1). The leaf area consumed by the larvae was recorded after 48 hrs of release by measuring the length and width of the parts of the leaf affected. The affected parts are seen as parallel streaks on the leaf was measured by using a scale and the leaf area consumed by the larvae was calculated by multiplying the total length of all such streaks on a leaf by 1.0 mm, the average width of one streak. To take a measurement, the leaf was clipped off the plant and placed between two transparent glass plates to prevent the leaves from rolling due to desiccation. The feeding ratio was calculated by using the formula as described by Wada and Muna Kata (1968). The formula is mentioned below.

$$\text{Feeding ratio} = \frac{\text{\% leaf area consumed in treatment}}{\text{\% leaf area consumed in control}} \times 100$$

The value thus collected was transformed into angular transformation and were analyzed for analysis of variance. F Test was used to determine the significant level and least significant difference (LSD) was calculated for comparison between two treatment means.

The maximum temperature during the experimental period ranged from 26°C - 28°C and minimum from 24°C - 25°C while relative humidity varied from 78 % - 88 %.

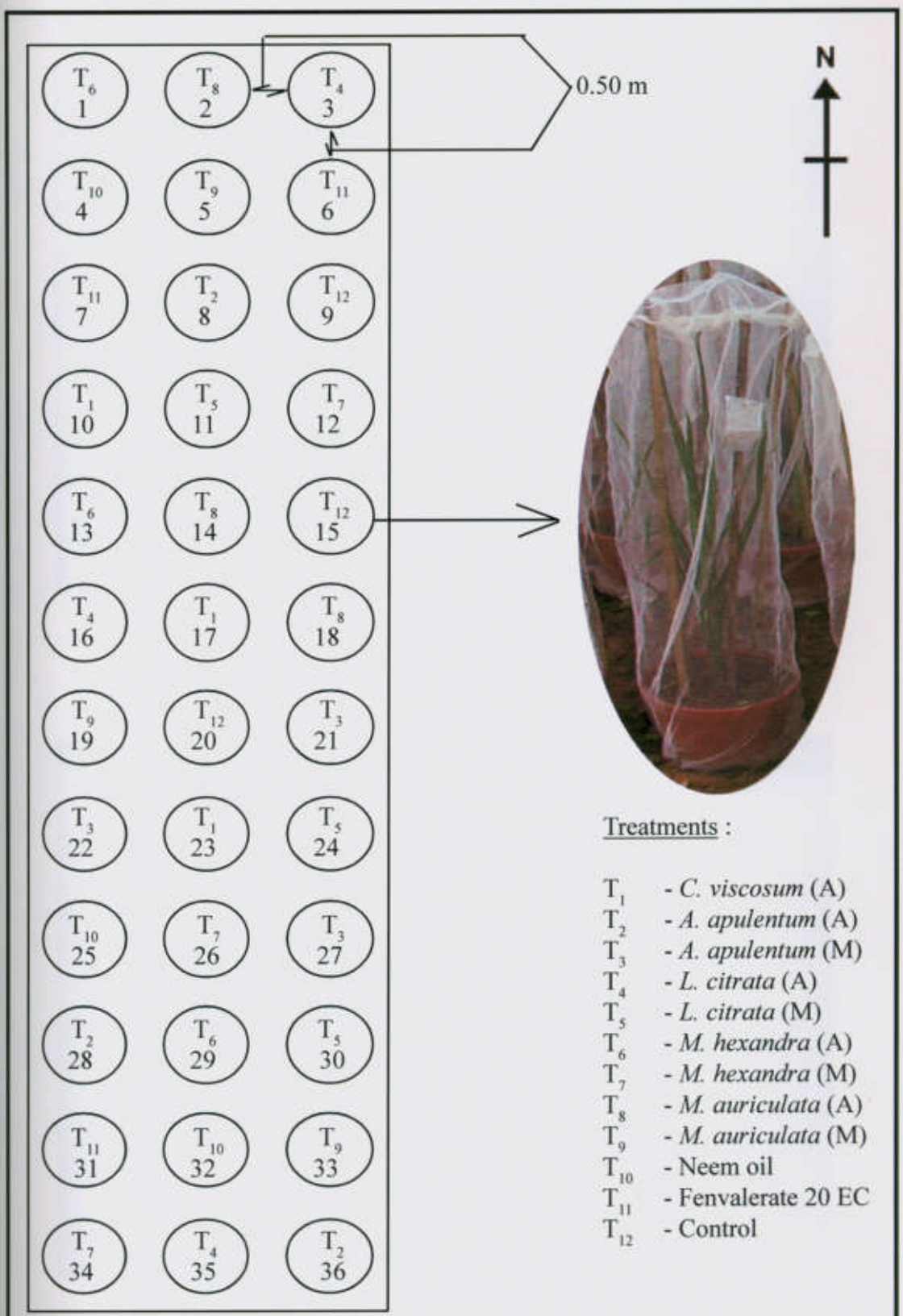


Fig. 1. Placement pattern of the treatments for the assesment of plant extract as antifeedant/ detterents against *C. medinalis* (Guenee).

A

B

Plate 10. Net house experiments set up for evaluation of plant extracts as
A. Antifeedants / feed deterrents and oviposition deterrent under Choice.
B. Oviposition deterrent under No-Choice.

3.5.6. Effect of plant extracts on oviposition of *Cnaphalocrocis medinalis* (Guenee):

Oviposition of *C. medinalis* (Guenee) was conducted under two different situations, no choice and Choice test method in the net house. The rice plants were sprayed with 2 % conc. plant extracts till run off stage Emulsions prepared from neem oil (1.5 %) and fenvalerate (0.1 %) were used as standard check and plants sprayed with plain water were kept as control and spraying was carried out by using pneumatic handspray.

3.5.6.1. No-Choice test:

In No choice experiment potted plants of the treatments were covered separately by nylon net and one pair of adult *C. medinalis* (Guenee) (one male and one female) was released in all the treatments (Plate 10B). The treatments were distributed in completely randomized design (CRD) under three replications (Fig. 2). Observations on number of eggs laid were recorded after 48 hours of release. The percent reduction in egg laying in different treatments over control was calculated by following the formula as described by Patil et al., (2003).

$$\text{Reduction in egg laying \%} = \frac{\text{No. of egg laid in control} - \text{No. eggs laid in treated plants}}{\text{No. of eggs laid in control}} \times 100$$

The data thus collected on reduction in oviposition were transformed into angular transformations and were subjected to analysis of variance. F test was used to determine the significant level and least significant difference (LSD) values were calculated for comparison between two treatment means.

The maximum temperature recorded during the period of experiment varied from 25°C - 26°C and minimum from 24°C - 25°C. Relative humidity ranged from 79% - 84%.

3.5.6.2. Choice test:

In choice test all the treated plants in pots after drying the leaf surface were covered by a nylon net (Plate 10A). All the treatments were replicated three times and the treatment sets were placed in completely randomized design (Fig. 3). Adult moths of *C. medinalis* (Guenee) (25 female and 20 male) were released into the treatment set. Observations were made as in the case of No choice test.

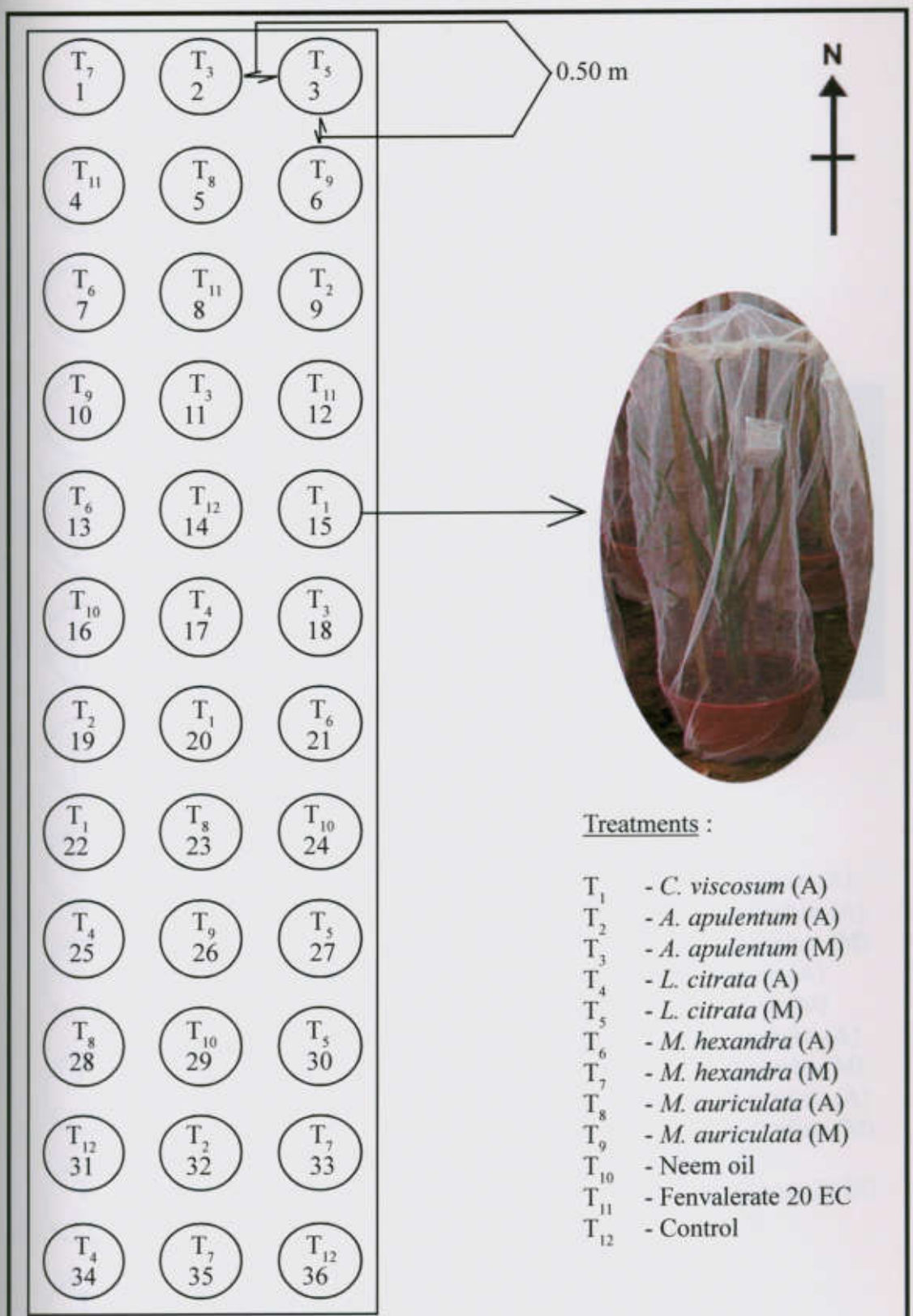


Fig. 2 Placement pattern of the treatments for the study on effect of plant extracts on oviposition of *C. medinalis* (Guenee) under No Choice situation.

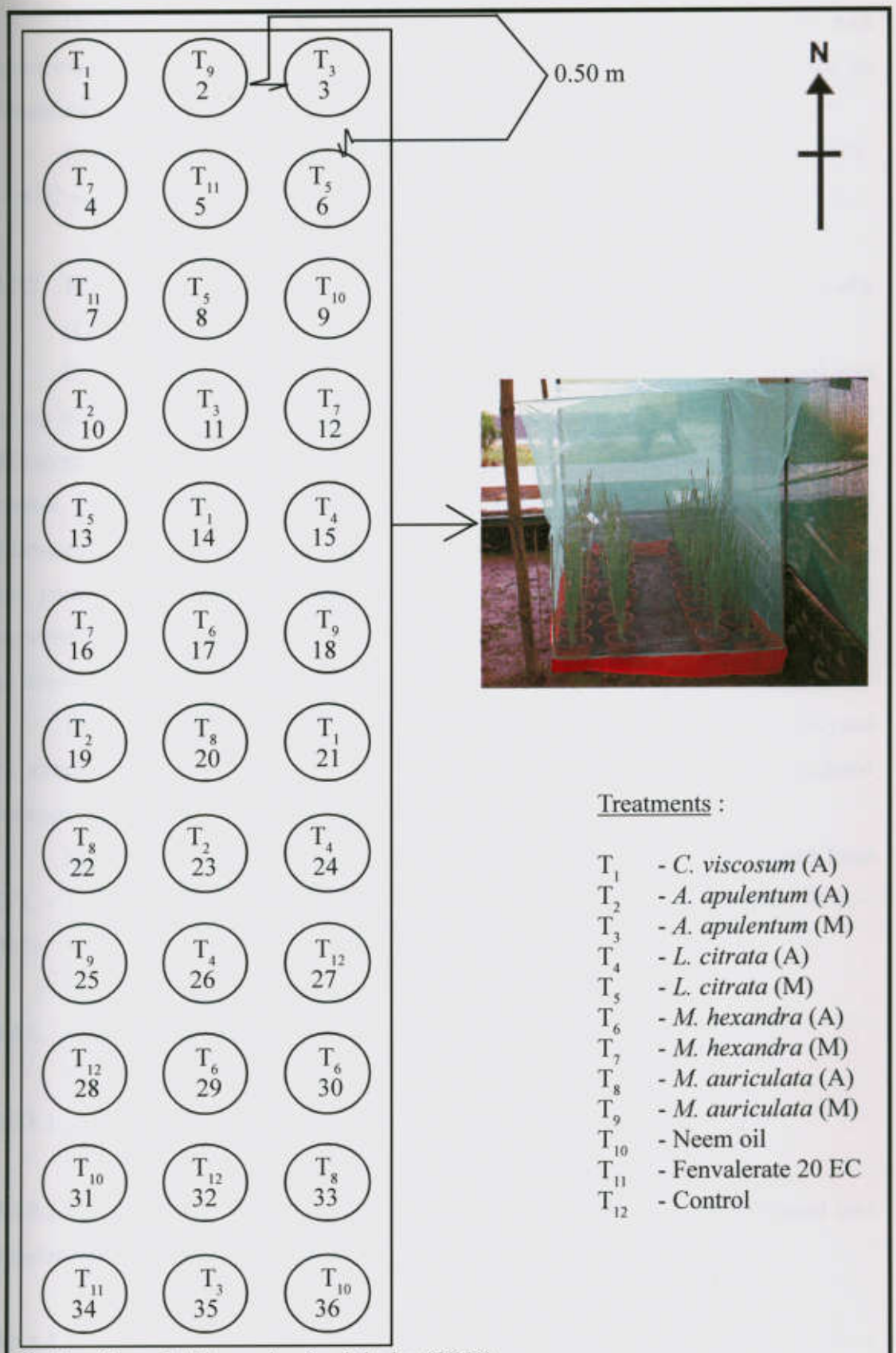


Fig.3. Placement pattern of the treatments for the study on effect of plant extracts on oviposition of *C. medinalis* (Guenee) under Choice test.

Data on reduction in oviposition were transformed into square root transformation and were analysed for analysis of variance. F test was used to determine significance level and least significant difference (LSD) were calculated.

During the experimental period the maximum temperature ranged from 26 °C – 28 °C and minimum from 24 °C – 25 °C. Relative humidity varied from 82 – 85 %.

3.5.7. Effect of plant extracts on larval development of *Cnaphalocrocis medinalis* (Guenee).

Effect of plant extracts on larval development of *C. medinalis* (Guenee) was set up in the net house in CRD design (Fig. 4). Emulsions of neem oil (1.5 %) and fenvalerate (0.1 %) were used as standard check and one treatment was kept as control, treated with plain water only. The treated plants were allowed to dry and 5 larva each of 4 day old preconditioned for 3 hours were released in all the treatments and potted plants were covered separately with nylon net. All treatments were recorded at 5 days interval and fresh treated plants of all treatments were supplied at an interval of 10 days till the larvae reached the adult stage (Plate 11).

Data recorded on larval growth and developments were statistically analyzed by simple linear regression analysis. Correlation coefficient has been calculated between larval growth and days of observation.

Maximum temperature recorded during the experimental period ranged from 24°C - 32°C and minimum from 23°C - 26°C. Relative humidity varied from 78 % – 90 %.

3.5.8. Statistical Analysis:

3.5.8.1. Antifeedant test:

3.5.8.1.1. Transformation of data: The data on feeding ratio were transformed into angular transformation before analyzing statistically.

3.5.8.1.2. Analysis of variance: The transformed values were subjected to analysis of variance and F-test was used to determine significant difference between two means. Least significant test (LSD) was calculated for comparison at 5 and 1 percent probability level. Co-efficient of variation (CV) was also calculated.

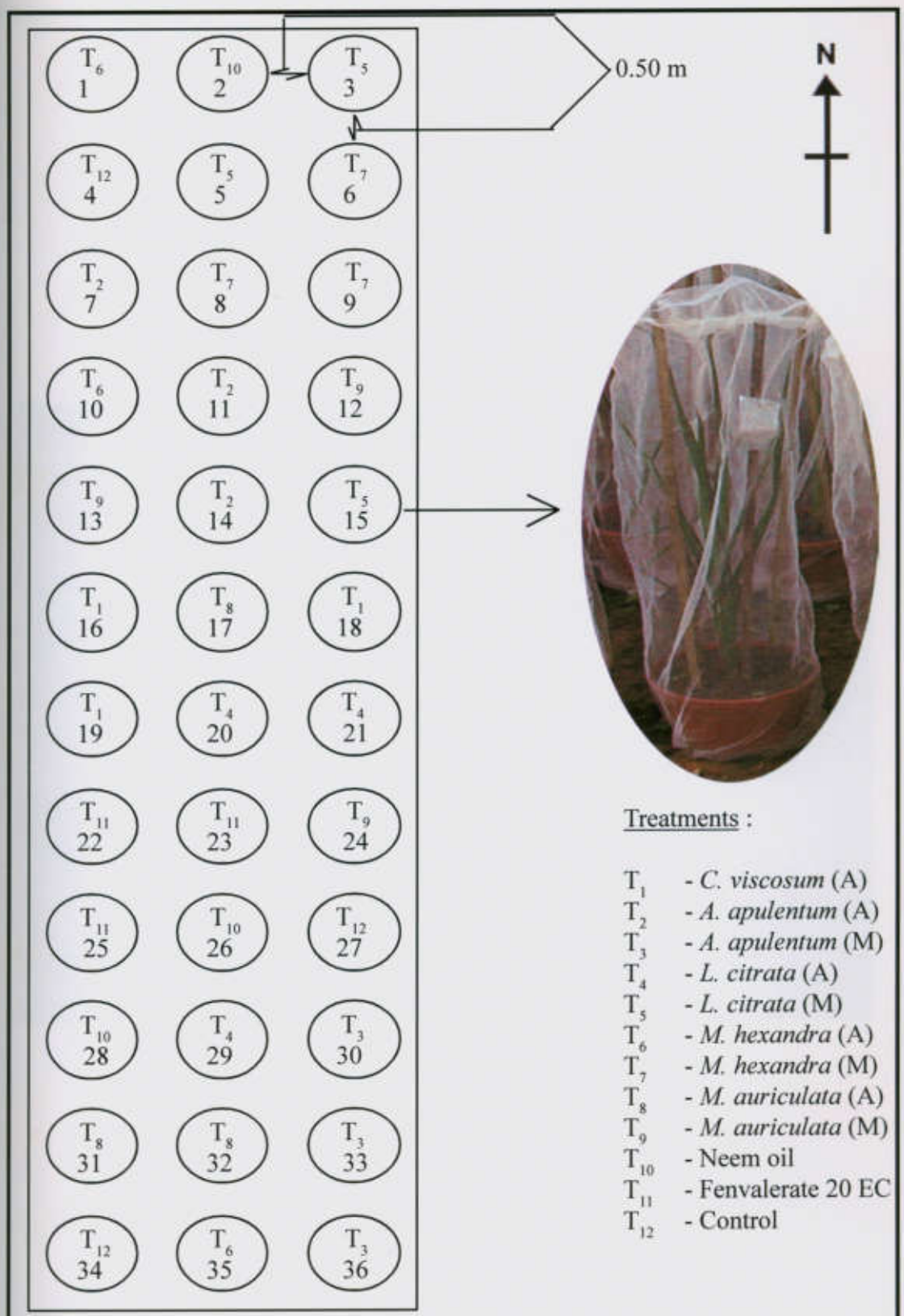


Fig. 4. Placement pattern of the treatments for the study on effect of plant extracts on the larval development of *C. medinalis* (Guenee).

Plate 11. Net house experiment on the effect of plant extracts on the larval development.

3.5.8.2. Oviposition test:

3.5.8.2.1. Transformation of data:

No-choice test: In force test study data on reduction in oviposition were transformed into angular transformation before analyzing statistically.

Choice test: The data on reduction in oviposition were transformed into square root transformation before proceeding to analysis of variance in Choice test.

3.5.8.2.2. Analysis of variance:

The transformed values were subjected to analysis of variance in both choice and force test. F-test was used to determine the significant difference between two treatment means and least significant difference were calculated for comparison. The co-efficient of variation were calculated in both the cases.

3.6. Field experiment:

3.6.1. Location: The trial was conducted in the experimental farm located at School of Agricultural Sciences and Rural Development farm of Medziphema. The place is situated in the foothills of Nagaland at an altitude of 304.80 m (above MSL) with geographical location of 24° 45' 45" N latitude and 90° 53' 04" E longitude.

3.6.2. Climate: The climate is humid sub-tropical climate with an average annual rainfall ranging from 2000 mm to 2700 mm. The mean summer temperature varies from 21° C to 31° C and rarely falls below 8° C in winter.

The investigation was carried out in wet season during 2002 - 2005 (May – Nov.) and details of meteorological observations during the experiment period are presented on forth nightly basis in Table 2 to 5 & Fig. 5 to 8.

Table 2. Meteorological data during the period of investigation (May – October 2002).

Period (fortnight)	Temperature °C		Relative humidity (RH)	Rainfall
2002	Max.	Min.	(%)	(mm)
1/5 – 14/5	27.77	21.70	77.71	6.45
15/5 – 28/5	29.51	24.11	72.07	3.8
29/5 – 12/6	32.59	22.14	80.29	4.96
13/6 – 26/6	30.26	25.83	80.64	8.82
27/6 – 10/7	30.99	26.5	78.14	4.30
11/7 – 24/7	30.89	25.99	78.57	4.25
25/7 – 7/8	30.47	25.67	80.86	21.16
8/8 – 21/8	28.92	25.22	82.42	12.70
22/8 – 4/9	30.68	25.35	80.50	5.30
5/9 – 18/9	31.51	24.59	79.07	5.92
19/9 – 2/10	28.30	23.98	83.64	4.45
3/10 – 16/10	29.43	22.28	82.50	0.47
17/10 – 30/10	27.29	21.32	76.07	0.31

Table 3. Meteorological data during the period of investigation (May – October 2003).

Period (fortnight)	Temperature °C		Relative humidity (RH)	Rainfall
2003	Max.	Min.	(%)	(mm)
1/5 – 14/5	28.8	22.12	75.28	8.15
15/5 – 28/5	30.08	24.1	77.78	2.38
29/5 – 11/6	30.47	24.93	74.5	8.70
12/6 – 26/6	30.04	25.62	79.35	7.32
27/6 – 9/7	29.75	25.44	81.78	3.18
10/7 – 23/7	29.78	25.15	82.71	9.32
24/7 – 6/8	27.88	25.58	83.57	3.42
7/8 – 20/8	25.88	24.90	86.35	10.23
21/8 – 3/9	28.03	24.93	84.28	10.11
3/9 – 17/9	25.81	25.78	84.35	4.30
18/9 – 1/10	24.91	24.05	84.28	9.02
2/10 – 15/10	26.04	22.7	85.57	13.90
16/10 – 29/10	23.19	21.92	85.78	1.05

Table 4. Meteorological data during the period of investigation (May – October 2004).

Period (fortnight)	Temperature °C		Relative humidity (RH)	Rainfall
2004	Max.	Min.	(%)	(mm)
1/5-14/5	31.28	29.65	84.50	0.66
15/5-28/5	29.22	27.22	82.42	4.17
29/5-11/6	31.10	29.32	83.57	5.85
12/6-25/6	30.50	28.07	79.92	8.53
26/6-9/7	31.00	28.80	69.57	11.92
10/7-23/7	28.55	27.00	72.85	10.37
24/7-6/8	31.27	29.54	65.50	17.00
7/8-20/8	31.18	28.84	66.00	9.25
21/8-3/9	31.50	30.28	65.57	3.36
4/9-17/9	29.39	28.37	70.21	11.82
18/9-1/10	30.10	28.61	64.57	11.22
2/10-15/10	28.00	26.44	65.57	10.35
16/10-29/10	28.54	26.46	55.64	0.50

Table 5. Meteorological data during the period of investigation (May – October 2005).

Period (fortnight)	Temperature °C		Relative humidity (RH)	Rainfall
2005	Max.	Min.	(%)	(mm)
1/5-14/5	28.45	19.62	81.50	3.44
15/5-28/5	27.95	21.71	81.14	9.55
29/5-11/6	31.02	23.80	82.64	0.77
12/6-25/6	30.38	25.69	79.57	9.36
26/6-9/7	31.00	26.07	79.50	10.64
10/7-23/7	29.98	25.32	79.85	3.35
24/7-6/8	30.48	26.07	82.50	8.54
7/8-20/8	30.08	25.62	82.71	21.40
21/8-3/9	30.44	24.60	80.28	1.35
4/9-17/9	31.04	23.22	84028	8.53
18/9-1/10	31.02	23.31	85.14	8.97
2/10-15/10	28.68	21.81	82.28	0.93
16/10-29/10	26.02	20.00	83.64	7.07

3.6.3. Evaluation of plant extracts on the incidence of rice leaffolder *Cnaphalocrocis medinalis* (Guenee).

3.6.3.1. Design of the experiment:

Evaluation of plant extracts for insecticidal property was conducted in "Randomized Complete Block design" (RCBD) with three replications during the wet season in 2002 and 2003. The field was divided into 3 equal blocks and each block was again divided into 12 equal plots. The plot size was 4 sqm. (2x2 m) and as such 36 plots were prepared. The plots were separated from each other by bunds / ridges of 0.5 m. The treatments were randomly distributed within the plots of a block. The details on the layout plan of experimental field are illustrated in Fig. 9(Plate 12 A & 12B).

3.6.3.2. Crop raising:

3.6.3.2.1. Nursery bed and raising of seedlings:

Plot for nursery bed was selected near the experimental area. Two beds were raised in an area of 5 sqm each (Length 5m and breadth 1m). The field was ploughed and mixed thoroughly with well decomposed FYM. Healthy dry seeds of *Jaya* variety were sown in lines 10 cm row to row distance and by dropping at 2 cm – 3 cm depth of furrows in the first week of May. After covering the furrows, water was sprinkled periodically to keep the soil moist and the beds were protected from birds and disturbances from other sources by putting a bamboo fence.

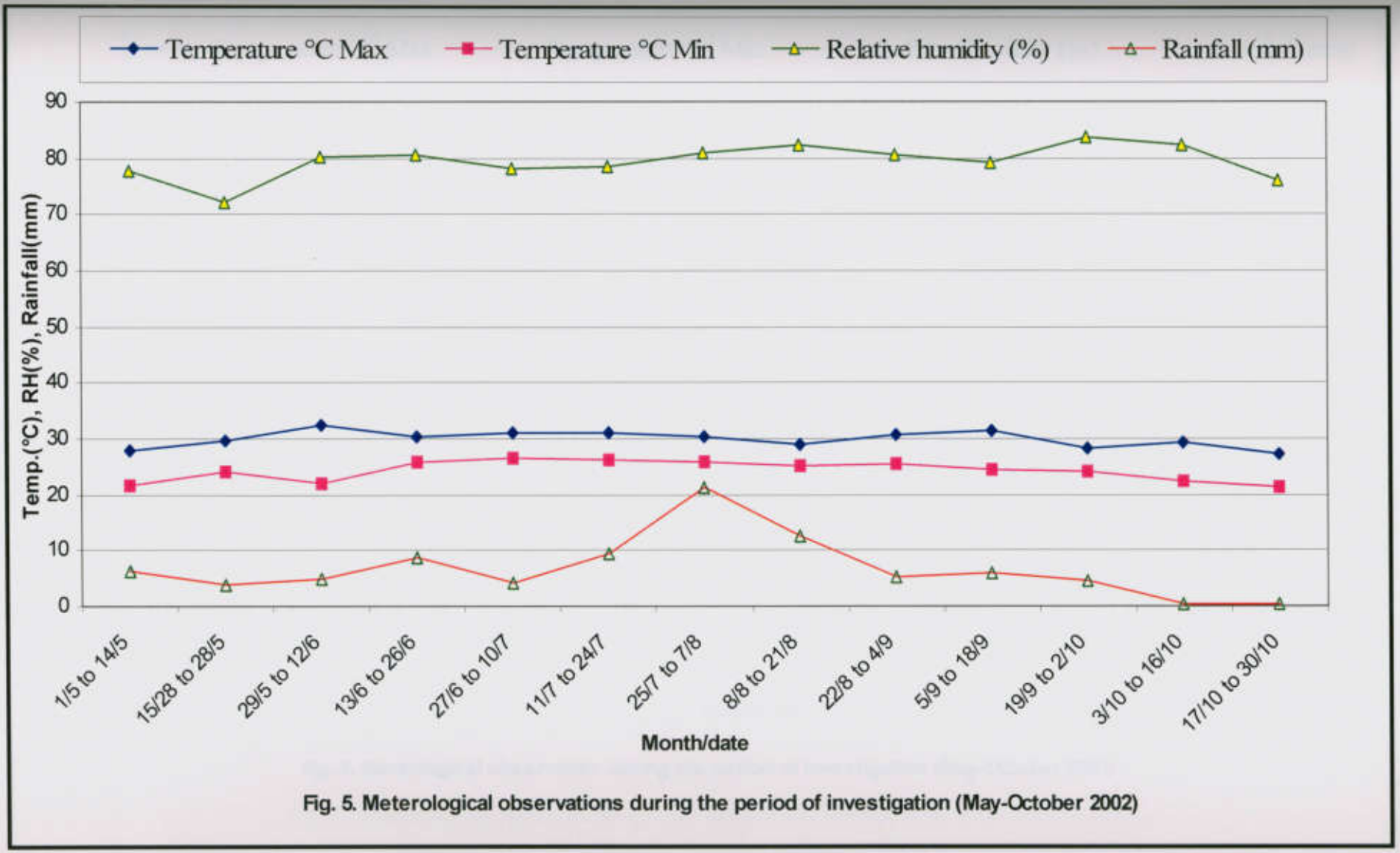


Fig. 5. Meterological observations during the period of investigation (May-October 2002)

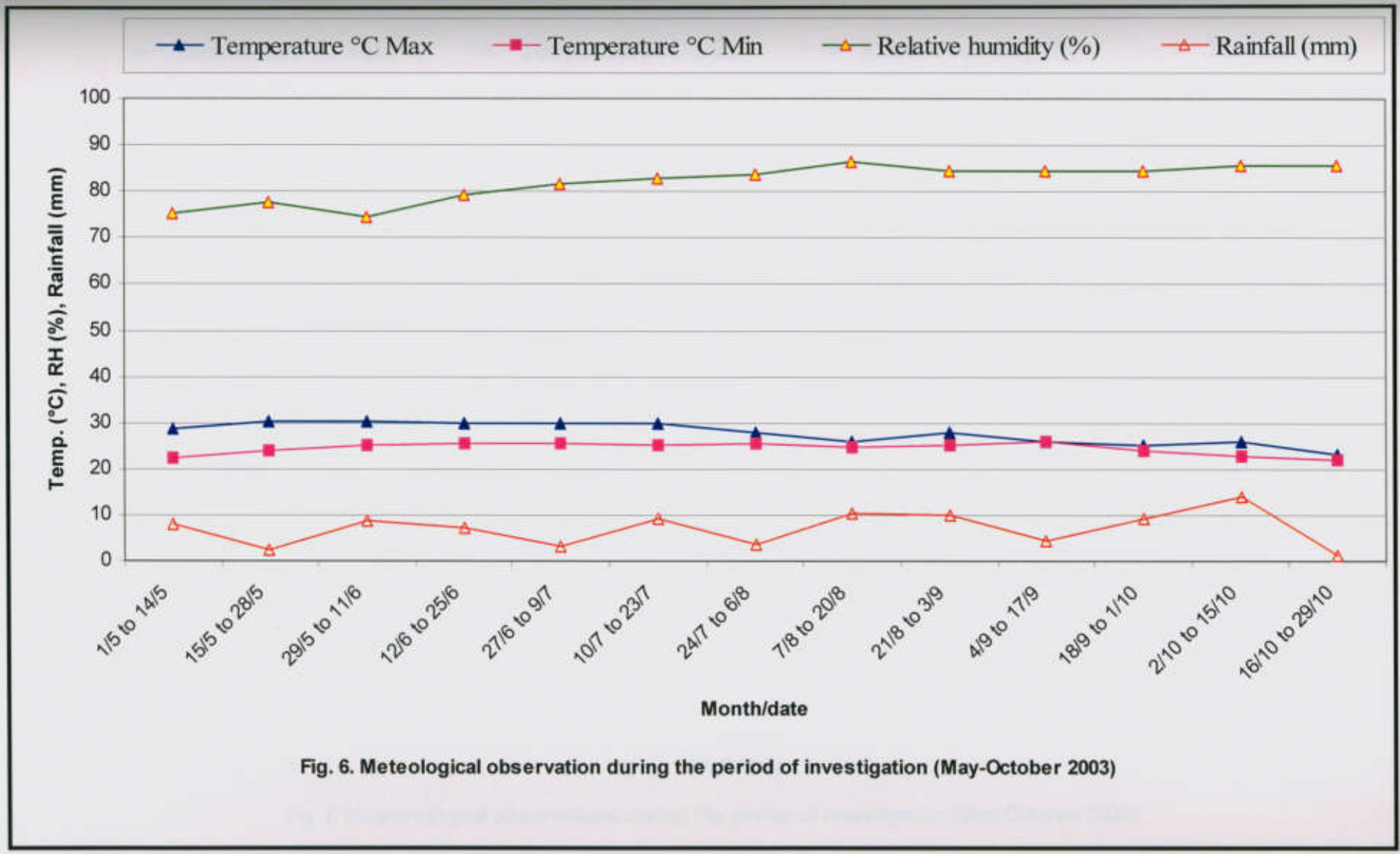


Fig. 6. Meteological observation during the period of investigation (May-October 2003)

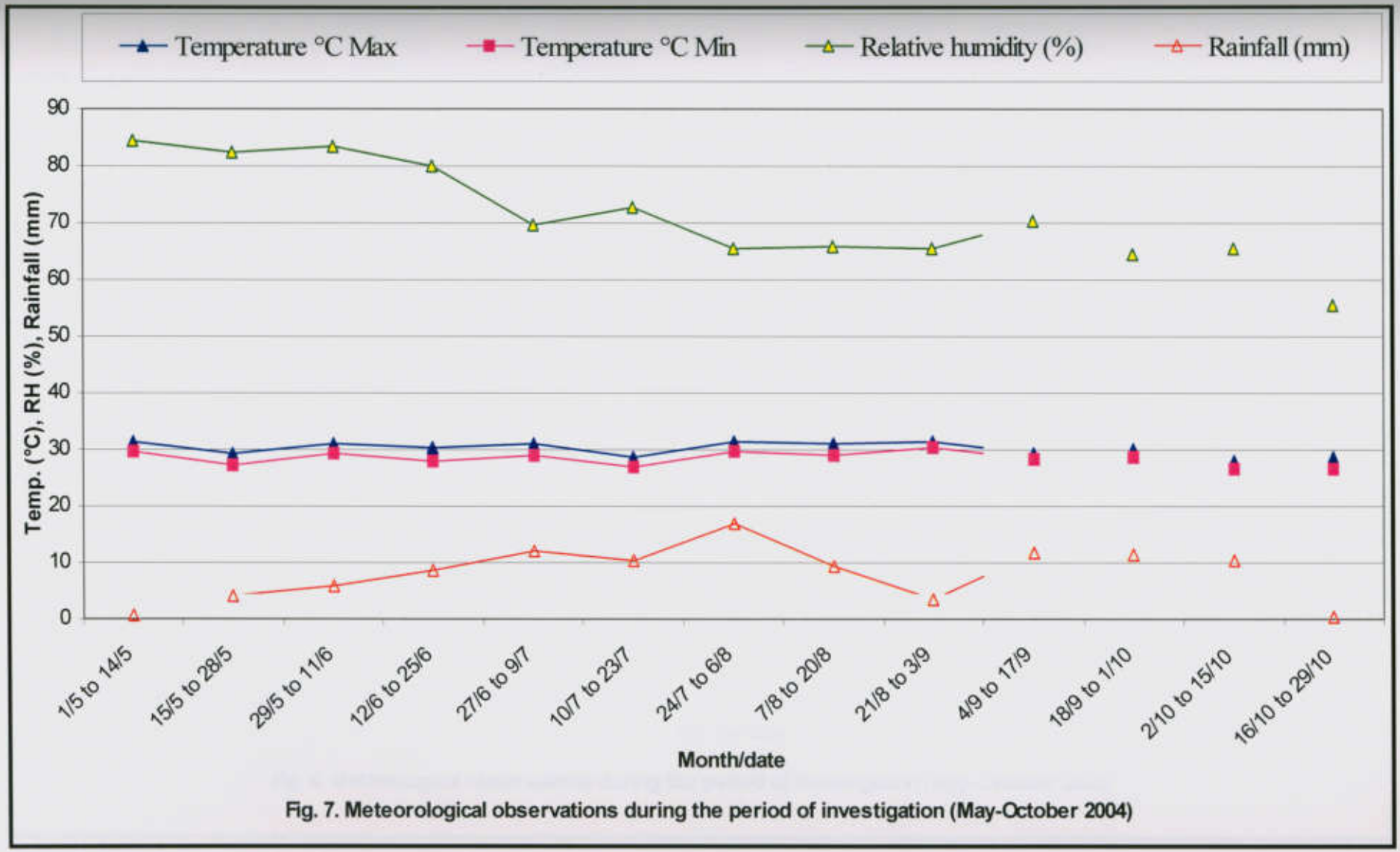


Fig. 7. Meteorological observations during the period of investigation (May-October 2004)

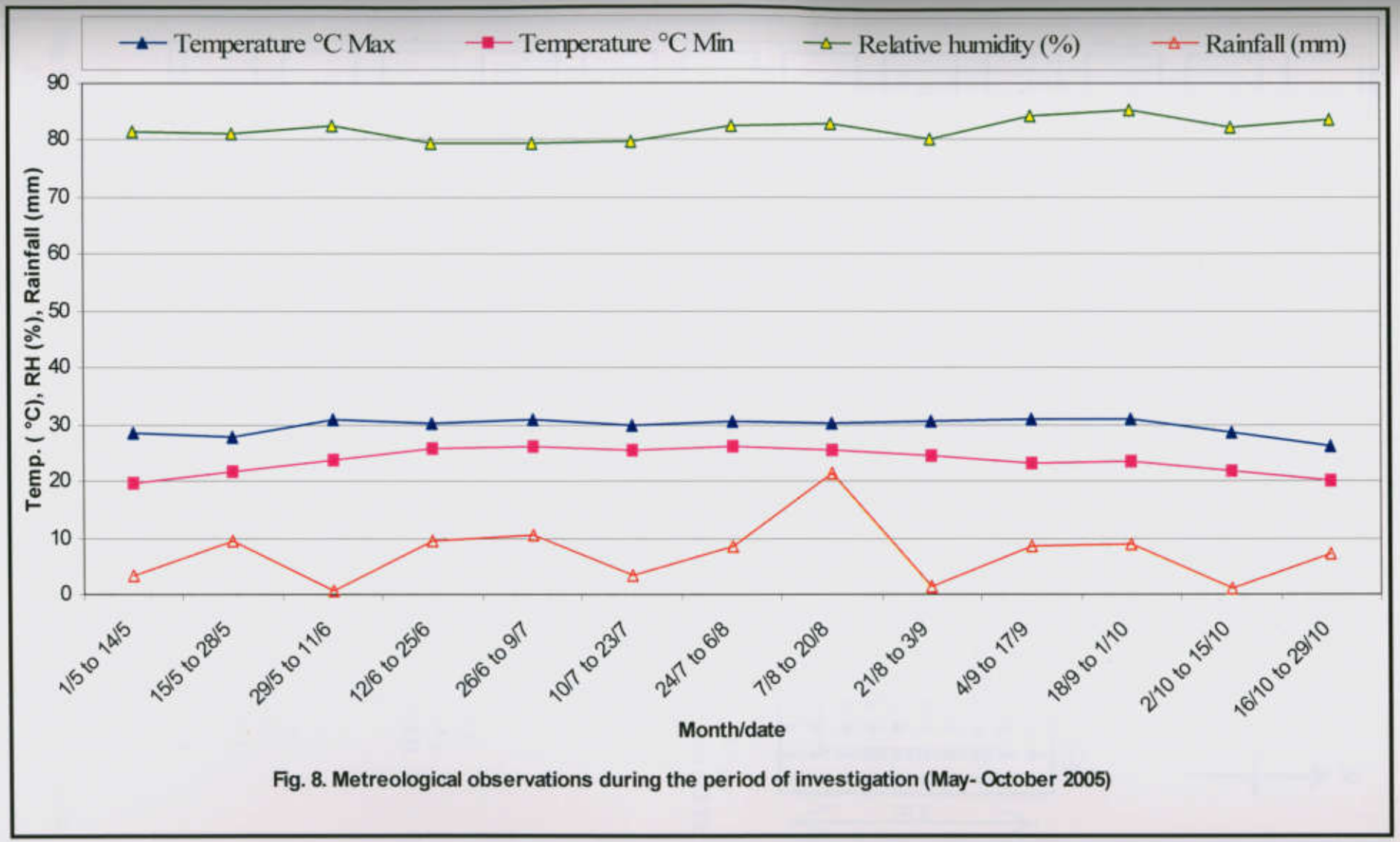


Fig. 8. Metreological observations during the period of investigation (May- October 2005)

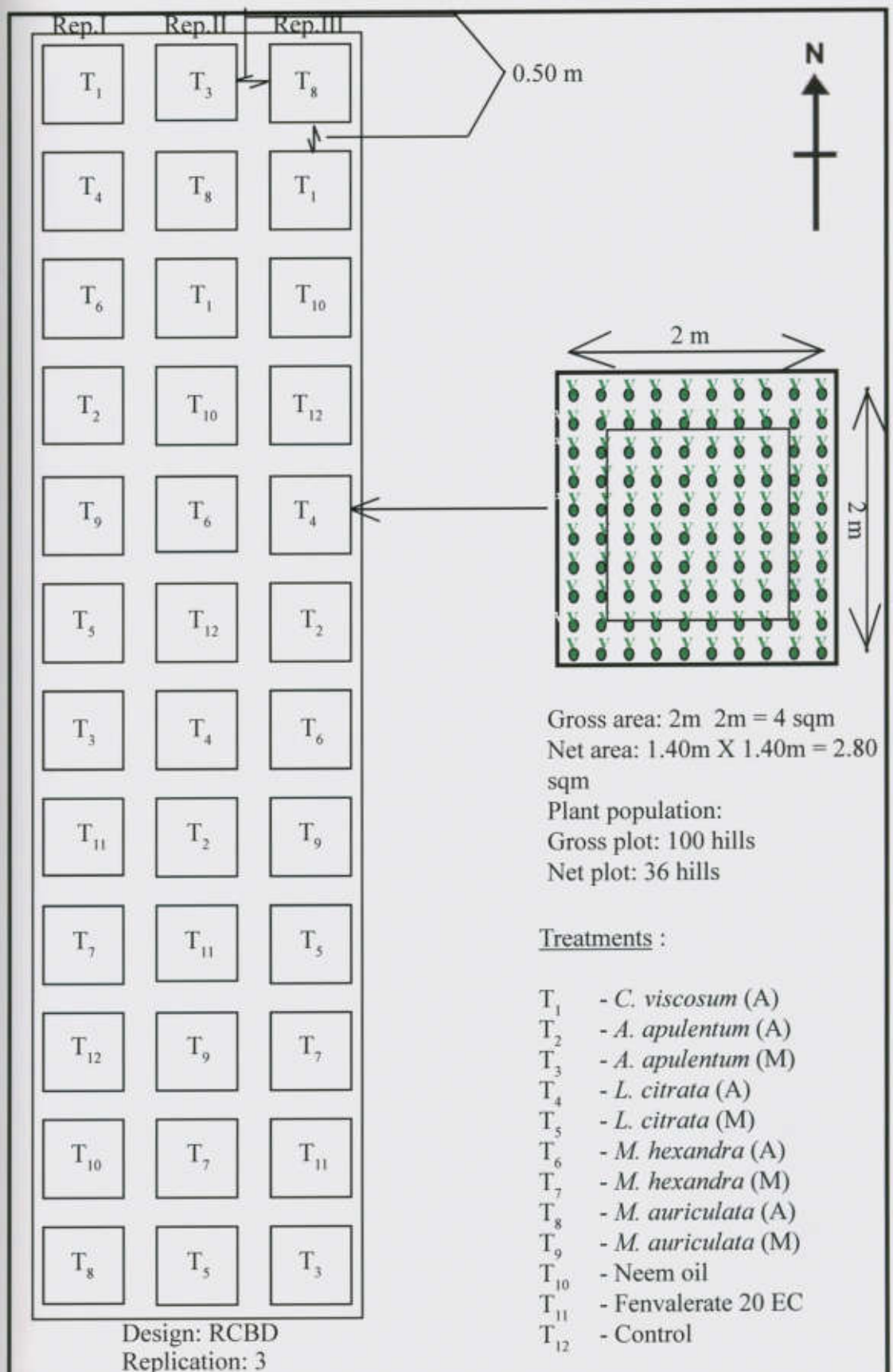
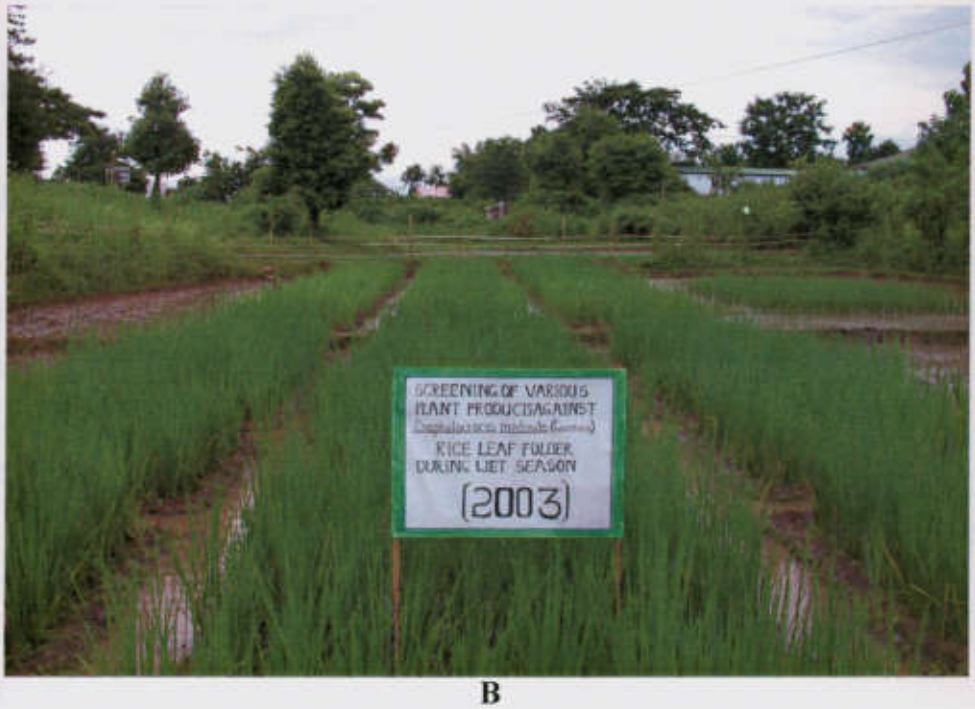


Fig. 9 Field layout of the experiment on evaluation of plant extracts in Randomised Complete Block Design (RCBD) during the Wet Season of 2002 and 2003.

A



B

Plate 12. Screening of various plant extracts against rice leaffolder during wet season **A**. 2002. **B**. 2003

3.6.3.2.2. Field preparation:

The experimental field was ploughed twice during the last fortnight of May by tractor drawn disc harrow and leveled properly. All stubbles and weeds were removed and then field was set according to the layout plan.

3.6.3.2.3. Manuring:

A well decomposed FYM was incorporated before 30 days of transplanting. No other chemical fertilizers were used and the crop was raised at natural available fertility level.

3.6.3.2.4. Transplanting:

Transplanting was done with 30 days old seedlings in the well puddled experimental plots with water level of nearly 5 cm. Plant population of 100 hills / plot with a spacing of 20x20 cm was maintained.

3.6.3.2.5. Weeding:

Manual weeding in the plots and ridges was done whenever necessary in order to keep the field free from weeds.

3.6.3.2.6. Gap filling and removal of off types:

Gap filling was done to remove the gaps developed due to non-establishment of seedlings in the field. Off type plants present in the field were roughed out manually as and when appeared.

3.6.3.2.7. Water management:

The water level in the plots were maintained at 5 to 10 cm. The crop did not suffer either from excess water or moisture stress during the experimental period.

3.6.3.2.8. Harvesting:

Harvesting was done when the plant showed physiological maturity discarding two border rows from all the sides of the plots. Harvested plants were kept separately in plot wise bundles.

3.6.3.3. Spraying of plant extract:

Plant extract emulsions (2%) prepared were sprayed in the field upto run off stage uniformly by using pneumatic hand sprayer. Sprayers in use were thoroughly washed with water at the time of changing the emulsions. Precautions were taken to avoid emulsion drift and contamination to adjacent plots at the time of spraying and a separate sprayer was used for spraying water to maintain the control treatment.

3.6.3.4. Collection of data:

In field experiment, data was collected on damaged leaves at 30 DAT and subsequent readings were recorded at an interval of 10 days prior to next spray after reading. From every plot / treatment, 15 hills were selected randomly and the total number of leaves and infested leaves by rice leaffolder were recorded. The plant in two border rows in each plot were not included in the observations. The infestation percentage (%) was calculated by using the following formula.

$$\text{Infestation percentage (\%)} = \frac{\text{No. of damage leaves}}{\text{Total No. of leaves}} \times 100$$

3.6.3.5. Measuring of grain yield:

Plant hills in two border rows from all the sides of the plot were discarded and remaining plants were harvested. After threshing, cleaning and drying, grain yield from each net plot were weighed separately. Immediately after weighing, the moisture content of the grain was measured. Grain weight was adjusted to 14 per cent moisture by using the formula suggested by Gomez (1972).

Adjusted grain weight = A x W

Where 'A' is the adjustment co-efficient and 'W' is the weight of harvested grains. The co-efficient 'A' was calculated by using the formula –

$$A = \frac{100-M}{86}$$

where 'M' is the moisture content (%) of the grain.

3.6.3.6. Grain yield measurement in plots with missing hills and off types:

Off-types roughed plants removed from harvest and plants surrounding the missing hills were not included in the harvest. Grain yield per plot was adjusted by using the formula suggested by Gomez (1972).

$$\text{Grain yield per plot} = \frac{W}{n} \times N$$

where W' is the weight of grains from harvested hills, 'n' the number of harvested hills and 'N' is the total number hills in normal plot. In none of the case, reduction in the no. of hills harvested due to the presence of either missing hills or off type were more than 10 per cent.

3.6.3.7. Calculation of yield per hectare:

Grain yield in kg per plot at 14 per cent moisture content was calculated to express as Kg/ha by using the formula –

$$\text{Grain yield / ha} = \frac{W \times 10,000}{A}$$

Where 'W' is the weight of the grain yield in net plot and 'A' is the area of the plot after discarding the border lines from all the sides.

3.6.3.8. Statistical Analysis:

3.6.3.8. 1. Transformation of data:

In screening of plant products and dose precession experiment, the data on leaf damage percentage were transformed into square root transformation (?x + 0.5) before analyzing statistically. (Where 'x' is the leaf damage per cent).

3.6.3.8.2. Analysis of variance:

The transformed values were subjected to analysis of variance. F-test was used to determine the significant level at 5 and 1 percent probability level. CV was also

calculated. The presence of (NS) indicates that F-test was not significant at respective probability level.

3.6.3.8.3. Comparison among treatment means:

Duncan's multiple range test (DMRT) was used to test differences among all possible pairs of treatment means and expressed with the help of alphabets (Gomez & Gomez 1984).

3.6.4. Efficacy of plant extracts at different concentrations on the incidence of *Cnaphalocrocis medinalis* (guence).

3.6.4.1. Design of the experiment:

The trial was laid down in split-plot design with 3 replications during the wet season in 2004 and 2005. Plant extracts were assigned to main plots and doses to sub-plot. The main plot was divided into 3 sub-plots of 4 sq.m size (2x2m) in order to accommodate 3 doses (0%, 2%, and 4%). Four plant extracts namely *A. apulentum* (methanol), *L. citrata* (acetone & methanol) and Neem oil were allotted to 4 main plots and whole set up was replicated 3 times. The main plots were separated from each other by passage of 0.75 m width where sub plots were separated by a passage of 0.5 m wide (Fig.10 & Photo Plate13A & 13B).

3.6.4.2. Spraying of plant extracts:

Plant extract emulsions 2% and 4% prepared were sprayed in the field up to the run off stage uniformly by using pneumatic hand sprayers. The sprayers were rinsed thoroughly with water at the time of changing the emulsions after use. Precautions were taken to avoid emulsions drift and contamination to adjacent plots at the time of spraying and a separate sprayer was used for spraying water for 0% concentration treatments.

Experiment on effect of plant extracts at different dosages against *C. medinalis* (Guenee) was conducted by following the same cultivation practices and data collection procedures as in the previous field experiment and similar steps were adopted for grain yield measurement and processing of data into hectare.

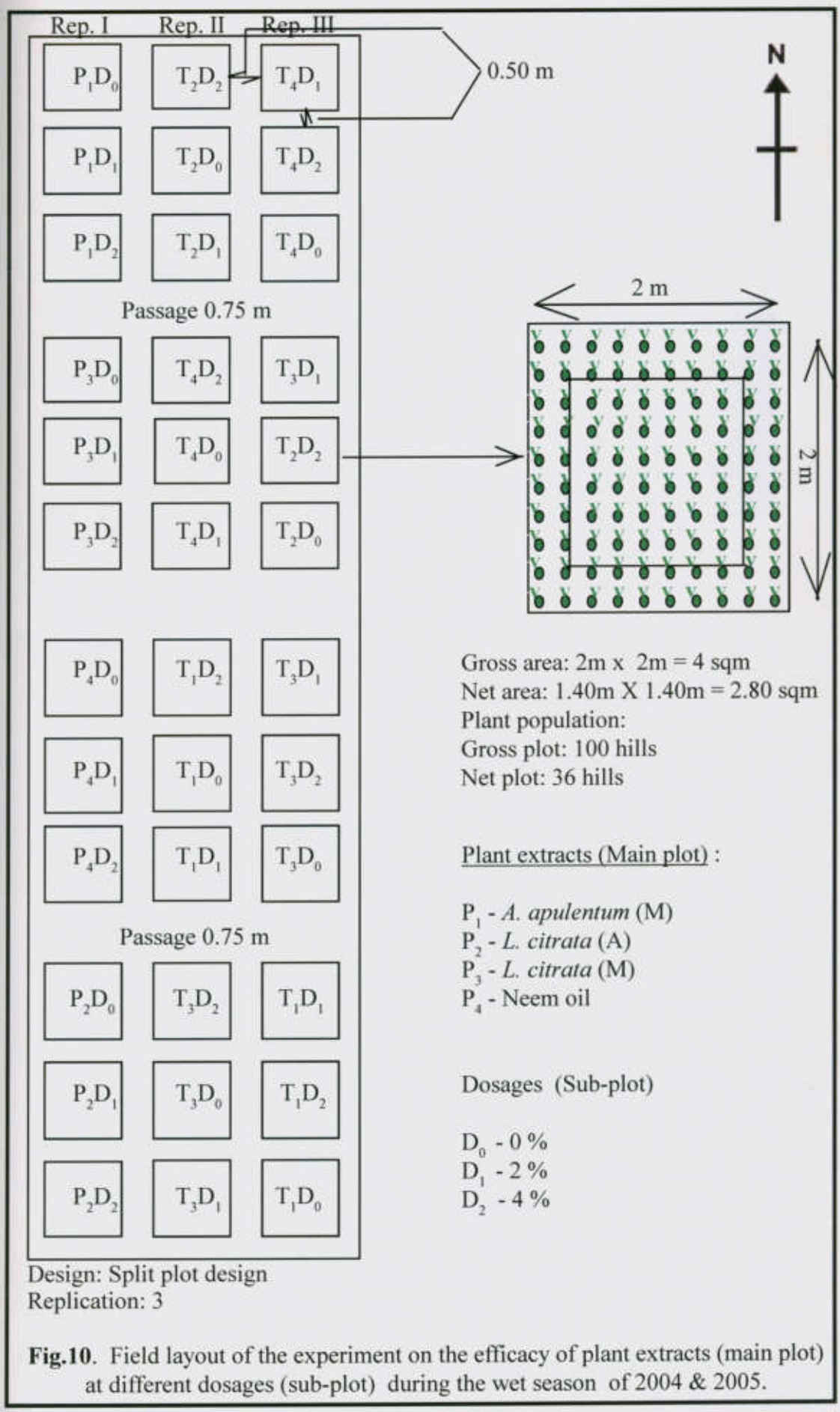


Fig.10. Field layout of the experiment on the efficacy of plant extracts (main plot) at different dosages (sub-plot) during the wet season of 2004 & 2005.

A

B

Plate. 13. Evaluation of some plant extracts under different conc. on rice leaffolder during wet season **A**. 2004. **B**. 2005.

3.6.4.3. Statistical Analysis:

3.6.4.3.1. Transformation of data:

The data on leaf damage percent were transformed into square root transformation before analyzing statistically. The formula used for transformation is

$\sqrt{x + 0.5}$

Where x is the leaf damage percent.

3.6.4.3.2. Analysis of variance:

The transformed values were subjected to analysis of variance and F-test was used to determine the level of significance at 5 % and 1 % probability level. Least significant difference (LSD) was calculated for comparison between the treatment means and the presence of (NS) in place of LSD indicated that F-test was not significant at respective probability level. Co-efficient of variation (CV) was calculated and since split-plot analysis had two error terms, two values were calculated, one for the main plot analysis $CV_{(a)}$ and another for sub-plot analysis $CV_{(b)}$ (Gomez & Gomez 1984).

FINDINGS

4. EXPERIMENTAL FINDINGS

Findings on the present investigation on the topic "Evaluation of some indigenous plants for their insecticidal property against rice leaf folder, *C. medinalis* (Guenee), a serious pest of rice in Nagaland" is being presented in this chapter by categorizing them under the Net house/ Laboratory and Field experiments. The results are described in the following manner. The data were analyzed statistically and are presented in tables and illustrated by erecting the histograms to give a quick visual assess of the silent findings.

4.1. Net house/laboratory experiment:

4.1.1. Evaluation of plant extracts for their antifeedant property against *Cnaphalocrocis medinalis* (Guenee):

It is revealed from the data presented in Table 6 and depicted in Fig.11, that none of the treatments exhibited absolute antifeedant property and larval feeding took place in all the treatments. The data on leaf area (cm^2) consumed by five larvae revealed that there were significant differences among the treatments and all the treatments recorded significantly lesser area consumed by the larvae than control. Moreover, in fenvalerate, minimum feeding ratio (15.29 %) with highest (84.71 %) protection was observed, which was at par with neem oil (15.89 %) feeding ratio. Acetone extracts of *A. apulentum* and *C. viscosum* were found to be equally effective as neem oil exhibiting 80.57 % and 80.12 % protection with 19.43 % and 19.88 % feeding ratio respectively. These were followed by methanol extract of *A. apulentum* with 25.98 % feeding ratio. Maximum feeding ratio of 62.65 % was recorded from methanol extract of *M. hexandra* with 37.35 % protection level.

On comparison with untreated control methanol extract of *M. hexandra* with maximum feeding ratio 62.65 % significantly reduced the feeding. A significant reduction in feeding ability of larvae were observed in all the treatments when compared with control.

The data on protection percentage on leaf area over control due to treatments in the chronological order of various treatments was: Fenvalerate > neem oil > A. apulentum (acetone extract) > C.viscosum (acetone extract) > A. apulentum

(methanol extract) > *L. citrata* (acetone extract) > *L. citrata* (methanol extract) > *M. auriculata* (acetone extract) > *M. hexandra* (acetone extract) > *M. auriculata* (methanol extract) > *M. hexandra* (methanol extract).

Table 6. Effect of plant extracts on the larval feeding of *Cnaphalocrocis medinalis* (Guenee).

Treatments		Conc. (%)	Mean (%)*		
			Feeding area (cm^2)	Feeding Ratio	Protection due to treatment over control
T_1	*C. viscosum* (A)	2.0	55.66	19.88(26.45)	80.12
T_2	*A. apulentum* (A)	2.0	54.66	19.43(26.14)	80.57
T_3	*A. apulentum* (M)	2.0	73.00	25.98(30.62)	74.02
T_4	*L. citrata* (A)	2.0	98.33	35.57(36.31)	64.43
T_5	*L. citrata* (M)	2.0	108.00	38.33(38.19)	61.67
T_6	*M. hexandra* (A)	2.0	124.66	45.09(42.07)	54.91
T_7	*M. hexandra* (M)	2.0	175.00	62.65(56.10)	37.35
T_8	*M. auriculata* (A)	2.0	124.00	44.05(41.56)	55.95
T_9	*M. auriculata* (M)	2.0	147.00	52.68(46.71)	47.32
T_{10}	Neem oil	1.5	56.66	15.89(23.52)	84.11
T_{11}	Fenvalerate 20 EC	0.1	43.00	15.29(23.01)	84.71
T_{12}	Control	0.0	280.66	100(90)	0
CV			25.56 %	16.51%	
LSD_{05}			48.13	11.15	
LSD_{01}			65.22	15.11	

* Mean of three replications
Figures in parentheses are angular transformation values.
A= Acetone extract, M= Methanol extract.

4.1.2. Effect of plant extracts on ovposition of *Cnaphalocrocis medinalis* (Guenee):

4.1.2.1. No-choice test:

The effect of treatments on oviposition of rice leaffolder was highly significant in No-choice condition and the percent reduction in egg laying ranged from 42.25 % to 80.99 %. Methanol extract of *A. apulentum* exhibited maximum reduction in oviposition with 80.99% and was significantly superior to neem oil which showed 72.07 % reduction in oviposition. Acetone extract of *A. apulentum* with 76.83 % reduction was at par with methanol extract of *M. hexandra* (76.83 %) while acetone extract of *L. citrata* with 76.53 % oviposition deterrency was equally effective with neem oil. Minimum reduction in oviposition was observed in acetone extract of *C. viscosum* (44.22 %) followed by fenvalerate (64.42 %) which also differed significantly with untreated control (Table 7 & Fig. 12).

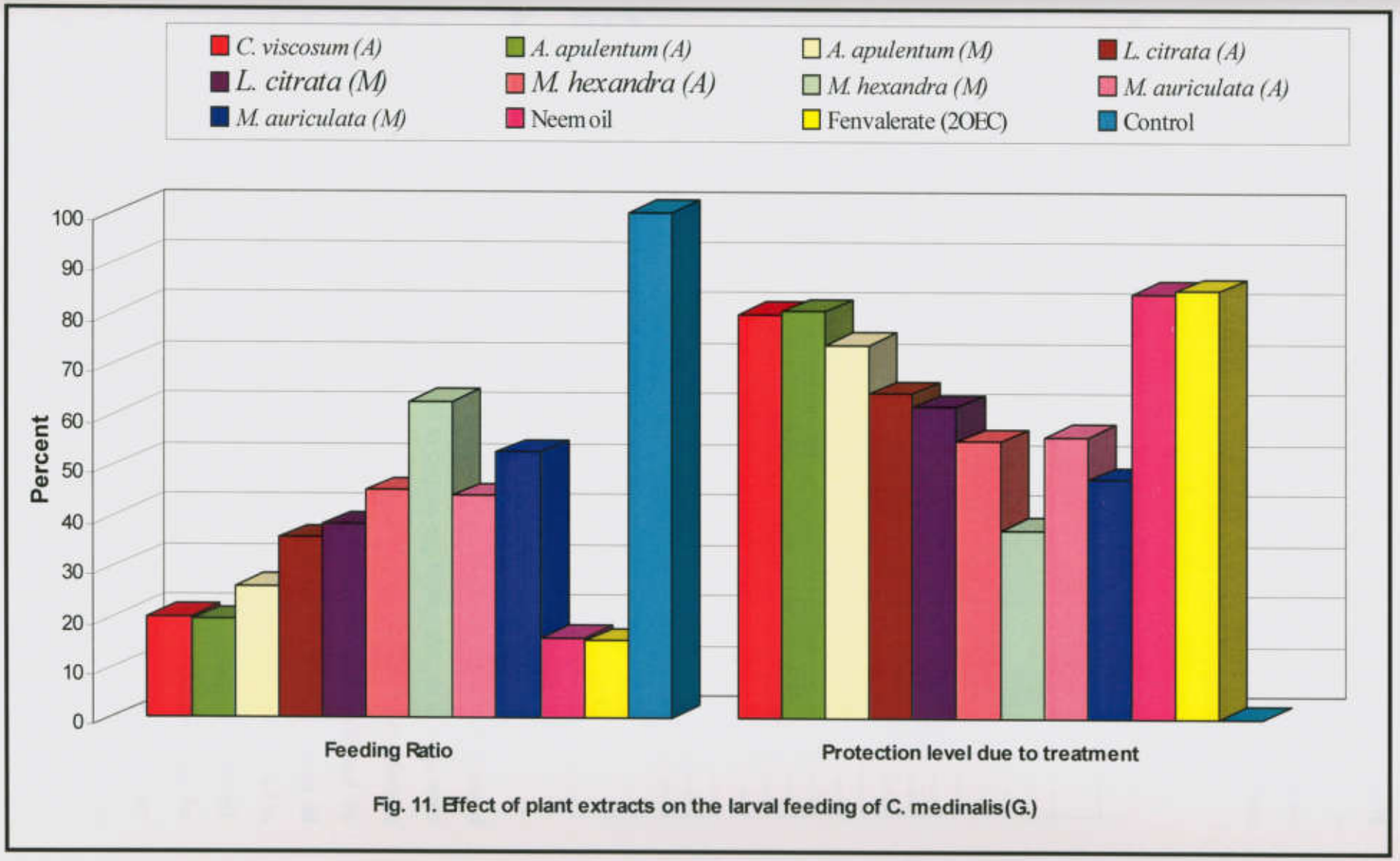


Fig. 11. Effect of plant extracts on the larval feeding of C. medinalis(G.)

The effect of plant extracts based on oviposition deterrency percentage in No-choice test in chronological order was: *A. apulentum* (methanol extract) > *A. apulentum* (acetone extract) > *L. citrata* (acetone extract) > *M. hexandra* (acetone extract) > *M. hexandra* (methanol extract) > *M. auriculata* (methanol extract) > neem oil > *L. citrata* (methanol extract) > *M. auriculata* (acetone extract) > fenvalerate.

Table 7. Reduction on rice leaffolder oviposition due to effect of treatments in net house experiment.

Treatments		Conc. (%)	Reduction in oviposition (%)*	
			No-Choice Test	Choice Test
T_1	*C. viscosum* (A)	2.0	44.25 (41.73)	70.51 (8.41)
T_2	*A. apulentum* (A)	2.0	76.83 (61.24)	77.02 (8.80)
T_3	*A. apulentum* (M)	2.0	80.99 (64.34)	87.45 (9.37)
T_4	*L. citrata* (A)	2.0	76.53 (61.11)	92.19 (9.62)
T_5	*L. citrata* (M)	2.0	73.97 (59.45)	92.29 (9.63)
T_6	*M. hexandra* (A)	2.0	76.05 (61.09)	98.15 (9.93)
T_7	*M. hexandra* (M)	2.0	76.83 (59.58)	100 (10.02)
T_8	*M. auriculata* (A)	2.0	69.80 (56.67)	87.81 (9.40)
T_9	*M. auriculata* (M)	2.0	73.49 (59.55)	96.29 (9.83)
T_{10}	Neem oil	1.5	72.07 (58.19)	93.26 (9.68)
T_{11}	Fenvalerate (20EC)	0.1	67.42 (55.21)	84.93 (9.23)
T_{12}	Control	0.0	0 (0)	0 (0.70)
CV			7.94 %	3.80 %
LSD_{05}			7.12	0.19
LSD_{01}			9.65	0.25

* Means of three replications.
Figures in parentheses in No-Choice test are Arc sine transformation.
Figures in parentheses in Choice test are Square root transformation.
A = Acetone extract, M = Methanol extract.

4.1.2.2. Choice test:

The plants treated with methanol extract of *M. hexandra* were not preferred for egg laying by the moths when allowed to choose egg laying site, as no eggs were found on the plants. However, preferential differences recorded significant effect of treatments on oviposition. Maximum reduction in oviposition was exhibited by acetone extract of *M. Hexandra* (98.15 %) and was significantly superior to neem oil (93.26 %). It was followed by acetone and methanol extract of *L. citrata* with 92.19 % and 92.29 % reduction in oviposition respectively, which were at par with neem oil. The moths preferred the plants treated with acetone extract of *C. viscosum* more for oviposition than other treatments and it showed the minimum oviposition deterrency (70.51 %). All plant extracts were highly effective in reducing egg laying ability of the moths (Table 7).

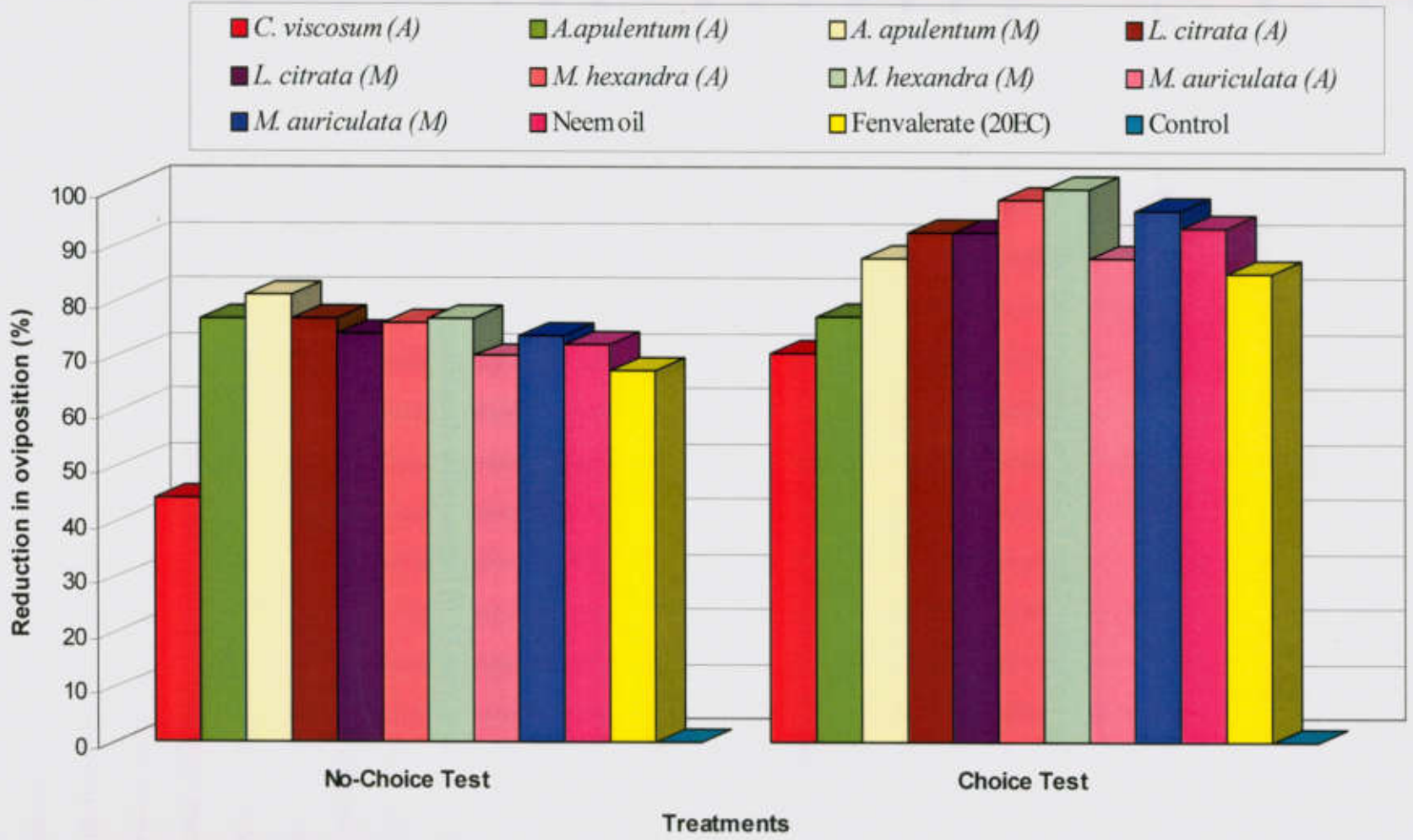


Fig.12. Reduction on oviposition of rice leaffolder due to effect of treatments.

The effect of plant extracts based on oviposition deterrency percentage in choice condition in chronological order was: *M. hexandra* (methanol extract) > *M. hexandra* (acetone extract) > *M. auriculata* (methanol extract) > Neem oil > *L. citrata* (methanol extract) > *L. citrata* (acetone extract) > *M. auriculata* (acetone extract) > *A. apulentum* (methanol extract) > Fenvalerate > *A. apulentum* (acetone extract) > *C. viscosum* (acetone extract).

4.1.3. Effect of treatments on larval development of *Cnaphalocrocis medinalis* (Guenee):

It is revealed from the data presented in Table 8 and depicted in Fig.-13 that none of the treatments could cause the larval mortality and all the larvae survived upto 24 hrs after foliar treatments. However on 6th DATr larvae could not survive in fenvalerate resulting in 100 % larval mortality. Observations recorded on 11th DATr revealed that larvae could survive only in acetone extract of *A. apulentum*, *M. hexandra* (acetone extract) and *M. auriculata* (acetone extract) treatments whereas on 16th DATr larvae survived only in methanol extract of *M. hexandra*. In none of the treatments larvae could reach the pupal stage whereas in control all the larvae survived resulting into moth emergence at 25 DATr.

Observation on the effect of plant extract on length and breadth of larvae indicated no difference among the treatments at 24 hrs of foliar spray. On 6th DATr maximum effect was exhibited by fenvalerate as the larvae could not survive beyond 24 hrs. Among the treatments acetone extract of *L. citrata* exhibited maximum retardation of growth (0.30 cm) on the larvae and differed significantly with control (0.35 cm). It was followed by *L. citrata* (methanol extract) and was at par with neem oil (0.32 cm). Methanol extract of *M. auriculata* was least effective in reducing the length of larvae (0.36 cm) and was at par with control (0.35 cm). Effect of treatments on the breadth of the larvae on 6th DATr were not significant. Observations on the length and breadth recorded on 11th DATr and 16th DATr could not be analyzed statistically due to the survival of larvae was observed in few treatments only. The lowest larval length (0.37 cm) was observed in methanol extract of *M. hexandra* whereas it was 1.25 cm in control at 11th DATr. While comparing the breadth of the larvae it was found 0.1 cm in acetone extract of *A. apulentum*, *M. hexandra* (acetone & methanol extract) whereas in the control it was 0.20 cm. Acetone extract of *M. hexandra* recorded on 16th DATr showed highly retarted larval growth (0.44 cm)

as compared to control where it was observed 1.43 cm, whereas the larval breadth in the same treatment was 0.14 cm as compared to 0.27 cm in control (Table 8).

Table 8. Effect of plant extracts on larval growth of *C. medinalis* (Guenee).

Treatments		Observation (DATr)							
		1 DATr		6 DATr		11 DATr		16 DATr	
		Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)
T_1	*C. viscosum* (A)	*0.30	0.10	0.35 (0.92)	0.10	-	-	-	-
T_2	*A. apulentum* (A)	0.30	0.10	0.36 (0.93)	0.10	0.39	0.10	-	-
T_3	*A. apulentum* (M)	0.30	0.10	0.37 (0.93)	0.10	-	-	-	-
T_4	*L. citrata* (A)	0.30	0.10	0.30 (0.89)	0.10	-	-	-	-
T_5	*L. citrata* (M)	0.32	0.10	0.32 (0.91)	0.13	-	-	-	-
T_6	*M. hexandra* (A)	0.32	0.10	0.33 (0.91)	0.10	0.51	0.10	0.44	0.14
T_7	*M. hexandra* (M)	0.32	0.10	0.36 (0.98)	0.10	0.37	0.10	-	-
T_8	*M. auriculata* (A)	0.32	0.10	0.39 (0.94)	0.10	-	-	-	-
T_9	*M. auriculata* (M)	0.32	0.10	0.37 (0.93)	0.10	-	-	-	-
T_{10}	Neem oil	0.30	0.10	0.32 (0.91)	0.10	-	-	-	-
T_{11}	Fenvalerate 20 EC	0.32	0.10	-	-	-	-	-	-
T_{12}	Control	0.32	0.10	0.35 (0.92)	0.20	1.25	0.20	1.43	0.27
LSD_{05}				0.04	NS				

DATr = Days after treatment
*= Mean of three replications.
- = moribund / dead larva.
NS= Non significant.
A= Acetone extract, M= Methanol extract.
Figures in the parentheses are $\sqrt{x + 0.5}$ values.

4.2. Field experiments:

4.2.1. Evaluation of plant extracts on the incidence of rice leaffolder *Cnaphalocrocis medinalis* (G) in the wet season during 2002 and 2003.

The experimental plots were observed for the assessment of infestation level before treatments were applied at 30 DAT. It was found that general infestation level was very low to the value of 3.58 % and 1.78 % at 30 DAT during 2002 and 2003 respectively.

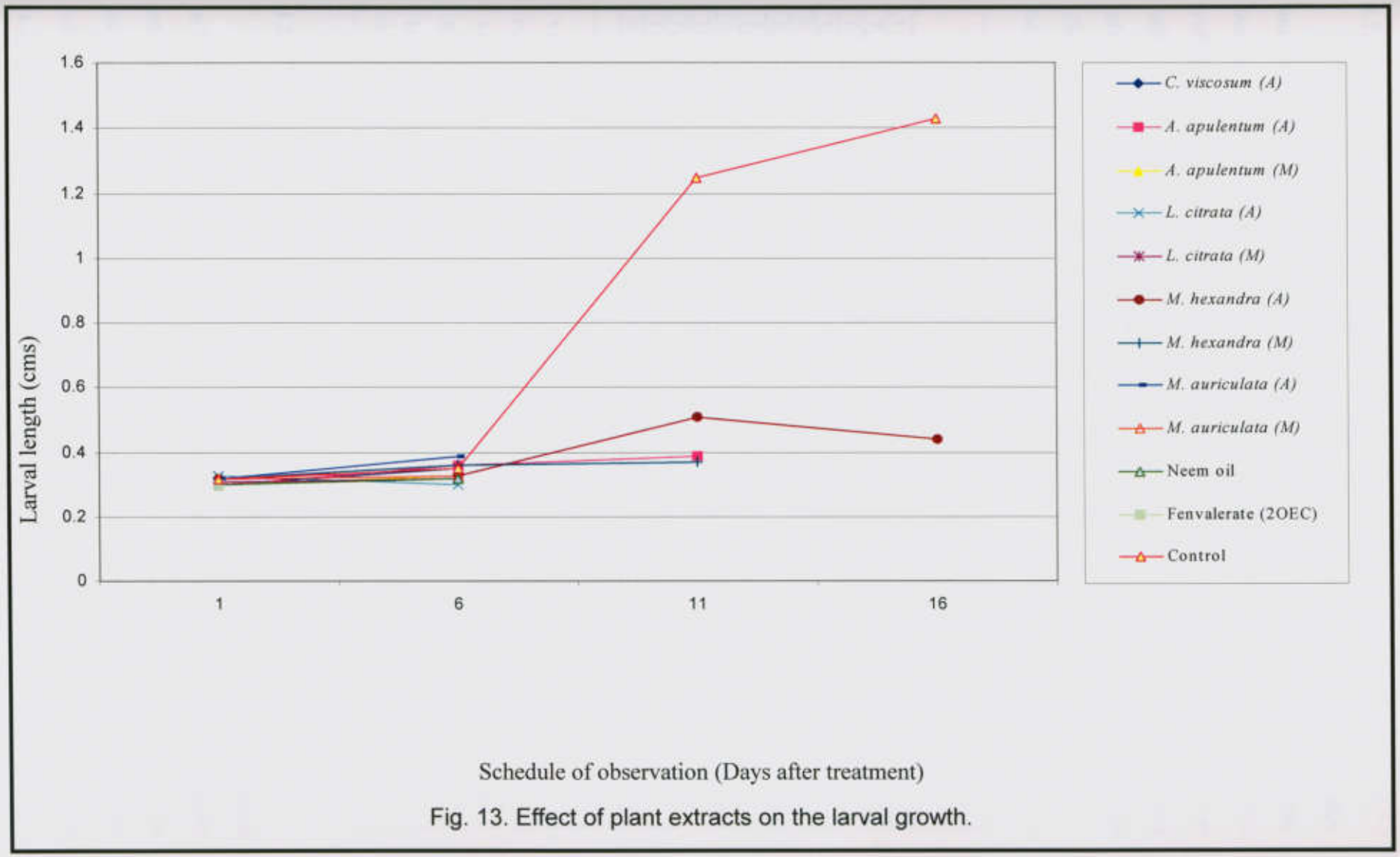


Fig. 13. Effect of plant extracts on the larval growth.

4.2.1.1. At 40 DAT-2002:

All the treatments were equally effective and were found to be at par with each other and were significantly superior than untreated control (Table 9 & Fig.14). Treatment fenvalerate was superior in reducing the leaffolder infestations from 2.12 % in untreated control to 0 % with 100 % treatment effectiveness and was followed by methanol extract of *A. apulentum* with 0.57 % level of infestation showing 73.11 % effectiveness over control while maximum infestation 1.36 % was exhibited by *M. hexandra* (methanol extract) giving 35.84 % effectiveness in comparison with the treatments over control.

Table 9. Effect of treatments on rice leaffolder infestation during the wet season of 2002.

Treatments		Conc. (%)	40 DAT		50 DAT	
			Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
T_1	*C. viscosum* (A)	2.0	*1.15(1.28)bc	45.75	0.36(0.93)bc	66.36
T_2	*A. apulentum* (A)	2.0	0.80(1.22)bcde	62.26	0.29(0.89)bc	72.90
T_3	*A. apulentum* (M)	2.0	0.57(1.03)bc	73.11	0.00(0.71)bd	100.0
T_4	*L. citrata* (A)	2.0	0.70(1.09)bcde	66.98	0.21(0.84)bcd	80.37
T_5	*L. citrata* (M)	2.0	0.77(1.12)bcde	63.68	0.22(0.85)bcd	79.44
T_6	*M. hexandra* (A)	2.0	0.82(1.15)bcde	61.32	0.30(0.89)bc	71.96
T_7	*M. hexandra* (M)	2.0	1.36(1.36)b	35.84	0.35(0.92)bc	67.29
T_8	*M. auriculata* (A)	2.0	1.23(1.31)b	41.98	0.36(0.92)bc	66.36
T_9	*M. auriculata* (M)	2.0	0.80(1.14)bcde	62.26	0.24(0.86)bcd	77.57
T_{10}	Neem oil	1.5	0.70(1.07)bcde	66.98	0.12(0.78)bcd	88.79
T_{11}	Fenvalerate 20 EC	0.1	0.00(0.70)bf	100.0	0.00(0.71)bd	100.0
T_{12}	Control	0.0	2.12(1.62)a		1.07(1.25)a	
CV			8.47 %		11.36 %	

* Mean of three replications

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

Means followed by some letters are not significantly different at P= 0.05, as per Duncan's Multiple Range Test.

DAT = Days after transplantation.

A= Acetone extract, M= Methanol extract.

4.2.1.2. At 40 DAT- 2003:

Effect of treatments on the incidence of rice leaffolder at 40 DAT in 2003 are presented in Table 10 and illustrated in Fig. 15. Comparison of treatment means revealed that maximum infestation (1.29 %) was observed in control followed by methanol extract of *M. hexandra* with 1.27 % infestation which were found to be at par with control while most effective treatment with 100 % effectiveness was exhibited by fenvalerate followed by methanol extract of *A. apulentum* with 0.34 % level of infestation showing 73.64 % effectiveness over control.

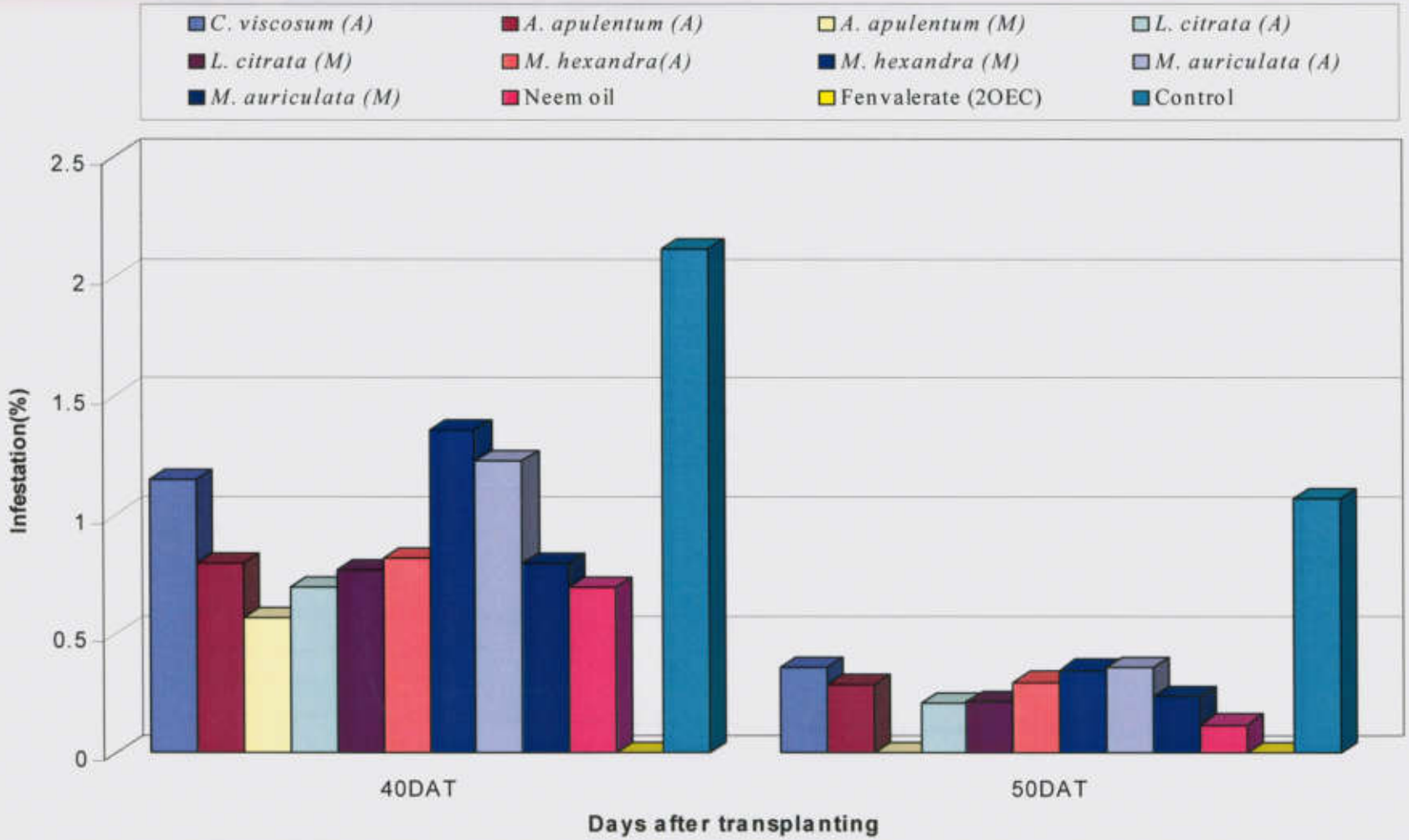


Fig. 14. Effect of treatmants on rice leaffolder during the wet season 2002.

Table 10. Effect of treatments on rice leaffolder infestation during the wet season of 2003.

Treatments		Conc. (%)	40 DAT		50 DAT		60 DAT	
			Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
T_1	*C. viscosum* (A)	2.0	*1.16(1.29)a	10.08	0.54(1.02)abc	22.86	0.38(0.94)a	33.33
T_2	*A. apulentum* (A)	2.0	1.07(1.25)abc	17.05	0.28(0.88)bcd	60.00	0.25(0.87)abc	56.14
T_3	*A. apulentum* (M)	2.0	0.34(0.19)e	73.64	0.00(0.70)d	100.0	0.00(0.70)bc	100.0
T_4	*L. citrata* (A)	2.0	0.67(1.09)cd	50.38	0.00(0.70)d	100.0	0.00(0.70)bc	100.0
T_5	*L. citrata* (M)	2.0	0.74((1.12)bcd	42.64	0.39(0.82)abc	44.29	0.11(0.78)abc	80.70
T_6	*M. hexandra* (A)	2.0	1.08(1.26)ab	16.28	0.32(0.90)abcd	54.29	0.35(0.90)ac	38.60
T_7	*M. hexandra* (M)	2.0	1.27(1.33)a	1.55	0.89(1.18)a	-27.14	0.45(0.97)a	21.05
T_8	*M. auriculata* (A)	2.0	1.19(1.30)a	7.75	0.68(1.09)ab	2.86	0.41(0.95)a	28.07
T_9	*M. auriculata* (M)	2.0	0.88(1.23)bc	31.78	0.18(0.82)cd	74.29	0.18(0.91)abc	68.42
T_{10}	Neem oil	1.5	0.60(1.05)de	53.49	0.00(0.70)d	100.0	0.00(70)bc	100.0
T_{11}	Fenvalerate 20 EC	0.1	0.00(0.70)f	100.0	0.00(0.70)d	100.0	0.00(70)bc	100.0
T_{12}	Control	2.0	1.29(1.35)a		0.70(1.09)ab		0.57(1.01)a	
CV			5.45 %		19.68 %		15.06 %	

* Mean of three replications

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

Means followed by some letters are not significantly different at P= 0.05, as per Duncan's Multiple Range Test.

DAT = Days after transplantation.

A= Acetone extract, M= Methanol extract.

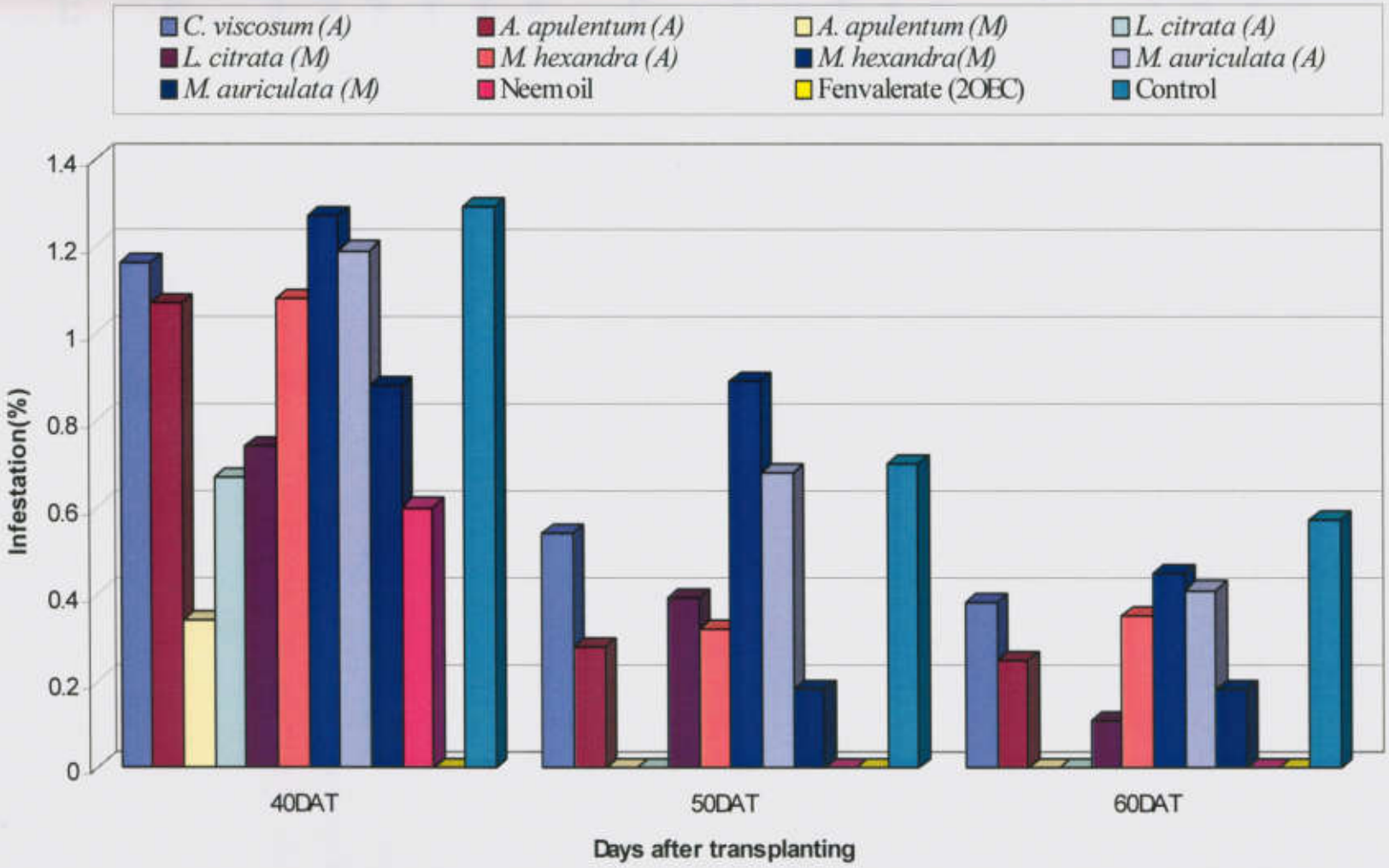


Fig. 15. Effect of treatments on rice leaf folder during the wet season 2003.

4.2.1.3. At 50 DAT-2002:

The differences among the treatments were not significant and were equally effective. All the treatments significantly reduced the incidence of rice leaffolder and treatment *A. apulentum* (methanol extract) and fenvalerate proved the best recording 0 % infestation followed by neem oil treatment with 0.12 % infestation as compared to 1.07 % untreated control (Table 9 & Fig.16). Among the treatments, acetone extract of *C. viscosum* recorded 0.36 % infestation which was next to untreated control with an effectiveness of 66.36 %.

4.2.1.4. At 50 DAT-2003:

Treatment effects on the level of rice leaffolder infestation at 50 DAT in Table 11 & Fig. 16 indicates the lowest level of infestation was observed in treatments *A. apulentum* (methanol extract), *L. citrata* (acetone extract), neem oil and fenvalerate exhibiting 100 % effectiveness followed by methanol extract of *M. auriculata* with 0.18 % infestation giving 74.29 % effectiveness of treatments while maximum infestation (0.89 %) was revealed by methanol extract of *M. hexandra* followed by control with 0.70 % infestation.

4.2.1.5. At 60 DAT 2003:

Comparison of treatment means reveals that highest infestation was observed in control with 0.57 % followed by methanol extract of *M. hexandra* with 0.45 % infestation while most effective treatment was observed in *A. apulentum* (acetone extract) showing 100 % effectiveness. Treatment *L. citrata* (acetone extract), neem oil and fenvalerate were found to at par with *A. apulentum* (acetone extract) followed by methanol extract of *L. citrata* with 0.11 % infestation. Methanol extract of *M. auriculata* (0.18 %) was at par with methanol extract of *L. citrata* showing 68.42 % effectiveness over control (Table 10 & Fig. 15).

4.2.2. Effect of treatments on grain yield:

4.2.2.1. Grain yield 2002:

The data on the effect of treatments on grain yield presented in Table 12 and illustrated in Fig. 17 revealed significant difference in grain yield among the treatments where highest yield (3901.59 kg/ha) was recorded in fenvalerate which

Table 11. Effect of treatments on rice leaffolder infestation during the wet Season of 2002 and 2003.

Treatments		Conc. (%)	40 DAT				50 DAT			
			2002		2003		2002		2003	
			Infestation (%)	Effective -ness (%)	Infestation (%)	Effective -ness (%)	Infestation (%)	Effective -ness (%)	Infestation (%)	Effective -ness (%)
T_1	*C. viscosum* (A)	2.0	* 1.15(1.28)bc	45.75	1.16(1.29)a	10.08	0,36(0.93)bc	66.36	0.54(1.02)abc	22.86
T_2	*A. opulentum* (A)	2.0	0.80(1.22)bcde	62.26	1.07(1.25)abc	17.05	0.29(0.89)bc	72.90	0.28(0.88)bcd	60.00
T_3	*A. opulentum* (M)	2.0	0.57(1.03)be	73.11	0.34(0.19)e	73.64	0.00(0.71)bd	100	0.00(0.70)d	100.0
T_4	*L. citrata* (A)	2.0	0.70(1.09)bcde	66.98	0.67(1.09)cd	50.38	0.21(0.84)bcd	80.37	0.00(0.70)d	100.0
T_5	*L. citrata* (M)	2.0	0.77(1.12)bcde	63.68	0.74(1.12)bcd	42.64	0.22(0.85)bcd	79.44	0.39(0.82)abc	44.29
T_6	*M. hexandra* (A)	2.0	0.82(1.15)bcde	61.32	1.08(1.26)ab	16.28	0.30(0.89)bc	71.96	0.32(0.90)abcd	54.29
T_7	*M. hexandra* (M)	2.0	1.36(1.36)b	35.84	1.27(1.33)a	1.55	0.35(0.92)bc	67.29	0.89(1.18)a	-27.14
T_8	*M. auriculata* (A)	2.0	1.23(1.31)b	41.98	1.19(1.30)a	7.75	0.36(0.92)bc	66.36	0.68(1.09)ab	2.86
T_9	*M. auriculata* (M)	2.0	0.80(1.14)bcde	62.26	0.88(1.23)bc	31.78	0.24(0.86)bcd	77.57	0.18(0.82)cd	74.29
T_{10}	Neem oil	1.5	0.70(1.07)bcde	66.98	0.60(1.05)de	53.49	0.12(0.78)bcd	88.79	0.00(0.70)d	100.0
T_{11}	Fenvalerate 20 EC	0.1	0.00(0.70)bf	100.0	0.00(0.70)f	100.0	0.00(0.71)bd	100	0.00(0.70)d	100.0
T_{12}	Control	0.0	2.12(1.62)a		1.29(1.35)a		1.07(1.25)a		0.70(1.09)ab	
CV			8.47 %		5.45 %		11.36 %		19.68 %	

* Mean of three replications

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

Means followed by some letters are not significantly different at P= 0.05, as per Duncan's Multiple Range Test.

DAT = Days after transplantation.

A= Acetone extract, M= Methanol extract.

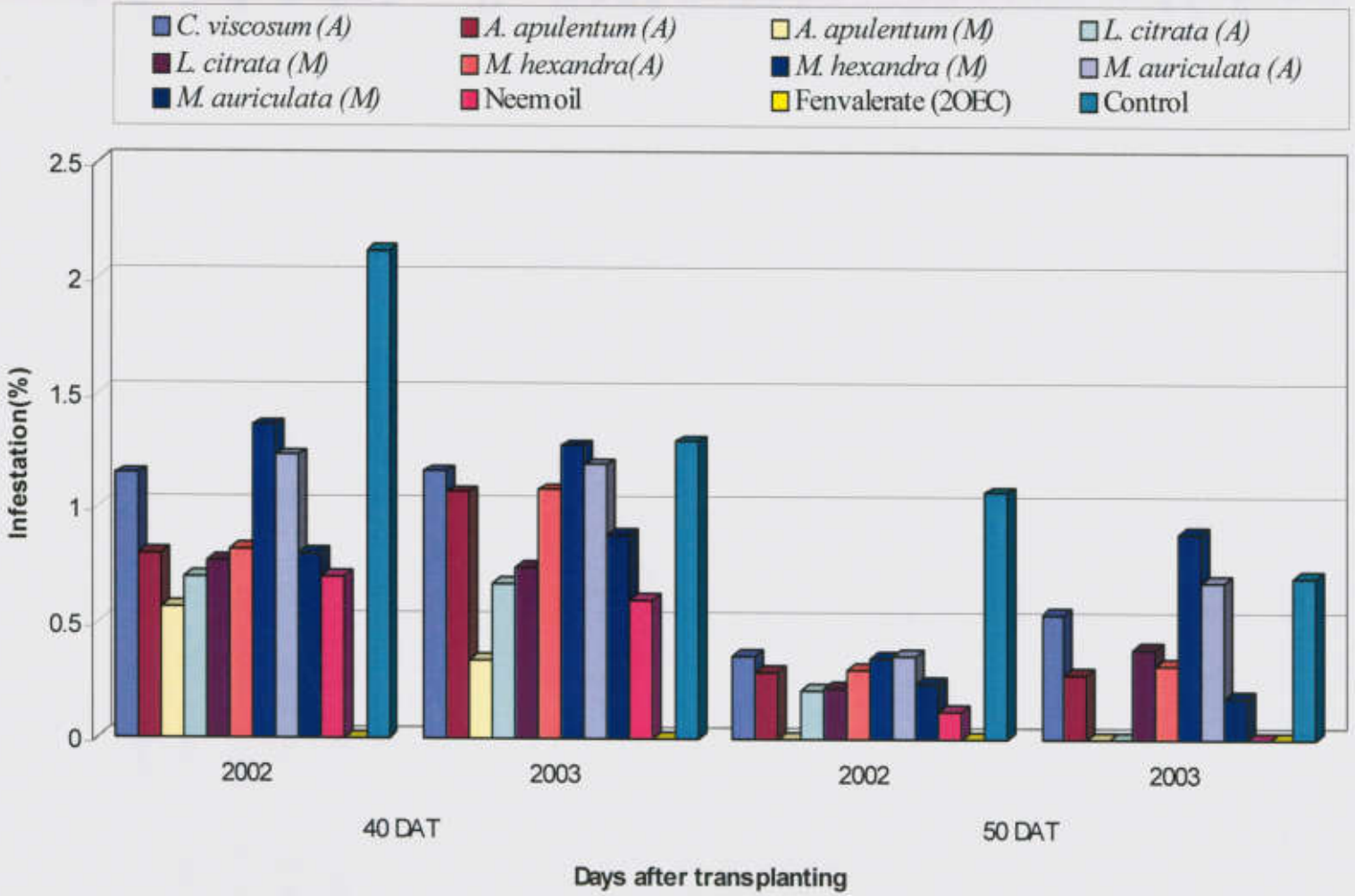


Fig. 16. Effect of treatments on rice leaf folder during the wet seasons 2002 & 2003.

was followed by methanol extract of *A. apulentum* with 3746.41 kg/ha yield. Neem oil (3710.88 kg/ha) was found to be at par with *A. apulentum* (methanol extract). Lowest grain yield was observed in acetone extract of *C. viscosum* with 2919.94 kg/ha followed by methanol extract of *M. hexandra* with 3097.22 kg/ha. Grain yield in acetone extract of *M. hexandra* with 3104.49 kg/ha were at par with methanol extract of *M. hexandra*.

Table 12. Grain yield due to the effect of treatments on rice leaf folder infestation during the wet season of 2002 & 2003.

Treatments		Grain yield * kg/ha	
		2002	2003
T_1	*C. viscosum* (A)	2919.94g	3912.43ab
T_2	*A. apulentum* (A)	3353adef	4113.12ab
T_3	*A. apulentum* (M)	3746.41abc	4120.23ab
T_4	*L. citrata* (A)	3615ad	4122.15ab
T_5	*L. citrata* (M)	3538.70ad	4117.29ab
T_6	*M. hexandra* (A)	3104.49	3968.56ab
T_7	*M. hexandra* (M)	3097.22fg	3542.41bc
T_8	*M. auriculata* (A)	3399.05ad	3542.71bc
T_9	*M. auriculata* (M)	3380.07ade	3925.71ab
T_{10}	Neem oil	3710.88abc	4502.20a
T_{11}	Fenvalerate	3901.59ab	4502.03a
T_{12}	Control	3616.69acd	3870.00ab
CV		9.62 %	9.06 %

* Means of three replications
Means followed by same letters in the column are not significantly different at P= 0.05, as per Duncan's Multiple Range Test.
A= Acetone extract.
M= Methanol extract.

4.2.2.2. Grain yield 2003:

Fenvalerate recorded maximum yield (4502.03 kg/ha) as it is revealed in Table 12 and depicted in Fig. 17 which were at par neem oil and this was followed by acetone extract of *L. citrata* with 4122.15 kg/ha. *A. apulentum* (methanol extract) and methanol extract of *L. citrata* with grain yield 4120.23 kg/ha and 4117.29 kg/ha respectively are at par with *L. citrata* (acetone extract). Minimum yield (3542.41 kg/ha) was observed in methanol extract of *M. hexandra* and are at par with methanol extract of *M. auriculata* (3925.71 kg/ha). Treatments effects in yield were found to be insignificant.

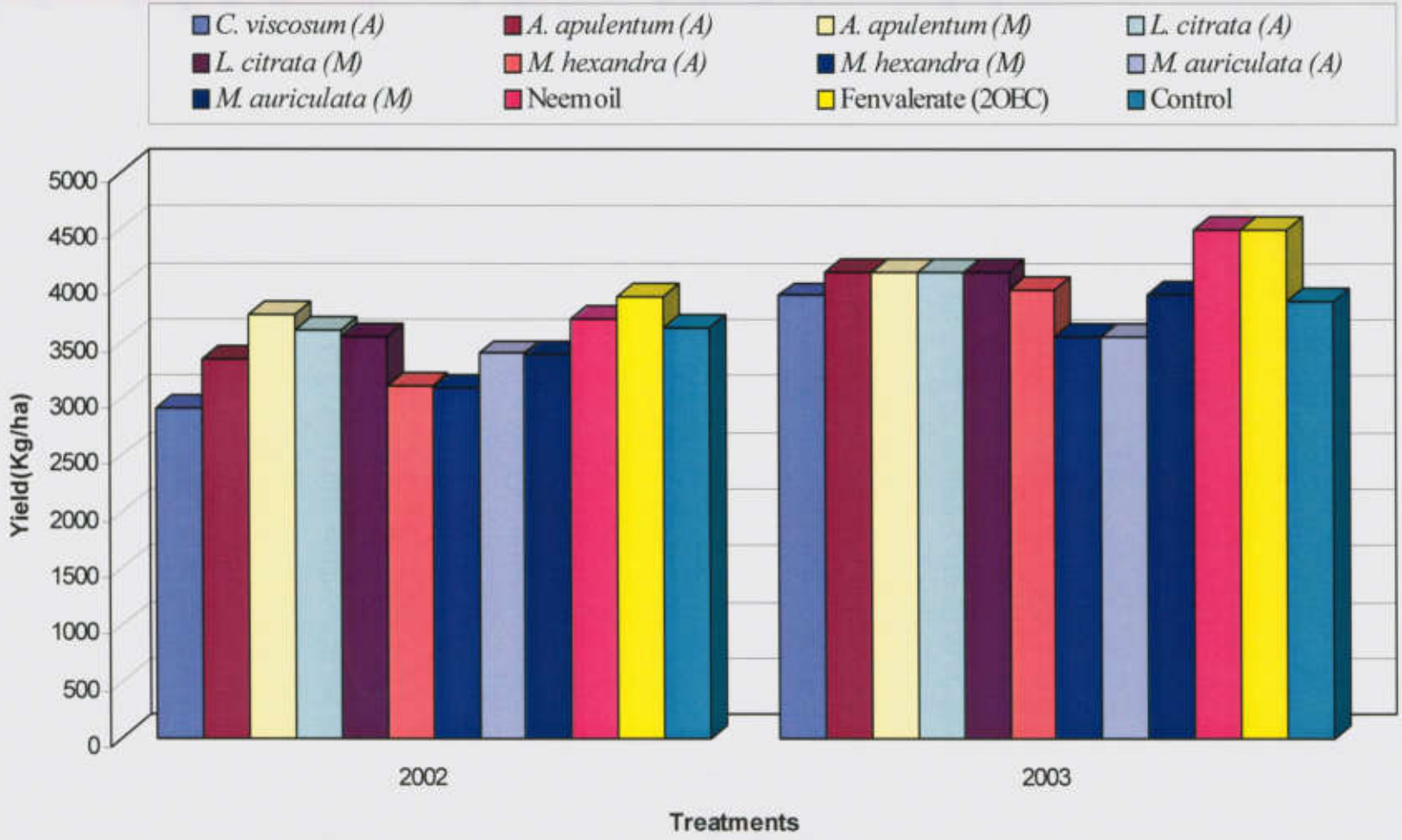


Fig. 17. Grain yield as influenced by the treatments on rice leaffolder infeatation during the wet seasons 2002 & 2003.

4.2.3. Efficacy of plant extracts at different concentrations against rice leaffolder during the wet season 2004 & 2005.

General infestation level of rice leaffolder was found to be low when assessed at 30 DAT, before spraying the plots with plant extracts. It was observed that infestation level in 2004 was 5.66 % while 5.11 % was recorded during 2005.

4.2.3.1 At 40 DAT - 2004:

The perusal of data in Table 13 revealed that all the plant extracts were effective in reducing the leaffolder infestation. The lowest infestation (3.78 %) was recorded in neem oil with 53.41 % effectiveness. It was significantly superior to other plant extracts.Neem oil was followed by methanol extract of *A. apulentum* (3.98 %) giving 46.45 % effectiveness.

Comparison of concentration means indicated that both the conc. were highly significant when compared with untreated control and higher conc. (4 %) was superior with 2.97 % leaf damage than 2 % conc. (3.10 %) in reducing the level of infestation (Fig.-18). The effectiveness of higher concentrations of treatments in the over control (4 %) was 48.98 % and lower conc. (2 %) was 46.62 %.

Though the interactions between plant extracts and conc. were insignificant, minimum infestation (2.63 %) was recorded in neem oil (4 %) while maximum infestation (3.24 %) was observed in *L. citrata* (methanol extract) (2 %) among the treatments.

4.2.3.2 At 40 DAT – 2005:

It is clear from the result (Table 14) that variations in the level of infestation due to different treatments were highly significant. Minimum infestation of 3.04 % was observed in methanol extract of *L. citrata* which was followed by neem oil treatment (3.64 %) while maximum infestation (3.97 %) was recorded in acetone extract of *L. citrata*.

Comparison of concentration means revealed the lowest infestation of 3.01 % in 4 % conc. with an effectiveness of 45.40 % and highest of 5.50 % in untreated control (Fig. 19) and both the concentrations were found to be highly significant when compared with untreated check.

Table 13. Effect of plant extracts in different concentrations on rice leaffolder infestation at 40 DAT during the wet season 2004.

Plant products	C_0	C_1		C_2		Mean	
	Infestation (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
A. apulentum (M)	*5.77 (2.50)	3.15 (1.91)	45.41	3.03 (1.88)	47.49	3.98 (2.10)	46.45
L. citrata (A)	5.78 (2.51)	3.20 (1.93)	44.64	3.08 (1.90)	46.71	4.02 (2.11)	45.68
L. citrata (M)	5.87 (2.52)	3.24 (1.93)	44.80	3.14 (1.91)	46.51	4.08 (2.12)	45.65
Neem oil	5.87 (2.53)	2.84 (1.83)	51.62	2.63 (1.77)	55.20	3.78 (2.04)	53.41
Mean	5.82 (2.52)	3.10 (1.90)	46.62	2.97 (1.87)	48.98		
$CV_{(a)} = 0.67\%$				$CV_{(b)} = 1.69\%$			

LSD			
		5%	1%
To compare any two treatment means	-	0.015	0.02
To compare any two conc. means	-	0.024	0.05
To compare any two conc. means of the same treatment	-	NS	NS
To compare any two treatment means at same level of conc.	-	NS	NS

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

* Mean of three replications

NS Non Significant

$CV_{(a)}$ = Co-efficient variation of main factor (treatment).

$CV_{(b)}$ = Co-efficient variation of sub factor (conc.).

C = Conc.

C_1 = 2%

C_0 = 0%

C_2 = 4%

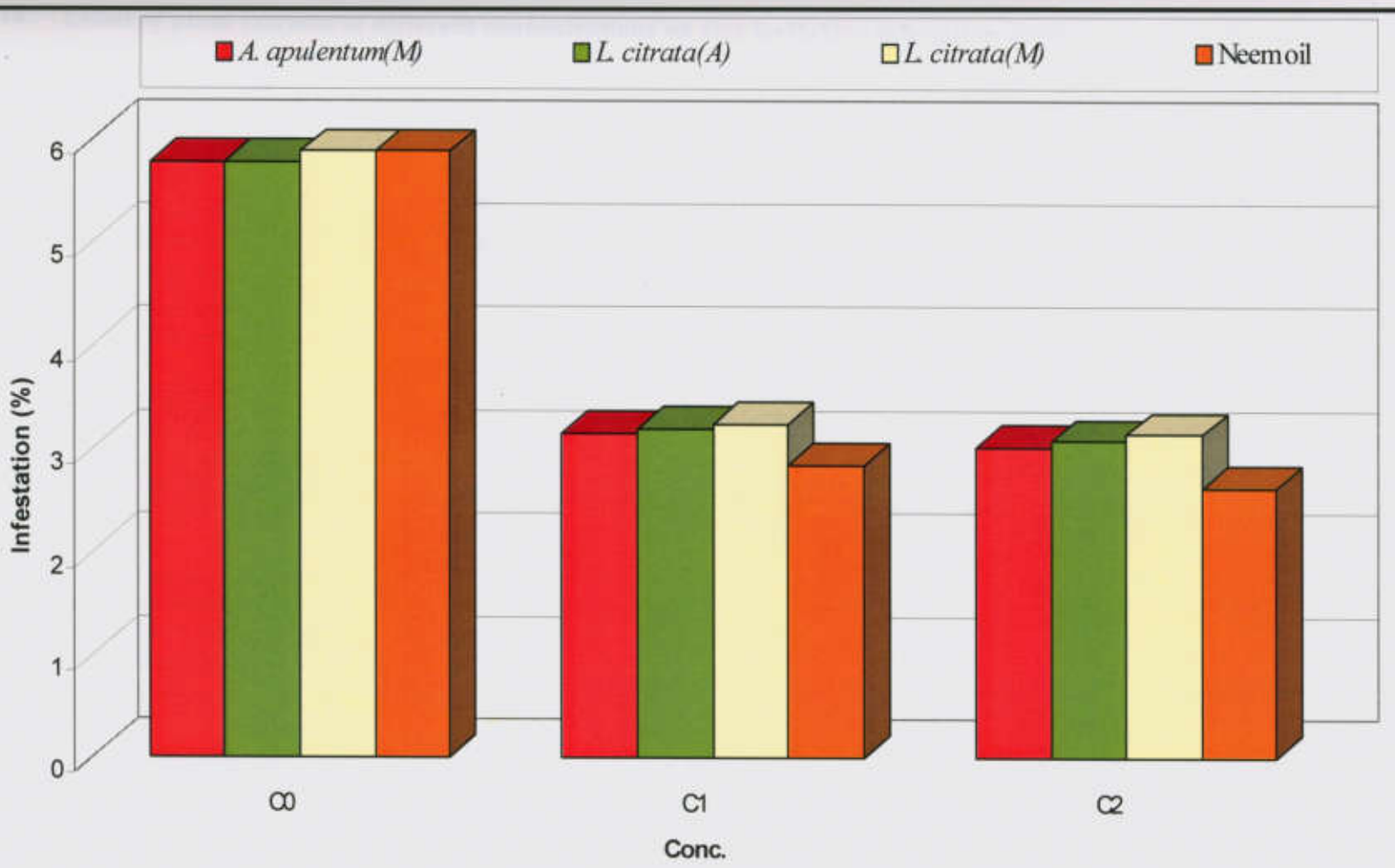


Fig. 18. Effect of plant extracts in different conc. on rice leaffolder infestation at 40DAT during the wet season 2004.

Table 14. Effect of plant extracts in different concentrations on rice leaffolder infestation at 40 DAT during the wet season 2005.

Plant products	C_0	C_1		C_2		Mean	
	Infestation (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
A. apulentum (M)	*5.61 (2.47)	3.13 (1.91)	44.21	3.02 (1.87)	46.17	3.92 (2.08)	45.19
L. citrata (A)	5.49 (2.45)	3.28 (1.95)	40.26	3.13 (1.91)	42.99	3.97 (2.10)	41.62
L. citrata (M)	5.55 (2.46)	3.35 (1.96)	39.64	3.22 (1.93)	41.98	3.04 (2.12)	40.81
Neem oil	5.35 (2.41)	2.93 (1.86)	43.23	2.65 (1.78)	50.47	3.64 (2.02)	47.85
Mean	5.50 (2.45)	3.17 (1.92)	42.34	3.01 (1.87)	45.40		
		$CV_{(a)}$ = 0.52%		$CV_{(b)}$ = 0.92%			

LSD		
	5%	1%
To compare any two treatment means	- 0.012	0.018
To compare any two conc. means	- 0.019	0.029
To compare any two conc. means of the same treatment	- 0.048	0.074
To compare any two treatment means at same level of conc.	- 0.097	0.148

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

* Mean of three replications

$CV_{(a)}$ = Co-efficient variation of main factor (treatment).

$CV_{(b)}$ = Co-efficient variation of sub factor (conc.).

C = Conc.

C_1 = 2%

C_0 = 0%

C_2 = 4%

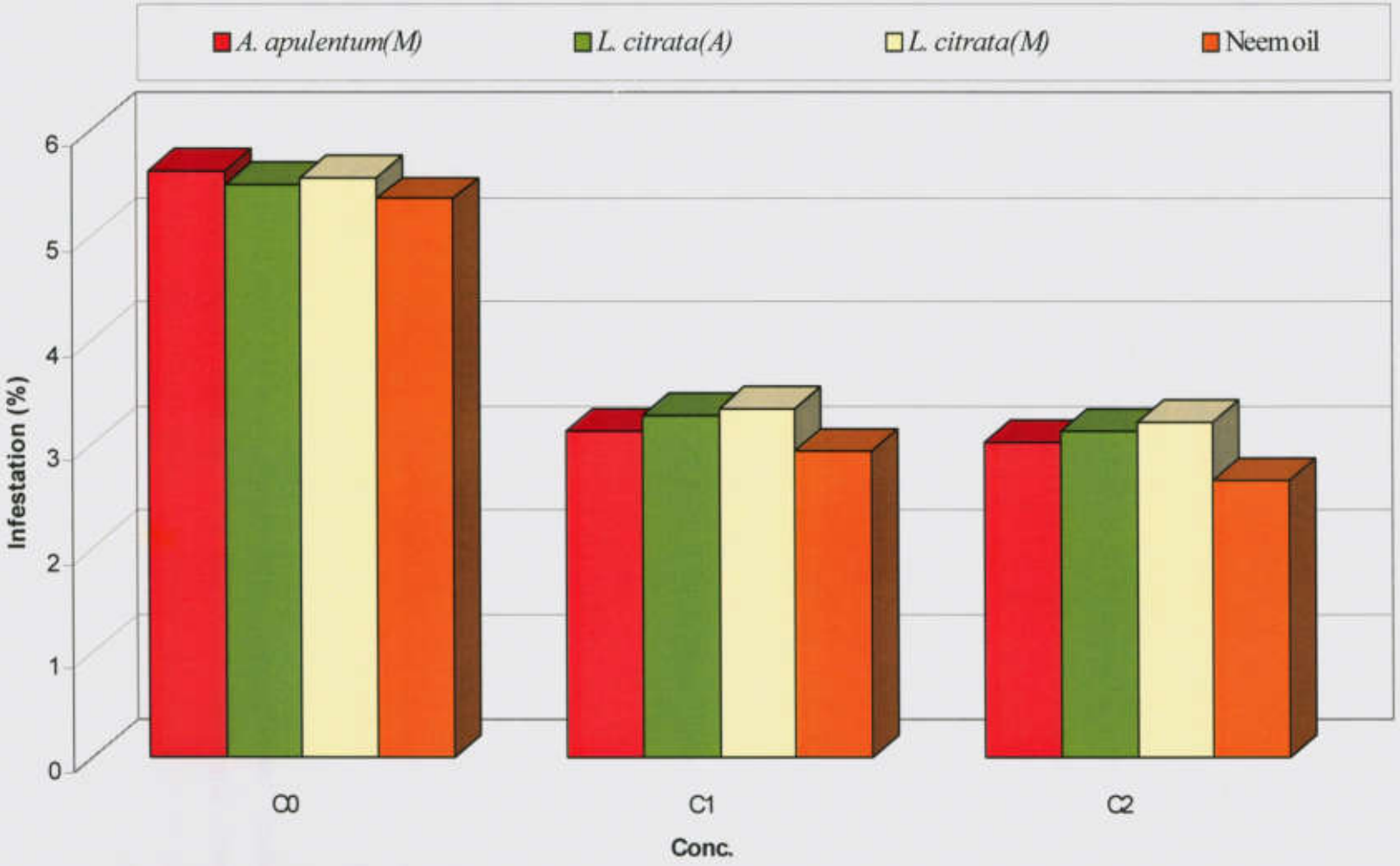


Fig. 19: Effect of plant extracts in different conc. on rice leaffolder infestation at 40 DAT during the wet season 2005.

The interaction of plant extracts and conc. were highly significant reflecting minimum infestation 2.65 % in 4 % neem oil treatment followed by neem oil (2 %) treatment with 2.93 % infestation while maximum infestation 3.35 % was recorded in methanol extract of *L. citrata* (2 %) among the plant extracts.

4.2.3.3. At 50 DAT-2004:

Critical reading of Table 15 revealed that effect of treatments on the level of infestation was highly significant. Minimum infestation of 2.51 % was recorded in neem oil treatment with an effectiveness of 84.89 % followed by methanol extract of *A. apulentum* (2.75 %) with an effectiveness of 80.17 % while maximum infestation of 3.02 % was observed in methanol extract of *L. citrata* with 70.94 % effectiveness.

Differences of the conc. means indicates that plant extracts at both the concentrations were significantly superior than untreated check and higher conc. of 4 % recorded the least infestation of 1.17 %. Infestation of 1.44 % was recorded in the lower conc. of 2 % with 75.16 % effectiveness over untreated check (Fig. 20).

The interaction of these two factors were found to be highly significant revealing minimum infestation of 0.80 % in 4 % neem oil followed by 0.95 % in 2 % neem oil treatment and maximum of 1.87 % in 2 % methanol extract of *L. citrata* (Table 15).

4.2.3.4. At 50 DAT-2005:

It is evident from the data in Table 16 and Fig. 21 that variations in the level of infestation due to different treatments were highly significant. Minimum infestation of 2.64 % with 86.64 % effectiveness was recorded in neem oil treatment which was followed by methanol extract of *A. apulentum* (2.79 %) with 79.90 % effectiveness. Observation in Acetone extract of *L. citrata* was found least effective with 2.99 % infestation level.

As it is revealed from Table 16, that both the concentrations significantly reduced the infestation level as compared with untreated control and differences among conc. were also highly significant. Minimum infestation (1.14 %) was recorded in higher conc. with an effectiveness of 80.97 % whereas in 2 % showed 1.35 % infestation with 77.50 % effectiveness. The untreated control depicted 6.01 % infestation.

The interaction of treatments and conc. which was found significant revealed that 4 % neem oil treatment showed the lowest (0.75 %) infestation which was

Table 15. Effect of plant extracts in different concentrations on rice leaffolder infestation at 50 DAT during the wet season 2004.

Plant products	C_0	C_1		C_2		Mean	
	Infestation (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
A. apulentum (M)	*5.90 (2.53)	1.27 (1.33)	78.47	1.07 (1.25)	81.86	2.75 (1.70)	80.17
L. citrata (A)	5.73 (2.50)	1.65 (1.47)	71.20	1.35 (1.36)	76.44	2.91 (1.78)	73.82
L. citrata (M)	5.73 (2.50)	1.87 (1.54)	67.36	1.46 (1.40)	74.52	3.02 (1.81)	70.94
Neem oil	5.79 (2.51)	0.95 (1.23)	83.59	0.80 (1.14)	86.18	2.51 (1.63)	84.89
Mean	5.79 (2.51)	1.44 (1.39)	75.16	1.17 (1.29)	79.75		
$CV_{(a)}$ = 1.82%				$CV_{(b)}$ = 0.93%			

LSD		
	5%	1%
To compare any two treatment mean	- 0.034	0.051
To compare any two conc. means	- 0.017	0.025
To compare any two conc. means of the same treatment	- 0.031	0.048
To compare any two treatment mean at same level of Conc.	- 0.056	0.085

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

* Mean of three replications

$CV_{(a)}$ = Co-efficient variation of main factor (treatment).

$CV_{(b)}$ = Co-efficient variation of sub factor (conc.).

C = Conc.

C_1 = 2%

C_0 = 0%

C_2 = 4%

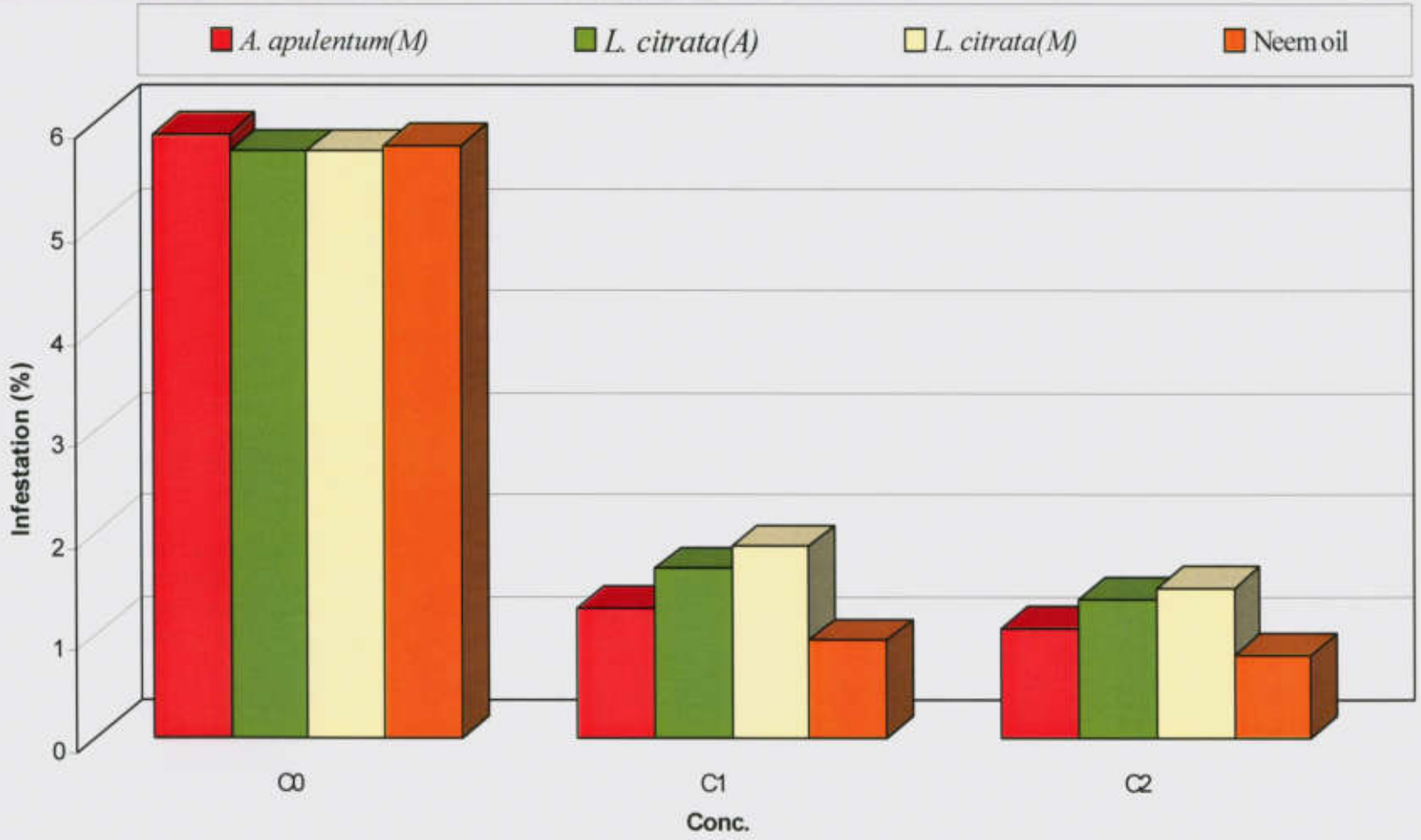


Fig. 20. Effect of plant extracts in different conc. on rice leaffolder infestation at 50DAT during the wet season 2004.

Table 16. Effect of plant extracts in different concentrations on rice leaffolder infestation at 50 DAT during the wet season 2005.

Plant products	C_0	C_1		C_2		Mean	
	Infestation (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
A. apulentum (M)	*5.97 (2.54)	1.32 (1.35)	77.89	1.08 (1.25)	81.91	2.79 (1.71)	79.90
L. citrata (A)	5.86 (2.52)	1.69 (1.48)	71.16	1.42 (1.39)	75.77	2.99 (1.80)	73.46
L. citrata (M)	5.96 (2.55)	1.45 (1.40)	75.67	1.30 (1.34)	78.19	2.90 (1.76)	76.92
Neem oil	6.25 (2.60)	0.92 (1.19)	85.28	0.75 (1.12)	88.00	2.64 (1.64)	86.64
Mean	6.01 (2.55)	1.35 (1.36)	77.50	1.14 (1.28)	80.97		
$CV_{(a)}$ = 1.20%				$CV_{(b)}$ = 1.45%			

LSD		
	5%	1%
To compare any two treatment means	- 0.022	0.033
To compare any two conc. means	- 0.024	0.037
To compare any two conc. means of the same treatment	- 0.048	0.074
To compare any two treatment means at same level of conc.	- 0.044	0.066

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

* Mean of three replications

$CV_{(a)}$ = Co-efficient variation of main factor (treatment).

$CV_{(b)}$ = Co-efficient variation of sub factor (conc.).

C = Conc.

C_0 = 0%

C_1 = 2%

C_2 = 4%

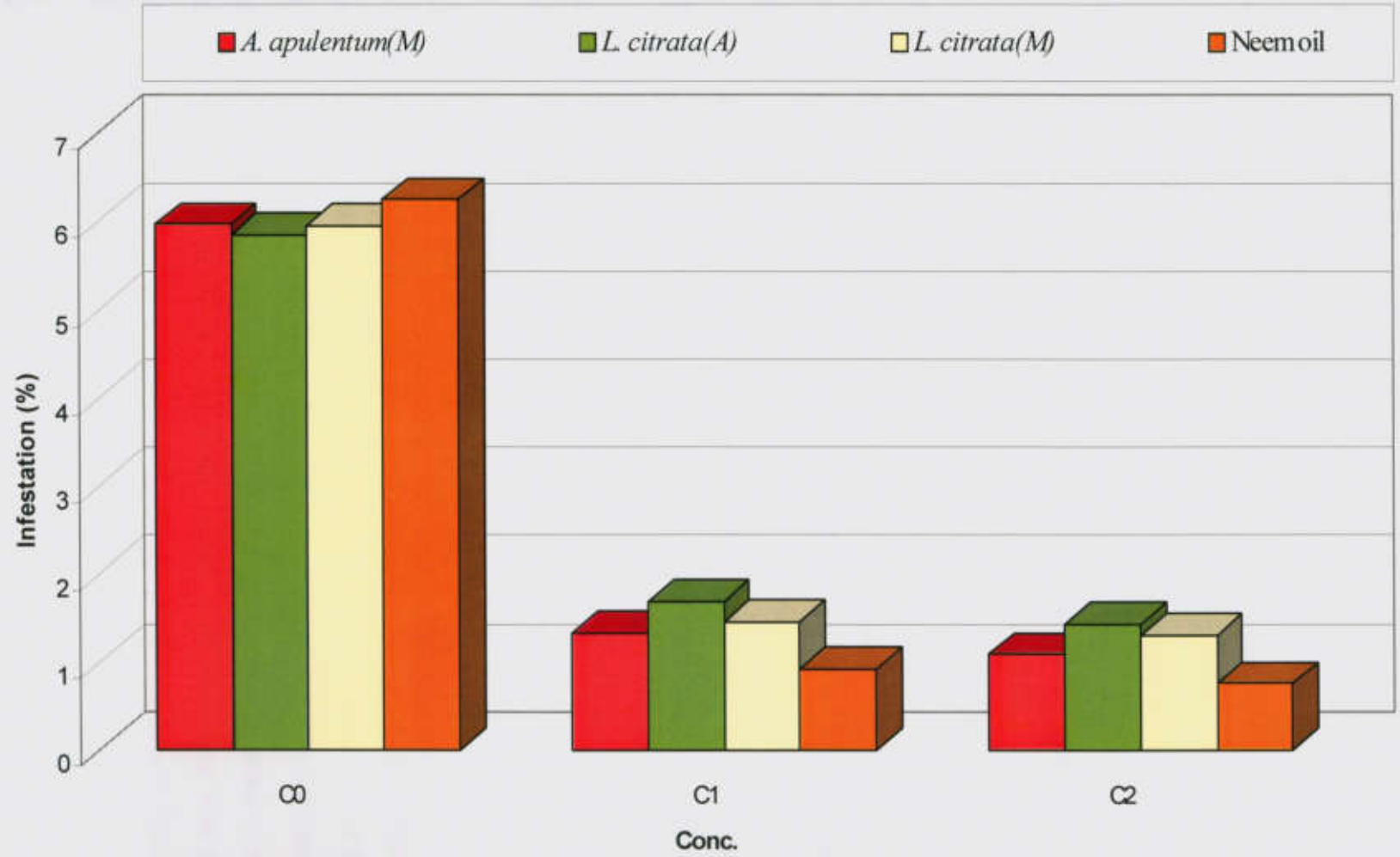


Fig. 21. Effect of plant extracts in different conc. on rice leaffolder infestation at 50 DAT during the wet season 2005.

followed by 0.92 % in 2 % neem oil treatment, while highest level of infestation 6.25 % was revealed in untreated control.

4.2.3.5. At 60 DAT – 2004:

The data on the effect of plant extracts in different conc. at 60 DAT in 2004 are presented in Table 17 and illustrated in Fig. 22. The data revealed that the variation due to different treatments were highly significant. Minimum level of infestation (2.20 %) with 93.09 % effectiveness was recorded in neem oil treatment whereas in acetone extract of *L. citrata*, maximum infestation of 2.99 % was recorded with 71.64 % effectiveness. Neem oil treatment was followed by methanol extract of *A. apulentum* with 2.58 % infestation and 84.41 % effectiveness.

Comparison of conc. means revealed that lowest infestation of 0.83 % with 85.63 % effectiveness was observed in higher conc. (4 %) and lower conc. (2 %) revealed 1.34 % infestation with 76.85 % effectiveness. The variations due to different level of conc. in infestation level were highly significant when compared with 0 % conc. and untreated control recorded a maximum of 5.79 % infestation.

The interaction between treatments and conc. were highly significant. Minimum infestation of 0.22 % in 4 % neem oil treatment which was followed by 2 % neem oil treatment (0.58 %) whereas maximum infestation (2.18 %) was observed in acetone extract of *L. citrata*. Neem oil at both the concentrations was superior to other plant extract (Table 19 & Fig. 24).

4.2.3.6. At 60 DAT – 2005:

The various levels of infestation due to effect of treatments at different conc. are tabulated in Table 18 and depicted in Fig. 23. Critical examination of the table revealed that there were significant effects of plant extracts on the level of infestation. Minimum infestation (2.17 %) with 93.30 % effectiveness was recorded in neem oil treatment which was followed by methanol extract of *A. apulentum* with 88.32 % effectiveness whereas acetone extracts of *L. citrata* proved the lowest effectiveness (74.60 %).

Comparison of conc. means reflected lowest infestation of 0.84 % in 4 % conc. and highest of 6.25 % infestation in untreated control while 1.24 % infestation with 79.50 % effectiveness was observed in 2 % conc. and the conc. effects were highly significant.

Table 17. Effect of plant extracts in different concentrations on rice leaffolder infestation at 60 DAT during the wet season 2004.

Plant products	C_0	C_1		C_2		Mean	
	Infestation (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
A. apulentum (M	*5.90 (2.53)	1.02 (1.23)	82.71	0.82 (1.15)	86.10	2.58 (1.64)	84.41
L. citrata (A)	5.73 (2.50)	2.18 (1.60)	61.95	1.07 (1.26)	81.32	2.99 (1.79)	71.64
L. citrata (M)	5.73 (2.50)	1.56 (1.44)	72.77	1.21 (1.30)	78.88	2.83 (1.75)	75.82
Neem oil	5.79 (2.51)	0.58 (1.04)	89.98	0.22 (0.84)	96.20	2.20 (1.46)	93.09
Mean	5.79 (2.51)	1.34 (1.33)	76.85	0.83 (1.14)	85.63		
$CV_{(a)}$ = 8.57%				$CV_{(b)}$ = 1.91%			

LSD		
	5%	1%
To compare any two treatment means	- 0.15	0.22
To compare any two conc. means	- 0.03	0.05
To compare any two conc. means of the same treatment	- 0.06	0.09
To compare any two treatment means at same level of conc.	- 0.23	0.36

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

* Mean of three replications

$CV_{(a)}$ = Co-efficient variation of main factor (treatment).

$CV_{(b)}$ = Co-efficient variation of sub factor (conc.).

C = Conc.

C_0 = 0%

C_1 = 2%

C_2 = 4%

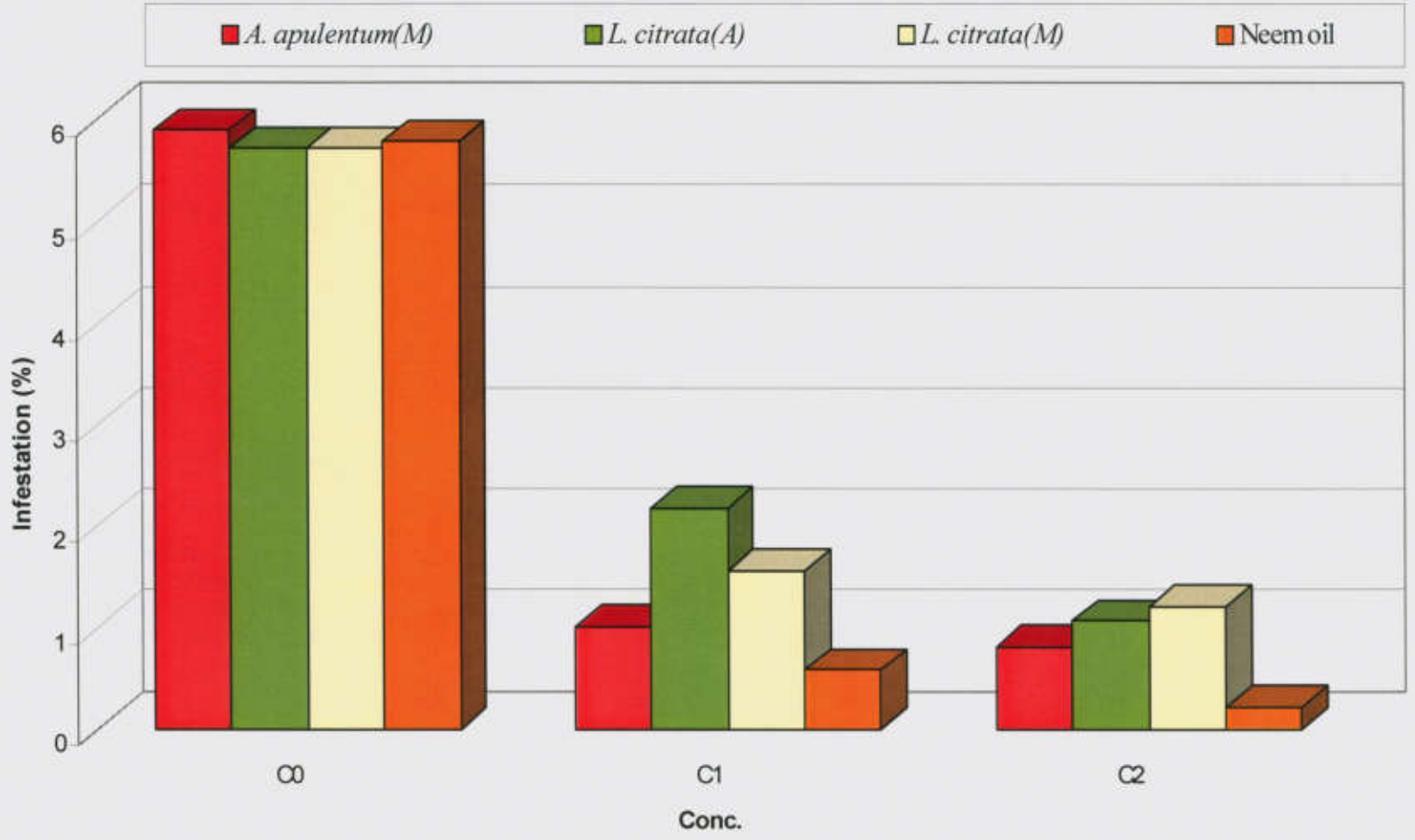


Fig. 22. Effect of plant extracts in different conc. on rice leaffolder infestation at 60DAT during the wet season 2004.

Table 18. Effect of plant extracts in different concentrations on rice leaffolder infestation at 60 DAT during the wet season 2005.

Plant products	C_0	C_1		C_2		Mean	
	Infestation (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)	Infestation (%)	Effectiveness (%)
A.apulentum (M)	*7.79 (2.51)	1.01 (1.22)	87.03	0.81 (1.41)	89.60	3.20 (1.62)	88.32
L. citrata (A)	5.63 (2.49)	1.79 (1.51)	68.21	1.07 (1.26)	80.99	2.83 (1.75)	74.60
L. citrata (M)	5.82 (2.52)	1.61 (1.45)	72.34	1.27 (1.33)	78.18	2.90 (1.77)	75.26
Neem oil	5.75 (2.50)	0.55 (1.02)	90.43	0.22 (0.85)	96.17	2.17 (1.46)	93.30
Mean	6.25 (2.51)	1.24 (1.30)	79.50	0.84 (1.14)	86.24		
$CV_{(a)}$ = 1.36%				$CV_{(b)}$ = 1.48%			
LSD							
		5%		1%			
To compare any two treatment means		- 0.026		0.041			
To compare any two conc. means		- 0.024		0.037			
To compare any two conc. means of the same treatment		- 0.048		0.074			
To compare any two treatment means at same level of conc.		- 0.053		0.081			

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

* Mean of three replications

$CV_{(a)}$ = Co-efficient variation of main factor (treatment).

$CV_{(b)}$ = Co-efficient variation of sub factor (conc.).

C = Conc.

C_1 = 2%

C_0 = 0%

C_2 = 4%

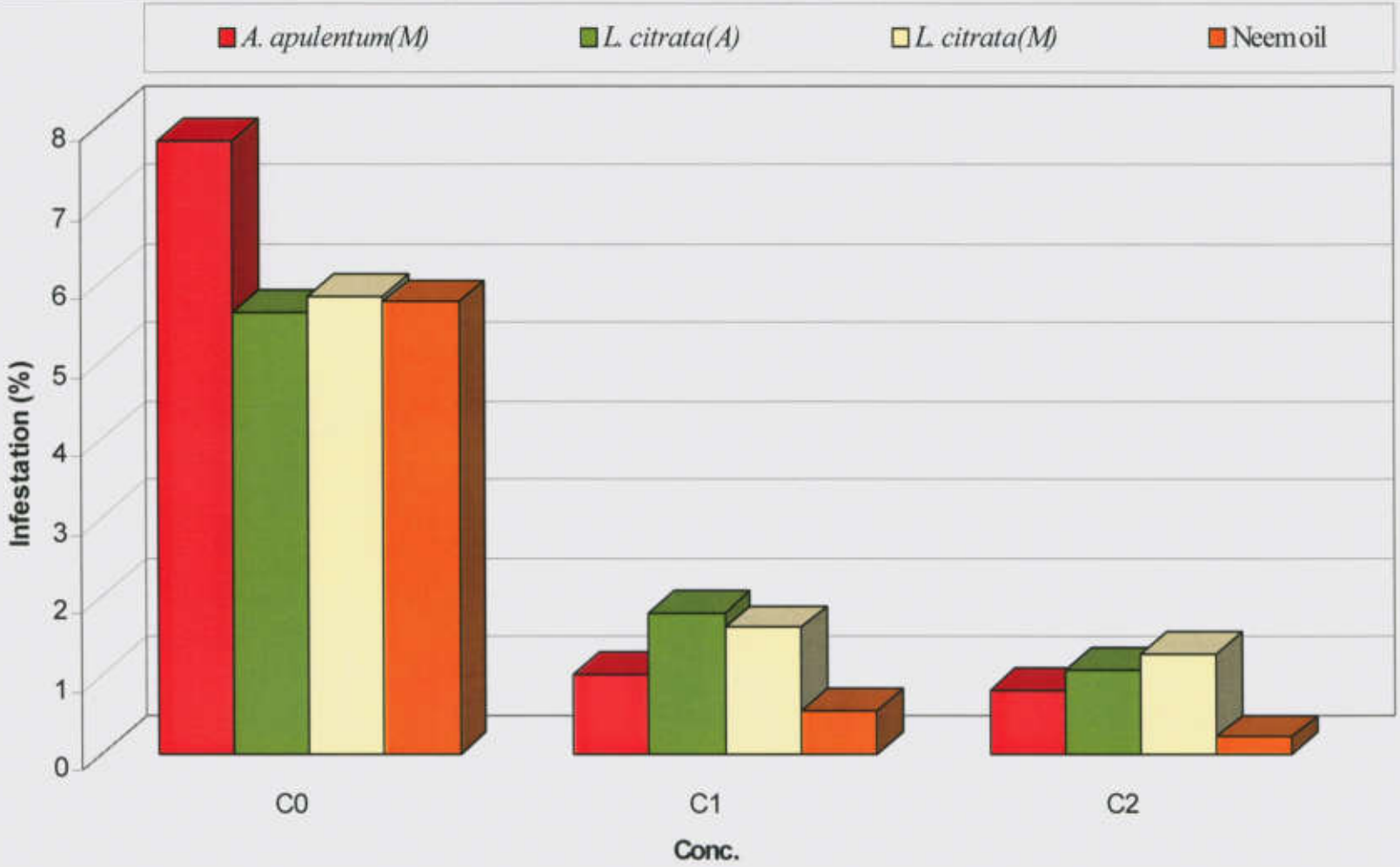


Fig. 23. Effect of plant extracts in different conc. on rice leaffolder infestation at 60 DAT during the wet season 2005.

Table 19. Effect of plant extracts in different concentrations on rice leaffolder infestation during the wet season of 2004.

Plant products	Conc	* Infested leaves %					
		40 DAT		50 DAT		60 DAT	
		2004	Effectiveness (%)	2004	Effectiveness (%)	2004	Effectiveness (%)
A. opulentum (M)	0.0	5.77(2.50)		5.90(2.53)		5.90(2.53)	
,,	2.0	3.15(1.91)	45.41	1.27(1.33)	78.47	1.02(1.23)	82.71
,,	4.0	3.03(1.88)	47.49	1.07(1.25)	81.86	0.82(1.15)	86.10
L. citrata (A)	0.0	5.78(2.51)		5.73(2.50)		5.73(2.50)	
,,	2.0	3.20(1.93)	44.64	1.65(1.47)	71.20	2.18(1.60)	61.95
,,	4.0	3.08(1.40)	46.71	1.35(1.36)	76.44	1.07(1.26)	81.32
L. citrata (M)	0.0	5.87(2.52)		5.73(2.50)		5.73(2.50)	
,,	2.0	3.24(1.93)	44.80	1.87(1.54)	67.36	1.56(1.44)	72.77
,,	4.0	3.14(1.91)	46.51	1.47(1.40)	74.52	1.21(1.30)	78.88
Neem oil	0.0	5.87(2.53)		5.79(2.51)		5.79(2.51)	
,,	2.0	2.84(1.83)	51.62	0.95(1.21)	83.59	0.58(1.04)	89.98
,,	4.0	2.63(1.77)	55.20	0.80(1.14)	86.18	0.22(0.84)	96.20
$CV_{(a)}$		0.67%		1.82%		8.57%	
$CV_{(b)}$		1.69%		0.93%		1.91%	
LSD		5% 1%		5% 1%		5% 1%	
To compare any two treatment means		0.015 0.02		0.034 0.051		0.015 0.22	
To compare any two c. means		0.03 0.05		0.017 0.025		0.03 0.05	
To compare any two c. means of the same treatment		NS NS		0.031 0.048		0.06 0.09	
To compare any two treatment means at the same level of conc.		NS NS		0.056 0.085		0.23 0.36	

Figures in the parentheses are $\sqrt{x+0.5}$ values
NS = Non Significant

* Mean of three replications
DAT = Days after transplantation

C = Concentration

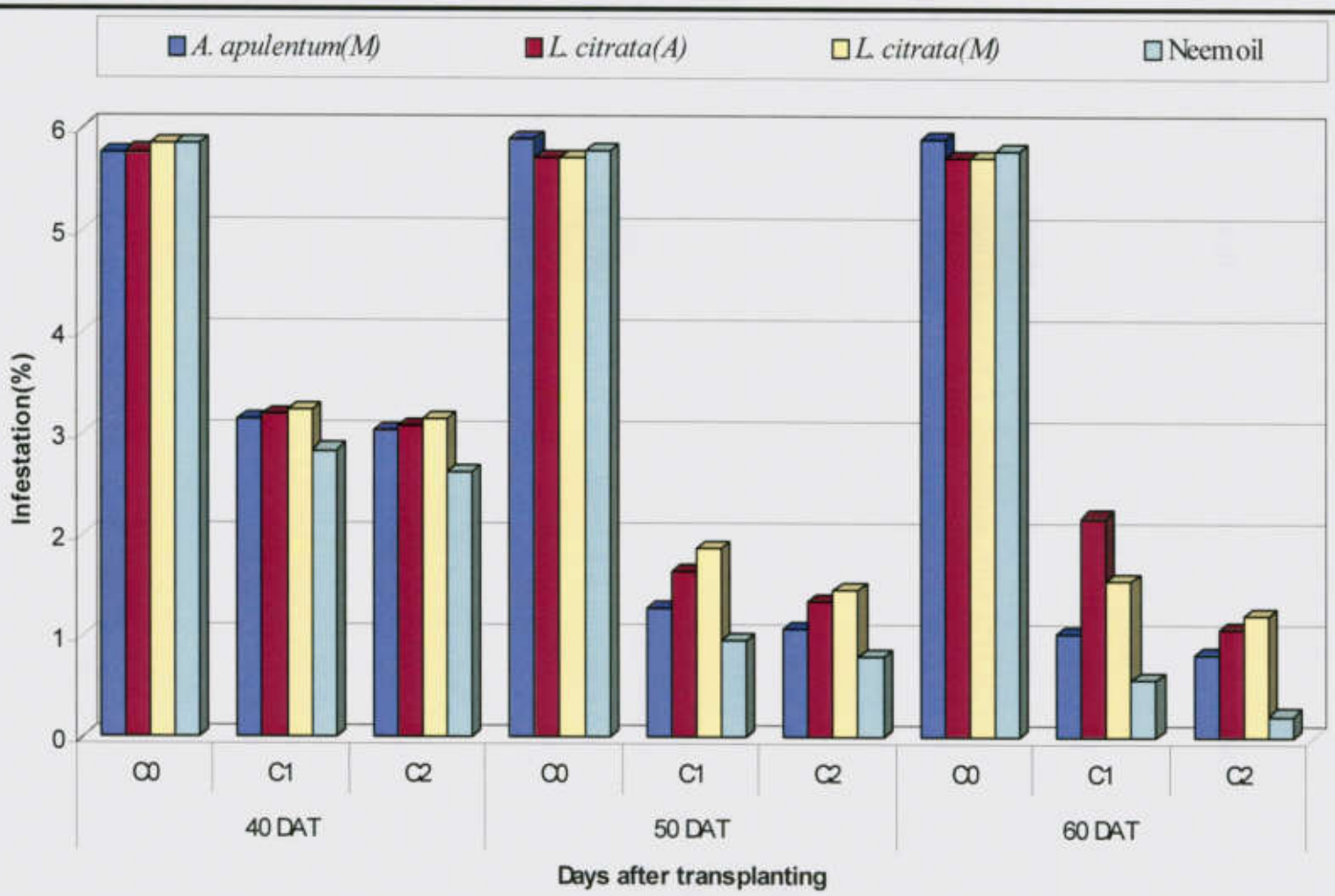


Fig. 24. Effect of plant extracts in different conc. on rice leaf folder infestation during the wet season 2004.

Interaction between treatment means and conc. were highly significant where minimum infestation 0.22 % was observed in 4 % neem oil treatment followed by 2 % neem oil treatment with 0.55 % infestation. Maximum infestation 1.79 % was recorded in acetone extract of *L. citrata* among the treatments (Table 20 & Fig. 25).

4.2.4. Influence of plant extracts in different concentrations on grain yield:

4.2.4.1. Grain yield 2004:

Differences among plant extracts on grain yield were found to be highly significant. Neem oil treated plots recorded maximum yield (3344.13 kg/ha) (Table 21 & Fig. 26) giving the highest grain yield increased (364.75 kg/ha). Neem oil was followed by methanol extract of *A. apulentum* with 3294.12 kg/ha grain yield which showed an increase (292.71 kg/ha). Minimum grain yield (3203.48 kg/ha) was recorded in methanol extract of *L. citrata* with lowest increase (168.50 kg/ha) in grain yield over control.

Both the concentrations resulted in significant increase in yield as compared to untreated control. Highest grain yield of 3377.15 kg/ha with highest increase in yield (285.50 kg/ha) was recorded in higher conc. (4 %) while 3369.71 kg/ha grain yield with 278.07 kg/ha increase in yield over control was recorded in lower conc. (2 %). Lowest grain yield (3091.64 kg/ha) was observed in untreated control (Fig. 26).

The interaction between these two factors ie. Plant extracts and concentrations were found to be highly significant where maximum grain yield of 3471.19 kg/ha was recorded in neem oil (4 %) followed by 3460.23 kg/ha yield in neem oil (2 %). Neem oil (4 %) gave the highest grain yield increase (370.23 kg/ha) over the control as compared to other plant extracts. Moreover neem oil (2 %) showed 359.29 kg/ha increase in grain yield over the control. Lowest yield (3256.76 kg/ha) was observed in 2 % methanol extract of *A. apulentum* recording 288.31 kg/ha increase in yield over the control.

4.2.4.2. Grain yield 2005:

The data on the effect of plant extracts in different conc. on grain yield are tabulated in Table 22 and illustrated in Fig. 27. The significant effect of plant extracts on grain yield is evident from with the record of highest grain yield (3776.54 kg/ha) in

Table 20. Effect of plant extracts in different concentrations on rice leaffolder infestation during the wet season of 2005.

Plant products	Conc	* Infested leaves %					
		40 DAT		50 DAT		60 DAT	
		2005	Effectiveness (%)	2005	Effectiveness (%)	2005	Effectiveness (%)
A. opulentum (M)	0.0	5.61(2.47)		5.97(2.54)		5.79(2.51)	
,,	2.0	3.13(1.91)	44.21	1.32(1.35)	77.89	1.01(1.22)	87.03
,,	4.0	3.02(1.87)	46.17	1.08(1.25)	81.91	0.81(1.14)	89.60
L. citrata (A)	0.0	5.49(2.45)		5.86(2.52)		5.63(2.49)	
,,	2.0	3.28(1.95)	40.26	1.69(1.48)	71.16	1.79(1.51)	68.21
,,	4.0	3.13(1.91)	42.99	1.42(1.39)	75.77	1.07(1.25)	80.99
L. citrata (M)	0.0	5.55(2.46)		5.96(2.55)		5.82(2.52)	
,,	2.0	3.35(1.96)	39.64	1.45(1.40)	75.67	1.61(1.45)	72.34
,,	4.0	3.22(1.93)	41.98	1.30(1.34)	78.19	1.27(1.33)	78.18
Neem oil	0.0	5.35(2.41)		6.25(2.60)		5.75(2.50)	
,,	2.0	2.93(1.86)	43.23	0.90(1.19)	85.28	0.54(1.02)	90.43
,,	4.0	2.68(1.78)	50.47	0.75(1.12)	88.00	0.22(0.85)	96.17
$CV_{(a)}$		0.52%		1.20%		1.36%	
$CV_{(b)}$		0.92%		1.45%		1.48%	
LSD		5% 1%		5% 1%		5% 1%	
To compare any two treatment means		0.012 0.018		0.022 0.033		0.026 0.041	
To compare any two C means		0.019 0.029		0.024 0.037		0.024 0.037	
To compare any two C means of the same treatment		0.048 0.074		0.048 0.074		0.048 0.074	
To compare any two treatment means at the same level of C		0.097 0.148		0.044 0.066		0.053 0.081	

Figures in the parentheses are $\sqrt{x+0.5}$ values * Mean of three replications C = Concentration DAT = Days after transplantation

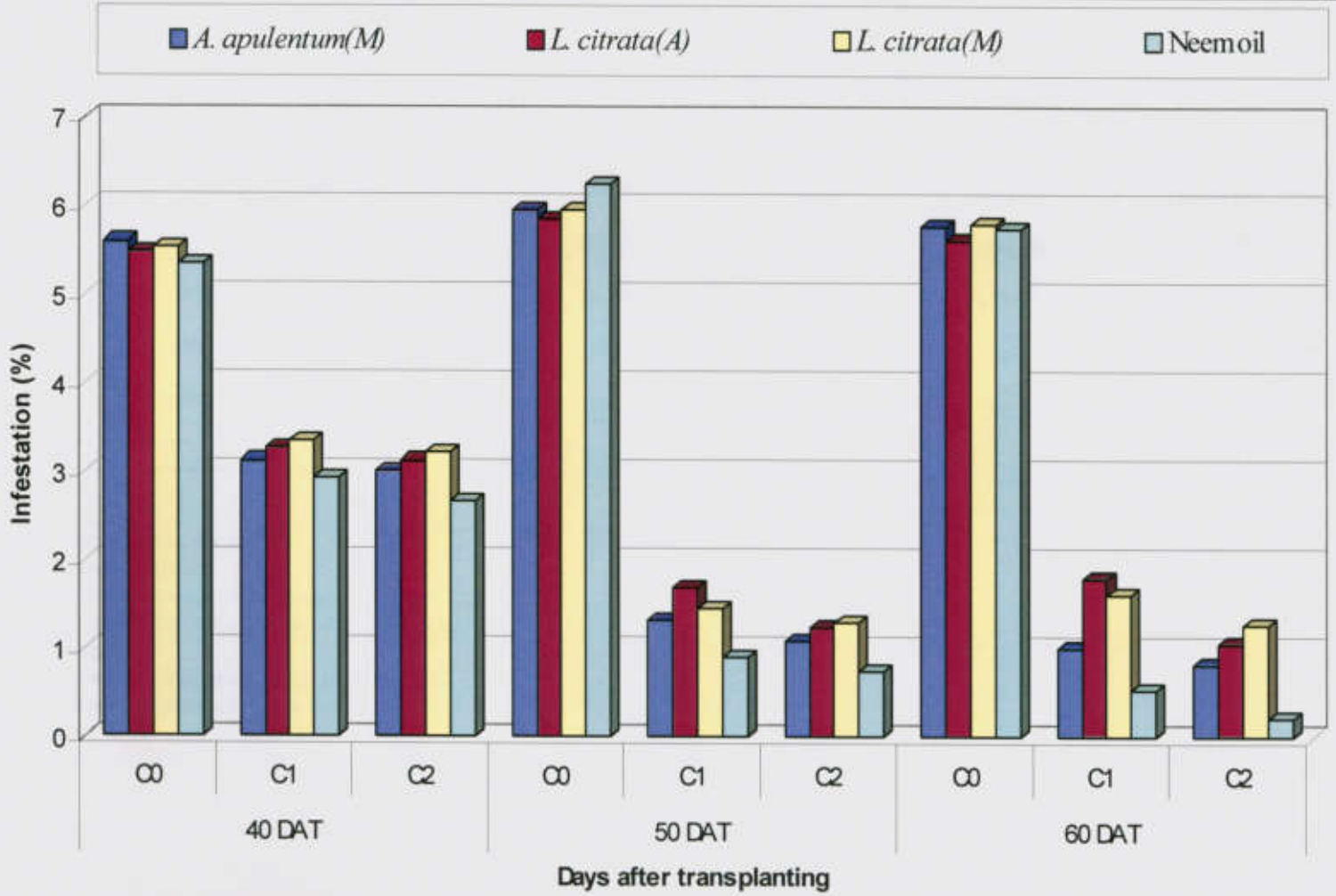


Fig. 25. Effect of plant extracts in different conc. on rice leaf folder infestation during the wet season 2005.

Table 21. Influence of plant extracts in different concentrations on grain yield during the wet season of 2004.

Plant products	* Grain Yield Kg/ha						
	C_0	C_1		C_2		C_3	
		Yield	Increase in yield over control	Yield	Increase in yield over control	Yield	Increase in yield over control
A. apulentum (M)	3098.98	3387.29	288.31	3396.08	297.10	3294.12	292.71
L. citrata (A)	3075.48	3374.60	299.12	3378.74	303.26	3276.27	301.19
L. citrata (M)	3091.15	3256.72	165.57	3262.57	171.42	3203.48	168.50
Neem oil	3100.96	3460.23	359.27	3471.19	370.23	3344.13	364.75
Mean	3091.64	3369.71	278.07	3377.15	285.50		
			$CV_{(a)}$ = 7.45%	$CV_{(b)}$ = 7.22%			

		LSD	
		5%	1%
To compare any two treatment means	-	9.89	14.98
To compare any two conc. means	-	4.14	6.26
To compare any two conc. means of the same treatment	-	8.27	12.53
To compare any two treatment means at same level of conc.	-	9.69	14.68

*Mean of three replications
$CV_{(a)}$ = Co-efficient variation of main factor (treatments)
$CV_{(b)}$ = Co-efficient variation of sub factor (conc.)
A= Acetone extract.
M= Methanol extract.

C = conc.
C_0 = 0%
C_1= 2%
C_2 = 4%

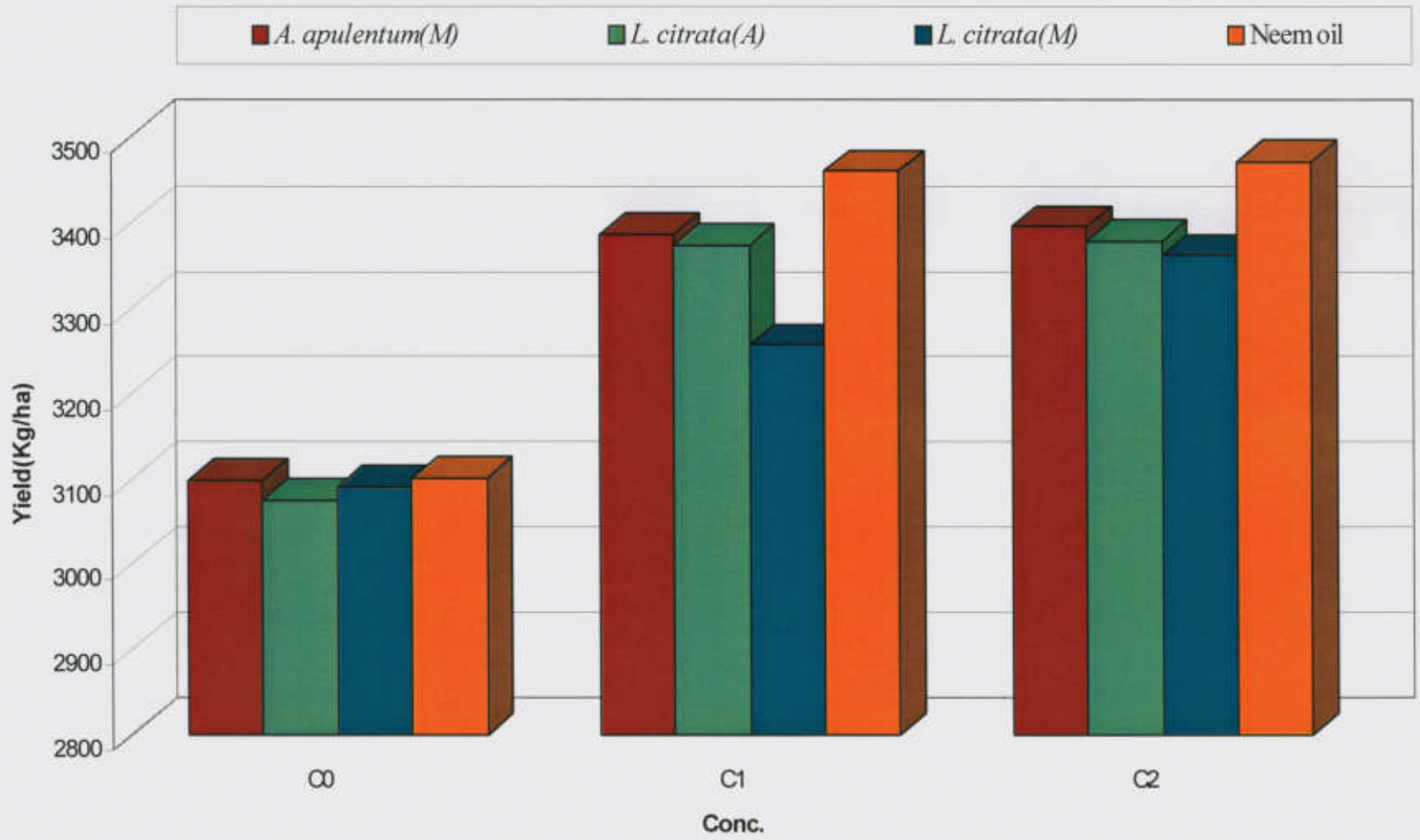


Fig. 26. Influence of plant extracts in different conc. on grain yield during wet season 2004.

Table 22. Influence of plant extracts in different concentrations on grain yield during the wet season of 2005.

Plant products	* Grain Yield Kg/ha						
	C_0	C_1		C_2		C_3	
		Yield	Increase in yield over control	Yield	Increase in yield over control	Yield	Increase in yield over control
A. apulentum (M)	3341.54	3964.84	623.30	3974.66	633.12	3760.35	628.21
L. citrata (A)	3350.89	3713.48	362.59	3895.33	544.44	3653.23	453.52
L. citrata (M)	3342.73	3726.93	384.20	3766.40	423.67	3612.02	408.44
Neem oil	3348.49	3985.40	636.91	3995.73	647.29	3776.54	655.60
Mean	3345.91	3847.66	576.75	3908.03	637.12		
	$CV_{(a)}$ = 0.074%			$CV_{(b)}$ = 0.072%			

	LSD	
	5%	1%
To compare any two treatment means -	3.13	4.74
To compare any two conc. means -	2.66	4.029
To compare any two conc. means of the same treatment -	5.33	8.08
To compare any two treatment means at same level of conc. -	6.22	9.41

*Mean of three replications
$CV_{(a)}$ = Co-efficient variation of main factor (treatments)
$CV_{(b)}$ = Co-efficient variation of sub factor (conc.)
A= Acetone extract.
M= Methanol extract.

C = conc.
C_1= 2%
C_0 = 0%
C_2 = 4%

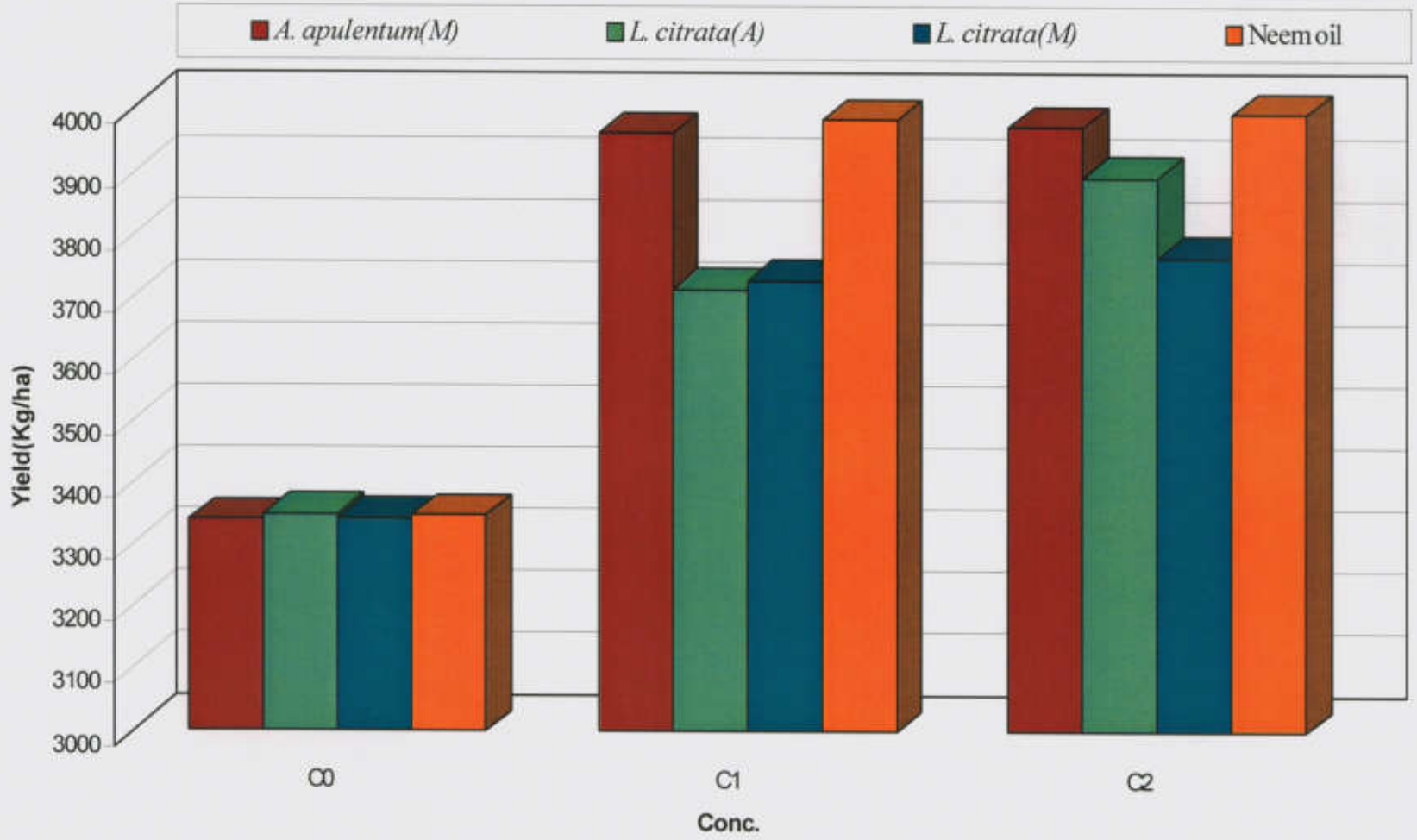


Fig. 27. Influence of plant extracts in different conc. on grain yield during the wet season 2005.

neem oil with 655.60 kg/ha increase in yield which was followed by methanol extract of A. apulentum (3760.35 kg/ha) giving 528.21 kg/ha increase in grain yield over control. Lowest yield (3612.02 kg/ha) with 408.44 kg/ha yield increase was recorded in methanol extract of *L. citrata*.

Both the conc. resulted in significant increase in grain yield as compared to untreated check and differed significantly with each other. Higher conc. (4 %), proved to be the best amongst the concentrations with 3908.03 kg/ha while lower conc. (2 %) of grain yield was recorded 3847.66 kg/ha. Higher conc. (4 %) foliar spray gave higher increase in yield (637.12 kg/ha) while in lower conc. (2 %) 576.75 kg/ha increase in yield was recorded over control.

The interaction of plant extracts and conc. were found to be significant revealing highest yield (3995.73 kg/ha) and highest increase in yield (647.29 kg/ha) in neem oil (4 %) which was followed by neem oil (2 %) (3985.40 kg/ha) showing 636.91 kg/ha increase in yield over control. Lowest yield (3713.48 kg/ha) with 362.59 kg/ha increase in yield over control was recorded in 2 % acetone extract of *L. citrata*.

DISCUSSION

5. DISCUSSION

5.1. Net house /laboratory experiment.

5.1.1. Evaluation of plant extract for their antifeedant property against *Cnaphalocrocis medinalis* (Guenee).

None of the treatments exhibited complete antifeedant activity and feeding took place in all the treatments. The data on the feeding ratio and protection due to different plant extracts revealed that maximum protection was observed in acetone extract of *A. apulentum* which was followed by acetone extract of *C. viscosum* and was found to be at par. However maximum antifeedant activity was offered by fenvalerate and neem oil among the treatments. Mayabeni (1997) reported that neem derivatives (neem oil, leaf extract and leaf decoction) reduced the feeding of 4th instar larvae of *C. medinalis* when recorded after 48 hours. Similarly feeding of *C. medinalis* were reduced on neem oil (3, 6, 13, 25 and 50 %) treated leaves when observed after 24 hours (IRRI 1979). Minimum antifeedant property was showed by *M. hexandra* (methanol extract) followed by *M. auriculata* (methanol extract) but they differ significantly with untreated control. Though complete feed deterrent was not offered by any of the plant extracts in the test, a high to moderate antifeedancy was recorded in all the treatments. Antifeedant activity against *C. medinalis* were reported by Saxena et al. (1980) where neem oil treated leaves significantly lowered the number of larvae arrived. Feeding activity at 12 % conc. reduced feeding period of leaffolder on neem seed bitters treated leaf cuts was shown by Kareem et al. (1988) and similarly on neem seed oil against *C. medinalis* (Saxena et al. 1987).These corroborate with the present findings on neem oil performance in the present study. These plant extracts under the investigation were not reported by research workers in the past, so a support to the result could not be assured and the findings seems to be a new report.

5.1.2. Effect of plant extracts on oviposition of *Cnaphalocrocis medinalis* (Guenee).

The present finding in reduction in oviposition under No-choice situation revealed that maximum reduction in oviposition was revealed by methanol extract of *A. apulentum* and was found to be superior than neem oil treatment which was followed by acetone extract of *A. apulentum*, *M. hexandra* (methanol extract) and acetone extract of *L. citrata* which were at par with neem oil treatment. Similar effect of neem oil as oviposition deterrent was reported by Krishnaiah and Kalode (1991) where 12 % conc. reduced egg

laying in *Nilaparvata lugens* and 25 % neem oil adversely affected the egg laying in *Nephotettix virescens*. Minimum reduction in oviposition was observed in *C. viscosum* (acetone extract) treatment followed by acetone extract of *M. auriculata* but they differ significantly with untreated control.

When the moths were given a choice for egg laying, methanol extract of *M. hexandra* was not preferred for egg laying while in other treatments egg laying took place. Maximum reduction in oviposition was exhibited by acetone extract of *M. hexandra* followed by *L. citrata* (acetone and methanol extract) and *A. apulentum* (methanol extract) which were at par with neem oil. In a report published by IRRI (1979) a similar effect of neem oil as oviposition deterrent against C. medinalis (Guenee) indicating 1/3 reduction in egg laying ability of the moth when applied as foliar spray at various conc. (3, 6, 13, 25 & 50). This is in line of present findings of neem oil against the moth under the test. Minimum reduction in oviposition was revealed in acetone extract of *C. viscosum* in Choice condition followed by acetone extract of *A. apulentum*.

Thus in both the situations (Choice and No Choice condition) plant extracts reduced the egg laying in *C. medinalis* and a prominent deviation in egg laying pattern was noticed in that eggs were not laid in clusters as in the case of untreated control; they laid singly which may be due to effect of plant extracts present on plant leaves. Though no comparison with earlier workers could be made with the present findings of the plant extracts, Kareem et al. (1989) reported that oviposition of *Nilaparvata lugens* and *Nephotettix virescens* was adversely affected when rice plants were sprayed with neem seed and leaf bitters at 500, 2500 and 5000 ppm. Moreover, the present findings on neem oil are in accordance with Nelson et al. (1996) where azadirachtin rich neem fractions (NS 58/GSN/OU) highly deterred the oviposition of *Sogatella furcifera* with 89.13 % reduction in egg laying as compared to control.

5.1.3. Effect of treatments on larval development of *Cnaphalocrocis medinalis* (Guenee).

All the larvae either died or were unable to emerge as normal adults in all the treatments and as such all the larvae developed into normal moth in water sprayed (untreated) control. It is revealed that the larvae in treatment *C. viscosum* (acetone extract), methanol extract of *A. apulentum*, acetone and methanol extract of *L. citrata*, acetone and methanol extract of *M. auriculata* and neem oil could not survive for more than 6 days and in treatment neem oil

and *L. citrata* (acetone and methanol extract), there were no growth in larvae while in others slight growth was observed but not as in untreated control. Moreover Saxena et al. (1980) reported that confinement of 5th instar larvae of *C. medinalis* to cut leaves treated with 12 % or more neem oil resulted in pronounce aberrations in larval behaviour and form resulting into enhanced mortality during metamorphosis. Similarly Mayabeni (1997) also reported that neem bark decoction effectively reduced the rate of pupation in *C. medinalis* when the larvae were fed for 48 hours. In acetone extract of *A. apulentum* and methanol extract of *M. hexandra* larvae could survive only for 11 days while in acetone extract of *M. hexandra* the larvae could survive for 16 days and failed to pupate unlike those larvae in untreated control. The present findings of neem oil is in confirmation with Schmutterer et al. (1983) where methanolic seed extract of *A. indica* and partially purified fractions of neem exhibited pronounced developmental abnormalities and high mortality rate in the succeeding larval instars and in pupal and adult stages.

There were no differences on the growth of the larvae after 24 hrs of foliar spray among the treatments but larvae on fenvalerate treated plants could not survive beyond 24 hrs after the treatments. Effect of treatments on the breadth of the larvae on 6th DATr were not significant but maximum retardation in length of the larvae was observed in acetone extract of *L. citrata* differing significantly with untreated control. It was followed by methanol extract of *L. citrata* and was at par with neem oil. Among the treatments Methanol extract of *M. auriculata* was least effective in reducing the length of the larvae and was at par with control. On 11th DATr, methanol extract of *M. hexandra* exhibited lowest larval length among the survived larvae while on 16th DATr larvae survived only in acetone extract of *M. hexandra* among the treatments showing a high level of retardation in length and breadth of the larvae as compared to control. No comparison with earlier workers could be made in support of the present findings and it seems to be the first report on these plant extracts.

5.2. Field evaluation:

The present findings of the investigation on "Evaluation of some indigenous plants for their insecticidal property against rice leaffolder *Cnaphalocrocis medinalis* (Guenee), a serious pest of rice in Nagaland" are being discussed in the light of information available in the literature and are presented in the following manner.

5.2.1. Evaluation of plant extracts on the incidence of rice leaffolder *Cnaphalocrocis medinalis* (Guenee).

From the present findings, it is observed that all the treatments significantly reduced the level of infestation as compared to the control. It is evident from the data in Table 12 & Fig.17 that methanol extract of *A. apulentum* provided better protection in the early stage of the crop growth and was found to be superior than neem oil treatment in reducing the rice leaffolder infestation in both the years (2002 & 2003). Moreover acetone extract of *L. citrata* was at par with neem oil which was followed by methanol extract of *L. citrata.* Velayutham et al., (1988) reported the effectiveness of 2 % neem oil in reducing the rice leaffolder incidence under field conditions which is in line with the present findings on neem oil. Methanol extract of *M. hexandra* was least effective followed by acetone extract of *M. auriculata* in both the years but they differ significantly with the untreated control in 2002 and 2003 and were at par. In the late stage of the crop growth, maximum protection against rice leaffolder infestation was recorded in methanol extract of *A. apulentum* and acetone extract of *L. citrata.* They were found to be at par with treatment of neem oil and fenvalerate. No information on effectiveness of these plant extracts is available in the literature, neither against *C. medinalis* (Guenee) nor other crop pests. Saroja and Raju, (1982) has reported the effectiveness of fenvalerate (22.99 % leaf damage) as compared to untreated control (39.13 5 leaf damage) in field condition against *C. medinalis* (Guenee). The present findings are in confirmation with Rao *et al.*, (2002), Dhaliwal *et al.* (1993) and Singh *et al.* (1990) where 2 % neem oil was reported to be effective in reducing rice leaffolder infestation.

Reduction in the level of infestation was also marked with increase in grain yield where maximum yield was recorded in methanol extract of *A. apulentum* followed by acetone extract of *L. citrata* in 2002 while maximum yield in 2003 was revealed by *L. citrata* (acetone) treatment which was followed by methanol extract of *A. apulentum* and *L. citrata.* Though increase in yield was observed in the treatments they do not differ significantly with the untreated control. Similar observations in neem oil treatments at different conc. was reported by Singh *et al.* (1993) where it resulted in significantly increased grain yield over the control. Acetone extract of *C. viscosum* yielded the lowest yield followed by methanol extract of *M. hexandra* in both the years. In 2002 it was observed that grain yield was low as when compared with 2003 yield and in treatment *C. viscosum* the yield was lower than the untreated control which may be due to heavy neck blast infection in the field and especially in that particular treatment where severe infection was observed during the late stage of the crop.

5.2.2. Efficacy of plant extracts at different concentration against rice leaffolder.

During the wet season 2004 and 2005 (Table 20 & 21) methanol extract of *A. apulentum* was found to be most effective and resulted in lowest infestation as when compared among the plant extracts while methanol extract of *L. citrata* was least effective in reducing the leaf damage in both the years. Neem oil gives maximum protection when compared among the treatments. Effectiveness of neem oil in controlling rice leaffolder damage has been reported by Murugesan and Venugopal (1987) where in 3 % neem oil at 40 days after treatment was as effective as phosphamidon @ 250 ml/ha or monocrotophos @ 500 ml/ha or endosulphan @ 750 ml/ha. Moreover Rajasekharan et al., (1988) also reported that neem oil at 5 % effectively reduced the damage due to rice leaffolder.

Treatments in higher conc. (4 %) showed more pronounced effect in all the cases when compared to lower conc. (2 %) and untreated control. It was observed that during the early and late stage of the crop growth, 4 % *A. apulentum* (methanol extract) gave the best result in reducing the level of infestation which was followed by 2 % *A. apulentum* (methanol extract) and 4 % acetone extract of *L. citrata*. Moreover 4 % *A. apulentum* (methanol extract) was found to be inferior than 2 % neem oil and therefore neem oil at both the conc. were superior among the treatments. Similar results were also reported by Nandu et al., (1996), Ambethgar (1996) and Krishnaiah and Kalode, (1990), where in 3 % neem oil reduced the leaffolder incidence in field condition. Though *L. citrata* extracts (methanol & acetone) could give only moderate protection and proved significantly better on comparison with untreated check. The interaction between treatments and conc. were highly significant and increase in yield was also recorded with the decrease in infestation level.

Maximum grain yield was recorded in methanol extract of *A. apulentum* while minimum yield was observed in methanol extract of *L. citrata* and they differ significantly with neem oil where highest yield was recorded among all the treatments. Interaction of the two factors factors were also highly significant.

Kaul and Sharma, (1999) reported that neem based insecticides not only reduce the level of infestation but also resulted in significantly higher yields (30.9 q/ha) as compared to 28.3 q/ha which corroborate with the present findings. Plant extracts of the present findings have not been reported by earlier workers and as such provide new information.

SUMMARY AND CONCLUSION

6. SUMMARY AND CONCLUSION

Rice leaffolder, *Cnaphalocrocis medinalis* (Guenee) is an important pest of rice in all rice growing countries of Asia. The larvae feed on the green matter by scrapping it from the leaf blade. Infested leaves show white streaks and in case of severe infestation, there is a heavy loss in grain yield. Synthetic insecticides though effective in quick reduction of pest populations, could not be considered ideal one due to reasons of safety to human beings, environment, pest resurgence etc.. Natural products, on the other hand with better degree of selective toxicity to various fauna may form ideal substitute for synthetic insecticides. So, the present study was carried out on the crude plant extracts of locally available plants namely, *Amphineuron apulentum* (Kaulf) Houltum, *Clerodendrum viscosum* (Vent), *Litsea citrata* Bl. Bejdr, *Millettia auriculata* Baker ex. Brand, *Mimusops hexandra* Roxb. Cor. extracted in acetone & methanol for their antifeedant property, oviposition deterrency and their effect on larval development in laboratory/net house conditions whereas in field condition crude plant extracts were screened out for their efficacy against the pest and the promising plant extracts were further evaluated at different conc. for their effectiveness. The findings of the investigations are summarized below:

- Evaluation of plant extracts for their antifeedant property was conducted in net house in completely randomized design (CRD) on rice variety *Jaya*. Potted rice plants were sprayed with 2 % crude plant extracts. Neem oil (1.5 %) and fenvalerate (0.1 %) were used as standard check for comparison and rice plants sprayed with plain water were kept as control. It was revealed that none of the treatments exhibited absolute antifeedant property and larval feeding took place in all the treatments. The data on leaf area (cm^2) consumed by the larvae recorded after 48 hrs of treatment revealed that there were significant differences among the treatments and all the treatments recorded significantly lesser area consumed by the larvae as compared to untreated control. Among the plant extracts minimum feeding ratio was exhibited by acetone extract of *A. apulentum* with highest protection level and was found to be equally effective as neem oil which was used as standard check. Antifeedancy of the treatments arranged in decreasing order is: fenvalerate > neem oil > *A. apulentum* (acetone extract) > *C. viscosum* (acetone extract) > *A. apulentum* (methanol extract) > *L. citrata* (acetone extract) > *L. citrata* (methanol extract) > *M. auriculata* (acetone extract) > *M. hexandra* (acetone extract) > *M. auriculata* (methanol extract) > *M. hexandra* (methanol extract).

• Effect of plant extracts on oviposition was carried out in net house in CRD design under No-choice and Choice situations. Potted rice plants were sprayed with 2 % crude plant extracts. Neem oil (1.5 %) and fenvalerate (0.1 %) were used as standard check for comparison and rice plants sprayed with plain water were kept as control. Treatment effect on oviposition after 48 hrs of moth release was highly significant in No-choice condition where maximum reduction in oviposition was recorded in methanol extract of *A. apulentum* and was significantly superior to neem oil. The effect of treatments based on oviposition deterrency in No-choice test in chronological order was: *A. apulentum* (methanol extract) > *A. apulentum* (acetone extract) > *L. citrata* (acetone extract) > *M. hexandra* (acetone extract) > *M. hexandra* (methanol extract) > *M. auriculata* (methanol extract) > neem oil > *L. citrata* (methanol extract) > *M. auriculata* (acetone extract) > fenvalerate > *C. viscosum* (acetone extract).

When the moths were given a choice for egg laying site plants treated with methanol extract of *M. hexandra* were not selected and as a result not even a single egg was seen on such plants. However, acetone extract of *M. hexandra* showed maximum reduction in oviposition and was significantly superior to neem oil. Oviposition deterrency under choice situation arranged in decreasing order is: *M. hexandra* (methanol extract) > *M. hexandra* (acetone extract) > *M. auriculata* (methanol extract) > neem oil > *L. citrata* (methanol extract) > *L. citrata* (acetone extract) M. auriculata (acetone extract) > *A. apulentum* (methanol extract) > fenvalerate > *A. apulentum* (acetone extract) > *C. viscosum* (acetone extract).

In both Choice and No-choice conditions a prominent deviation in egg laying pattern was noticed wherein eggs were not laid in clusters as in the case of untreated control, the moths laid eggs singly on treated plants.

• Net house experiment on the effect of treatments on larval development of *C. medinalis* (Guenee) was laid down in CRD design on *Jaya* cultivar. Potted rice plants were sprayed with 2 % crude plant extracts. Neem oil (1.5 %) and fenvalerate (0.1 %) were used as standard check for comparison and rice plants sprayed with plain water were kept as control. It was revealed that none of the treatments could cause the larval mortality and all the larvae survived up to 24 hrs after foliar spray. However on 6th DATr larvae could not survive in fenvalerate resulting in 100 % larval mortality. Observations recorded on 11th DATr revealed that larvae could survive only in acetone extract of *A. apulentum*, *M. hexandra* (acetone extract) and *M. auriculata* (acetone extract) treatments whereas on 16th DATr larvae survived only in acetone extract of *M. hexandra* but their length was significantly retarded as compared to

untreated control. In none of the treatments larvae could reach the pupal stage whereas in control all the larvae survived resulting into 100 % moth emergence at 25 DATr.

- Screening of plant extracts against rice leaffolder in field condition during the wet season 2002 and 2003 was laid down in completely randomized block design (CRBD) on rice variety *Jaya*. The crop was sprayed at 30, 40, and 50 DAT with 2 % crude plant extracts. Neem oil (1.5 %) and fenvalerate (0.1 %) were used as standard check for comparison and rice plants sprayed with plain water were kept as control. Methanol extract of *A. apulentum* was recorded as most effective treatment and was at par with fenvalerate. Treatment effects on the incidence of leaffolder differed significantly with control as evident by reduction in infestations at various intervals of observations (40, 50, 60 DAT). Effectiveness of treatments at 50 DAT during 2002 arranged in decreasing order was: Fenvalerate = *A. apulentum* (methanol extract) > neem oil > *L. citrata* (acetone extract) > *L. citrata* (methanol extract) > *M. auriculata* (methanol extract) > *A. apulentum* (acetone extract) > *M. hexandra* (methanol extract) > *M. auriculata* (acetone extract) = *C. viscosum* (methanol extract).

Reduction in level of infestation was also marked with increase in grain yield where maximum yield was recorded in methanol extract of *A. apulentum*. Grain yield arranged in decreasing order was: Fenvalerate > A. *apulentum* (methanol extract) > neem oil > *L. citrata* (acetone extract) > *L. citrata* (methanol extract) > *M. auriculata* (acetone extract) > *M. auriculata* (methanol extract) > *A. apulentum* (acetone extract) > *M. hexandra* (methanol extract) > *M. hexandra* (acetone extract) > C. *viscosum* (acetone extract). More or less similar results were obtained during 2003 wet season which confirm findings of the experiment during 2002.

- Promising plant extracts based on the findings of field experiment conducted during 2002 and 2003 viz. *A. apulentum* (methanol extract), *L. citrata* (acetone & methanol extract) were evaluated at different concs. ie. 2 % and 4 % in split plot design on rice variety *Jaya* during 2004 and 2005 wet seasons. Effectiveness of treatment arranged in decreasing order was: Neem oil > *A. apulentum* (methanol extract) > *L. citrata* (methanol extract) > *L. citrata* (acetone extract). Comparison of conc. means revealed that higher conc. (4 %) showed greater effectiveness and higher grain yield. Efficacy of plant extracts revealed that minimum infestations with maximum effectiveness were recorded in methanol extract of *A. apulentum* at 4 % conc. The findings were confirmed in the next year 2005 wet season as more or less similar trend was recorded during the observation on infestation level and grain yield.

CONCLUSION

The findings of the present investigation on the plant extracts in lowering down the pest infestation in the field by their antifeedant property, oviposition deterrency and effect on the larval development has generated the hope that use of these plant extracts could provide improved management tactics in the management of *Cnaphalocrocis medinalis* which could be utilized in designing integrated pest management programmes. These plant extracts provide a better management practice of the pest and safeguard the environment and agro-ecosystem as these are eco-friendly. The salient findings are concluded as per the following:

- Among the plant extracts, acetone extracts of *A. apulentum* and *C. viscosum* exhibited the highest antifeedant property.
- In No-choice condition maximum reduction in oviposition was revealed by methanol extract of *A. apulentum* while in Choice condition the moths did not prefer to lay eggs on the plants treated with methanol extracts of *M. hexandra* and as such not even a single egg was noticed on treated plants.
- The larvae could not develop into adult stage in all the treatments even though larval feeding took place.
- It is revealed that methanol extract of *A. apulentum* was the most effective plant extract in lowering the level of leaffolder infestation in both the early and latter stage of the crop growth. Reduction in the level of infestation with marked increase in grain yield was recorded in all the treatments. Highest grain yield was observed in methanol extract of *A. apulentum*.
- Effectiveness of plant extracts increased with increase in conc. and 4 % methanol extract revealed maximum reduction in the level of infestation and recorded the highest grain yield than the lower conc.

These plant extracts were for the first time tested against rice leaffolder infestation. The findings seems to be the first report which requires further confirmation in testing at large scale before recommending them for use in making formulations at commercial level and recommending the use against rice leaffolder *C. medinalis*. These findings have further provided support to plant products/botanicals for their safe use in integrated pest management system.

The results obtained in the net house/laboratory experiments with plant extracts are explainable on the basis of field experiments as properties of the plant extracts might have worked well in making the plant extracts effective in lowering the pests' incidence significantly in the field.

APPENDICES

APPENDICES

I. Analysis of variance for antifeedant test on feeding area by rice leaffolder due to effect of treatments in net house experiment. Design: CRD.

Sl. no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5 %	1 %
1	Treatment	11	149859.22	13623.57	16.70**	3.39	4.59
2	Error	24	19576.00	815.67			
3	Total	35					
CV = 25.56 %							
** = Significant at 1 % level							

II. Analysis of variance for antifeedant test on feeding ratio by rice leaffolder due to effect of treatments in net house experiment. Design: CRD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5 %	1 %
1	Treatment	11	12604.92	1145.90	26.18**	3.39	4.59
2	Error	24	1050.42	43.77			
3	Total	35					
CV = 16.51 %							
** = Significant at 1 % level							

III. Analysis of variance for reduction on rice leaffolder oviposition in No-choice test due to effect of treatments in net house experiment. Design: CRD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tab. value	
						5 %	1%
1.	Treatment	11	10309.53	937.23	52.53**	3.395	4.595
2.	Error	24	428.08	17.84			
3.	Total	35	10737.61	955.07			
CV = 7.94 %							
** Significant at 1 % level							

IV. Analysis of variance for reduction on rice leaffolder oviposition in Choice-test due to effect of treatments in net house experiment. Design: CRD.

Sl.no.	Source of variation	Degree of freedom	Sum of square	Mean sum of squares	F-cal. value	F-tab. value	
						5 %	1%
1.	Treatment	11	217.51	19.77	179.72**	3.39	4.59
2.	Error	24	2.52	0.11			
3.	Total	35	220.03	19.88			
CV = 3.80 %							
** Significant at 1 % level							

V. Analysis of variance on larval length for the effect of treatments in net house experiment. Design: CRD.

Sl.no.	Source of variation	Degree of freedom	Sum of square	Mean sum of squares	F-cal. value	F-tab. value	
						5 %	1%
1.	Treatment	10	0.04	0.004	4*	3.39	4.60
2.	Error	22	0.02	0.001			
3.	Total	32	0.6	0.005			
CV = 3.80 %							
* Significant at 5 % level							

VI. Analysis of variance on rice leaffolder infestation at 40 DAT during the wet season of 2002. Design: CRBD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5 %	1 %
1	Replication	2	0.06	0.03			
2	Treatment	11	1.57	0.14	14**	3.19	2.27
3	Error	22	0.15	0.01			
4	Total	35	1.78				
CV = 8.47 %							
** Significant at 1 % level							

VII. Analysis of variance on rice leaffolder infestation at 50 DAT during the wet season of 2002. Design: CRBD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5 %	1 %
1	Replication	2	0.03	0.02			
2	Treatment	11	0.69	0.06	6 **	3.19	2.27
3	Error	22	0.12	0.01			
4	Total	35	0.84				
CV = 11.36 %							
** Significant at 1 % level							

VIII. Analysis of variance on grain yield due to the influence of plant extracts on rice leaffolder during the wet season of 2002. Design: CRBD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1	Replication	2	559549.79	279774.90			
2	Treatment	11	2893172.78	263015.70	2.39*	2.27	3.19
3	Error	22	2419817.72	2419817.72			
4	Total	35					
CV = 9.62 %							
* Significant at 5 % level.							

IX. Analysis of variance on rice leaffolder infestation at 40 DAT during the wet season of 2003. Design: CRBD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5 %	1 %
1	Replication	2	0.04	0.02			
2	Treatment	11	4.51	0.41	102.5**	2.27	3.19
3	Error	22	0.09	0.004			
4	Total	35	4.64				
CV = 5.45 %							
** = Significant at 1 % level							

X. Analysis of variance on rice leaffolder infestation at 50 DAT during the wet season of 2003. Design: CRBD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5 %	1 %
1	Replication	2	0.16	0.08			
2	Treatment	11	0.99	0.09	3*	2.27	3.19
3	Error	22	0.60	0.03			
4	Total	35	1.75				
CV = 19.68 %							
* = Significant at 5 % level							

XI. Analysis of variance on rice leaffolder infestation at 60 DAT during the wet season of 2003. Design: CRBD.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5 %	1 %
1	Replication	2	0.10	0.05			
2	Treatment	11	0.48	0.04	2.5*	2.27	3.19
3	Error	22	0.36	0.016			
4	Total	35	0.94				
CV = 15.06 %							
* = Significant at 5 % level							

XII. Analysis of variance on grain yield due to the influence of plant extracts on rice leaffolder during the wet season of 2003. Design: CRBD

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	315243.32	157621.70			
2.	Treatment	11	3012147.80	273831.60	2.06^{ns}	2.27	3.19
3.	Error	22	2919276	132694.40			
4.	Total	35					
CV = 9.06 %							
ns = Non significant.							

XIII. Analysis of variance on rice leaffolder infestation in different conc. at 40 DAT during the wet season of 2004. Design: Split-plot.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	0.0001	0.00005			
2.	Main factor (A) (plant products)	3	0.0354	0.0118	59**	3.58	5.51
3.	Error (a)	6	0.001	0.0002			
4.	Sub-factor (B) (conc.)	2	3.2	1.6	1280**	3.00	4.13
5.	Interaction AxB	6	0.025	0.004	3.2^{NS}	3.34	4.54
6.	Error (b)	16	0.02	0.00125			
7.	Total	35	3.28				
$CV_{(a)} = 0.67\%$				$CV_{(b)} = 1.69\%$			
** = Significant at 1% level NS= Non-significant							

XIV. Analysis of variance on rice leaffolder infestation in different doses at 50 DAT during the wet season of 2004. Design: Split-plot.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	0.004	0.002			
2.	Main factor (A) (plant products)	3	0.20	0.066	66**	3.58	5.51
3.	Error (a)	6	0.006	0.001			
4.	Sub-factor (B) (conc.)	2	11.01	5.505	21173.07**	3.00	4.13
5.	Interaction AxB	6	0.13	0.021	80.76**	3.34	4.54
6.	Error (b)	16	0.0043	0.00026			
7.	Total	35	11.35				
$CV_{(a)} = 1.82\%$				$CV_{(b)} = 0.93\%$			
** = Significant at 1% level.							

XV. Analysis of variance on rice leaffolder infestation in different conc. at 60 DAT during the wet season of 2004. Design: Split-plot.

Sl.no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	0.02	0.01			
2.	Main factor (A) (plant products)	3	0.57	0.19	9.50**	3.58	5.51
3.	Error (a)	6	0.12	0.20			
4.	Sub-factor (B) (conc.)	2	13.20	6.60	6600**	3.00	4.13
5.	Interaction A x B	6	0.38	0.06	60**	3.34	4.54
6.	Error (b)	16	0.02	0.001			
7.	Total	35	14.31				
$CV_{(a)}$ = 8.57%				$CV_{(b)}$ = 1.91%			
** = Significant at 1% level.							

XVI. Analysis of variance on grain yield due to the influence of plant extracts on rice leaffolder during the wet season of 2004. Design: Split-plot.

Sl. no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	81.77	40.88			
2.	Main factor (A) (plant products)	3	91614.95	30538.32	1784.36**	3.58	5.51
3.	Error (a)	6	109.12	18.19			
4.	Sub-factor (B) (conc.)	2	635563	317781.5	18568.03**	3.00	4.13
5.	Interaction A x B	6	40466.68	6744.45	394.08**	3.34	4.54
6.	Error (b)	16	273.83	17.11			
7.	Total	35					
$CV_{(a)}$ = 7.45%				$CV_{(b)}$ = 7.22%			
** = Significant at 1% level.							

XVII. Analysis of variance on rice leaffolder infestation in different conc. at 40 DAT during the wet season of 2005. Design: Split-plot.

Sl. no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	0.00025	0.00012			
2.	Main factor (A) (plant products)	3	0.0503	0.0167	139.16**	3.58	5.51
3.	Error (a)	6	0.00075	0.00012			
4.	Sub-factor (B) (conc.)	2	2.4615	1.2307	3326.21**	3.00	4.13
5.	Interaction AxB	6	0.0108	0.0018	4.86**	3.34	4.54
6.	Error (b)	16	0.006	0.00037			
7.	Total	35	2.53				
$CV_{(a)} = 0.52\%$				$CV_{(b)} = 0.92\%$			
** = Significant at 1% level.							

XVIII. Analysis of variance on rice leaffolder infestation in different conc. at 50 DAT during the wet season of 2005. Design: Split-plot.

Sl. no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	0.00009	0.000045			
2.	Main factor (A) (plant products)	3	0.13	0.043	100**	3.58	5.51
3.	Error (a)	6	0.0026	0.00043			
4.	Sub-factor (B)	2	12.3392	6.1696	9793.01**	3.00	4.13
5.	Interaction AxB	6	0.1393	0.0232	37.01**	3.34	4.54
6.	Error (b)	16	0.0102	0.00063			
7.	Total	35	12.62				
$CV_{(a)} = 1.20\%$				$CV_{(b)} = 1.45\%$			
** = Significant at 1% level.							

XVIX. Analysis of variance on rice leaffolder infestation in different conc. at 60 DAT during the wet season of 2005. Design: Split-plot.

Sl. no.	Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	0.002	0.001			
2.	Main factor (A) (plant products)	3	0.55	0.18	360.00**	3.58	5.51
3.	Error (a)	6	0.003	0.0005			
4.	Sub-factor (B) (conc.)	2	13.18	6.59	10983.33**	3.00	4.13
5.	Interaction AxB	6	0.31	0.05	83.33**	3.34	4.54
6.	Error (b)	16	0.01	0.0006			
7.	Total	35	14.06				
$CV_{(a)}$ = 1.36%				$CV_{(b)}$ = 1.48%			
** = Significant at 1% level.							

XX. Analysis of variance on grain yield due to the influence of plant extracts on rice leaffolder during the wet season of 2005. Design: Split-plot.

Sl. no.	Source of variation	D.F	Sum of squares	Mean sum of squares	F-cal. value	F-tabulated	
						5%	1%
1.	Replication	2	11.23	5.62			
2.	Main factor (A) (plant products)	3	174836.09	58278.70	7855.93**	3.58	5.51
3.	Error (a)	6	44.51	7.42			
4.	Sub-factor (B) (conc.)	2	2285481.80	1142740.9	160834.60**	3.00	4.13
5.	Interaction AxB	6	118246.58	19707.76	2773.76**	3.34	4.54
6.	Error (b)	16	113.68	17.11			
7.	Total	35					
$CV_{(a)}$ = 0.074%				$CV_{(b)}$ = 0.072%			
** = Significant at 1% level.							

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Moanaro, S. Changkija, D.P. Chaturvedi 2004. Comparative evaluation of some indigenous plant extracts for the control of rice leaffolder, Cnaphalocrocis medinalis (Guenee)(Lepidoptera: Pyralidae). NURJ. 2: 18-24.

6.2. Research Paper accepted:

Moanaro, S. Changkija, D.P. Chaturvedi 2007. Antifeedant property of certain plant extracts against the larvae of rice leaffolder,Cnaphalocrocis medinalis (Guenee). J.Appl. Zool. Res. 18(1). (To be released shortly).

6.3. Research Paper communicated:

Moanaro, S. Changkija, D.P. Chaturvedi. 'Oviposition deterrent property of certain plant extracts against rice leaffolder, Cnaphalocrocis medinalis (Guenee),Entomon.

6.4. Popular Article / Newspaper releases:

Moanaro, S. Changkija, D.P. Chaturvedi 2006. 'Rare phenomenon in wetland rice cultivation'. Nagaland Post, 12th October 2006, P-2.

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