# "SEASONAL INCIDENCE AND MANAGEMENT OF LEPIDOPTERAN PESTS IN CASHEW"

By

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# CERTIFICATE

This is to certify that the thesis entitled **" SEASONAL INCIDENCE AND MANAGEMENT OF LEPIDOPTERAN PESTS IN CASHEW "** submitted in partial fulfillment of the requirements for the degree of "**MASTER OF SCIENCE IN AGRICULTURE**" in the major field of **ENTOMOLOGY** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out **by Mr.Y. SUBBA RAO** under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee.

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

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# DECLARATION

I, Mr. **Y. SUBBA RAO** hereby declare that the thesis entitled **" SEASONAL INCIDENCE AND MANAGEMENT OF LEPIDOPTERAN PESTS IN CASHEW "** submitted to the Acharya N.G. Ranga Agricultural University for the degree of Master of Science in Agriculture in the major field of **ENTOMOLOGY** is the result of original research work done by me. I also declare that the thesis or any part thereof has not been published earlier in any manner.

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Mr. **Y. SUBBA RAO** has satisfactorily prosecuted the course of research and that the thesis entitled **" SEASONAL INCIDENCE AND MANAGEMENT OF LEPIDOPTERAN PESTS IN CASHEW "** submitted is the result of original research work and of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part there of has not been previously submitted by him for a degree of any university.

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## LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| % | : | per cent |
| @ | : | at the rate of |
| $^0C$ | : | Degree centigrade |
| a.i | : | active ingredient |
| ANB | : | Apple nut borer |
| cm | : | centimeter |
| DAT | : | days after treatment |
| E | : | evening |
| EC | : | Emulsified concentration |
| *et al.* | : | and others |
| *etc* | : | etcetera |
| ETL | : | Economic Threshold Level |
| fig. | : | figure |
| g | : | gram |
| h | : | hours |
| $ha^{-1}$ | : | per hectare |
| *i.e.* | : | that is |
| L | : | litre |
| $L^{-1}$ | : | per litre |
| LF | : | leaf folder |
| LM | : | leaf miner |
| m | : | meter |
| M | : | morning |
| Max. | : | Maximum |
| Min. | : | minimum |
| $m^2$ | : | square meter |
| ml | : | Milli litre |
| mt | : | metric tones |
| q | : | quintal |
| r | : | correlation coefficient |
| $R^2$ | : | co-efficient of determination |
| RH | : | Relative Humidity |
| SC | : | Soluble Concentration |
| *sp.* | : | species |
| STC | : | shoot tip caterpillar |
| t | : | tonnes |
| Temp | : | temperature |
| *viz*., | : | namely |
| WP | : | wettable powder |

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## ABSTRACT



| | | |
|---|---|---|
| **AUTHOR** | **:** | **Y. SUBBA RAO** |
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Field investigations were carried out to elicit information on seasonal incidence, effect of insecticides on natural enemies and chemical control pertaining to different lepidopteran pests on cashew at the Cashew Research Station, Bapatla, Andhra Pradesh during 2004-05.

The ecological studies revealed the peak incidence of leaf and blossom webber, shoot tip and inflorescence caterpillar, leaf miner, leaf folder and apple and nut borer as second week of May, first week of March, second week of December, second week of November and last week of February, respectively.

The correlation studies showed that temperature had positive relationship while morning relative humidity had a significant negative relationship with leaf and blossom webber. With regard to the incidence of shoot tip and inflorescence caterpillar the multiple regression analysis clearly revealed that minimum temperature exerted a strong negative effect while evening relative humidity had a positive effect.

The relationship between abiotic components and leaf miner as well as leaf folder incidence revealed negative role of temperature. This was found true even with the incidence of natural enemies.

Three insecticides namely, spinosad, thiodicarb and profenophos were proved equally effective and best for the control of lepidopteran pests followed by chlorpyriphos and cartap hydrochloride. However, ecofriendly chemicals *viz*., neem oil and *B.t.* proved inferior as straight insecticides.

Regarding the safety of natural enemies (spiders) neem oil and *B.t.* alone treatments were found relatively safer to spiders with remaining insecticides proving highly detrimental for their survival.

# CHAPTER - I

# INTRODUCTION

Cashew (*Anacardium occidentale* L.) belongs to the family Anacardiaceae which is an important cash crop grown all over the world. Cashew is a potential crop for transformation of waste lands in to economic means of income which generate substantial employment potential in industrial and rural sector (Balasubramanian,1998). Cashew tree is a native of South Eastern Brazil, was introduced to west coast of India by Portugeese during sixteenth century.

At present cashew is grown in the states of Kerala, Karnataka, Goa, Maharashtra, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal. The Government of India has set up "Indian Cashew Development Council " in 1966 to bestow special attention to its cultivation, post harvest technology and use of by-products.

Cashew is grown over an area of 7.70 lakh hectares in India producing 5.00 lakh tonnes of kernels that has earned a foreign exchange of 1804.43 crores of rupees (CEPCI, 2004). In Andhra Pradesh it is cultivated in an area of 1.36 lakh hectares with very low returns mainly due to the ravages caused by insect pests.

Cashew is ravaged by more than 60 insect pests as reported by Pillai *et al*. (1976) while Rai (1984) described 150 species of pests that were attacking cashew. Among many pests, leaf and blossom webber, *Lamida moncusalis* Wlk., apple and nut borer, *Nephopteryx eugraphella* Rag., leaf miner, *Acrocercops syngramma* Meyr., shoot tip and inflorescence caterpillar, *Hypatima haliramma* Meyr. *etc*. are the most important lepidopteran pests of cashew. Basuchoudari (1962) had estimated that *A. syngramma* alone was capable of causing 75 to 80 per cent leaf damage while *L. moncusalis* and *N. eugraphella* Rag. were reported to cause 25 and 60 per cent damage, respectively (Dharmaraju *et al*, 1975).

Of late, lepidopteran pests have attained a major pest status and became problematic in and around Guntur district of Andhra Pradesh. Recently much of the emphasis is being given on sustainable agriculture based on suitable integrated pest management strategies. Hence, knowledge of pest population ecology is essential for appropriate control strategies. Further, the pest's interaction with abiotic factors helps in planning need based application of insecticides as it clearly reveals the insects peak activity periods during the crop growth. Hence, information on seasonal incidence and influence of weather on development of pests is of prime importance for forecasting the incidence of pests in a particular region.

As cashew is a valuable crop, farmers are applying insecticides at regular short intervals leading to undesirable problems such as environmental pollution, presence of residues in fruits and kernels, development of resistance to insecticides, resurgence, secondary infestation and harmful effects to beneficial organisms. This has led entomologists all over the world to develop suitable pest management strategies based on sound ecological principles. Hence, there is a need to evaluate new, ecofriendly and safer chemicals which are effective, less persistent and safe to non target organisms. Keeping all these in view the present studies were designed with the following objectives.

- To study the incidence of major lepidopteran pests on cashew.

- To study the efficacy of certain new insecticides against major lepidopteran pests on cashew and

- To study the occurrence of natural enemies as well as the influence of these insecticides (objective 2) on natural enemies.

# CHAPETR - II

# REVIEW OF LITERATURE

## 3.1 SEASONAL INCIDENCE OF MAJOR LEPIDOPTERAN PESTS

### 3.1.1 **Shoot and Blossom Webber**, *Lamida moncusalis* Wlk.

Fletcher (1914) recorded *Lamida moncusalis* Wlk. as a minor pest on mango (*Mangifera indica* L.) in South India and Ayyar (1940) subsequently confirmed the same observation. However, Abraham (1958) reported the occurrence of *Lamida moncusalis* Wlk. on cashew for the first time in Kerala.

Basheer and Jayaraj (1964) and Pruthi (1969) observed serious damage by the pest in Andhra Pradesh to cashew foliage during flushing and blossoming stage by webbing and feeding on the shoots and inflorescence.

Vincenteestibeiro (1970) studied the incidence of the webber and the results revealed that the pest appears at the time of new flush and webs the shoots and inflorescence and feeds on them.

Pillai *et al*. (1976) noticed severe leaf webber infestation on cashew in Tamil Nadu and Orissa and observed severe reduction of cashew yield during 1973-74 due to infestation of leaves, inflorescence, fruits and nuts by *Lamida moncusalis* Wlk.

Arjunarao (1978) reported the pest to occur throughout the year attacking cashew leaves, shoots, inflorescence, apples and nuts and the peak population was reported to synchronize with the new flush and blossoming stage.

Sathiamma (1978) from Kerala recorded mild damage due to webber during April, September and October, moderate damage during February, March, November and December and no damage during August.

Haribabu *et al*. (1983) recorded the regular occurrence of webber throughout the year and the results revealed that incidence was more especially at the time of emergence of new flush in June-July and January-March in Andhra Pradesh.

Ramadevi and Radhakrishnamurthy (1983) noticed severe damage from June to September and February to May and mild infestation from October to January in and around Bapatla.

Tejkumar *et al*. (1985) considered *Lamida moncusalis* Wlk. as a serious pest on cashew which effect all parts of crop *viz.,* shoots, leaves, inflorescence, apple and nuts throughout the year.

Ayyanna *et al*. (1985) recorded mild to severe damage in all districts of Andhra Pradesh with 100 per cent damage in Nellore district (100% laterals infested).

Chatterjee (1988) reported from West Bengal that *Lamida moncusalis* Wlk. incidence was at peak in December-February, moderate in November – March and low in April-October.

Panigrahi (1988) reported from Orissa that the peak activity of *Lamida moncusalis* Wlk. (9-12% damage) was noticed during March to May.

Tirumalaraju *et al*. (1991) reported from Karnataka that the population built up of leaf and blossom webber started during 2$^{nd}$ fortnight of June on younger plants and incidence reached maximum during first fortnight of January (25%).

Ramadevi and Radhakrishna (1991) studied the incidence of leaf and blossom webber and reported that increase in temperature and fall in relative humidity was congenial for the pest outbreak.

Ramakrishnarao and Haribabu (2003) reported that the incidence of shoot and blossom webber was more from July to October and February to March with a peak during first fortnight of September in and around Tirumala hills of Andhra Pradesh and exhibited a significant negative correlation with maximum temperature with non-significant relation between incidence and minimum temperature, relative humidity and rainfall.

According to AICRP on Cashew Reports (2004) leaf and blossom webber incidence was observed almost throughout the year. Among the abiotic factors both maximum and minimum temperatures were significantly positive and relative humidity (morning) was found to have significant negative influence at Bapatla.

### 3.1.2 Leaf Miner, *Acrocercops syngramma* Meyr.

Ayyar (1940, 1941 and 1942) reported the incidence of leaf miner on cashew from Tamil Nadu.

Khan (1963) and Basheer and Jayaraj (1964) recorded the appearance of the pest at the time of new flush on cashew with greater susceptibility of young plants.

Sundararaju (1984) recorded the infestation of the pest to coincide with post monsoon flushes of young plantations.

Arjunarao (1978) recorded the leaf miner as an important pest on cashew in Guntur and Prakasam districts of Andhra Pradesh occurring mostly at the time of new flush.

Sathiamma (1978) from Kerala reported that the leaf miner infestation was mild from Jan-April, November and December, moderate from August to October but totally absent from May to July.

Ramadevi and Radhakrishnamurthy (1983) stated that the leaf miner was a regular pest in and around Bapatla and the infestation was severe from September to December, moderate from May to August and low from January to April.

Haribabu *et al*. (1983) observed the leaf miner as a major pest in Andhra Pradesh appearing regularly during the post harvest flush (June-July) and reproductive flush (January-February) under east coast conditions.

Jena *et al*. (1985) reported that the leaf miner appeared on cashew in Orissa from September to December mostly on the post monsoon flushes, the peak period being October to November with as many as eleven larvae on a single leaf.

Jena and Satapathy (1988) recorded the seasonal incidence of leaf miner and the damage was observed during the beginning of September and December with peak activity during second fort night of November when temperature ($25^0$C) and relative humidity (68%) were quite low.

Chatterjee (1988) reported from West Bengal that the leaf miner usually become serious in September to November and moderate in July, August and December.

Tirumalaraju *et al*. (1991) revealed that the pest incidence started during second fortnight of June, gradually increased reaching peak in second fortnight of November and there after gradually decreased and vanished completely after second fortnight of February in Maidan parts of Karnataka.

Ramadevi and Radhakrishna (1991) recorded the incidence of leaf miner from October to February coinciding with the decrease in temperature, rainfall and relative humidity.

Senguttuvan and Muralibhaskaran (1993) studied the influence of weather factors on the incidence of leaf miner and found that rainfall had a significant positive correlation with leaf miner infestation.

Anujbhatnagar *et al*. (1996) reported the incidence of leaf miner as moderate to severe, particularly on young flushes during January to March from Bastar Plateau zone of Madhya Pradesh.

Mohapatra and Barik (1996) recorded the activity of cashew leaf miner from first fortnight of August with gradual increase reaching its maximum infestation during second fortnight of September in Orissa conditions.

Mohapatra (1997)indicated that the pest commenced during second fortnight of August, reaching to a peak in late October and declined by December at Bhuvaneswar.

Ramakrishnarao and Haribabu (2003) recorded the seasonal incidence of leaf miner and recorded that the pest was severe from September to December with a peak during first fortnight of November in and around Tirumala hills of Andhra Pradesh. Relative humidity and rainfall had positive correlation while maximum and minimum temperatures have no significance.

The reports of AICRP on cashew (2004) reported that activity of leaf miner was found to coincide with the occurrence of new flush during the months of September and November, respectively. Maximum and minimum temperatures have negative influence while morning relative humidity has positive influence on pest population in Bapatla.

### 3.1.3 Shoot Tip and Inflorescence Caterpillar, *Hypatima haligramma* Meyr.

The shoot tip and inflorescence caterpillar *Hypatima haligramma* M. was first recorded by Abraham (1958) as a pest in cashew in Kerala.

Arjunarao (1978) recorded the shoot tip and inflorescence caterpillar as an important pest on cashew in Guntur and Prakasam districts of Andhra Pradesh and found that the infestation was high at the time of new flush and blossoming stage.

Ramadevi and Radhakrishnamurthy (1983) reported that the shoot tip and inflorescence caterpillar was a regular pest on cashew in and around Bapatla and the infestation was moderate during January and February, severe from March to May and mild during June to December.

According to Satapathy *et al*. (1985) the pest starts attacking the crop in Orissa in the month of July with emergence of new flush and reaches its peak during September-October.

Jena *et al*. (1985) reported that the caterpillar appeared in July and attained peak during September – October with complete vanishment by mid November.

Jena and Satapathy (1988) studied the seasonal incidence of *Hypatima haligramma* Meyr. and observed the peak incidence to be in the second fortnight of September.

Ramadevi and Radhakrishna (1991) observed increase in the population of shoot tip and inflorescence caterpillar with increase in temperature, relative humidity and rainfall.

Senguttuvan and Muralibhaskaran (1993) recorded the incidence of *Hypatima haligramma* Meyr. and found that increase in maximum and minimum temperatures were unfavourable for multiplication of shoot tip and inflorescence caterpillar.

According to Jena (1998) and Routray (2000), the peak level of activity of shoot tip and inflorescence caterpillar was during September – October with initial infestation in July.

### 3.1.4 Apple and Nut Borer, *Nephopteryx eugraphella* Rag.

Abraham (1958) recorded *Nephopteryx eugraphella* Rag. as a borer on cashew apples and tender nuts in Tiruchirapalli while Dharmaraju *et al.* (1975) recorded *Nephopteryx eugraphella* Rag. as an apple and nut borer on cashew in Andhra Pradesh.

Sreeramulu *et al*. (1979) recorded this species as mango fruit borer in Andhra Pradesh. According to Ramadevi and Radhakrishnamurthy (1983) infestation by apple and nut borer in and around Bapatla was moderate during January – February and severe from March to May while Chatterjee (1988) reported that the pest was at its peak in February to March and declined by April and May at Jhargram region of West Bengal.

Thirumalaraju *et al*. (1991) reported from Karnataka that this pest incidence was noted during second fortnight of February and reached maximum during first fortnight of May (22.22%) and gradually decreased thereafter with severe incidence in off-bearing nuts.

Ramadevi and Radhakrishna (1991) observed apple and nut borer to appear as fruit feeder from February and continued upto May with maximum infestation in April.

According to AICRP on cashew (2004) reports, apple and nut borer was restricted during the period of apple and nut formation from January to April and none of the weather factors were found significant in Bapatla.

### 3.1.5 Leaf Rollers

Abraham (1958) recorded the leaf roller, *Sylepta aurantiacalis* F. as a major pest in Kerala feeding on cashew foliage while Ayyanna *et al*. (1977) have reported from Andhra Pradesh that *Chelaria (Hypatima ) haligramma* M. the shoot tip and inflorescence caterpillar alone as a leaf folder.

Ramadevi and Radhakrishnamurthy (1983) reported that damage by leaf folders was mild during September, moderate during October-November and was absent from December to August in and around Bapatla.

Ayyanna and Ramadevi (1987) reported three species of folders and rollers viz.,

1. *Dudua aprobola* Meyrick Fy: Tortricidae.
2. *Caloptilia tiselaea* Meyrick Fy: Gracillaridae
3. *Sylepta derogata* Fab. Fy: Pyraustidae infesting

the cashew from October to December along with *Hypatima haligramma* M. when the crop was in new flush.

According to reports of AICCIP (1989) the pest incidence of leaf folder was observed during April with eight per cent leaf damage in Tamil Nadu.

Senguttuvan *et al*. (1990) identified a new species of leaf folder *Sylepta aurantiacalis* Fisch. on cashew during February and March months in Vriddha Chalam of Tamil Nadu.

Punnaiah and Devaprasad (1996) observed leaf folder damage from second fortnight of August to first fortnight of March and noted that maximum temperature and relative humidity has a significant negative effect while minimum temperature had a significant positive effect on population fluctuations.

The reports of AICRP on cashew (2004) reported that activity of leaf folder was found to coincide with the occurrence of new flush during the months of September and November, respectively. Maximum and minimum temperatures have negative influence while morning relative humidity has positive influence on pest population in Bapatla.

### 3.1.6 Bag Worm, *Eumeta sp.*

Rai (1981) observed bag worms incidence mostly during July-August on the coastal tracks of Karnataka while Jena *et al*. (1987) reported that the incidence of this pest was from April-May in Orissa.

### 3.1.7 Tussock Caterpillar, *Lymantria obuscata* Walker.

Samiayyan *et al*. (1988) reported that an epidemic out break of the tussock caterpillar, *Lymantria obuscata* Walker was noticed in the major cashew grown areas of South Arcot in Tamil Nadu during January, 1986.

## 3.2 EFFICACY OF INSECTICIDES ON LEPIDOPTERAN PESTS

### 3.2.1 Chlorpyriphos

Chlorpyriphos is a non systemic broad spectrum organo phosphorus insecticide having contact and stomach action with slight fumigant action (Gupta, 1999).

Hanumantharao *et al*. (1989) obtained good control with chlorpyriphos, fenvalerate and monocrotophos each at 0.01% concentration from *Acrocercops syngramma* Meyr. (Leaf miner), *Lamida moncusalis* Wlk. (Shoot and blossom webber) and *Nephopteryx eugraphella* Rag. (Fruit and nut borer).

Satapathy *et al*. (1990) revealed that the methyl parathion 0.05% caused highest mortality of leaf miner larvae after 12 hours of treatment followed by quinalphos, chlorpyriphos and monocrotophos (0.05%) which were also quite effective.

The studies conducted by Mohapatra *et al*. (2000) revealed that monocrotophos 0.05% and chlorpyriphos 0.05% were the most effective chemicals against cashew shoot tip and inflorescence caterpillar.

### 3.2.2 Thiodicarb

Thiodicarb is an oxime carbamate predominantly with stomach action and with limited contact action (Tomlin, 1995). It was introduced recently in Indian market as an effective insecticide against lepidopteran pests under the trade name Larvin 75WP.

Since there was no literature with regard to its efficacy on cashew pests, a few latest reports of its efficacy on varied pests infesting different crops was presented here under.

Dandale *et al*. (2000a) reported that thiodicarb @ 0.7 Kg a.i $ha^{-1}$ was very effective against boll worm complex of cotton by recording only 5.88 per cent infestation in squares and green bolls when compared to 12.95 per cent in check. The yield was also higher in thiodicarb treated plot (587 Kg ha$^{-1}$), than untreated check (447 Kg ha$^{-1}$).

Umeda *et al*. (2000) reported that thiodicarb (1.0 lb a.i/acre) was more effective on *Plutella xylostella* L. when compared to indoxacarb (0.007 lb a.i/ acre) and spinosad (0.009 lb a.i/acre) on cabbage.

Khalidahmed *et al*. (2000) recorded that thiodicarb was most effective by recording the highest larval mortality of 94.44% at 72 hours after treatment followed by chlorpyriphos (87.49%) against mid-larval instar of *Spodoptera exigua* (Hubner).

Brickle *et al*. (2001) reported that spinosad and thiodicarb were very effective in controlling *Helicoverpa zea* (Boddie) on non *B.t.* cotton.

Balaji (2002) recorded 13.87 per cent shoot infestation by *Leucinodes orbonalis* (Guenee) on brinjal as against 18.8 per cent in untreated check showing a moderate efficacy of thiodicarb when used at 1 g L$^{-1}$.

Giraddi *et al*. (2002) reported that thiodicarb @ 625 g a.i $ha^{-1}$ recorded lower pod damage (29.8%) by *Helicoverpa armigera* (Hubner) and higher seed yield (1.34 t $ha^{-1}$) in pigeonpea.

Mahalakshmi *et al*. (2002) reported that thiodicarb @ 0.075% was highly effective on mustard against *Plutella xylostella* (Linn.) at second day after spraying.

### 3.2.3 Profenophos

Profenophos is a non systemic insecticide from organo phosphorous group with contact, stomach and acaricidal action (Hill, 1983). It has a broad spectrum of activity against wide range of chewing, mining and sucking insects with a swift knockdown action.

Nandakishore (1993) reported that among the insecticidal treatments polytrin C 0.05 per cent , profenophos 0.1 and 0.2 per cent, methomyl 0.1 per cent were most effective against leaf miner, shoot tip caterpillar and shoot and blossom webber of cashew.

Suvarnaraju (1996) concluded that profenophos 0.05% was highly effective against leaf miner, shoot tip and inflorescence caterpillar, leaf folders, leaf and blossom webber with 74.00, 78.33, 73.60 and 77.13 per cent reduction, respectively.

Mohapatra *et al*. (2000) reported that profenophos (0.05%) was very effective against shoot tip and inflorescence caterpillar, *Hypatima haligramma* Meyr. along with chlorpyriphos @ 0.05%.

According to AICRP on cashew (2004), profenophos (0.05%) was found the most effective chemical even 30 days after treatment for the control of shoot tip and inflorescence caterpillar and leaf and blossom webber followed by chlorpyriphos (0.02%).

### 3.2.4 Cartap Hydrochloride

Cartap is a "Nereis toxin" isolated from the marine annelids *Lumbrineris heteropoda* and *L. brevicirra* was found to possess insecticidal properties. The insecticidal activity of cartap hydrochloride is attributed to its blocking action in the central nervous system that leads to paralysis (David and Swami, 1982).

Nandakishore (1993) reported that cartap 0.05 per cent, neem oil 0.1 and 0.5 per cent were found moderately effective against the leaf miner, shoot tip and inflorescence caterpillar and shoot and blossom webber on cashew.

Suvarnaraju (1996) reported that profenophos and cartap hydrochloride 0.05% were highly effective and recorded 78.33 and 70.31 per cent reduction against shoot tip and inflorescence caterpillar and 77.13 and 74.86 per cent reduction of larval population of shoot and blossom webber over untreated control in cashew, respectively.

### 3.2.5 Spinosad

Spinosad (Tracer ® ) a new compound in Indian market, is a mixture of Spinosyn A + D. Spinosyns are naturally derived group of insect control molecules from a new species of actinomycetes, *Sachharopolyspora spinosa*. Spinosyn A and D are the two most active naturally occurring metabolites (Krist *et al*., 1992).

Spinosad acts both as a contact and stomach poison and has low mammalian toxicity. Spinosyn A @ 400 ppm was active especially against lepidopteran pests, spiders, mites, plant hoppers and cockroaches but no activity was observed on aphids and nematodes (De Amicis *et al*., 1997).

Since there was no literature with regard to its efficacy on cashew pests, a few latest reports of its efficacy on varied pests infesting different crops was presented hereunder.

Dandale *et al*. (2000b) reported that spinosad 48SC both @ 75 and 50 g a.i $ha^{-1}$ was effective in controlling the infestation of *Helicoverpa armigera* (Hub.) in green fruiting bodies of cotton at fourteen days after treatment.

Gopalaswamy *et al*. (2000) evaluated bio-efficacy of spinosad 48SC, a natural source insecticide against pink bollworm in cotton. It was stated that spinosad 48SC @ 50 g a.i $ha^{-1}$ recorded minimum percentage of rosette flowers and minimum percentage of green boll damage.

Vadodaria *et al*. (2001) recorded lower population of *Helicoverpa armigera* (Hub.) with higher seed cotton yield from plots treated with spinosad 48SC @ 75 g a.i $ha^{-1}$.

Dey and Somchoudhury (2001) reported that spinosad 48SC @ 15-25 g a.i $ha^{-1}$ was the most effective in controlling *Plutella xylostella* (Linn.), *Hellula undalis* (Fab.) and *Spodoptera litura* (Fab.) on cabbage. The results revealed that the highest dose of spinosad (25 g a.i $ha^{-1}$) gave almost total control of *Plutella xylostella* (Linnaeus).

Mahalakshmi *et al*. (2002) conducted a field study against *Plutella xylostella* (Linn.) and *Crocidolomia binotalis* (Zell) on mustard. The results revealed that spinosad (2.5SC) 0.01% was highly effective in controlling *Plutella xylostella* L. and *Crocidolomia binotalis* Z. and also recorded higher pod yield.

Siddegowda *et al*. (2003) evaluated the spinosad with four dosages *viz*., 45, 56, 73 and 90 g a.i $ha^{-1}$ in comparison with endosulfan 35EC (700 g a.i $ha^{-1}$) against pigeonpea pod borer, *Helicoverpa armigera* (Hub.). The results revealed that spinosad 45SC at higher doses recorded significantly lower pod damage and higher grain yield. However, the lower dosage of spinosad 45SC @ 56 g a.i $ha^{-1}$ recorded on par damage and higher grain yield compared to endosulfan @ 700 g a.i $ha^{-1}$.

Soujanya *et al*. (2004) reported that spinosad 0.015% reduced *Plutella xylostella* (Linn.) and *Spodoptera litura* (Fab.) population by 66.70 and 59.00 per cent, respectively in cabbage.

### 3.2.6 Neem Oil

The plant products are considered to be more safe ecologically and environmentally. Neem oil is an oil based neem seed kernal extract of the tree *Azadirachta indica* Juss. The crushed neem seed after extraction of the oil is used as neem cake. Neem products are known for their antifeedant, repellant and insect growth regulatory effects on various insect pests (David and Swamy, 1982).

Nandakishore (1993) reported that among the insecticidal treatments, neem oil 1.0 per cent and 0.5 per cent were found moderately effective against leaf miner, shoot tip and inflorescence caterpillar and shoot and blossom webber on cashew.

Senguttuvan *et al*. (1993) observed neem oil 0.5 per cent ineffective against shoot tip and inflorescence caterpillar and leaf miner on cashew.

Suvarnaraju (1996) observed neem treatments recording comparatively higher populations than the remaining treatments though they were superior over the untreated control.

### 3.2.7 *Bacillus thuringiensis* Berliner

*Bacillus thuringiensis* Berliner is a microbial insecticide, effective against a number of lepidopteran and coleopteran pests (Hall and Andress, 1959).

The insecticidal activity is due to delta endotoxin which is formed during sporulation process and deposited in a crystalline form within the sporangium. The germinated cell cause "Septicemia" resulting in larval death within a few hours to few days as it enters into haemolymph through the disintegrated gut wall (Maddox, 1994).

Since there was no literature with regard to its efficacy on cashew pests, a few latest reports of its efficacy on varied pests infesting different crops was presented hereunder.

Sharma *et al*. (2000) conducted a field study on the efficacy of *B.t.* K. formulations *viz*., Bioasp, Biolep and Halt against *Plutella* *xylostella* Linn. The results showed that Bioasp and Biolep @ 2Kg $ha^{-1}$ gave the highest larval mortality where as Halt @ 1.0 Kg $ha^{-1}$ was proved less effective.

Pawar and Charati (2000) evaluated *B.t.* formulations against *Spilosoma obliqua* Walker. on groundnut and sunflower crops. Among the treatments Bactate bite @ 500 g $ha^{-1}$ or Biobit @ 250 g $ha^{-1}$ were equally effective as endosulfan or methomyl @ 0.05%.

Chandrakar and Srivastava (2001) reported that Dipel 8L @ 500 ml $ha^{-1}$ was very effective in controlling the pod borer complex of urd bean.

Ghosh *et al*. (2001) reported that avermectin 0.01% and *B.t.* (Halt) @ 1g $L^{-1}$ were the best suited for the management of cabbage pests and also reported that there was an increase in the yield of cabbage.

Babu (2002) recorded 25.99 per cent reduction of *Spodoptera litura* (Fab.) larvae when treated with *B.t.* in groundnut ecosystem.

Sreedhar *et al*. (2003) concluded that the *Helicoverpa armigera* (Hub.) was effectively controlled with *B.t.* formulations Bioasp and Biolep @ 1.5 Kg $ha^{-1}$ and 2Kg $ha^{-1}$ .

Soujanya *et al*. (2004) reported that *B.t.* 0.2% was the least effective against *Plutella xylostella* Linn. and *Spodoptera litura* (Fab.) larvae with a mean reduction of 25.95 and 25.32 per cent larval population, respectively.

### 3.2.8 Chlorpyriphos + Neem Oil

The literature on combination effects of chlorpyriphos + neem oil was nil on cashew pests. Hence the combined effects on other pests was reviewed and presented below.

Sundararaj *et al*. (1998) reported that the treatment of chlorpyriphos gave maximum reduction in larval and adult population of *Patialus tecomella* Pajni, Kumar and Rose which is on par with neem formulations particularly neem gold at 1.0% and the combination of neem gold @ 0.5% with chlorpyriphos @ 0.1%

Bhalkare *et al*. (2000) reported that the combination of chlorpyriphos 0.02% + neem seed oil 1.0% and neemark 0.4% were significantly superior to control in reducing the population of pest complex on soybean.

Sanjay Keshawraut (2000) reported that the combination of chlorpyriphos 0.025% + neemectin (2.5 ml $L^{-1}$ of water) were found moderately effective against stem borer in rice with 5.9% dead hearts and 7.2% white ear heads.

### 3.2.9 Chlorpyriphos + *B.t.*

Benz (1971) reported that the efficacy of *B.t.* may be increased by the addition of sub-lethal doses of pesticides.

The increased efficacy of insecticides in combination with *B.t.* in different formulations against lepidopterous pests was reported by Dabi *et al*. (1988) and Shankar *et al*. (1992).

The literature on combination effects of chlorpyriphos + *B.t.* was nil on cashew pests. Hence the combined effects on other pests was reviewed and presented below.

Manjula and Padmavathamma (1996) studied the efficacy of different microbial insecticides alone and combinations with chemical insecticides and reported that maximum larval population reduction (53.18%) of *Maruca vitrata* Geyer were recorded with *B.t. K* @ 0.2% + monocrotophos @ 0.025%.

Rameshbabu and Krishnayya (1998) reported that the combination of *B.t.* with quinalphos were effective than their individual treatments against cauliflower caterpillars on cauliflower. Further they indicated that more number of sprays at still more shorter intervals may be required for the natural insecticides and their combinations to be on par with quinalphos and cartap which are nerve poisons.

Rao (2000) reported that combination of *B.t.* with conventional insecticides were highly effective against *Helicoverpa armigera* (Hub.) in pigeonpea.

Visalakshmi *et al*. (2000) reported that the combination of *B.t.* K. (0.075%) with neem oil (0.05%) gave 31.56 per cent mean reduction of *Spodoptera litura* (Fab.) on sunflower.

## 3.3 NATURAL ENEMIES AND THE INFLUENCE OF INSECTICIDES ON NATURAL ENEMIES

### 3.3.1 Leaf and Blossom Webber

Ramadevi and Subbarao (1982) observed ten to fifty per cent parasitization by *Elasmus johnstonii* Ferriere during July to August irrespective of spraying the crop with insecticides.

Jena *et al*. (1987) has reported 80% larval parasitization by *Bracon brevicornis* Wlk. apart from recording two hymenopteran parasites *viz*., *Apanteles sp*. (Braconidae) and *Elasmus johnstonii* Ferriere (Elasmidae) in treated plots.

### 3.3.2 Leaf Miner

Sundararaju (1984) and Pathummalbeevi *et al*. (1993) recorded two parasites *i.e. Sympiesis sp.* (Eulophidae; Hymenoptera) and *Chelonus sp*. (Braconidae : Hymenoptera) while

Sundararaju (1984) recorded that upto 59 per cent parasitization of the leaf miner by *Sympiesis* species in Goa. Mohapatra (1997) also recorded 56 per cent parasitization by *Sympiesis sp*. during second fortnight of October in Bhavaneswar.

According to reports of AICRP on cashew (2004), *Sympiesis sp*. caused 20 per cent parasitization at Bhuvaneswar.

### 3.3.3 Shoot Tip and Inflorescence Caterpillar

The report of AICRP on cashew (2004) indicated that the larval parasitoid, *Elasmus sp.* caused a maximum parasitization of 16 per cent during peak period of infestation.

### 3.3.4 Apple Nut Borer

Pillai (1980) reported that natural enemies on apple and nut borer are *Hadrophanurus sp.* (Scelionidae) and *Anestatus sp.* (Eupesnidae) as egg parasites.

### 3.3.5 Leaf Eating Caterpillar

Godse (2002) reported that *Apanteles colemani* Vierek was found parasitizing leaf eating caterpillar and the common predators were spiders *viz*., *Uloborus krishnae* Tikader, *Neoscona nautica* (L.) Koch and *Oxyopes shweta* Tikader.

### 3.3.6 Tussock Caterpillar

According to AICRP on cashew (2004) reports hairy caterpillar (*Lymantria obuscata* Wlk.) larvae was parasitized by NPV during January to February with a mean infection of 20.4 per cent.

### 3.3.7 Bag Worm

Jena *et al*. (1987) reported the tachinid fly was most effective parasite and observed to cause 82% parasitization during April-May.

### 3.3.8 Influence of Insecticides on Predators

Reports of AICRP on cashew (2004) revealed that spiders were highly effected by Lambida cyahalothrin 0.003% followed by chlorpyriphos 0.05% and profenophos 0.05% treatments.

# CHAPTER – III

# MATERIALS AND METHODS

The present investigations on "Seasonal Incidence and Management of Lepidopteran Pests in Cashew" were undertaken during June,2004 to May 2005 at Cashew Research Station, Bapatla.

The different materials and the methods employed during the period of investigation are presented below.

## 3.1 SEASONAL OCCURRENCE OF LEPIDOPTERAN PESTS ON CASHEW IN RELATION TO WEATHER PARAMETERS

Studies were carried out, on the seasonal occurrence and intensity of lepidopteran pests of cashew during 2004-05. Twelve unprotected trees selected at random in the cashew plantations of Cashew Research Station, Bapatla were earmarked for generation of data.

### 3.1.1 Pests Studied During the Experimental Period

The lepidopteran pests observed during the season for seasonal incidence studies were given below.

| S.No | Common Name | Scientific Name | Family/Order |
|---|---|---|---|
| 1 | Leaf & blossom webber | *Lamida moncusalis* Walker | Pyralidae/ Lepidoptera |
| 2 | Shoot tip and inflore-scence caterpillar | *Hypatima haligramma* Meyr. | Gelechidae/ Lepidoptera |
| 3 | Leaf miner | *Acrocercops syngramma* Meyr. | Gracillaridae/ Lepidoptera |
| 4 | Leaf folders | *Caloptilia tiselaea* Meyr. | Gracillaridae/ Lepidoptera |
| 5 | Apple and nut borer | *Nephopteryx eugraphella* Rag. | Pyralidae/ Lepidoptera |

### 3.1.2 Recording the Experimental Data

The data was collected at weekly intervals by placing a frame of 1.0 sq.m area on the tree canopy on all the four (East, West, North, South) sides and data was recorded from June, 2004 onwards till the end of May, 2005 on the following parameters *viz*.,

1. Number of leaders.
2. Number of non-flowering laterals.
3. Number of flowering laterals.
4. Number of laterals damaged (non flowering/flowering) by leaf and blossom webber.
5. Number of leaf and blossom webber larvae.
6. Number of laterals damaged by leaf miner.
7. Number of leaves damaged in five laterals by leaf miner.
8. Number of laterals damaged by leaf folder.

9. Number of leaves damaged in five laterals by leaf folder.
10. Number of laterals damaged by shoot tip and inflorescence caterpillar.
11. Total number of nuts.
12. Number of nuts damaged by apple and nut borer.
13. Number of nuts damaged by leaf and blossom webber larvae.

Based on the data generated on the above parameters, per cent infestation/damage was calculated as given below for every meteorological week.

### 3.1.3 Leaf and Blossom Webber

The caterpillar webs the leaves of terminal shoots (laterals), panicles (blossom) and feed on them resulting in skeletinization. During nut development, it scrapes the nuts and apple surface. The per cent infestation/damage was worked out taking the number of laterals damaged among the total laterals observed on all the four sides of twelve randomly selected trees.

### 3.1.4 Shoot Tip and Inflorescence Caterpillar

The larvae feeds on shoot tips and inflorescence and occasionally bore into the tender shoot tips to depth of 2.5 cm. This injury leads to gummosis and the shoot tip withers and dries up. Total number of laterals and number of laterals exhibiting gummosis, which indicate the presence of shoot tip and inflorescence caterpillar, were recorded. The per cent infestation/damage was worked out taking the number of laterals damaged and that of total laterals observed on all the four sides of twelve randomly selected trees.

### 3.1.5 Leaf Miner

The caterpillars mines into the epidermal layers of the tender leaves and cause leaf blisters which on drying results in distortion, browning, curling and drying of the leaves. The infestation/damage was worked out by taking the number of leaves infested out of five tender leaves in each of the five laterals per sq.m and the mean damage was worked out and expressed in percent damaged leaves.

### 3.1.6 Leaf Folders

The caterpillars of the leaf folder fold the tender leaves from the tip and feed from inside. The infestation/damage was worked out by taking the number of leaves infested out of five tender leaves in each of the five laterals per sq.m and the mean percent damage was worked out.

### 3.1.7 Apple and Nut Borer

The caterpillars of this pest moved to the point of attachment of apple and nuts. The entry hole was minute and plugged with excreta. The number of nuts exhibiting frass material at the joint of apple and nut indicates the presence of apple and nut borer. The number of nuts damaged among the total nuts in each sq.m area of tree canopy from four sides of the twelve trees selected for this purpose were recorded and expressed as per cent nuts damaged.

## 3.2 EFFICACY OF CERTAIN INSECTICIDES FOR THE CONTROL OF LEPIDOPTERAN PESTS ON CASHEW

Studies on chemical control of major lepidopteran pests of cashew were carried out on 8 years old cashew plantation at Cashew Research Station, Bapatla during 2004-05 to evaluate the efficacy of certain insecticides.

The trial was laid out in a randomized block design with 10 treatments including untreated control, replicated thrice with two trees per replication. Three sprays were given coinciding with flushing, flowering and nut development stage. The details of the treatments along with their formulations are presented here under.

### 3.2.1 Details of Treatments

| Treatment | Common name | Formulation | Concentration |
|---|---|---|---|
| $T_1$ | Chlorpyriphos | 20 EC | 0.05% |
| $T_2$ | Thiodicarb | 75 WP | 0.075% |
| $T_3$ | Profenophos | 50 EC | 0.05% |
| $T_4$ | Cartap hydrochloride | 50 WP | 0.05% |
| $T_5$ | Spinosad | 45 SC | 0.015% |
| $T_6$ | Neem oil | - | 0.5% |
| $T_7$ | *B.t.* | 8L | 0.2% |
| $T_8$ | Chlorpyriphos + neem oil | - | 0.025 + 0.25% |
| $T_9$ | Chlorpyriphos + *B.t.* | - | 0.025+0.1% |

| | | | |
|---|---|---|---|
| $T_{10}$ | Untreated check. | - | - |

### 3.2.2 Preparation and Application of Insecticide Treatments

The insecticides were applied as foliar spray. The required quantity of each pesticide was measured and thoroughly mixed with small quantity of water and later made up with water. The spray fluid was stirred well before spraying.

Foot sprayer was used for applying the insecticides. Spraying was under taken during the morning hours and care taken to prevent the drift of the spray fluid to the adjacent trees by providing a sheet of polythene barrier tied to bamboos on either side. The trees in each treatment were thoroughly covered with spray fluid to the point of run off. The spraying was completed on the same day in all the treatments. The sprayer and the container used for preparing spray fluid were thoroughly cleaned with water before changing the insecticide and rinsed with the spray fluid to be applied next.

The first spraying in all the treatments was given at the time of flushing (1st December, 2004) when the moderate incidence of leaf miner, shoot tip and inflorescence caterpillar and leaf and blossom webber was noticed.

The second spraying in all the treatments was given at the time of flowering (10th January) and the third spray was given at the time of nut development stage (20th February).

The following pests were observed to cross ETL during the period of experimentation.

### 3.2.3 The Relative Efficacy of Insecticides was Studied Against the Following Major Pests

| Common Name | Scientific name | Family/Order |
|---|---|---|
| 1. Leaf and blossom webber | *Lamida moncusalis* Wlk. | Pyralidae/ Lepidoptera |
| 2. Shoot tip and inflore-scence caterpillar | *Hypatima haligramma* Meyr. | Gelechidae/ Lepidoptera |
| 3. Apple and nut borer | *Nephopteryx eugraphella* Rag. | Pyralidae/ Lepidoptera |

The efficacy of the treatments against the leaf miner and leaf folders were not studied since the pests were not to the extent to cause economic damage.

### 3.2.4 Details of the Observations

The observations on the pest incidence were recorded one day before application of treatments as pre treatment count while post treatment counts were taken at 5,10,20,30 days after spraying. The data was subjected to statistical analysis and the overall efficacy of different treatments against each pest worked out.

### 3.2.5 Leaf and Blossom Webber

The larval population of shoot and blossom webber was recorded in four quadrates of each tree.

### 3.2.6 Shoot Tip and Inflorescence Caterpillar

The larval population of shoot tip and inflorescence caterpillar was recorded in four quadrates of each tree.

### 3.2.7 Apple and Nut Borer

The number of nuts damaged among the total nuts in four quadrates were recorded in each tree.

### 3.2.8 Statistical analysis

The population reduction of leaf and blossom webber and shoot tip and inflorescence caterpillar and apple and nut borer in each treatment were calculated by applying modified Abbot's formula (Fleming and Ratnakaran, 1985).

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

The values of per cent reduction were transformed into angular values and subjected to statistical analysis.

## 3.3 STUDIES ON OCCURENCE OF NATURAL ENEMIES AND INFLUENCE OF INSECTICIDES ON NATURAL ENEMIES

While recording the data from the experiments of earlier objectives simultaneously larvae of leaf and blossom webber, *Lamida moncusalis* Wlk., shoot tip and inflorescence caterpillar, *Hypatima haligramma* Meyr., leaf miner, *Acrocercops syngramma* Meyr., leaf folder, *Caloptilia tiselaea* Meyr. and apple and nut borer, *Nephopteryx eugraphella* Rag. were collected from unprotected trees (objective 1) and reared in the laboratory for possible emergence of parasitoids. Similarly counts of spiders were taken from unprotected trees (objective 1) for studying seasonal incidence of spiders. Even counts of spiders were taken from the insecticide treated plots (objective 2) to study the influence of insecticides especially on spiders and the data was subjected to statistical analysis.

# CHAPTER- IV

# RESULTS

The results of the investigation on seasonal occurrence and their correlation with weather parameters, efficacy of certain newer insecticides against major lepidopteran pests and occurrence of natural enemies as well as the influence of these insecticides on natural enemies, carried out at Cashew Research Station, Bapatla are presented here under.

## 4.1 SEASONAL OCCURRENCE OF THE CASHEW PESTS AND THEIR CORRELATION WITH WEATHER PARAMETERS

The results of the investigation from June 2004 to May, 2005 on seasonal occurrence, intensity of pest infestation of major lepidopteran pests of cashew and their correlation with weather parameters are presented in Tables 1,2, 3 and fig.1.

### 4.1.1 Leaf and Blossom Webber, *Lamida moncusalis* Walker

The leaf and blossom webber infestation was noticed through out the year. The pest infestation varied between 1.38 and 12.31 per cent during the study period. The highest infestation (12.31%) was observed during 2$^{nd}$ week of May 2005 when the maximum and minimum temperatures were 34.7$^{o}$C and 26.4$^{0}$C and relative humidity 71.5 and 60.2 per cent at morning and evening hours, respectively with no rainfall. The lowest infestation (1.38%) was observed during 1st week of January 2005 when the maximum and minimum temperatures were $30.0^0$C and $18.1^0$C, respectively, with a morning and evening relative humidity of 92.1 and 68.5 per cent.

A significant positive correlation was observed between larval incidence and maximum temperature ( r = 0.6835*) and minimum temperatures (r= 0.7574*) whereas significant negative correlation was noticed with morning relative humidity (r = -0.6764*). All the remaining abiotic factors were found to be non-significant (Table 2).

The data on larval incidence when subjected to multiple linear regression analysis gave the following equation.

$$Y = -10.6209+0.2049X_1 + 0.5008\ X_2 - 0.1313\ X_3 + 0.1350\ X_4 + 0.0008\ X_5 - 0.8761\ X_6$$

It was observed that the co-efficient of determination for larval incidence was 0.6886 which shows that the climatic factors together were able to explain the variation in the larval incidence to the extent of 68.86 out of 100. However the partial regression co-efficients were found to be non-significant (Table 3).

### 4.1.2 Shoot Tip and Inflorescence Caterpillar, ***Hypatima haligramma*** Meyr.

The infestation by shoot tip and inflorescence caterpillar on shoot tip started from last week of October 2004 and continued upto 2nd week of May, 2005 on unopened buds, inflorescence, fruits and nuts. The infestation varied between 0.06 to 28.51 per cent with maximum infestation (28.51%) during the 1st week of March, 2005 when the maximum and minimum temperatures were $33.0^0$C and $19.3^0$C, respectively while the morning and evening relative humidity were 89.7 and 63.7 per cent, with no rainfall. Lowest infestation (0.06%) was observed during 2nd week of May, 2005 when the maximum and minimum temperatures were $34.7^0$C and $26.4^0$C, respectively while the morning and evening relative humidity were 71.5 and 60.2 per cent with no rainfall.

A perusal of the data (Table 2) regarding correlation indicates that the infestation was positive and significantly correlated with morning relative humidity (r = 0.4152*) while a significant negative correlation was observed with maximum temperature ( r = -0.3978*), minimum temperatures ( r = -0.5722*) and rainy days (r= -0.4437*). Evening relative humidity and rainfall had no significant correlation with infestation.

The regression model for the infestation was given as

$$Y = 20.0821 + 0.9848X_1 - 2.0978^*X_2 - 0.3553X_3 + 0.4738^*X_4 - 0.0040X_5 - 1.9785X_6$$

It was observed that co-efficient of determination ($R^2$ = 0.5119) was able to explain the variation in the infestation to the extent of 51.19 out of 100, and the partial regression co-efficient for minimum temperature was found to be negative and significant while it was positively significant for evening relative humidity (Table 3).

### 4.1.3 Leaf Miner, *Acrocercops syngramma* Meyr.

The infestation of leaf miner was observed from last week of July, 2004 and continued upto 1st week of May, 2005. The pest infestation ranged between 0.08 to 9.76 per cent and the maximum infestation (9.76%) was observed during second week of December, when maximum and minimum temperatures were 30.0$^0$C and 17.5$^0$C, respectively while morning and evening relative humidities were 94.4 and 71.0 per cent with no rainfall. The lowest infestation (0.08%) was observed during last week of July when the maximum and minimum temperatures were 32.1 and 23.6$^0$C, morning and evening relative humidities were 83.1 and 66.4 per cent.

The correlation between population and maximum (r=-0.5563*) and minimum (r=-0.6289*) temperatures were significantly negative whereas positively significant with morning relative humidity (r = 0.5682*) and all the remaining abiotic factors were found to be non-significant (Table 2).

The data on larval incidence when subjected to multiple linear regression analysis, the following equation was achieved.

$$Y = 2.8124 - 0.0939X_1 - 0.1191X_2 + 0.1373X_3 - 0.0854\,X_4 - 0.0086X_5 + 0.1253X_6$$

It was observed that the co-efficient of determination ($R^2$) for larval incidence was 0.4369 which shows that the climatic factors together were able to explain the variation in the incidence to the extent of 43.69 out of 100. However the partial regression co-efficients were found to be non-significant (Table 3).

### 4.1.4 Leaf Folder, *Caloptilia tiselaea* Meyr.

The leaf folders infestation was noticed throughout the year starting from last week of July, 2004 and continued upto 1$^{st}$ week of June, 2005. However infestation was absent during 2$^{nd}$ fortnight of June, 1$^{st}$ fortnight of July and 2$^{nd}$ fortnight of May. The pest infestation ranged between 0.08 to 17.43 per cent, with highest infestation (17.43%) during 2$^{nd}$ week of November when the maximum and minimum temperatures were 28.9$^{0}$C and 21.8$^{0}$C, morning and evening relative humidities of 94.1 and 85.1 per cent, respectively with a rainfall of 26.7 mm in a span of two rainy days. The least infestation (0.08%) was observed during last week of July when the maximum and minimum temperatures were 32.1 and 23.6$^0$C, morning and evening relative humidities of 83.1 and 66.4 per cent with a rainfall of 33mm within a span of three rainy days.

The correlation between maximum (r=-0.6386*) and minimum (r=-0.6865*) temperatures were negatively significant while morning and evening (r=0.6224* and r=0.3807*) relative humidities were positively significant. The remaining abiotic factors were found non-significant (Table 2).

The data on larval incidence when subjected to multiple linear regression analysis gave the following equation

$$Y = 27.7162 - 0.3223\ X_1 - 0.6972\ X_2 - 0.0066X_3 + 0.0611\ X_4 - 0.0119X_5 - 0.1888X_6$$

It was observed that the co-efficient of determination ($R^2$) for larval incidence was 0.5065 which shows that the climatic factors together were able to explain the variation in the larval incidence to the extent of 50.65 out of 100. However, the partial regression co-efficients were found to be non-significant (Table 3).

### 4.1.5 Apple and Nut Borer- *Nephopteryx eugraphella* Rag.

The apple and nut borer infestation was observed during the 1$^{st}$ week of January 2005 to 1$^{st}$ week of May,2005. Peak period of infestation was recorded during the last week of February with 16.19 per cent and the data regarding to correlation (Table 2) indicates that all abiotic factors were found non-significant with the incidence of apple and nut borer .

The data on larval incidence when subjected to multiple linear regression analysis, the following equation was achieved

$$Y = -19.0962 + 0.6181X_1 - 0.3552X_2 - 0.1013X_3 + 0.2650X_4 + 0.0003X_5 - 1.1750X_6$$

It was observed that the co-efficient of determination ($R^2$) for larval incidence was 0.2447 which shows that the climatic factors together were able to explain the variation in the incidence to an extent of 24.47 out of 100. However all the partial regression co-efficients were found to be non-significant.

## 4.2 EFFICACY OF CERTAIN NEWER INSECTICIDES FOR THE CONTROL OF CASHEW LEPIDOPTERAN PESTS

### 4.2.1 Effect of Insecticides against Cashew Leaf and Blossom Webber

**First spray**

The efficacy of various insecticidal treatments in bringing down the cashew leaf and blossom webber population are presented in Table 4. Pre treatment counts were taken one day before spraying. The data revealed that leaf and blossom webber population ranged between 9.67 to 13.00 on an average on four square meters and there was no significant difference between the treatments.

The data at five days after spraying revealed that spinosad (0.015%) with 95.35 per cent mean reduction was found the most effective chemical followed by cartap hydrochloride (0.05%), thiodicarb (0.075%), profenophos (0.05%) and chlorpyriphos (0.05%) with a mean per cent reduction of 91.37, 91.20, 91.20 and 90.92 per cent, respectively and the treatments were on par with each other. The least effective chemicals were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 66.12 and 65.17 per cent, respectively and were on par with each other. The treatments that followed the effective chemicals were the combination treatments *viz*., chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy. However all the treatments were significantly superior in reduction of larval population over control.

A perusal of data at 10 days after spraying, revealed that the best treatments were spinosad (0.015%), thiodicarb (0.075%), chlorpyriphos (0.05%), profenophos (0.05%) and cartap hydrochloride (0.05%) with a mean per cent reduction of 91.80, 90.85, 89.42, 88.29 and 87.96 per cent, respectively and the treatments were on par with each other. The least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 63.09 and 60.47 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) +*B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy. However all the treatments were significantly superior over control in reduction of larval population.

The best treatments at 20 days after spraying were spinosad (0.05%), thiodicarb (0.075%), profenophos (0.05%) and chlorpyriphos (0.05%) with a mean per cent reduction of 87.34, 83.48, 82.81 and 81.68 per cent, respectively and found on par with each other. The treatment that followed the best effective chemicals was cartap hydrochloride (0.05%) with mean reduction of 80.35% and however it was on par with chlorpyriphos (0.05%). The least effective chemicals were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 57.31 and 57.18 per cent, respectively. Chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par with each other and moderate in efficacy. All the treatments were statistically superior over control after 20 days of treatment.

A perusal of the data at 30 days after spraying revealed that all the treatments were superior over control in reducing the larval population and there was progressive decrease in the efficacy of all treatments. Even at 30 days after spraying the best treatments were spinosad (0.015%), thiodicarb (0.075%) and profenophos

(0.05%) with mean per cent reduction of 76.15, 75.39 and 75.06 per cent, respectively and were on par. The least effective chemicals were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 46.40 and 40.87 per cent, respectively and the treatments were on par. The treatments which were on par and that followed the best effective chemicals were cartap hydrochloride (0.05%), chlorpyriphos (0.05%), chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with a mean reduction of 65.77, 65.28, 63.57 and 63.01 per cent, respectively and observed to have moderate efficacy.

Considering the overall efficacy it was observed that all the insecticidal treatments were significantly superior over control in bringing down the larval population of shoot and blossom webber. Among the treatments, spinosad (0.015%), thiodicarb (0.075%) and profenophos (0.05%) were the best with a mean per cent reduction of 87.66, 85.23 and 84.48, respectively and were on par. The next best treatments were chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) with mean reduction of 81.67 and 81.34 per cent, respectively. The least effective chemicals were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 57.99 and 56.19 per cent, respectively and the treatments were on par with each other. The treatments which were on par and with moderate efficacy were chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) with a mean per cent reduction of 71.51 and 70.85, respectively. However, chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) were on par with the best treatment profenophos (0.05%).

**Second spray**

The efficacy of insecticides after second spray application are presented in table 5.

Pre treatment counts were taken one day before spraying and the data revealed that the larval population ranged between 10.33 to 13.33 per four square meters and there was no significant difference between the treatments.

The post treatment count at five days after second spray indicated spinosad (0.015%), thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) as the best treatments with a mean per cent reduction of 94.53, 94.17, 92.85, 92.33 and 91.46 per cent, respectively and the treatments were on par with each other. While neem oil (0.5%) with 64.92 per cent reduction was found least effective. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) +neem oil (0.25%), chlorpyriphos (0.025%) + *B.t.* (0.1%) and *B.t.* (0.2%) which were on par and found moderately effective. However the treatment neem oil (0.5%) was on par with *B.t.* (0.2%). All the treatments were statistically significant in reduction of population over control.

The post treatment count at 10 days after spraying revealed that spinosad (0.015%), thiodicarb (0.075%), chlorpyriphos (0.05%) and profenophos (0.05%) with a mean reduction of 93.10, 91.70, 89.92 and 89.79 per cent, respectively stood first and were on par followed by cartap hydrochloride (0.05%) with 87.12 per cent mean reduction. The least effective chemicals were *B.t.* (0.2%) and neem oil (0.5%) with 66.86 and 64.26 per cent reduction, respectively and the treatments were on par. The treatments that followed the effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) which were on par and moderate in efficacy. However the treatment cartap hydrochloride (0.05%) was found on par with the best treatment chlorpyriphos (0.05%). All the treatments were statistically significant in reduction of population over control.

The best treatments at 20 days after spraying were spinosad (0.015%), thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) with a mean population reduction of 86.49, 83.08, 82.44, 82.40 and 81.49 per cent, respectively and were found to be on par followed by chlorpyriphos (0.025%) + neem oil (0.25%), *B.t.* (0.2%), neem oil (0.5%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with 69.38, 63.25, 62.95 and 62.53 per cent reduction, respectively and were on par with each other. However all the chemical treatments were superior over the control.

Post-treatment count at 30 days after spraying revealed that all the treatments were superior over control in reducing the larval population and the efficacy of all treatments decreased considerably. The best treatments that were on par were spinosad (0.015%), profenophos (0.05%), thiodicarb (0.075%), chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) with a mean reduction of 73.97, 73.85, 69.49, 66.91 and 66.22 per cent, respectively. The least effective chemicals were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 48.93 and 48.26 per cent, respectively and were on par with each other. The treatments with moderate efficacy were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par and in turn these treatments were on par with the best treatment cartap hydrochloride (0.05%).

Considering the overall efficacy after second round of spray it was observed that all the insecticidal treatments were superior over control. Among the tested chemicals spinosad (0.015%), profenophos (0.05%) and thiodicarb (0.05%) were best with a mean per cent reduction of 87.03, 84.73 and 84.61 per cent, respectively and these treatments were on par with each other. Chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) were next best chemicals and also on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with 61.89 and 60.09 per cent reduction, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with a mean reduction of 71.92 and 68.69 per cent, respectively. These treatments were on par and moderate in efficacy. However the treatments chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) were on par with the best treatment profenophos (0.05%).

**Third spray**

The efficacy of insecticidal spray given as third application are presented in Table 6 and Fig.4.

The pre treatmental counts were taken one day before spraying and the data revealed that the mean larval population ranged between 9.66 to 12.66 per four square meters and there was no significant difference between the treatments.

It was observed from the table 6, the best treatments at 5 days after spraying were spinosad (0.015%), chlorpyriphos (0.05%) cartap hydrochloride (0.05%), thiodicarb (0.05%) and profenophos (0.05%) with a mean per cent reduction of 94.38, 92.13, 92.11, 92.10 and 91.67, respectively and the treatments were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 70.11 and 69.86 per cent, respectively and the treatments were on par with each other.

The treatments with moderate efficacy were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) which on par and gave more than 80% reduction. However all the treatments were statistically significant in reduction of larval population.

The data at 10 days after third application showed that the best treatments were spinosad (0.015%), cartap hydrochloride (0.05%), chlorpyriphos (0.05%), profenophos (0.05%) and thiodicarb (0.05%) with a mean reduction in larval population to the extent 91.35, 90.73, 90.31, 89.57 and 89.49 per cent, respectively and the treatments were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a reduction of 68.46 and 66.70 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%)+ *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy. However all the treatments were statistically superior in reduction of population over control.

The best treatments which were on par at 20 days after spraying were spinosad (0.015%), profenophos (0.05%), chlorpyriphos (0.05%), thiodicarb (0.075%) and cartap hydrochloride (0.05%) with a mean reduction of 79.20, 78.32, 77.29, 74.77 and 74.62 per cent, respectively. The least effective treatments that were on par were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 65.30 and 64.59 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + *B.*t (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy. However the combination treatments chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par with thiodicarb (0.075%). All the treatments were significantly superior over control.

The post treatment counts at 30 days after third spray revealed that all the treatments were significantly superior over control and the efficacy of the treatments waned off slowly as day passed by. But still some efficacy was observed and the best treatments were spinosad (0.015%), thiodicarb (0.075%), profenophos (0.05%) and cartap hydrochloride (0.05%) with a mean reduction of 69.89, 68.56, 67.65 and 66.51 per cent, respectively and the treatments were on par with each other. Chlorpyriphos (0.05%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with 61.35 and 60.80 per cent reduction was next best treatments. The least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with mean reduction of 54.28 and 54.22 per cent, respectively. The treatment that followed the effective chemicals was chlorpyriphos (0.025%) + neem oil (0.25%) which was moderate in efficacy. However, the treatments chlorpyriphos

(0.05%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par with cartap hydrochloride (0.05%), chlorpyriphos (0.025%) + neem oil (0.25%) was on par with chlorpyriphos (0.025%) + *B.t.* (0.1%) and neem oil (0.5%) and *B.t.* (0.2%) were on par with the combination of chlorpyriphos (0.025%) + neem oil (0.25%).

The overall efficacy after third application indicated that all the insecticidal treatments were superior over control. Among the tested chemicals spinosad (0.015%), profenophos (0.05%), thiodicarb (0.075%), cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) with a mean per cent reduction of 83.70, 81.80, 81.23, 80.88 and 80.27, respectively proved the best which were on par while the least effective chemicals were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 64.34 and 64.03 per cent, respectively. The treatments that followed the best effective chemicals were combination treatments *viz*., chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) with a mean reduction of 72.07 and 71.99 per cent, respectively which were on par and moderate in efficacy.

The cumulative efficacy of insecticidal treatments after three applications against leaf and blossom webber revealed that all the insecticidal treatments were significantly superior to control. It was observed from the table 7 and fig.3, the best treatments were spinosad (0.015%), thiodicarb (0.075%) and profenophos (0.05%)

with a mean per cent reduction of 86.13, 83.69 and 83.69 per cent, respectively and the treatments were on par with each other. Chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) with a mean reduction of 81.45 and 81.44 per cent were the next best chemicals which were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 60.80 and 60.70 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with a mean reduction 71.58 and 60.80 per cent, respectively which were on par and moderate in efficacy. However, the treatments chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) were found on par with the best effective treatments thiodicarb (0.075%) and profenophos (0.05%) in checking the larval population of leaf and blossom webber after three rounds of spraying.

### 4.2.2 Effect of Insecticides on Shoot Tip and Inflorescence Caterpillar

**First spray**

The efficacy of various insecticidal treatments in bringing down the cashew shoot tip and inflorescence caterpillar population are presented in table 8. Pre treatmental counts were taken one day before spraying and the data revealed that the shoot tip and inflorescence caterpillar population ranged between 11.66 to 18.00

per four square meters and there was no significant difference between the treatments.

The post treatment count at 5 days after first application revealed that the best treatments were thiodicarb (0.075%), profenophos (0.05%), spinosad (0.015%), cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) with a mean larval reduction of 95.68, 94.16, 94.03, 93.69 and 93.52 per cent, respectively and the treatments were on par with each other. The least effective chemicals were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 74.91 and 75.93 per cent, respectively. The treatments that followed the best treatments were chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy. However all the treatments were statistically significant in reduction of larval population over control.

The post treatment counts at 10 days after first spray showed that the best treatments were thiodicarb (0.015%), spinosad (0.015%), profenophos (0.05%), cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) with a mean per cent reduction of 89.88, 89.06, 88.76, 88.21 and 87.78, respectively while the least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 73.54 and 72.27 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + *B. t* (0.1%) and chlorpyriphos (0.05%) +

neem oil (0.25%) which were on par and found moderate in efficacy. However all the treatments were statistically significant in reduction of larval population over control.

The efficacy of the insecticidal treatments 20 days after spraying showed that all the treatments were statistically superior over control. The best treatments were thiodicarb (0.075%), profenophos (0.05%) and spinosad (0.015%) with a mean reduction of 80.76, 78.76 and 77.75 per cent, respectively and the treatments were on par with each other. Cartap hydrochloride (0.05%) with 76.10 per cent reduction was found the next best treatment. The least effective chemicals were *B.t.* (0.2%) and neem oil (0.5%) which gave 66.13 and 63.01 per cent reduction over control. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%), chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.05%) with 72.39, 72.25 and 71.53 per cent reduction which were moderate in efficacy. However, cartap hydrochloride (0.05%) was on par with spinosad (0.015%) while combination treatments were on par with cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) was on par with chlorpyriphos (0.025%) + *B.t.* (0.1%) combination.

The data observed at 30 days after spraying showed that all the insecticidal treatments were significantly superior over control and the efficacy was decreased gradually. The best treatments at

30 days after spraying, were thiodicarb (0.075%), chlorpyriphos (0.05%), spinosad (0.015%), cartap hydrochloride (0.05%), profenophos (0.05%), chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) with 54.36, 51.97, 51.75, 51.23, 50.39, 50.33 and 50.21 per cent mean reduction and the treatments were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 34.73 and 30.75 per cent which were on par with each other.

The overall efficacy after first application showed that all the treatments were significantly superior over check. The highest reduction in larval population was observed with thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) with a mean per cent reduction of 80.17, 78.14 and 78.01 per cent, respectively which were on par with each other. These were closely followed by the treatments cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) with 77.31 and 76.20 per cent mean reduction and the treatments were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with 61.96 and 60.78 per cent reduction and were on par. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) with a mean reduction of 72.05 and 71.84 per cent which were on par and moderate in efficacy. However chlorpyriphos (0.05%) was on par with the best treatment profenophos (0.05%) in bringing down the larval population.

**Second spray**

The efficacy of insecticidal treatments given as second application are presented in table 9. The pre treatmental counts were taken one day before spraying and the data revealed that larval population ranged between 14.33 to 16.66 on four square metres and there was no significant difference between the treatments.

The post treatmental count at 5 days after spraying revealed that the best treatments were thiodicarb (0.075%), spinosad (0.015%), profenophos (0.05%), chlorpyriphos (0.05%) and cartap hydrochloride (0.05%)with 95.93, 94.16, 94.06, 93.95 and 93.37 per cent mean reduction and the treatments were on par with each other. The least effective chemicals were neem oil (0.5%) and *B.t.* (0.2%) with mean reduction of 69.24 and 67.01 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) +*B.t.* (0.1%) which were on par and moderate in efficacy. However all the insecticidal treatments were significantly superior over control.

The post treatmental count at 10 days after second application revealed that the best treatments were thiodicarb

(0.075%), spinosad (0.015%), profenophos (0.05%), chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) with a mean per cent reduction of 88.63, 87.62, 86.42, 86.36 and 84.25, respectively and the treatments were on par with each other. The least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 63.28 and 60.37 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy. However all the treatments were statistically significant in reduction of larval population over control.

The efficacy of insecticides 20 days after second spray revealed that the best treatments were thidocarb (0.075%), profenophos (0.05%) and spinosad (0.015%) with a mean per cent reduction of 77.39, 76.60 and 75.91, respectively and the treatments were on par with each other. The least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 59.20 and 58.49 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.05%), chlorpyriphos (0.025%) + neem oil (0.25%), cartap hydrochloride (0.05%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with a mean reduction of 67.02, 65.93, 65.91and 65.25 per cent, respectively which were on par and moderate in efficacy.

However all the treatments were statistically significant in reduction of population over control.

The efficacy of insecticides 30 days after spraying revealed that all the treatments were significantly superior over control and the efficacy decreased as days passed by. The best treatments were thiodicarb (0.075%), chlorpyriphos (0.05%), profenophos (0.05%), cartap hydrochloride (0.05%), spinosad (0.015%), chlorpyriphos (0.025%) + neem oil (0.25%) with 57.65, 55.70, 54.80, 54.60, 54.37 and 53.56 per cent reduction, respectively and the treatments were on par with each other. The least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with a mean per cent reduction of 36.02 and 34.46, respectively. The treatment that followed the best effective treatment was chlorpyriphos (0.025%) + *B.t.* (0.1%) which was on par with chlorpyriphos (0.025%) + neem oil (0.25%) and found moderately effective against shoot tip and inflorescence caterpillar.

The overall efficacy after second application indicated that all the insecticidal treatments were superior over control. Among the tested chemicals, the best treatments were thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) with a mean per cent reduction of 79.90, 78.02 and 78.00, respectively and the treatments were on par with each other. The treatments that followed the descending order of efficacy were chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) with 75.75 and 74.54

per cent mean reduction, respectively while the least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with 56.93 and 55.08 per cent mean reduction, respectively. The treatments that followed the best effective treatments were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with a mean reduction of 70.12 and 69.55 per cent which were on par and moderate in efficacy. However the treatments chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) were on par with the best treatment spinosad (0.015%) after second spray against shoot tip and inflorescence caterpillar.

**Third Spray**

The efficacy of insecticidal treatments after third application are presented in the table 10. Pre treatmental counts were taken on day before spraying and the data revealed that the larval population ranged between 9.66 to 13.66 per four square meters and there was no significant difference between the treatments.

The post treatmental count at 5 days after third spray revealed that the best treatments were thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.05%), chlorpyriphos (0.05%) and spinosad (0.015%) with a mean per cent reduction of 95.32, 94.11, 93.25, 92.87 and 91.40, respectively and the treatments were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 65.19 and 64.78 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) which were on par and moderate in efficacy. However, all the treatments were statistically significant in reduction of larval population over control.

The data at 10 days after spraying revealed thiodicarb (0.075%), profenophos (0.05%), chlorpyriphos (0.05%), spinosad (0.015%) and cartap hydrochloride (0.05%) as the best treatments with a mean per cent reduction of 90.57, 88.49, 87.34, 87.25 and 86.08, respectively and the treatments were on par with each other. The least effective treatments were neem oil (0.5%) and *B.t.* (0.2%) with 62.29 and 60.15 per cent mean larval reduction, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) which were on par and moderate in efficacy. However all the treatments were significantly superior over control.

The best treatments observed at 20 days after spraying include thiodicarb (0.075%), spinosad (0.015%), chlorpyriphos (0.05%), cartap hydrochloride (0.05%) and profenophos (0.05%) with a mean per cent reduction of 75.40, 74.66, 74.64, 70.60 and 69.23, respectively and the treatments were on par with each other. The rest of the treatments *viz*., chlorpyriphos (0.025%) + neem oil (0.25%), chlorpyriphos (0.025%) + *B.t.* (0.1%), neem oil (0.5%) and *B.t.* (0.2%) were on par with each other with moderate efficacy. However all the treatments were significantly superior over control.

The data observed at 30 days after spraying showed that all the insecticidal treatments were significantly superior over control and the efficacy decreased as days passed by. The best treatments were thiodicarb (0.075%), spinosad (0.015%), chlorpyriphos (0.05%), profenophos (0.05%) and cartap hydrochloride (0.05%) with a mean per cent reduction of 54.26, 51.04, 50.69,50.62 and 48.86, respectively and the treatments were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with mean reduction of 27.34 and 24.57 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) which were on par and moderate in efficacy. However the treatments chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par with best treatment cartap hydrochloride (0.05%).

The overall efficacy after third spraying indicated that the all the insecticidal treatments were significantly superior over control in bringing down the larval population of shoot tip and inflorescence caterpillar. Among the tested chemicals the best treatments were thiodicarb (0.075%), chlorpyriphos (0.05%) and spinosad (0.015%) with a mean per cent reduction of 78.89, 76.24 and 76.08, respectively and the treatments were on par with each other. Next in the descending order of efficacy were profenophos (0.05%) and cartap hydrochloride (0.05%) with 75.61 and 74.68 per cent mean reduction which were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 49.94 and 49.69 per cent, respectively. The combinations that followed the best effective chemicals were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with a mean reduction of 62.51 and 61.43 per cent which were on par and moderate in efficacy. However the treatments profenophos (0.05%) and cartap hydrochloride (0.05%) were on par with spinosad (0.015%).

The cumulative efficacy of insecticide treatments after three applications showed that all the treatments were significantly superior over control. It was observed from the table 11 and fig.4. the best treatment was thiodicarb (0.075%) with 79.65 per cent mean larval reduction. The treatments that closely followed in the descending order of efficacy were spinosad (0.015%), profenophos (0.05%), chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) with a mean per cent reduction of 77.41, 77.20, 76.06 and 75.51, respectively and these treatments were on par with each other. The least effective chemicals were neem oil (0.5%) and *B.t.* (0.2%) with a mean reduction of 55.80 and 55.66 per cent, respectively. The treatments that closely followed the best effective treatments were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) with 68.15 and 67.68 per cent reduction and the treatments were on par and found moderate efficacy in bringing down the shoot tip and inflorescence caterpillar population.

### 4.2.3 Effect of Insecticides on Apple and Nut Borer.

The efficacy of various insecticidal treatments in bringing down the cashew apple and nut borer are presented in table 12 and fig.4. Pre treatmental counts were taken one day before spraying. The data revealed that the larval population ranged between 10.21 to 12.33 on an average per four square meters and there was no significant difference between the treatments.

The data at 5 days after imposing treatments revealed that the best treatments were thiodicarb (0.075%), spinosad (0.015%), chlorpyriphos (0.05%), cartap hydrochloride (0.05%) and profenophos (0.05%) with a mean per cent reduction of 66.42, 64.10, 63.85, 63.75 and 62.90, respectively and the treatments were on par with each other. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 37.37

and 35.55 per cent, respectively. The treatments that followed the best effective treatments were chlorpyriphos (0.025%) +*B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy. However all the treatments were statistically significant in reduction of larval population over control.

The data at 10 days after third spraying revealed that thiodicarb (0.075%), spinosad (0.015%), profenophos (0.05%), cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) were the best effective treatments with a mean per cent reduction of 63.06, 62.08, 60.70, 60.35 and 59.37, respectively and the best treatments were on par with each other while the least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with mean reduction of 35.54 and 34.85 per cent, respectively. The treatments that followed the most effective treatments were chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) that were on par and moderate in efficacy. However all the insecticidal treatments were statistically superior over control.

The efficacy of various insecticidal treatments at 20 days after spraying revealed the best treatments as thiodicarb (0.075%), spinosad (0.015%), profenophos (0.05%), chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) with a mean per cent reduction of 57.41, 56.80, 55.91, 53.99 and 52.10, respectively and the treatments were on par with each other. The rest of the chemicals that were on par were chlorpyriphos (0.025%) + *B.t.* (0.1%), chlorpyriphos (0.025%) + neem oil (0.25%), *B.t.* (0.2%) and neem oil (0.5%) with a reduction of 35.76, 35.48, 34.40 and 32.16 per cent, respectively. However all the treatments were statistically superior over control.

The efficacy of the insecticidal treatments at 30 days after spraying showed that all the treatments were significantly superior over control and the efficacy was decreased considerably. Among the tested chemicals, the best treatments were thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) with a mean per cent reduction of 45.13, 44.99 and 44.33, respectively and the treatments were on par with each other followed by the rest of the treatments *viz*., cartap hydrochloride (0.05%), chlorpyriphos (0.025%) + neem oil (0.25%), chlorpyriphos (0.05%), chlorpyriphos (0.025%) + *B.t.* (0.1%), neem oil (0.5%) and *B.t.* (0.2%) with 32.70, 30.85, 30.80, 30.14, 29.92 and 28.01 per cent larval reduction over control, respectively and these treatments were on par with each other.

The overall efficacy after third application showed that all the insecticidal treatments were significantly superior over control. Among the tested chemicals thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) were superior with a mean per cent reduction of 58.00, 56.99 and 55.95, respectively and the treatments were on par with each other. The next best treatments were cartap hydrochloride (0.05%) and chlorpyriphos (0.05%) and these treatments were on par. The least effective treatments were *B.t.* (0.2%) and neem oil (0.5%) with a mean reduction of 33.81 and 33.27 per cent, respectively. The treatments that followed the best effective chemicals were chlorpyriphos (0.025%) + *B.t.* (0.1%) and chlorpyriphos (0.025%) + neem oil (0.25%) which were on par and moderate in efficacy with a mean reduction of 41.51 and 40.15 per cent. However, the treatments chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) were on par with the best effective treatment profenophos (0.05%) in bringing down the larval population after third spray against apple and nut borer.

## 4.3 OCCURRENCE OF NATURAL ENEMIES

The results of the investigation from June, 2004 to May, 2005 on occurrence of natural enemies and their correlation with weather parameters are presented in the Tables 1,2,3 and fig.2.

### 4.3.1 Spiders

The spiders population was noticed throughout the year from June, 2004 to May, 2005, except during 3$^{rd}$ week of May. The spider population varied between 1 to 20 per twelve trees. The maximum population (20 spiders/12 trees) was observed during last week of February when the maximum and minimum temperatures were 31.5 and 20.0$^0$C, respectively, morning and evening relative humidities were 87.5 and 67.0 per cent with no rainfall. No population was observed during 3rd week of May when the maximum and minimum temperatures were 39.6 and 28.2$^0$C, respectively, morning and evening relative humidities were 58.2 and 51.5 per cent with no rainfall.

A significant negative correlation was observed between spider incidence and maximum (r=-0.4449*) and minimum (r=-0.5805*) temperatures whereas significant positive correlation was noticed with morning relative humidity(r=0.4344*).All the remaining abiotic factors were found to be non-significant (Table 2).

The data on spider incidence when subjected to multiple linear regression, the following equation was achieved.

$$Y = 19.1234 + 0.0319X_1 - 0.6594X_2 + 0.0182X_3 - 0.0301X_4 - 0.0157X_5 + 0.2649X_6$$

It was observed that the coefficient of determination ($R^2$) for spider incidence was 0.3508 which shows that the climatic factors together were able to explain the variation in the incidence to the extent of 35.08 out of 100. However all the partial regression coefficients were found to be non-significant (Table 3).

### *4.3.2 Bracon brevicornis* Wlk.

Larval parasitization *Bracon brevicornis* Wlk. was observed on leaf and blossom webber during the last week of November 2004 and continued upto the last week of February 2005. Parasitization ranged between 1.92 to 11.50 per cent and the highest parasitization (11.50%) was observed during second week of January, when the maximum and minimum temperatures were 30.3$^0$C and 18.0$^0$C, respectively, morning and evening relative humidities were 90.0 and 67.2 per cent with no rainfall. The lowest parasitization (1.92%) was observed during the last week of February when the maximum and minimum temperatures were 31.5$^0$C and 20.0$^0$C, respectively, morning and evening relative humidities were 87.8 and 67.0 per cent with no rainfall.

The correlation between *Bracon brevicornis* Wlk. incidence and maximum (r=-0.5873*) and minimum (r=-0.8075*) temperatures were negatively significant, while positively significant with morning relative humidity (r=0.5633*). All the remaining abiotic factors were found to be non-significant (Table 2).

The regression model for the parasitization was given as

$$Y = 26.8316 - 0.1914X_1 - 0.6609^*X_2 + 0.0562X_3 - 0.1116X_4 + 0.0005X_5 - 0.4628X_6.$$

It was observed that co-efficient of determination ($R^2$ = 69.76) was able to explain the variation in the infestation to the extent of 69.76 out of 100 and the partial regression co-efficient for minimum temperature was found to be negative and significant, while other abiotic factors were non-significant.

### 4.3.3 Effect of Insecticides on Natural Enemies (spiders)

**First spray**

The effect of insecticidal treatments on natural enemies (spiders) are presented in table 13. Pre treatmental counts were taken one day before spraying and the data revealed that the spider population ranged between 1.66 to 2.66 on an average on four square meters and there was no significant difference between the treatments.

The data at 5 days after first spray revealed that untreated check was on par with neem oil (0.5%) and *B.t.* (0.2%) treatments by recording spider population of 2.33, 2.33 and 2.33, respectively. The remaining treatments namely chlorpyriphos (0.05%), thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.05%), spinosad (0.015%), chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par and recorded no spider population and these insecticides were found harmful to spiders.

The data at 10 days after spraying gave similar trend as observed at 5 DAS with the treatments, untreated check, neem oil (0.5%) and *B.t.* (0.2%) recording 2.66, 2.33 and 2.33 spiders per four square metres area, respectively.

However at 20 days after spraying the combinational treatments chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) joined with other safe treatments namely untreated ckeck, neem oil (0.5%) and *B.t.* (0.1%) which were on par by recording spider population of 2.33, 2.00, 2.33, 2.00 and 2.33, respectively. The remaining treatments proved harmful by recording less number of spider population and these were chlorpyriphos (0.05%), thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.055) and spinosad (0.15%) with 0.66, 0.66, 0.66, 0.66 and 0.66 spiders per four square meters.

However, the data at 30 days after spraying indicated that all the treatments were on par in recording the spider population and there was no significant difference between the treatments including check.

The overall effect of the insecticidal treatments after first spray revealed that the untreated check was on par with *B.t.* (0.2%) and neem oil (0.5%) treatments by recording spider population of 2.50, 2.33 and 2.25, respectively. The highest negative effect was with the treatment profenophos (0.05%) which had recorded 0.66 spiders per four square metres and all remaining treatments were moderately harmful and on par with each other.

**Second spray**

The effect of insecticidal treatments, after second round application against spiders are presented in table 14.

Pre treatmental counts were taken one day before spraying and the data revealed that the spider population ranged between 1.33 to 2.66 on an average on four square meters and there was no significant difference between the treatments.

The data at 5 days after spraying revealed that untreated check was on par with *B.t.* (0.2%) and neem oil (0.5%) by recording spider population of 2.66, 2.66 and 2.33, respectively. The remaining treatments namely chlorpyriphos (0.05%), thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.05%), spinosad (0.01%), chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par and recorded no spider population indicating the harmful effect of these insecticides on spiders.

At 10 days after spraying, similar trend was observed with untreated check, *B.t.* (0.2%) and neem oil (0.5%) only recording spider population to the extent of 2.33, 2.66 and 2.33 spiders per four square meters, respectively.

However the data at 20 days after spraying indicated that the combination treatments chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) and *B.t.* (0.1%) joined with other safe treatments namely untreated check, neem oil (0.5%) and *B.t.* (0.2%) by recording spider population of 2.33, 2.00, 2.66, 2.33 and 2.33, respectively which were found on par. The other treatments chlorpyriphos (0.05%), thiodicarb (0.075%), profenophos (0.05%) and cartap hydrochloride (0.05%) recorded a population of 0.33, 0.66, 0.66 and 0.66 spiders, respectively and these treatments were on par.

The data at 30 days after spraying revealed that all the treatments were on par in recording the spider population and there was no significant difference between the treatments.

Considering overall efficacy after second spraying it was observed that the untreated check was on par with *B.t.* (0.2%) and neem oil (0.5%) by recording spider population of 2.58, 2.50 and 2.25, respectively. The most harmful treatments was chlorpyriphos (0.05%) with spider population of 0.66. The remaining treatments were moderately harmful and on par with each other. However, the harmful treatment chlorpyriphos (0.05%) was on par with profenophos (0.05%) in recording the spider population.

**Third spray**

The effect of insecticidal treatments after third spraying are presented in table 15.

The pre treatmental counts were taken one day before spraying and the data revealed that the spider population ranged between 2.00 to 3.00 on an average in four square meters and there was no significant difference between the treatments.

The data at 5 days after spraying revealed that the untreated check was on par with neem oil (0.5%) and *B.t.* (0.2%) by recording the spider population of 2.33, 2.00 and 1.66, respectively. The remaining treatments *viz*., chlorpyriphos (0.05%), thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.05%), spinosad (0.015%), chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) were on par and recorded no spider population indicating the harmful effect of these insecticides on spider population.

The data at 10 days after spraying revealed similar trend with the treatments, untreated check, neem oil (0.5%) and *B.t.* (0.2%) recording 2.66, 2.66 and 2.33 spiders per four square meters, respectively.

However at 20 days after spraying, the combinational treatments chlorpyriphos (0.025%) + *B.t.* (0.1%), chlorpyriphos

(0.025%) + neem oil (0.25%) and cartap hydrochloride (0.05%) joined with other safe chemicals namely untreated check, neem oil (0.5%) and *B.t.* (0.1%) by recording the spider population of 2.33, 2.00, 1.00, 2.33, 2.33, 2.00 and 2.33, respectively. The most harmful treatments were spinosad (0.015%) with 0.33 spider population. The moderately harmful treatments were chlorpyriphos (0.05%), thiodicarb (0.075%) and profenophos (0.05%) with 0.66, 0.66 and 0.66 spider population and the treatments were on par with each other.

The data at 30 days after spraying indicated that all the treatments were on par with each other in recording the spider population and there was no significant difference between the treatments.

The overall effect of insecticidal treatments after third spraying revealed that the untreated check was on par with neem oil (0.5%) and *B.t.* (0.2%) by recording 2.50, 2.33 and 2.16 spider population while the most harmful treatments were chlorpyriphos (0.05%), thiodicarb (0.075%), profenophos (0.05%) and spinosad (0.015%) with a spider population of 0.75, 0.75, 0.75 and 0.66, respectively and the treatments were on par with each other. The remaining treatments were moderately harmful and were on par with each other.

The cumulative effect of various insecticidal treatments after three applications revealed that the untreated check was on par with neem oil (0.5%) and *B.t.* (0.2%) by recording spider population of 2.52, 2.27 and 2.33, respectively. The harmful treatments were chlorpyriphos (0.5%), thiodicarb (0.075%), profenophos (0.05%), cartap hydrochloride (0.05%) and spinosad (0.01%) by recording 0.69, 0.74, 0.72, 0.77 and 0.77 spiders, respectively and the treatments were on par with each other. The combination treatments were chlorpyriphos (0.025%) + neem oil (0.25%) and chlorpyriphos (0.025%) + *B.t.* (0.1%) that were on par and moderately harmful to spiders (table 16 and fig.6).

Leaf and blossom webber (Infesting shoot)

Leaf and blossom webber ( Infesting inflorescence)

**Leaf folder**

**Apple and nut borer**

ANB

| | 5 DAT | 10 DAT | 20 DAT | 30 DAT | Overall |
|---|---|---|---|---|---|
| T1 | 63.85 | 59.37 | 53.99 | 30.8 | 52 |
| T2 | 66.42 | 63.06 | 57.41 | 45.13 | 58 |
| T3 | 62.9 | 60.7 | 55.91 | 44.33 | 55.95 |
| T4 | 63.75 | 60.35 | 52.1 | 32.7 | 52.22 |
| T5 | 64.1 | 62.08 | 56.8 | 44.99 | 56.99 |
| T6 | 35.55 | 34.85 | 32.16 | 29.92 | 33.27 |
| T7 | 37.37 | 35.54 | 34.4 | 28.01 | 33.81 |
| T8 | 48.66 | 45.99 | 35.48 | 30.85 | 40.15 |
| T9 | 50.48 | 49.75 | 35.76 | 30.14 | 41.51 |
| T10 | 0 | 0 | 0 | 0 | 0 |

**Fig. 5 Efficacy of treatments against *N. eugraphella* on cashew during 2004-05**

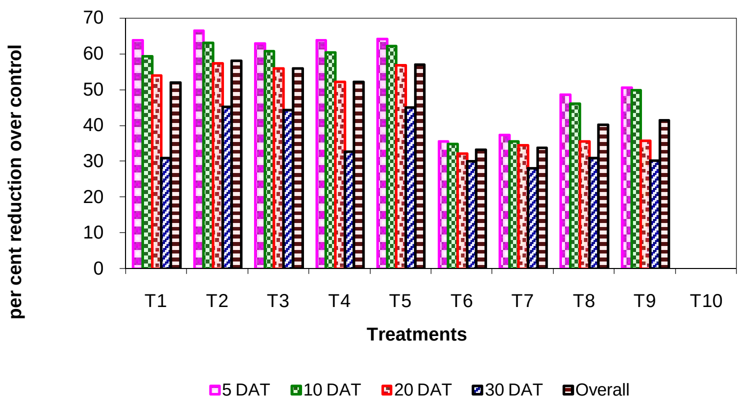
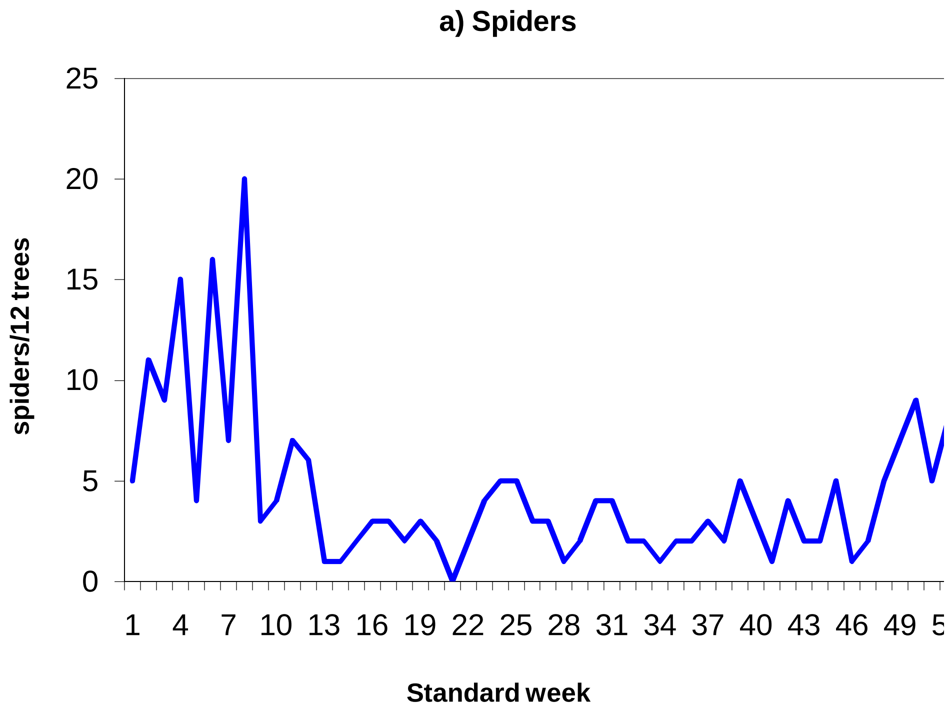


**Fig.2 Seasonal incidence of natural enemies on cashew during 2004-(**



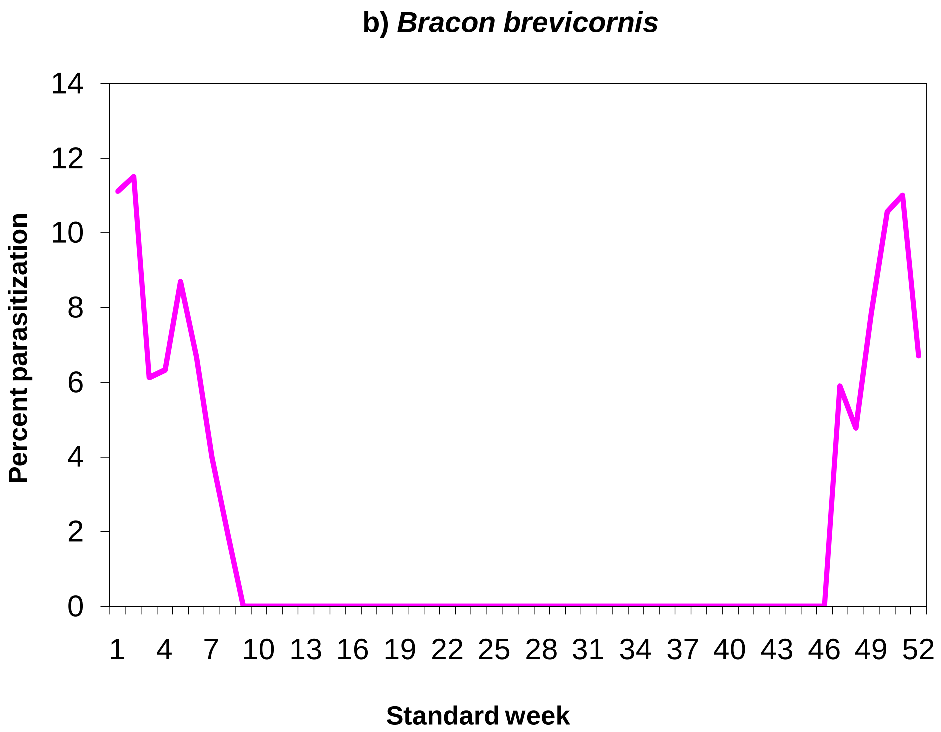



**Fig. 1 Seasonal incidence of lepidopteran pests on cashew during 2004-05**

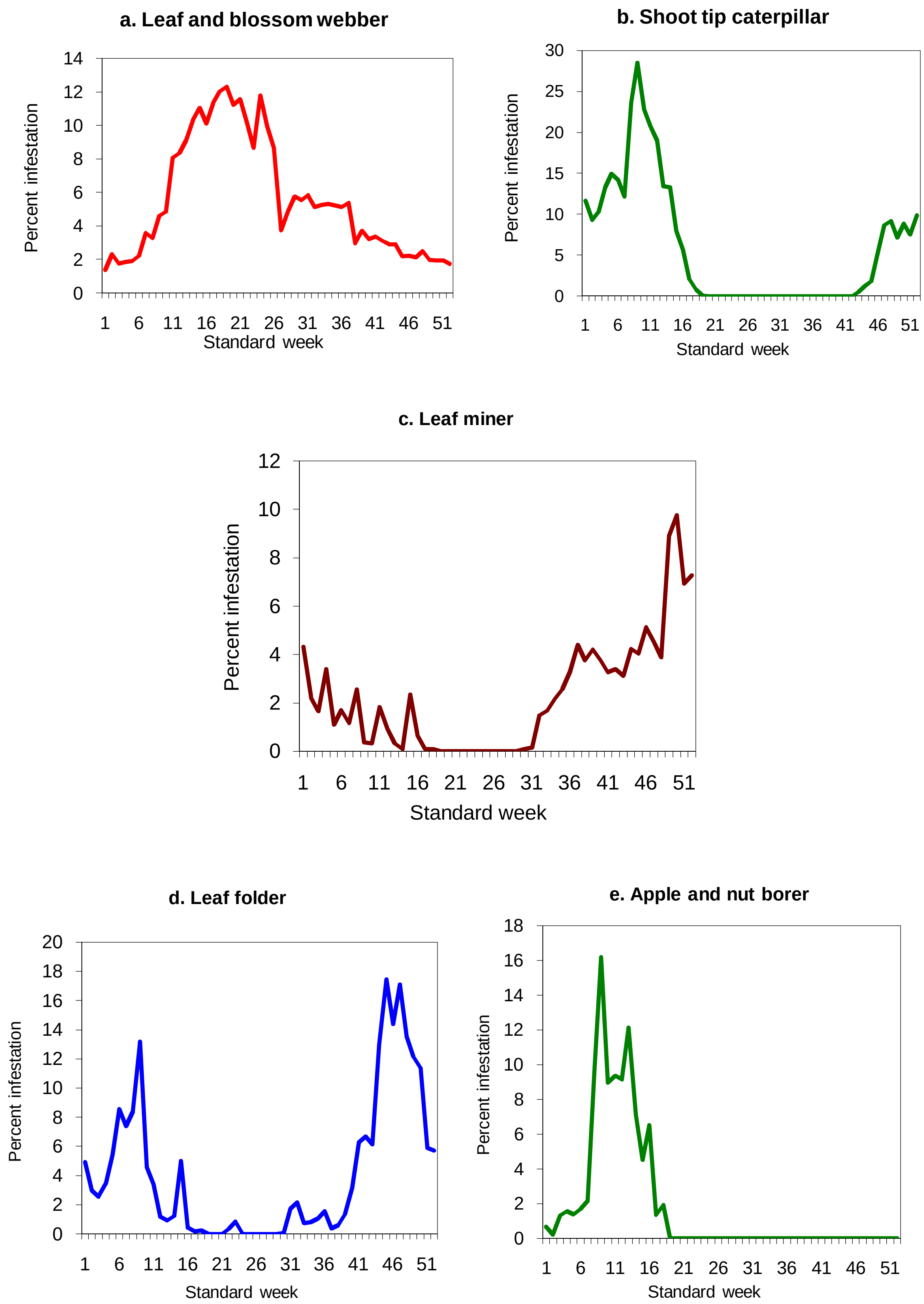


Plate 1 : Leaf and blossom webber (Infesting shoot)

Plate 2 : Leaf and blossom webber ( Infesting inflorescence)

Plate 3 : Shoot tip and inflorescence caterpillar

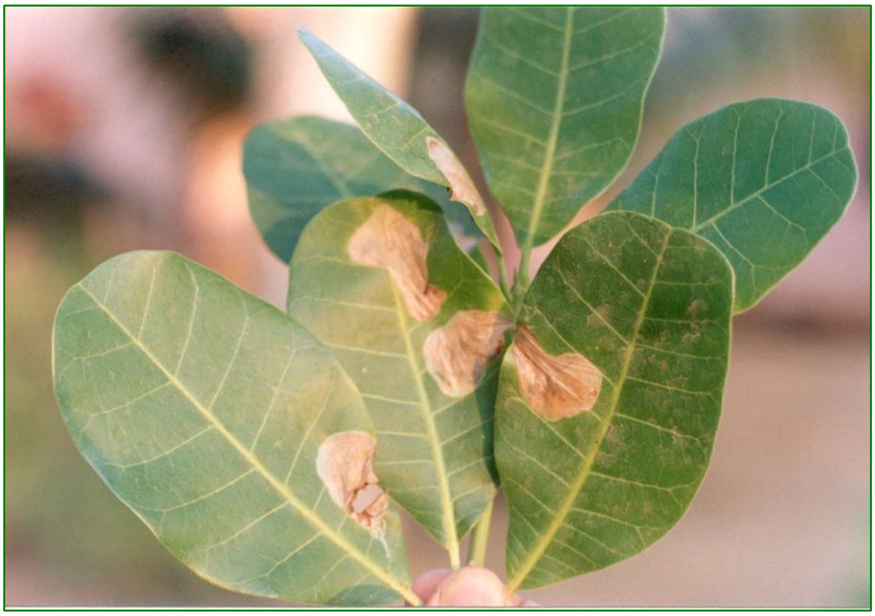


Plate 4 : Leaf miner

**Plate 5 : Leaf folder**

**Plate 6 : Apple and nut borer**

**Table1 : Influence of weather parameters on population fluctuation of major lepidopteran pests and natural enemies in cashew ecosystem during 2004-05**

| Standard week | Period | R.F (mm) | Rainy days | Temp ($^0$C) | | R.H (%) | | LBW% | STC% | ANB% | LM% | LF% | Spiders per 12 trees | *Bracon sp* % parasitization |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Max. | Min. | M | E | | | | | | | |
| 1 | Jan1-7 | - | - | 30.0 | 18.1 | 92.1 | 68.5 | 1.38 | 11.66 | 0.65 | 4.31 | 4.93 | 5 | 11.10 |
| 2 | 8-14 | - | - | 30.3 | 18.0 | 90.0 | 67.2 | 2.30 | 9.33 | 0.20 | 2.21 | 2.98 | 11 | 11.50 |
| 3 | 15-21 | - | - | 30.2 | 17.3 | 93.7 | 69.2 | 1.76 | 10.24 | 1.30 | 1.66 | 2.55 | 9 | 6.11 |
| 4 | 22-28 | 2.7 | 1 | 30.4 | 19.8 | 92.7 | 74.2 | 1.83 | 13.30 | 1.56 | 3.38 | 3.46 | 15 | 6.33 |
| 5 | Jan 29-Feb.4 | 3.0 | 1 | 29.7 | 20.0 | 88.0 | 70.5 | 1.92 | 14.97 | 1.38 | 1.09 | 5.42 | 4 | 8.69 |
| 6 | 5-11 | - | - | 31.0 | 17.8 | 91.7 | 69.4 | 2.21 | 14.16 | 1.68 | 1.70 | 8.55 | 16 | 6.66 |
| 7 | 12-18 | - | - | 33.2 | 19.4 | 78.2 | 63.8 | 3.57 | 12.19 | 2.15 | 1.16 | 7.38 | 7 | 4.00 |
| 8 | 19-25 | - | - | 31.5 | 20.0 | 87.5 | 67.0 | 3.26 | 23.64 | 9.59 | 2.55 | 8.39 | 20 | 1.92 |
| 9 | Feb 26-Mar.4 | - | - | 33.0 | 19.3 | 89.7 | 63.7 | 4.60 | 28.51 | 16.19 | 0.37 | 13.17 | 3 | - |
| 10 | 5-11 | - | - | 32.4 | 21.3 | 76.8 | 72.4 | 4.85 | 22.81 | 8.97 | 0.33 | 4.59 | 4 | - |
| 11 | 12-18 | - | - | 33.0 | 22.8 | 81.2 | 72.1 | 8.07 | 20.79 | 9.36 | 1.83 | 3.42 | 7 | - |
| 12 | 19-25 | - | - | 32.8 | 23.9 | 78.5 | 72.1 | 8.36 | 19.00 | 9.14 | 0.92 | 1.16 | 6 | - |
| 13 | Mar.26- April1 | - | - | 33.4 | 26.3 | 79.5 | 79.7 | 9.12 | 13.44 | 12.13 | 0.33 | 0.91 | 1 | - |
| 14 | 2-8 | - | - | 33.8 | 24.1 | 79.8 | 75.2 | 10.31 | 13.28 | 7.12 | 0.08 | 1.25 | 1 | - |
| 15 | 9-15 | - | - | 34.8 | 27.0 | 74.5 | 71.4 | 11.05 | 8.01 | 4.52 | 2.33 | 5.00 | 2 | - |
| 16 | 16-22 | - | - | 34.8 | 26.0 | 75.2 | 68.2 | 10.10 | 5.64 | 6.51 | 0.67 | 0.42 | 3 | - |
| 17 | 23-29 | - | - | 35.9 | 27.4 | 74.1 | 71.5 | 11.32 | 2.09 | 1.33 | 0.08 | 0.17 | 3 | - |
| 18 | April30-May6 | - | - | 32.8 | 25.5 | 76.4 | 72.8 | 12.03 | 0.83 | 1.90 | 0.08 | 0.25 | 2 | - |
| 19 | 7-13 | - | - | 34.7 | 26.4 | 71.5 | 60.2 | 12.31 | 0.06 | - | - | - | 3 | - |
| 20 | 14-20 | - | - | 36.6 | 26.9 | 69.5 | 54.7 | 11.24 | - | - | - | - | 2 | - |
| 21 | 21-27 | - | - | 39.6 | 28.2 | 58.2 | 51.5 | 11.56 | - | - | - | - | - | - |
| 22 | May 28-June3 | 0.5 | - | 35.6 | 26.4 | 74.5 | 65.5 | 10.16 | - | - | - | 0.34 | 2 | - |
| 23 | 4-10 | 74.4 | 2 | 35.8 | 25.4 | 76.4 | 65.5 | 8.65 | - | - | - | 0.84 | 4 | - |
| 24 | 11-17 | 11.9 | 2 | 33.1 | 26.2 | 69.8 | 64.2 | 11.78 | - | - | - | - | 5 | - |
| 25 | 18-24 | - | - | 37.8 | 27.6 | 54.5 | 43.0 | 9.95 | - | - | - | - | 5 | - |
| 26 | June 25- July 1 | 16.9 | 2 | 38.1 | 26.1 | 67.5 | 52.6 | 8.67 | - | - | - | - | 3 | - |

Cont.,

| Standard week | Period | R.F | Rainy days | Temp ($^0C$) | | R.H (%) | | LBW% | STC% | ANB% | LM% | LF% | Spiders per 12 trees | *Bracon sp* % parasitization |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Max. | Min. | M | E | | | | | | | |
| **27** | 2-8 | 31.3 | 2 | 35.4 | 26.0 | 76.1 | 72.7 | 3.74 | - | - | - | - | 3 | - |
| **28** | 9-15 | 215.2 | 3 | 32.3 | 24.3 | 84.7 | 72.5 | 4.85 | - | - | - | - | 1 | - |
| **29** | 16-22 | 5.6 | 1 | 34.4 | 26.5 | 74.4 | 67.1 | 5.75 | - | - | - | - | 2 | - |
| **30** | 23-29 | 33.0 | 3 | 32.1 | 23.6 | 83.1 | 66.4 | 5.53 | - | - | 0.08 | 0.08 | 4 | - |
| **31** | July 30- Aug5 | 15.9 | 3 | 31.9 | 24.6 | 79.1 | 64.1 | 5.83 | - | - | 0.16 | 1.75 | 4 | - |
| **32** | 6-12 | 1.6 | - | 35.5 | 26.5 | 63.5 | 46.4 | 5.12 | - | - | 1.47 | 2.17 | 2 | - |
| **33** | 13-19 | 2.0 | - | 36.7 | 26.9 | 58.0 | 39.5 | 5.24 | - | - | 1.67 | 0.75 | 2 | - |
| **34** | 20-26 | 9.6 | 1 | 37.0 | 26.3 | 61.0 | 50.2 | 5.31 | - | - | 2.16 | 0.83 | 1 | - |
| **35** | Aug 27-Sept2 | - | - | 37.9 | 25.5 | 60.2 | 43.5 | 5.23 | - | - | 2.56 | 1.08 | 2 | - |
| **36** | 3-9 | 32.3 | 2 | 34.0 | 24.8 | 80.5 | 63.5 | 5.14 | - | - | 3.28 | 1.55 | 2 | - |
| **37** | 10-16 | 4.8 | 1 | 34.2 | 24.7 | 75.4 | 60.7 | 5.38 | - | - | 4.39 | 0.39 | 3 | - |
| **38** | 17-23 | 64.2 | 3 | 34.5 | 24.8 | 80.1 | 66.8 | 2.97 | - | - | 3.75 | 0.62 | 2 | - |
| **39** | 24-30 | 11.3 | 2 | 31.9 | 23.7 | 83.5 | 74.8 | 3.71 | - | - | 4.20 | 1.34 | 5 | - |
| **40** | Octo1-7 | 81.8 | 4 | 31.1 | 23.6 | 89.5 | 79.4 | 3.21 | - | - | 3.75 | 3.17 | 3 | - |
| **41** | 8-14 | 0.2 | - | 33.0 | 24.8 | 85.1 | 75.1 | 3.36 | - | - | 3.26 | 6.27 | 1 | - |
| **42** | 15-21 | 24.6 | 1 | 31.6 | 23.2 | 85.1 | 74.1 | 3.12 | - | - | 3.39 | 6.67 | 4 | - |
| **43** | 22-28 | 1.3 | - | 32.2 | 23.4 | 88.1 | 74.1 | 2.90 | 0.49 | - | 3.10 | 6.14 | 2 | - |
| **44** | Oct29-Nov4 | 37.6 | 2 | 29.9 | 22.0 | 88.0 | 79.4 | 2.89 | 1.25 | - | 4.23 | 12.94 | 2 | - |
| **45** | 5-11 | 26.7 | 2 | 28.9 | 21.8 | 94.1 | 85.1 | 2.19 | 1.81 | - | 4.03 | 17.43 | 5 | - |
| **46** | 12-18 | 2.0 | 1 | 31.1 | 21.1 | 93.1 | 74.7 | 2.21 | 5.43 | - | 5.13 | 14.36 | 1 | - |
| **47** | 19-25 | - | - | 30.7 | 18.1 | 88.0 | 69.7 | 2.13 | 8.71 | - | 4.52 | 17.06 | 2 | 5.90 |
| **48** | Nov26-Dec2 | - | - | 30.3 | 17.5 | 84.4 | 63.7 | 2.51 | 9.20 | - | 3.89 | 13.51 | 5 | 4.77 |
| **49** | 3-9 | - | - | 30.1 | 16.8 | 92.0 | 70.7 | 1.98 | 7.18 | - | 8.91 | 12.14 | 7 | 7.84 |
| **50** | 10-16 | - | - | 30.0 | 17.5 | 94.4 | 71.0 | 1.94 | 8.85 | - | 9.76 | 11.37 | 9 | 10.55 |
| **51** | 17-23 | - | - | 30.2 | 17.0 | 93.5 | 65.4 | 1.94 | 7.53 | - | 6.92 | 5.88 | 5 | 11.00 |
| **52** | 24-31 | - | - | 30.8 | 17.3 | 92.7 | 68.6 | 1.73 | 9.89 | - | 7.27 | 5.73 | 8 | 6.70 |

**- : nil**

**Table 2 : Correlation co-efficient between weather parameters and influence of major lepidopteran pests during 2004-05.**

| S.No | Pest | Temperature ($^oC$) | | R.H (%) | | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|---|---|
| | | Max. | Min. | M | E | | |
| 1 | Leaf and blossom webber(% shoot tips infested) | 0.6835* | 0.7574* | -0.6764* | -0.2703 | -0.0844 | -0.1366 |
| 2. | Shoot tip and inflorescence caterpillar (% shoot tips infested) | -0.3978* | -0.5722* | 0.4152* | 0.2703 | -0.3004 | -0.4437* |
| 3 | Leaf miner (% leaves infested) | -0.5563* | -0.6289* | 0.5682* | 0.2424 | -0.1119 | -0.0727 |
| 4 | Leaf folder (% leaves infested) | -0.6386* | -0.6865* | 0.6224* | 0.3807* | -0.1560 | -0.1632 |
| 5 | Apple and nut borer (% nuts infested) | -0.0334 | -0.0679 | 0.0879 | 0.2151 | -0.1994 | -0.3258 |
| 6 | Spider population (per 12 trees) | -0.4449* | -0.5805* | 0.4344* | 0.1455 | -0.1764 | -0.1514 |
| 7 | *Bracon spp* (% of parasitization) | -0.5873* | -0.8075* | 0.5633* | 0.1179 | -0.2162 | -0.3068 |

**Table 3 : Multiple linear regression model for insect population/ damage in relation to abiotic factors.**

| S.No | Pest | Intercept (A) | Temperature($^0$C) | | R.H (%) | | Rainfall (mm) | Rainy days | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | Max. | Min. | M | E | | | |
| **1** | Leaf and blossom webber (% shoot tips infested) | -10.6209 | 0.2049 | 0.5008 | -0.1313 | 0.1350 | 0.0008 | -0.8761 | 68.86 |
| **2.** | Shoot tip and inflorescence caterpillar (% shoot tips infested) | 20.0821 | 0.9848 | -2.0978* | -0.3553 | 0.4738* | -0.0040 | -1.9785 | 51.19 |
| **3** | Leaf miner (% leaves infested) | 2.8124 | -0.0939 | -0.1191 | 0.1373 | -0.0854 | -0.0086 | 0.1253 | 43.69 |
| **4** | Leaf folder (% leaves infested) | 27.7162 | -0.3223 | -0.6972 | -0.0066 | 0.0611 | -0.0119 | -0.1888 | 50.65 |
| **5** | Apple and nut borer (% nuts infested) | -19.0962 | 0.6181 | -0.3552 | -0.1013 | 0.2650 | 0.0003 | -1.1750 | 24.47 |
| **6** | Spider population (per 12 trees) | 19.1234 | 0.0319 | -0.6594 | 0.0182 | -0.0301 | -0.0157 | 0.2649 | 35.08 |
| **7** | *Bracon spp.* (% of parasitization) | 26.8316 | -0.1914 | -0.6609* | 0.0562 | -0.1116 | 0.0005 | -0.4628 | 69.76 |

**Table 4 : Effect of insecticidal spray on *Lamida moncusalis* Wlk. (First spray)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| $T_1$ : Chlorpyriphos 0.05% | 10.33 | 90.92 (71.92) | 89.42 (71.32) | 81.68 (64.69) | 65.28 (53.91) | 81.67 (64.67) |
| $T_2$ : Thiodicarb 0.075% | 11.66 | 91.20 (72.82) | 90.85 (72.52) | 83.48 (66.07) | 75.39 (60.32) | 85.23 (67.44) |
| $T_3$ : Profenophos 0.05% | 11.33 | 91.20 (72.77) | 88.29 (70.70) | 82.81 (65.69) | 75.06 (60.08) | 84.48 (66.81) |
| $T_4$ : Cartap hydro-chloride 0.05% | 11.33 | 91.37 (73.11) | 87.86 (69.81) | 80.35 (63.74) | 65.77 (54.20) | 81.34 (64.45) |
| $T_5$ : Spinosad 0.015% | 13.00 | 95.35 (79.80) | 91.80 (73.53) | 87.34 (69.16) | 76.15 (60.79) | 87.66 (69.47) |
| $T_6$ : Neem oil 0.5% | 11.66 | 65.17 (53.87) | 63.09 (52.59) | 57.31 (49.21) | 46.40 (42.92) | 57.99 (49.60) |
| $T_7$ : *B.t.* 0.2% | 9.67 | 66.12 (54.40) | 60.47 (51.10) | 57.18 (49.15) | 40.87 (39.66) | 56.19 (48.57) |
| $T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%) | 10.67 | 78.25 (62.25) | 74.89 (59.93) | 66.71 (54.83) | 63.57 (52.88) | 70.85 (57.33) |
| $T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%) | 12.00 | 80.56 (63.87) | 76.47 (61.17) | 66.13 (54.44) | 63.01 (52.58) | 71.51 (57.76) |
| $T_{10}$ : Check | 13.00 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| F -test | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| C.D (p =0.05) | | 6.25 | 5.95 | 5.28 | 5.01 | 3.64 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 5 : Effect of insecticidal spray on *Lamida moncusalis* Wlk. (Second spray)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| **$T_1$ : Chlorpyriphos 0.05%** | 10.33 | 91.46 (73.02) | 89.82 (71.43) | 81.49 (64.59) | 66.91 (54.89) | 82.42 (65.23) |
| **$T_2$ : Thiodicarb 0.075%** | 11.33 | 94.17 (78.55) | 91.70 (73.46) | 83.08 (66.08) | 69.49 (56.67) | 84.61 (67.14) |
| **$T_3$ : Profenophos 0.05%** | 12.33 | 92.85 (74.50) | 89.79 (71.68) | 82.44 (65.24) | 73.85 (59.27) | 84.73 (67.02) |
| **$T_4$ : Cartap hydro-chloride 0.05%** | 12.00 | 92.33 (74.03) | 87.12 (69.12) | 82.40 (65.19) | 66.22 (54.47) | 82.01 (64.91) |
| **$T_5$ : Spinosad 0.015%** | 10.66 | 94.53 (78.90) | 93.10 (74.78) | 86.49 (68.44) | 73.97 (59.33) | 87.03 (68.93) |
| **$T_6$ : Neem oil 0.5%** | 11.66 | 64.92 (53.69) | 64.26 (53.29) | 62.95 (52.51) | 48.26 (44.00) | 60.09 (50.83) |
| **$T_7$ : *B.t.* 0.2%** | 12.00 | 68.53 (55.89) | 66.86 (54.87) | 63.25 (52.70) | 48.93 (44.38) | 61.89 (51.89) |
| **$T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%)** | 13.33 | 80.17 (63.56) | 76.20 (60.81) | 69.38 (56.42) | 61.95 (57.91) | 71.92 (58.00) |
| **$T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%)** | 11.00 | 78.47 (62.49) | 75.38 (60.33) | 62.53 (52.31) | 58.36 (49.81) | 68.69 (56.01) |
| **$T_{10}$ : Check** | 12.33 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| **F -test** | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| **C.D (p=0.05)** | | 7.84 | 3.89 | 4.97 | 5.27 | 3.67 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 6 : Effect of insecticidal spray on *Lamida moncusalis* Wlk. (Third spray)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| $T_1$ : Chlorpyriphos 0.05% | 12.33 | 92.13 (73.75) | 90.31 (72.03) | 77.29 (61.61) | 61.35 (51.57) | 80.27 (63.65) |
| $T_2$ : Thiodicarb 0.075% | 10.33 | 92.10 (73.69) | 89.49 (71.49) | 74.77 (59.86) | 68.56 (55.91) | 81.23 (64.33) |
| $T_3$ : Profenophos 0.05% | 10.66 | 91.67 (73.28) | 89.57 (71.38) | 78.32 (62.29) | 67.65 (55.42) | 81.80 (64.81) |
| $T_4$ : Cartap hydro-chloride 0.05% | 11.33 | 92.11 (73.74) | 90.73 (72.72) | 74.62 (59.90) | 66.51 (54.65) | 80.88 (64.10) |
| $T_5$ : Spinosad 0.015% | 9.66 | 94.38 (78.75) | 91.35 (72.91) | 79.20 (62.91) | 69.89 (56.73) | 83.70 (66.20) |
| $T_6$ : Neem oil 0.5% | 11.66 | 69.86 (56.70) | 66.70 (54.77) | 65.30 (53.91) | 54.28 (47.45) | 64.03 (53.15) |
| $T_7$ : *B.t.* 0.2% | 12.66 | 70.11 (56.87) | 68.46 (55.90) | 64.59 (53.56) | 54.22 (47.42) | 64.34 (53.36) |
| $T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%) | 9.66 | 81.89 (64.84) | 79.99 (63.50) | 66.04 (54.43) | 60.04 (50.79) | 71.99 (58.06) |
| $T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%) | 11.66 | 80.23 (63.64) | 80.46 (63.97) | 66.83 (54.87) | 60.80 (51.24) | 72.07 (58.12) |
| $T_{10}$ : Check | 11.66 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| F -test | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| C.D (p=0.05) | | 6.02 | 6.63 | 5.59 | 3.41 | 3.16 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 7 : Effect of insecticidal spray on *Lamida moncusalis* Wlk.**

**(All three applications)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| $T_1$ : Chlorpyriphos 0.05% | 10.99 | 91.20 (72.76) | 89.84 (71.42) | 80.15 (63.59) | 64.51 (53.44) | 81.45 (64.49) |
| $T_2$ : Thiodicarb 0.075% | 11.10 | 92.82 (74.49) | 90.68 (72.28) | 80.44 (63.76) | 71.15 (57.53) | 83.69 (66.19) |
| $T_3$ : Profenophos 0.05% | 11.44 | 91.90 (73.47) | 89.43 (71.03) | 81.18 (64.34) | 72.18 (58.19) | 83.69 (66.19) |
| $T_4$ : Cartap hydro-chloride 0.05% | 11.55 | 91.93 (73.60) | 88.57 (70.41) | 79.10 (62.84) | 66.17 (54.43) | 81.44 (64.50) |
| $T_5$ : Spinosad 0.015% | 11.10 | 94.75 (76.76) | 92.08 (73.70) | 84.35 (66.70) | 73.34 (58.91) | 86.13 (68.13) |
| $T_6$ : Neem oil 0.5% | 11.66 | 66.65 (54.72) | 64.68 (53.54) | 61.85 (51.86) | 49.64 (44.79) | 60.70 (51.18) |
| $T_7$ : *B.t.* 0.2% | 11.44 | 68.25 (55.70) | 65.26 (53.92) | 61.67 (51.78) | 48.00 43.85 | 60.80 (51.25) |
| $T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%) | 11.22 | 80.10 (63.51) | 77.02 (61.37) | 67.37 (55.17) | 61.85 51.85 | 71.58 (57.78) |
| $T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%) | 11.55 | 79.75 (63.27) | 77.43 (61.65) | 65.16 (53.85) | 60.72 51.20 | 70.75 (57.27) |
| $T_{10}$ : Check | 12.33 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| F -test | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| C.D (p=0.05) | | 1.85 | 3.35 | 3.69 | 2.89 | 2.31 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 8 : Effect of insecticidal spray on *Hypatima haligramma* Meyr. (First application)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| **$T_1$ : Chlorpyriphos 0.05%** | 14.66 | 93.52 (75.27) | 87.78 (69.55) | 71.53 (57.76) | 51.97 (46.13) | 76.20 (60.80) |
| **$T_2$ : Thiodicarb 0.075%** | 14.33 | 95.68 (80.18) | 89.88 (71.55) | 80.76 (64.00) | 54.36 (47.51) | 80.17 (63.56) |
| **$T_3$ : Profenophos 0.05%** | 16.33 | 94.16 (76.03) | 88.76 (70.48) | 78.76 (62.63) | 50.39 (45.22) | 78.01 (62.05) |
| **$T_4$ : Cartap hydro-chloride 0.05%** | 15.50 | 93.69 (75.46) | 88.21 (69.92) | 76.10 (60.74) | 51.23 (45.70) | 77.31 (61.55) |
| **$T_5$ : Spinosad 0.015%** | 11.66 | 94.03 (75.86) | 89.06 (70.69) | 77.75 (61.89) | 51.75 (46.00) | 78.14 (62.13) |
| **$T_6$ : Neem oil 0.5%** | 15.66 | 75.93 (60.62) | 73.54 (59.06) | 63.01 (52.54) | 30.75 (33.67) | 60.78 (51.22) |
| **$T_7$ : *B.t.* 0.2%** | 16.33 | 74.91 (59.96) | 72.27 (58.28) | 66.13 (54.42) | 34.73 (36.02) | 61.96 (51.93) |
| **$T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%)** | 16.00 | 85.19 (67.50) | 79.57 (63.18) | 72.39 (58.30) | 50.21 (45.12) | 71.84 (57.96) |
| **$T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%)** | 18.00 | 85.54 (67.72) | 80.12 (63.54) | 72.25 (58.22) | 50.33 (45.18) | 72.05 (58.08) |
| **$T_{10}$ : Check** | 16.33 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00). |
| **F -test** | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| **C.D (p=0.05)** | | 5.23 | 3.23 | 2.75 | 3.67 | 1.92 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 9 : Effect of insecticidal spray on *Hypatima haligramma* Meyr. (Second application)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| $T_1$ : Chlorpyriphos 0.05% | 15.00 | 93.95 (75.76) | 86.36 (68.44) | 67.02 (54.95) | 55.70 (48.27) | 75.75 (60.50) |
| $T_2$ : Thiodicarb 0.075% | 15.00 | 95.93 (80.47) | 88.63 (70.63) | 77.39 (61.84) | 57.65 (49.40) | 79.90 (63.37) |
| $T_3$ : Profenophos 0.05% | 15.33 | 94.06 (75.90) | 86.42 (69.13) | 76.60 (61.08) | 54.80 (47.75) | 78.00 (62.06) |
| $T_4$ : Cartap hydro-chloride 0.05% | 14.66 | 93.37 (77.95) | 84.25 (66.66) | 65.91 (54.29) | 54.60 (47.64) | 74.54 (59.71) |
| $T_5$ : Spinosad 0.015% | 16.33 | 94.16 (76.06) | 87.62 (69.44) | 75.91 (60.62) | 54.37 (47.51) | 78.02 (62.04) |
| $T_6$ : Neem oil 0.5% | 16.66 | 69.24 (56.32) | 63.28 (52.71) | 59.20 (50.30) | 36.02 (36.86) | 56.93 (48.98) |
| $T_7$ : *B.t.* 0.2% | 14.66 | 67.01 (54.96) | 60.37 (50.98) | 58.49 (49.89) | 34.46 (35.92) | 55.08 (47.91) |
| $T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%) | 14.66 | 83.44 (66.10) | 77.55 (61.81) | 65.93 (54.36) | 53.56 (47.04) | 70.12 (56.90) |
| $T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%) | 14.33 | 82.34 (65.43) | 78.15 (62.14) | 65.25 (53.89) | 52.47 (46.41) | 69.55 (56.51) |
| $T_{10}$ : Check | 15.66 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| F -test | NS | Sign | Sign | Sign | Sign | Sign |
| C.D (p=0.05) | | 8.41 | 5.81 | 4.50 | 2.60 | 2.48 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 10 : Effect of insecticidal spray on *Hypatima haligramma* Meyr. (Third application)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| $T_1$ : Chlorpyriphos 0.05% | 12.33 | 92.87 (73.87) | 87.34 (69.56) | 74.64 (59.76) | 50.69 (45.39) | 76.24 (60.83) |
| $T_2$ : Thiodicarb 0.075% | 13.00 | 95.32 (79.77) | 90.57 (72.41) | 75.40 (60.33) | 54.26 (47.44) | 78.89 (62.65) |
| $T_3$ : Profenophos 0.05% | 10.33 | 94.11 (78.47) | 88.49 (70.38) | 69.23 (56.37) | 50.62 (45.35) | 75.61 (60.42) |
| $T_4$ : Cartap hydro-chloride 0.05% | 13.66 | 93.25 (74.96) | 86.08 (68.13) | 70.60 (57.17) | 48.86 (44.35) | 74.68 (57.79) |
| $T_5$ : Spinosad 0.015% | 11.33 | 91.40 (73.02) | 87.25 (69.10) | 74.66 (59.85) | 51.04 (45.59) | 76.08 (60.73) |
| $T_6$ : Neem oil 0.5% | 10.33 | 64.78 (53.79) | 62.29 (52.13) | 47.13 (43.35) | 24.57 (29.70) | 49.69 (44.82) |
| $T_7$ : *B.t.* 0.2% | 13.66 | 65.19 (53.85) | 60.15 (50.87) | 47.09 (43.32) | 27.34 (31.47) | 49.94 (44.96) |
| $T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%) | 9.66 | 80.37 (63.72) | 72.93 (58.71) | 49.82 (44.90) | 46.93 (43.23) | 62.51 (52.25) |
| $T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%) | 13.66 | 79.15 (62.85) | 71.51 (57.75) | 48.32 (44.03) | 46.85 (43.18) | 61.43 (51.61) |
| $T_{10}$ : Check | 12.66 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| F -test | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| C.D (p=0.05) | | 7.31 | 5.32 | 4.04 | 3.45 | 2.04 |

**Table 11 : Effect of insecticidal spray on *Hypatima haligramma* Meyr. (All three applications)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| **$T_1$ : Chlorpyriphos 0.05%** | 13.99 | 93.24 (74.94) | 87.16 (69.09) | 71.06 (57.45) | 52.84 (46.63) | 76.06 (60.71) |
| **$T_2$ : Thiodicarb 0.075%** | 14.11 | 95.64 (77.95) | 89.71 (71.35) | 77.85 (61.99) | 55.41 (48.11) | 79.65 (63.19) |
| **$T_3$ : Profenophos 0.05%** | 13.99 | 94.11 (76.11) | 87.93 (69.77) | 74.86 (59.91) | 51.93 (46.10) | 77.20 (61.48) |
| **$T_4$ : Cartap hydro-chloride 0.05%** | 14.60 | 93.42 (75.32) | 86.18 (68.17) | 70.86 (57.33) | 51.57 (45.90) | 75.51 (60.34) |
| **$T_5$ : Spinosad 0.015%** | 13.10 | 93.19 (74.91) | 87.98 (69.71) | 76.10 (60.74) | 52.38 (46.36) | 77.41 (61.62) |
| **$T_6$ : Neem oil 0.5%** | 14.21 | 69.98 (56.80) | 66.36 (54.55) | 56.41 (48.68) | 30.44 (33.48) | 55.80 (48.33) |
| **$T_7$ : *B.t.* 0.2%** | 14.88 | 69.03 (56.19) | 64.26 (53.29) | 57.18 (49.13) | 32.17 (34.50) | 55.66 (48.25) |
| **$T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%)** | 13.44 | 83.00 (65.69) | 76.68 (61.14) | 62.71 (52.37) | 50.23 (45.13) | 68.15 (55.65) |
| **$T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%)** | 15.33 | 82.32 (65.18) | 76.59 (61.06) | 61.92 (51.90) | 49.88 (44.93) | 67.68 (55.35) |
| **$T_{10}$ : Check** | 14.88 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| **F -test** | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| **C.D (p=0.05)** | | 3.21 | 2.44 | 2.66 | 2.63 | 1.51 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 12 : Effect of insecticidal spray on Apple and nut borer, *Nephopteryx eugraphella* Rag.**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| **$T_1$ : Chlorpyriphos 0.05%** | 12.22 | 63.85 (53.07) | 59.37 (50.41) | 53.99 (47.29) | 30.80 (33.70) | 52.00 (46.14) |
| **$T_2$ : Thiodicarb 0.075%** | 11.40 | 66.42 (54.64) | 63.06 (52.58) | 57.41 (49.27) | 45.13 (42.19) | 58.00 (49.60) |
| **$T_3$ : Profenophos 0.05%** | 12.33 | 62.90 (52.50) | 60.70 (51.18) | 55.91 (48.41) | 44.33 (41.73) | 55.95 (48.42) |
| **$T_4$ : Cartap hydro-chloride 0.05%** | 11.41 | 63.75 (52.98) | 60.35 (50.99) | 52.10 (46.21) | 32.70 (34.79) | 52.22 (46.27) |
| **$T_5$ : Spinosad 0.015%** | 12.04 | 64.10 (53.19) | 62.08 (52.00) | 56.80 (48.97) | 44.99 (42.11) | 56.99 (49.02) |
| **$T_6$ : Neem oil 0.5%** | 10.21 | 35.55 (36.60) | 34.85 (36.17) | 32.16 (34.51) | 29.92 (33.12) | 33.27 (35.22) |
| **$T_7$ : *B.t.* 0.2%** | 11.31 | 37.37 (37.68) | 35.54 (36.59) | 34.40 (35.73) | 28.01 (31.89) | 33.81 (35.53) |
| **$T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%)** | 10.71 | 48.66 (44.22) | 45.99 (42.69) | 35.48 (36.55) | 30.85 (33.69) | 40.15 (39.31) |
| **$T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%)** | 11.14 | 50.48 (45.28) | 49.75 (44.86) | 35.76 (36.72) | 30.14 (33.28) | 41.51 (40.11) |
| **$T_{10}$ : Check** | 11.70 | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| **F -test** | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| **C.D (p=0.05)** | | 4.31 | 3.79 | 6.45 | 3.76 | 2.74 |

Figures in parenthesis are angular transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

## Table 13 : Effect of insecticidal spray on spiders (First application)

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| **$T_1$ : Chlorpyriphos 0.05%** | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 1.05 (0.66) | 1.55 (2.00) | 1.07 (0.66) |
| **$T_2$ : Thiodicarb 0.075%** | 2.00 | 0.00 (0.7071) | 0.7071 (0.00) | 1.05 (0.66) | 1.67 (2.33) | 1.11 (0.75) |
| **$T_3$ : Profenophos 0.05%** | 2.00 | 0.7071 (0.00) | 0.7071 (0.00) | 1.05 (0.66) | 1.55 (2.00) | 1.06 (0.66) |
| **$T_4$ : Cartap hydro-chloride 0.05%** | 1.66 | 0.7071 (0.00) | 0.7071 (0.00) | 1.05 (0.66) | 1.67 (2.33) | 1.11 (0.75) |
| **$T_5$ : Spinosad 0.015%** | 1.66 | 0.7071 (0.00) | 0.7071 (0.00) | 1.05 (0.66) | 1.67 (2.33) | 1.11 (0.75) |
| **$T_6$ : Neem oil 0.5%** | 2.33 | 1.67 (2.33) | 1.67 (2.33) | 1.55 (2.00) | 1.67 (2.33) | 1.65 (2.25) |
| **$T_7$ : *B.t.* 0.2%** | 2.33 | 1.67 (2.33) | 1.67 (2.33) | 1.67 (2.33) | 1.67 (2.33) | 1.68 (2.33) |
| **$T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%)** | 2.66 | 0.7071 (0.00) | 0.7071 (0.00) | 1.67 (2.33) | 1.55 (2.00) | 1.25 (1.08) |
| **$T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%)** | 2.00 | 0.7071 (0.00) | 0.7071 (0.00) | 1.55 (2.00) | 1.67 (2.33) | 1.25 (1.08) |
| **$T_{10}$ : Check** | 2.00 | 1.67 (2.33) | 1.77 (2.66) | 1.67 (2.33) | 1.77 (2.66) | 1.73 (2.50) |
| **F -test** | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| **C.D (p=0.05)** | | 0.13 | 0.16 | 0.47 | 0.18 | 0.18 |

Figures in parenthesis are arcsine transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

### Table 14 : Effect of insecticidal spray on spiders (Second application)

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| **$T_1$ : Chlorpyriphos 0.05%** | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 0.33 (0.87) | 2.33 (1.67) | 0.66 (1.07) |
| **$T_2$ : Thiodicarb 0.075%** | 2.00 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.05) | 2.33 (1.67) | 0.75 (1.11) |
| **$T_3$ : Profenophos 0.05%** | 2.00 | 0.00 (0.00) | 0.00 (0.7071) | 0.66 (1.05) | 2.33 (1.65) | 0.75 (1.10) |
| **$T_4$ : Cartap hydro-chloride 0.05%** | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.05) | 2.33 (1.67) | 0.75 (1.11) |
| **$T_5$ : Spinosad 0.015%** | 1.66 | 0.00 (0.7071) | 0.00 (0.7071) | 1.00 (1.22) | 2.66 (1.77) | 0.91 (1.18) |
| **$T_6$ : Neem oil 0.5%** | 2.66 | 2.33 (1.67) | 1.67 (2.33) | 2.33 (1.67) | 2.00 (1.55) | 2.25 (1.65) |
| **$T_7$ : *B.t.* 0.2%** | 2.00 | 2.66 (1.77) | 1.77 (2.66) | 2.33 (1.67) | 2.33 (1.67) | 2.50 (1.73) |
| **$T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%)** | 1.33 | 0.00 (0.7071) | 0.00 (0.7071) | 2.33 (1.65) | 2.33 (1.67) | 1.16 (1.28) |
| **$T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%)** | 2.00 | 0.00 (0.7071) | 0.00 (0.7071) | 2.00 (1.55) | 2.33 (1.67) | 1.08 (1.25) |
| **$T_{10}$ : Check** | 2.33 | 1.77 (2.66) | 1.67 (2.33) | 1.77 (2.66) | 1.77 (2.66) | 1.75 (2.58) |
| **F -test** | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| **C.D (p=0.05)** | | 0.16 | 0.14 | 0.46 | 0.16 | 0.18 |

Figures in parenthesis are arcsine transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

**Table 15 : Effect of insecticidal spray on spiders (third application)**

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| $T_1$ : Chlorpyriphos 0.05% | 2.66 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.05) | 2.33 (1.67) | 0.75 (1.11) |
| $T_2$ : Thiodicarb 0.075% | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.05) | 2.33 (1.67) | 0.75 (1.11) |
| $T_3$ : Profenophos 0.05% | 2.00 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.05) | 2.33 (1.67) | 0.75 (1.11) |
| $T_4$ : Cartap hydro-chloride 0.05% | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 1.00 (1.17) | 2.33 (1.67) | 0.83 (1.15) |
| $T_5$ : Spinosad 0.015% | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 0.33 (0.87) | 2.33 (1.67) | 0.66 (1.07) |
| $T_6$ : Neem oil 0.5% | 2.66 | 2.00 (1.55) | 2.66 (1.77) | 2.00 (1.55) | 2.66 (1.77) | 2.33 (1.68) |
| $T_7$ : *B.t.* 0.2% | 2.33 | 1.66 (1.46) | 2.33 (1.67) | 2.33 (1.67) | 2.33 (1.67) | 2.16 (1.63) |
| $T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%) | 3.00 | 0.00 (0.7071) | 0.00 (0.7071) | 2.00 (1.55) | 2.66 (1.77) | 1.16 (1.28) |
| $T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%) | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 2.33 (1.67) | 2.33 (1.67) | 1.16 (1.28) |
| $T_{10}$ : Check | 2.00 | 2.33 (1.67) | 2.66 (1.77) | 2.33 (1.67) | 2.66 (1.77) | 2.50 (1.73) |
| F -test | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| C.D (p=0.05) | | 0.23 | 0.15 | 0.51 | 0.12 | 0.16 |

Figures in parenthesis are arcsine transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

## Table 16 : Effect of insecticidal spray on spiders (All three applications)

| Treatments | Mean population before treatment | Mean per cent reduction over untreated control | | | | Overall efficacy |
|---|---|---|---|---|---|---|
| | Larvae/4m$^2$ | 5 DAT | 10 DAT | 20 DAT | 30 DAT | |
| $T_1$ : Chlorpyriphos 0.05% | 2.44 | 0.00 (0.7071) | 0.00 (0.7071) | 0.55 (1.02) | 2.22 (1.64) | 0.69 (1.09) |
| $T_2$ : Thiodicarb 0.075% | 2.11 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.07) | 2.33 (1.68) | 0.74 (1.11) |
| $T_3$ : Profenophos 0.05% | 2.00 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.05) | 2.22 (1.63) | 0.72 (1.09) |
| $T_4$ : Cartap hydro-chloride 0.05% | 2.10 | 0.00 (0.7071) | 0.00 (0.7071) | 0.77 (1.11) | 2.33 (1.68) | 0.77 (1.12) |
| $T_5$ : Spinosad 0.015% | 1.88 | 0.00 (0.7071) | 0.00 (0.7071) | 0.66 (1.07) | 2.44 (1.71) | 0.77 (1.12) |
| $T_6$ : Neem oil 0.5% | 2.55 | 2.22 (1.64) | 2.44 (1.71) | 2.10 (1.60) | 2.32 (1.67) | 2.27 (1.66) |
| $T_7$ : *B.t.* 0.2% | 2.22 | 2.22 (1.64) | 2.44 (1.71) | 2.33 (1.68) | 2.33 (1.68) | 2.33 (1.68) |
| $T_8$: Chlorpyriphos + neem oil (0.025% + 0.25%) | 2.33 | 0.00 (0.7071) | 0.00 (0.7071) | 2.22 (1.64) | 2.33 (1.68) | 1.13 (1.27) |
| $T_9$: Chlorpyriphos + *B.t.* (0.025%+0.1%) | 2.11 | 0.00 (0.7071) | 0.00 (0.7071) | 2.11 (1.61) | 2.33 (1.68) | 1.11 (1.26) |
| $T_{10}$ : Check | 2.11 | 2.44 (1.71) | 2.55 (1.74) | 2.44 (1.71) | 2.66 (1.77) | 2.52 (1.73) |
| F -test | NS | Sig. | Sig. | Sig. | Sig. | Sig. |
| C.D (p=0.05) | | 0.11 | 0.05 | 0.29 | 0.10 | 0.11 |

Figures in parenthesis are arcsine transformed values

Sig. – Significant NS - Non-significant DAT- Days after treatment

# CHAPTER – V

# DISCUSSION

The results obtained in the present study entitled “ Seasonal Incidence and Management of Lepidopteran Pests in Cashew “ are discussed here under in the light of available literature.

## 5.1 SEASONAL INCIDENCE OF MAJOR LEPIDOPTERAN PESTS

### 5.1.1 Shoot and Blossom Webber, *Lamida moncusalis* Walker

The seasonal incidence of shoot and blossom webber was studied by recording per cent infestation/damage throughout the year. The highest infestation (12.31%) was observed during the second week of May and gradually declined thereafter. It is evident from these studies that the shoot and blossom webber infestation was found throughout the year with high damage during April and May. These results are in agreement with the observations of Arjunarao (1978), Sathiamma (1978), Haribabu *et al*. (1983), Ramadevi and Radhakrishnamurthy (1983), Tejkumar *et al*. (1985) and Panigrahi (1988). However, the present findings of higher seasonal activity in April-May do not agree with the findings of Chatterjee (1988), Tirumalaraju *et al*. (1991) and Ramakrishnarao and Haribabu (2003) who reported high incidence during December-February (West Bengal), January (Karnataka) and September (Chittor district of A.P.), respectively. This clearly indicated that geographical location might played a crucial role in the infestation of shoot and blossom webber.

Studies on the interaction between pest infestation and abiotic components have indicated a positive and significant correlation with maximum and minimum temperature and negative significant correlation with morning relative humidity. It was observed that there was close interaction among different abiotic components with a contribution of 68.86 out of 100. These results are in agreement with the observations of Ramadevi and Radhakrishna (1991) who reported that increase in temperature and fall in relative humidity was congenial for the pest out break. Similarly, the reports of AICRP on cashew indicate the same result. On contrary, Ramakrishnarao and Haribabu (2003) reported significant negative correlation with maximum temperature.

Thus, the results have conclusively shown that the morning relative humidity as one of the important abiotic component of environment which influences the infestation levels with temperature having no marked role as infestation was found throughout the year, however, with fluctuations.

### 5.1.2 Shoot Tip and Inflorescence Caterpillar, *Hypatima haligramma* Meyr.

The seasonal incidence of shoot tip and inflorescence caterpillar was studied by recording laterals exhibiting gummosis symptoms which indicate the presence of caterpillar throughout the year.

The caterpillar incidence was more during the second fortnight of February and first fortnight of March coinciding with blossoming and inflorescence stage and gradually declined with no infestation during second fortnight of May to first fortnight of October. These results are in agreement with the observations of Arjunarao (1978) and Ramadevi and Radhakrishnamurthy (1983). However, the present findings do not agree with the findings of Satapathy *et al*. (1985), Jena *et al*. (1985), Jena and Satapathy (1988), Jena (1998) and Routray (2000) who has reported high incidence between September-October from Orissa and other places. Probably the varietal variation and geographical location might have played a crucial role in the larval incidence.

Studies on the interaction between pest incidence and abiotic components have indicated a positive and significant correlation between incidence and morning relative humidity while a significant negative correlation was observed with maximum and minimum temperatures and rainy days. It was observed that the coefficient of determination was found to be influenced by the climatic factors to the extent of 51.19 per cent out of which a significant negative contribution was made by minimum temperature while significant positive contribution was made through evening relative humidity. These results are in agreement with the observations of Ramadevi and Radhakrishna (1991) and Senguttuvan and Muralibhaskaran (1993).

Thus, the results have conclusively shown that the number of rainy days and drop in minimum temperatures had negative impact in this region and hence no infestation was observed during September-October as was reported elsewhere.

### 5.1.3 Leaf Miner, *Acrocercops syngramma* Meyr.

The seasonal incidence of leaf miner was studied by recording mined leaves throughout the year.

The leaf miner incidence was at its peak during second week of December with no infestation during May-June. Studies on the interaction between pest incidence and abiotic components had indicated a negative and significant correlation between the leaf miner incidence and maximum and minimum temperatures and positive and significant correlation with morning relative humidity. It was observed that climatic factors have close interaction and hence none of the partial regression coefficients were found to be significant.

The results are in agreement with the observations of Sundararaju (1984), Arjunarao (1978), Sathiamma (1978), Ramadevi and Radhakrishnamurthy (1983), Jena and Satapathy (1988) and Ramakrishnarao and Haribabu (2003) who reported that leaf miner incidence starts during July and reaches a peak by November – December. Similarly the positive influence of relative humidity in the present study was in agreement with the observations of Ramakrishnarao and Haribabu (2003) who reported positive correlation between relative humidity and incidence.

However, the present findings of higher seasonal activity of leaf miner in the month of December do not agree with the findings of Jena *et al*. (1985), Chatterjee (1988) and Mohapatra *et al*. (1996) who has reported highest peak during October. Probably the variation in geographical location might have played a crucial role in the larval incidence.

### 5.1.4 Apple and Nut Borer, *Nephopteryx eugraphella* Rag.

The seasonal incidence of apple and nut borer was studied by recording per cent damaged nuts throughout the year. The apple and nut borer infestation was observed during first week of January to first week of May with peak infestation during last week of February (16.19%). It is evident from the studies that the cashew suffered with apple and nut borer incidence coinciding with apple and nut formation.

Studies on the interaction between the apple and nut borer incidence and abiotic components have indicated no significant relationship with any of the abiotic factors. Further, it was observed that coefficient of determination ($R^2$ = 0.2447) was found to be influenced by the climatic factors to the extent of 24.47 per cent only. This merits further intensive probe by including some other factors which have a bearing on the incidence and reducing the interval for recording the data.

These results are in agreement with the observations of Ramadevi and Radhakrishnamurthy (1983) and Chatterjee (1988) who reported highest apple and nut borer incidence during February onwards. However, the findings of peak activity during February do not agree with the findings of Thirumalaraju *et al*. (1991) who reported high incidence during May in Karnataka while Ramadevi and Radhakrishna (1991) reported a peak during April. Probably the geographical variation might have played a crucial role in the larval incidence.

### 5.1.5 Leaf Roller, *Caloptilia tiselaea* Meyr.

The seasonal incidence of leaf folder was studied by recording number of infested leaves out of five tender leaves in each of the five laterals per sq.m and mean per cent damage was worked out.

The leaf folder incidence was highest during second week of November coinciding with new flush and blooming stage. These results are in agreement with the observations of Ramadevi and Radhakrishnamurthy (1983) and Punnaiah and Devaprasad (1996). However, the present findings differ from the observations of Senguttuvan *et al*. (1990) who reported leaf folder incidence as February and March in Vriddachalam of Tamilnadu. Probably the different species involved and geographical location might have played a crucial role in the larval incidence.

Studies on the interaction between leaf folder incidence and abiotic components have indicated a negative and significant correlation with maximum and minimum temperatures while a significant positive correlation was observed with morning and evening relative humidity. Further, there was interaction among abiotic components with none of the partial regression coefficients being significant and their contribution was to the extent of 50.65 per cent. These results are partially in agreement with the observations of Punnaiah and Devaprasad (1996) who reported significant negative effect of maximum temperature but relative humidity has a significant negative effect.

Thus the seasonal incidence studies for the major lepidopteran pests in the Guntur district of Andhra Pradesh has provided information as to the period of peak occurrence as well as its low level of activity and this knowledge can be utilized to time various approaches for their effective control through ecologically sound methods.

## 5.2 EFFICACY OF INSECTICIDES ON MAJOR LEPIDOPTERAN PESTS

In order to evaluate the efficacy of certain insecticides for control of major lepidopteran pests, a field experiment was carried out during 2004-05 season at Cashew Research Station, Bapatla. The chemicals choosen for study included traditional insecticides *viz*., chlorpyriphos, profenophos besides combination treatments of chlorpyriphos with neem oil and *B.t.*. at half of their normal concentrations. Apart from the above, a few of the new insecticides *viz*., thiodicarb, cartap hydrochloride and spinosad were also evaluated. The results pertaining to this study are interpreted and discussed below.

### 5.2.1 Bioefficacy of Insecticides against Leaf and Blossom Webber

In all, three sprays were given for the control of *L. moncusalis* coinciding with flushing, flowering and nut development stage. A general trend having similar efficacy was exhibited by the chemicals with minute variations. The cumulative efficacy of all the three sprays indicated that the new insecticide spinosad proved to be highly effective over all other treatments at five days after treating the crop. Though the reports on the efficacy of the new insecticide against cashew pests was not available, the recent finding by Dandale *et al*. (2000) that spinosad at 50 g a.i $ha^{-1}$ was highly effective for suppressing *Helicoverpa armigera* Hub. on cotton even at 14 days after treatment clearly supports the present results. Similar results were also obtained by Gopalaswamy *et al*. (2000) on pink bollworm in cotton, Vadodaria *et al*. (2001) on *H. armigera* in cotton, Dey and Somchoudhury (2001) on borers in cabbage, Mahalakshmi *et al*. (2002) on *Plutella xylostella* (Linn.) and *Crocidolomia binotalis* (Zell) in mustard, Siddegowda *et al*. (2003) on *H. armigera* in pigeonpea and Soujanya *et al*. (2004) on *P. xylostella* and *Spodoptera litura* (Fab.) in cabbage are in agreement with the present finding that the new insecticide spinosad was effective in controlling shoot and blossom webber in cashew.

At ten days after spraying chlorpryiphos, thiodicarb and profenophos joined the best treatment spinosad but chlorpyriphos and cartap hydrochloride were relegated to second position at 20 and 30 DAT. This suggest that spinosad (0.015%), thiodicarb (0.075%) and profenophos (0.05%) were the best even at 30 DAT.

Thiodicarb is an oxime carbamate of recent origin having stomach and contact action. This product provided excellent control of bollworm complex on cotton (Dandale *et al*., 2000), *P. xylostella* on cabbage (Umeda, 2001), *S. exigua* on chillies (Khalidahmed et al., 2000), *Helicoverpa zea* (Boddie) on non *B.t.* cotton (Brickle *et al*., 2001), and *P. xylostella* on mustard (Mahalakshmi *et al*., 2002). Similarly, the highest efficacy of profenophos against shoot and blossom webber was in agreement with the findings of Nandakishore (1993), Suvarnaraju (1996) and Mohapatra *et al*. (2000). The next effective treatments even at 30 DAT were chlorpyriphos (0.05%) and cartap hydrochloride (0.05%) and the efficacy of the former treatment was in agreement with the studies of Hanumantharao (1989) who obtained good control of *L. moncusalis* with chlorpyriphos (0.01%). The efficacy of cartap hydrochloride was already documented by Nandakishore (1993) and Suvarnaraju (1996).

The performance of ecofriendly chemicals *viz*., neem and *B.t.* combining with chlorpyriphos at half of their original concentrations were found moderate in efficacy against the shoot and blossom webber. The moderate efficacy of chlorpyriphos + neem oil is in accordance with the findings of Bhalkare *et al*. (2000) and Sanjaykeshawraut (2000) and that of chlorpyriphos + *B.t.* with Benz (1971), Dabi *et al*. (1988) and Shankar *et al*. (1982).

Throughout the experiment the neem oil and *B.t.* showed poor efficacy but however superior over untreated check. The present results are in accordance with the findings of Nandakishore (1993) who reported neem oil 1.0% as moderately effective on shoot and blossom webber and Suvarnaraju (1996). The *B.t.* formulation though effective against *Spilosoma oblique* Walker on groundnut and sunflower crops (Pawar and Charati, 2000); against pod borer complex of urd bean (Chandrakar and Srivastava, 2001); against *H. armigera* (Sreedhar *et al*., 2003), the results of present investigation are against the above reports and in accordance with the findings of Sharma *et al*. (2000), Babu (2002) and Soujanya *et al*. (2004).

The overall efficacy of treatments against larval populations of *L. moncusalis* showed that the new insecticides spinosad, thiodicarb and profenophos were the top followed by conventional insecticides like chlorpyriphos whose efficacy was lost by 20 DAT. The combination treatments were moderately effective against *L. moncusalis* and this may be due to usage of half of their original concentrations in combination. Neem was less effective and this might be due to loss of insecticidal activity due to photodegradation caused by UV radiation in the sunlight and high temperature. The other probable cause of lower efficacy of neem and *B.t.* was due to the fact that *L. moncusalis* had the peculiar habit of webbing the shoots and blossom. This typical behaviour might have protected the larvae from acquiring the insecticides at lethal doses. So the efficacy of these slow acting biorational insecticides might have lost.

### 5.2.2 Bioefficacy of Insecticides against Shoot Tip and Inflorescence Caterpillar

The evaluation of insecticidal treatments against shoot tip and inflorescence caterpillar during the first spray revealed that the treatment thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) were the best treatments followed by chlorpyriphos (0.05%) and cartap hydrochloride (0.05%). The combination treatments *viz*., chlorpyriphos + *B.t.* and chlorpyriphos + neem oil proved to be moderate in efficacy and at all stages neem oil alone and *B.t.* alone treatments proved to be inferior in checking the caterpillar incidence. In the second spray also the results followed the same trend with thiodicarb, spinosad and profenophos proving to be superior. However, the overall efficacy of third spray indicate that thiodicarb, chlorpyriphos and spinosad as the best treatments with profenophos being relegated to second position.

From the mean efficacy of the three sprays it is clear that the shoot tip and inflorescence caterpillar was effectively controlled by thiodicarb followed by spinosad, profenophos, chlorpyriphos and cartap hydrochloride. Chlorpyriphos combination with neem oil and *B.t.* proved to be moderately effective while neem oil and *B.t.* alone treatments were found to be less effective.

Umeda *et al.* (2000) reported high efficacy of thiodicarb in the control of *Plutella xylostella* L. when compared to indoxacarb and spinosad on cabbage. Similarly, Khalidahmed *et al*. (2000) reported that thiodicarb was the best treatment followed by chlorpyriphos against *Spodoptera exigua* Hb. The finding in the present study with regard to thiodicarb was in confirmation with that of above workers. Even the effectiveness of other insecticides *viz*., chlorpyriphos (Mohapatra *et al*., 2000); profenophos (Nandakishore, 1993; Suvarnaraju, 1996 and Mohapatra *et al*., 2000); cartap hydrochloride (Nandakishore, 1993 and Suvarnaraju, 1996) and spinosad (Soujanya *et al*., 2004) was well documented and supports the present findings.

With regard to combination treatments only moderate efficacy was observed in the present study which was contrary to the results reported by Sundararaj *et al*. (1998) and Rao (2000) and this might be due to variation in the host crop and the pest itself. There were ample reports to suggest that the host crop influences the susceptibility of the insect to insecticides.

The lower efficacy of neem and *B.t.* treatments might be due to less acquisition of these products there by showing low levels of activity. Even, there were reports to suggest that neem oil (0.5%) was ineffective against shoot tip and inflorescence caterpillar in cashew (Senguttuvan *et al*., 1993) and *B.t.* alone was ineffective on other pests (Soujanya *et al*., 2004).

### 5.2.3 Bioefficacy of Insecticides against Apple and Nut Borer

On fifth day after spraying the insecticides *viz*., thiodicarb, spinosad, chlorpyriphos, cartap hydrochloride and profenophos were found to be equally effective followed by combination treatments of chlorpyriphos + *B.t.* and chlorpyriphos + neem oil. Throughout the experiment neem oil and *B.t.* treatments showed poor efficacy. Similar trend was observed even at ten and twenty days after spraying. However, chlorpyriphos and cartap hydrochloride treatments were relegated to second position at thirty days after treatment.

The overall efficacy of treatments against larval population of apple and nut borer showed that the insecticides thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) were the top followed by chlorpyriphos (0.05%) and cartap hydrochloride (0.05%). Eventhough earlier reports on the efficacy of the thiodicarb against apple and nut borer was not available, the recent findings by Brickle *et al*. (2001) had revealed that spinosad and thiodicarb were effective against *Helicoverpa zea* (Boddie) on non *B.t.* cotton. Similarly, Suvarnaraju (1996) also reported profenophos to be most effective against cashew pests and these results are in agreement with present findings.

The performance of ecofriendly chemicals *viz*., neem and *B.t.* combination with chlorpyriphos at half of their original concentrations were found to be less effective than the chlorpyriphos alone treatment suggesting that the dose might be not enough to have on par results as that of effective straight insecticides. The other probable cause of lower efficacy of combination and neem and *B.t.* alone treatments was due to the fact that apple and nut borer had the habit of boring into apples and nuts. This typical behaviour might have protected the larvae from acquiring the slow acting insecticides coming in contact with insecticides directly. So the efficacy of these biorational insecticides might have lost.

## 5.3 SEASONAL INCIDENCE OF MAJOR NATURAL ENEMIES

### 5.3.1 Spiders

In general spider population was noticed throughout the year except third week of May with maximum population during last week of February. Godse (2002) also reported that spiders were the common predators in cashew ecosystem.

With regard to abiotic factors a significant negative correlation was observed for maximum and minimum temperature while significant positive correlation was noticed with morning relative humidity. But the multiple regression analysis failed to bring out any significant factor. Even the contribution of the taken abiotic factors was only 35.08 out of 100. This merits further intensive probe including some other factors and reducing the time lag between two successive observations.

### 5.3.2 ***Bracon brevicornis*** **Wlk.**

With regard to parasites only *B. brevicornis* was observed to parasitize shoot and blossom webber during November last week to last week of February with a peak parasitization during second week of January.

The correlation between *B. brevicornis* incidence and maximum and minimum temperatures were negatively significant while positively significant with morning relative humidity. Even the negative impact of minimum temperature was clearly evident from multiple regression analysis. Jena *et al*. (1987) has reported 80% larval parasitization by *Bracon brevicornis* Wlk. and the present study results are nearer to it.

### 5.3.3 Effect of Treatments on Natural Enemies (Spiders)

The relative safety of different treatments against spiders revealed that all the insecticides *viz*., thiodicarb, spinosad, chlorpyriphos, profenophos and cartap hydrochloride recorded highest reduction of spider population indicating their toxic nature when compared to the rest of the treatments. The toxic nature of chlorpyriphos and profenophos on spiders was already reported by AICRP on cashew (2004).

The combination treatments of chlorpyriphos with ecofriendly agents neem oil and *B.t.* were less toxic compared to the individual treatment of chlorpyriphos. This might be due to reduced dosage of chlorpyriphos in the combination treatments. Based on the overall mean efficacy of the treatments the ecofriendly chemicals *viz*., neem oil and *B.t.* were found to be less toxic against spiders over the insecticides.

**CONCLUSIONS**

The following conclusions are drawn from the results obtained.

- In the Guntur district of Andhra Pradesh on cashew the shoot and blossom webber, shoot tip and inflorescence caterpillar, leaf miner, leaf folder and apple and nut borer population reached peak in the month of May, February-March, December, November and February, respectively.

- Among abiotic factors, minimum temperature has significant negative influence with larval incidence of shoot tip and inflorescence caterpillar while evening relative humidity has significant positive influence.

- Throughout the insecticide evaluation experiment the treatments thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) showed better efficacy against lepidopteran pests followed by chlorpyriphos (0.05%) and cartap hydrochloride (0.05%).

- Combination treatments (chlorpyriphos 0.025% + *B.t.* 0.1% and chlorpyriphos 0.025% + neem oil 0.25%) at half of their original dose were moderately effective against lepidopteran pests.

- Always neem oil and *B.t.* alone treatments showed poor efficacy against lepidopteran pests.

- Regarding the safety to spiders, all insecticidal treatments found toxic followed by the insecticide combination treatments. However neem oil and *B.t.* were found relatively safer to spiders.

## CHPATER- VI

## SUMMARY

A field experiment entitled " Seasonal Incidence and Management of Lepidopteran Pests in Cashew " was conducted at Cashew Research Station, Bapatla during 2004-2005. The results of the study showed that per cent damage of lepidopteran pests peaked at different times and in some cases there was considerable influence by the different weather parameters.

The leaf and blossom webber infestation was found to be in its peak during second week of May and low activity was observed during first week of January. Larval incidence has significant positive correlation with maximum and minimum temperatures while morning relative humidity had a significant negative relationship.

The shoot tip and inflorescence caterpillar incidence was highest in March with low activity during May. The incidence had a significant and positive correlation with morning relative humidity while a significant negative correlation was observed with maximum and minimum temperature and rainy days. The multiple regression analysis clearly revealed that minimum temperature exerted a strong negative effect on incidence while evening relative humidity had a positive effect.

The leaf miner was active with highest incidence during second week of December and lowest incidence was noticed in July. Maximum and minimum temperatures had a significant negative correlation with incidence while morning relative humidity had a significant positive correlation.

The leaf folder infestation was noticed almost throughout the year with highest incidence during second week of November and the pest was absent during parts of May, June and July. For the leaf folder activity relative humidity was found to be significant and positively influencing its incidence, whereas temperature was found to be a negative factor.

In respect of apple and nut borer, infestation was observed during January to May with highest incidence during February and none of the abiotic factors had any significant role in its infestation.

The incidence of spiders was observed throughout the year except during third week of May with peak activity during February. Temperature had a negative correlation while morning relative humidity had a significant positive correlation with spider incidence.

Highest larval parasitization with *Bracon brevicornis* Wlk. was observed on leaf and blossom webber during second week of

January with a maximum and minimum temperature of 30.3 and 18.0$^{0}$C and morning and evening relative humidities of 90.0 and 67.2 per cent, respectively.

Studies on the chemical control of lepidopteran pests revealed spinosad, thiodicarb and profenophos as the best treatments followed by chlorpyriphos and cartap hydrochloride. Neem oil and *B.t.* in combination with chlorpyriphos even at half of their original dosage were found superior than their straight application.

Regarding the effects of insecticides on natural enemies particularly spiders all insecticide treatments proved detrimental to their survival and even the ecofriendly chemicals *viz*., neem and *B.t.* in combination with insecticide proved toxic. However, neem oil and *B.t.* alone treatments were found relatively safer to spiders.

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* Originals not seen

Note : The literature is cited as per the "Thesis Guidelines" prescribed by Acharya N.G. Ranga Agricultural University, Rajendranagar, hyderabad.