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IPM Strategies to Combat Emerging Pests in the Current Scenario of Climate Change

Symposium Abstracts

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SYMPOSIUM ABSTRACTS

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Proceedings of the National Symposium on IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh

Biodiversity of coleopteran fauna in Nagaland maize ecosystems

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Maize is the second major cereal grown in Nagaland after rice. With the advancement of agriculture during the last twenty five years, the maize is grown round the year *i.e.*, *Kharif*, *Rabi* and spring seasons. Continuous cropping of maize enhances the appearance of certain pests continuously causing major losses. Moreover, farmers do not possess knowledge to distinguish harmful and useful insects in order to conserve the different important promising species. Therefore, study of some Coleoptera was taken up to find out the diverse arthropod fauna including the beneficial fauna and their seasonal abundance.

The study was carried out in three different locations in Dimapur, Medziphema and Kohima having altitudes of 260,310 and 1440 meters above MSL respectively during 2002 to 2004. Four types of sampling methods were employed *viz*., pitfall, soil extraction, light trap and net sweep. Observations were recorded at fortnightly intervals and analysed by using Shannon-Weiner diversity index. This index considers both the number of species and the distribution of individuals among species (Kikkawa, 1996).

Table 1 Biodiversity index of coleopteran insects in maize ecosystem (2002 - 2004)

COLEOPTERA FAMILY	Autumn Sep-Nov 2002	Winter Dec-Feb 2002-03	Spring Mar-May 2003	Summer Jun-Aug 2003	Autumn Sep-Nov 2003	Winter Dec-Feb 2003-04	Spring Mar-May 2004	Summer Jun-Aug 2004	Shannon-Weiner diversity index H = Pi Log(1/Pi)
PLAIN AREA (DIMAPUR)									
Carabidae	* 3.76	4	11.05	14.79	5.61	3.36	6.66	10.56	0.66131006
Scarabaeidae	2.35	1.04	25.84	17.46	3.99	2.82	4.4	4.39	0.72750491
Cerambycidae	0.38	0	0	0.3	0	0	0.1	0.11	0.04672106
Cicindelidae	0.15	0.07	2.02	4.8	1.47	0.61	4.12	2.63	0.14244962
Chrysomelidae	0	0	0	1.46	0	0	0.8	0.23	0.09201641
Total	6.64	5.11	38.91	38.81	11.07	6.79	16.08	17.92	141.33
FOOT-HILL AREA (MEDZIPHEMA)									
Carabidae	2.26	3.03	3.22	5.85	1.49	1.24	7.52	2.8	0.01976267
Scarabaeidae	2.7	5.52	12.75	14.8	4.28	4.99	15.03	12.68	1.02025903
Cerambycidae	0	1.4	0.15	0.25	0.25	1.12	0.23	0.3	0.11459525
Cicindelidae	1.02	0.12	0.28	0.22	0.17	1.05	0.49	0.2	0.11216882
Chrysomelidae	0	0	0.2	0.07	0.23	0	0.23	0.3	0.05179737
Total	5.98	10.07	16.6	21.91	6.42	8.4	23.5	16.28	108.44
UP-LAND AREA (KOHIMA)									
Carabidae	1.12	0.04	0.8	1.47	1.12	1.12	0.67	1.9	0.15554558
Scarabaeidae	0.13	0	0.09	0.25	0.06	0.06	0.22	0.25	0.05284632
Cerambycidae	0.07	0	0.12	0.1	0.12	0	0.1	0.07	0.03419901
Cicindelidae	0.08	0	0.16	0.2	0.23	0.09	0.12	0.47	0.06237253
Chrysomelidae	0.27	0.11	0.9	0.93	0.31	0.1	0.79	0.49	0.11768819
Total	1.69	0.15	2.07	2.95	1.84	1.37	1,9	3.18	15.13

*Values are the mean of the means, three months

The data are presented season wise average value of three months calculated as the mean of the means from four different collection methods (Table 1), which revealed the occurrence of five families of which Scarabaeidae dominate in both plains and foot-hill (0.72 and 1.02) respectively, whereas Carabidae (0.15) dominates the uplands, whereas in case of families *viz*., Cerambycidae, Cicindelidae and Chrysomelidae, 0.00 population was found. Season wise diversity observations revealed that the coleopteran population tends to be highest during summer months (June to August) and decreasing in winter months (December to February). Diversities of coleopteran population are in close conformity with the observations of Khokhar and Khokhar (2003) on Hemiptera which reported that Cydnidae, Pentatomidae, Plataspidae, Dinidoridae and Scutelleridae peaked during July to September. The diversity of coleopteran families at different altitudes varies (141.33, 108.44 and 15.13 in plain, foot-hill and up-land respectively). The diversities in their occurrence were mainly due to the sampling approach (Chung *et al.*, 2000).

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On the species diversity of mealybugs on cotton

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Mealybugs have recently emerged as a major pest across all the cotton growing tracts, with outbreaks occurring in both Bt and non Bt cotton.Perusal of literature reveals that twenty species of mealybugs are known to infest cotton, its different species and cultivars. These include *Dysmicoccus brevipes, Dysmicoccus neobrevipes, Ferrisia consobrina, Ferrisia virgata, Maconellicoccus hirsutus, Nipaecoccus nipae, Nipaecoccus viridis, Paracoccus burnerae, Paracoccus solani, Phenacoccus gossypii, Phenacoccus gossypiphilous, Phenacoccus madriensis, Phenacoccus solani, Phenacoccus solenopsis, Planococcus citri, Planococcoides lindingeri, Pseudococcus elisae, Pseudococcus neomaritimus, Rastrococcus iceryoides* and *Rhizoecus macregori* (Ramakrishna Ayyar, 1919; Ben Dov, 1994; Williams, 2004). Of these six species had been reported from India (Table 1). The analysis of taxonomic information indicate that there had been synonyms and misidentifications and the taxonomic studies to characterize these species are imminent.

Table 1 Mealybugs reported from India on cotton (*Gossypium* spp.)

Species	Synonyms/misidentifications*	References
Ferrsia virgata	*Pseudococcus virgatus*	Ramakrishna Ayyar (1921)
	Dactylopius sp.	Misra (1920)
	Dactylopius ceriferus	Fletcher (1920)
Maconellicoccus hirsutus	*Phenacoccus hirsutus*	Misra (1921), Fletcher (1920)
Nipaecoccus nipae	*Pseudococcus (Dactylopius) nipae*	Ramakrishna Ayyar (1921)
Nipaecoccus viridis	*Pseudococcus corymbatus*	Misra (1920)
Phenacoccus solenopsis	*Phenacoccus solani**	Hodgson *et al.* (2008), (Gautam *et al.*, 2007; Suresh and Kavitha 2006)*
Rastrococcus iceryoides	*Phenacoccus iceryoides*	Williams (2004)

The detailed taxonomic studies revealed that these six species under five genera can be broadly characterized under the subfamilies Phenacoccinae and Pseudococcinae. Studies were undertaken at the Indian Agricultural Research Institute on three species for the salient ones with taxonomic characters at generic and species level to enable their authentic identification and document the salient ones with comprehensive illustrations (Table 2)

Table 2 Salient taxonomic characters distinguishing species of mealybugs studied

Subfamily		Pseudococcinae	Pseudococcinae	Phenacoccinae
Genera		*Maconellicoccus*	*Nipaecoccus*	*Phenacoccus*
Species		*hirsutus*	*viridis*	*solenopsis*
Taxonomic features	Number of antennal segments	9	7	9
	Oral rim duct	present	absent	absent
	cerarii	4-5pairs	12-17	18
	No.of setae with cerarii	2	2	2
	Tarsal digitule	knobbed	knobbed	setose
	Claw denticle	absent	absent	present
	Anal bar	present	absent	absent
Distribution		Maharashtra, New Delhi	Maharashtra	Andhra Pradesh, Gujarat, Haryana, Maharashtra, New Delhi, Rajasthan, Punjab, Tamil Nadu and Uttar Pradesh

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The outbreak of mealybugs in cotton and other plants in the last two years seems to be largely due to the climate change and the plant phenology changes due to the current cultivars. Though there are no significant differences on the abundance of the populations in the Bt and non Bt cotton, the plant phenological changes will affect the infestation. There are no confirmed reports as to how the abiotic factors like temperature, rainfall and humidity influence the abundance of the populations; it is presumed that long dry spells with high relative humidity will contribute to their outbreak. It has been established that the populations of major species of mealybugs occurring in cotton show intraspecific variations and complexities with regard to few key characters defining the species, and environmentally induced variations have not been ruled out, especially in *Phenacoccus solenopsis* (Hodgson *et al*., 2008). It can be concluded that to solve the problems in the complexity of these species and populations, the morphometric studies in consonance with exploring molecular systematic studies and insect-plant relationships are imminent.

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Species diversity and relative abundance of geometrid defoliators in tea plantations of Dooars, West Bengal

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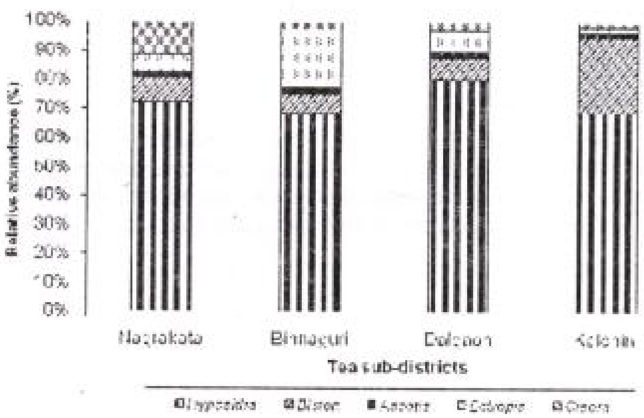
Pest problem continues to be the prime concern for tea plantations of Dooars, West Bengal. Although tea bushes in Dooars are attacked by different insect pests, geometrid defoliators, commonly called "loopers" are considered to be the most notorious of all. In recent past, tea bushes are subjected to severe stress for productivity under changed climate coupled with intensive agronomic practices. This is accentuated by the invasion of different species of loopers that were not known earlier. The present study is therefore undertaken to know the species diversity of geometrid defoliators associated with tea plantation of Dooars and to generate information on their relative abundance.

Periodic surveys were conducted at four tea subdistricts of Dooars (26° 44' N to 26° 54' N latitude and 88° 55' E to 89° 28' E longitude) situated at the foothills of subHimalayan West Bengal during September 2006 to August 2008. Samples of different species of loopers defoliating tea bushes as well as the shade trees and native vegetations were collected from these locations and kept under laboratory conditions. The moths of different species have been identified with the help of relevant literature (Hampson, 1895; Holloway, 1993). The relative abundance was worked out by computing percent population share.

The study revealed that 6 species belonging to 5 genera are associated. Apart from tea, these loopers were collected from 15 other host plants belonging to the Leguminosae (12), Verbenaceae (2) and Rubiaceae (1). Some of the loopers like *Hyposidra*, *Cleora* and *Ectropis* have been recorded as new pests. While others like *Biston supressaria* and *Ascotis* (*Boarmia*) *selenaria* were already reported to infest tea in this region (Das, 1994). Amongst different loopers, two species of *Hyposidra* (*H. talaca* and *H. infixaria*) were found to dominate with 72.58% of the larvae collected (Fig. 1).

Fig. 1 Relative abundance of geometrid defoliators - Tea plantations of Dooars, West Bengal



While *Biston supressaria*, *Ectropis* sp., *Ascotis* (*Boarmia*) *selenaria* and *Cleora* sp. represented 12.13%, 8.98%, 1.93% and 4.4% of the total collected larvae, respectively. These loopers, particularly *Hyposidra*, were found to occur all round the year in Dooars. All these species were reported to be highly polyphagous and associated with forests (Holloway, 1993). It has been observed that the trees commonly used as shade in tea estates are the primary source. Again, plantations nearer to the denuded forests were found more prone. All these indicated that increased deforestation and its replacement by monoculture like tea might have compelled these insects to change their habitat. The geometrid looper diversity in Dooars tea plantations is far more diverse than reported previously.

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Biodiversity and abundance of insect visitors on mango bloom at Pantnagar

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Pollinating insects are indispensable to the reproduction of the 80% of terrestrial vegetation represented by flowering plants that produce seeds. Several horticulture crops cultivated in India derive benefit or are dependent on pollinating insects for effective qualitative and quantitative improvement. Effective insect pollination is essential for good fruit set and yield in mango (*Mangifera indica* L.). Present investigation was initiated to study the abundance of insect visitors/pollinators on mango bloom at Horticulture Research Center, Pantnagar during 2006-2007 and 2007-2008. A field survey was carried out to identify the diversity of insect pollinators. In total, individuals belonging to 10 insect species were observed visiting mango flowers. These included five dipteran species, four hymenopterans and one coleopteran.

The dipterans constituted major group and belong to the family Syrphidae (subfamily Syrphinae and Eristalinae). The species included *Episyrphus balteatus* DeGeer, *Melanostoma orientale* Wied, *Syrphus corollae* F. and *Eristalis tenax* L. Of these, *E. balteatus* exhibited markedly higher incidence. The adult syrphidflies are effective pollinators and they spend a great deal of time in visiting flowers. Besides syrphids, other dipterans, the Musca species though rare were also observed visiting the flowers.

Hymenoptera was the next to contribute visiting on flowers. Of these, the family Apidae (subfamily Apinae and Melliponae) constituted the major group. The Apinae was represented by three main species of *Apis* namely *Apis dorsata* F., *Apis mellifera* L. and *Apis cerana indica* Fab. The most important genus of subfamily Melliponinae was *Trigona*. The large numbers of ladybird beetle, *Coccinella septempuctata* L. (Coleoptera: Coccinellidae: Coccinellinae) was also found, visiting the flowers of mango.

Table 1 Insect pollinators observed on mango at HRC, Pantnagar

S.No	Insect Pollinators	Order (Family:Subfamily)	Status*
1	*Melanostoma orientale* Wied	Diptera (Syrphidae : Syrphinae)	VF
2	*Syrphus corollae* F.	Diptera (Syrphidae: Syrphinae)	VF
3	*Episyrphus balteatus* DeGeer	Diptera (Syrphidae: Eristalinae)	VF
4	*Eristalis tenax* L.	Diptera (Syrphidae: Eristalinae)	VF
5	*Musca* spp.	Diptera (Muscidae: Muscinae)	R
6	*Apis dorsata* F.	Hymenoptera (Apidae: Apinae)	VF
7	*Apis mellifera* L.	Hymenoptera (Apidae : Apinae)	VF
8	*Apis cerana indica* F.	Hymenoptera (Apidae : Apinae)	F
9	*Trigona* spp.	Hymenoptera (Apidae: Melliponinae)	F
10	*Coccinella septempunctata* L.	Coleoptera (Coccinellidae : Coccinellinae)	F

* VF = Very frequent, F = Frequent, R = Rare

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Diversity of fruit flies from north India

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Tephritidae belongs to superfamily Tephritoidea and these are biologically and economically important group of Diptera. About 4,500 species are distributed in tropical, subtropical and subtemperate regions. They exhibit greater diversity in India and are represented by 243 species belonging to 79 genera, 18 tribes and 4 subfamily. None of the Tephritidae is endemic to India, but 74 species (30.33%) are endemic. Forty species of *Bactrocera* is among the most established and pestiferous in India, while among *Dacus* and *Carpomyia* only 1 or 2 economically important species exist. Studies on Indian Tephritidae are with only few publications (Bezzi, 1913; Kapoor, 1993; Drew and Raghu, 2002; Agarwal and Sueyoshi, 2005). All the studies are mainly restricted to particular subregion in India viz. southern region (Western Ghat and Andaman and Nicobar Islands). None of the workers had given emphasis to northern part of India, which exhibits greater faunal diversity.

Due to scattered and very old information, it was very necessary to compile the diversity and distribution of North Indian fruit flies. Fruit flies were collected by net sweeping, using pheromone trap and rearing infested fruit in the laboratory. Wherever necessary, the insects were processed and mounted on the cards for further identification. Also specimens were studied from National Pusa Collection (NPC) with the use of available database.

During the course of present study the survey cum collection tour were undertaken at various localities in North India (Himachal Pradesh, Uttar Pradesh, Punjab, Haryana, Chandigarh and Uttarakhand) from June 2007 to October 2008. This survey led to the collection of 22 species. Distribution of some of the important fruit flies of north Indian subregion with respect to other subregions is shown in Fig 1. Sixty five species of fruit flies were studied belonging to north Indian subregion from NPC and these are categorized in Table 1. An analysis of data from survey as well as from the NPC on the host information indicate that many fruits and vegetables are infested (Table 1).

An analysis of host plants reveal that it is closely associated with many fruits and vegetables. Dacini are entirely frugivorous, some also infest flowers. Most species of *Bactrocera* are polyphagous and breed on fruits and vegetables. Although tephritids are commonly known as fruit flies, a variety of host parts and tissues are also attacked, including flowers, stems, buds, leaves and roots. Many Trypetini are also leaf or stem miners, and some Gastrozonina and Acanthonevrini breed in bamboo shoots. The members of the Tephritinae are specialized in attacking Asteraceae and a few other families namely Acanthaceae, Goodeniaceae, Lamiaceae and Verbenaceae.

It can be concluded that studies on the distribution of different fruit fly species not only in terms of spatial but also over temporal dimensions is required for their area wide management. The management of fruit flies unlike other crop pests requires to be undertaken through special approach involving area wide measure. The area wide measures are likely to be dependent on climatic factors the temperature, rainfall and relative humidity. It is certain that climatic changes will have lot of implication for such an area wide approach.

Table 1 Fruit fly pest species of importance in north Indian subregion

Fruit fly species	Important hosts	Taxa	No. of Species
Bactrocera (Bactrocera)	Mango, guava, citrus, banana, ber,	Dacinae	
dorsalis	pear,fig litchi, apple, avocado	Dacini	19
B. (B.) correcta	Guava, mango, peach, rose apple, sandal	Gastrozonini	8
B. (B.) zonata	Guava, mango, citrus, peach	Phytalminae	
B. (B.) latifrons	Chillies, tomato, black nightshade, brinjal	Acanthevrini	5
B. (Hemigymnodacus) diversa	Pumpkin, sponge gourd, Riged gourd	Trypetinae	
B. (Zeugodacus) cucurbitae	Snake gourd, bitter gourd, bottle gourd	Adramini	6
	melons, sponge gourd , coccinia,	Carpomyini	2
	pumpkin	Hexachaetini	5
B. (Z.) tau	Cucumber, bottle gourd, bitter gourd,	Tephritinae	
	pumpkin	Cecidocharini	3
B. (Z.) scutelaris	Pumpkin, black eyed pea, cucumber,	Pleomelaenini	2
	peach, gourds	Scistopterini	2
B. (Z.) caudata	pumpkin, snake gourds, cucumber	Tephrellini	13
Carpomya vesuviana	Ber		
Dacus (Didacus) ciliatus	Cucumber, gherkin, melon, pumpkin,	Total	65
	snake gourd, bitter gourd, water melon		

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Fig. 1 Distribution of major fruit flies in India

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Record of insect pest, disease and natural enemies of rainfed citrus in Jammu

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Subtropical region of Jammu is known for cultivation of rainfed fruits like citrus, which occupy an area of nearly 10,000 ha with an annual production of 14,718 metric tonnes. Among several constraints to citrus production, incidence of insect pests and diseases play a major role in adversely affecting its yield. In India, 250 species of insect pests have been reported attacking different species of citrus (Nayar *et al.*, 1976). The factors like prolonged dry spells and excessive moisture conditions during crop growth period influence the crop infestation by insects. In recent years, these altered biotic and abiotic stresses have resulted in increased incidence of citrus psylla (*Diaphorina citri* Kuwayama), leaf miner (*Phyllocnistis citrella* Staint), black fly (*Aleurocanthus woglumi* Ashby), lemon butterfly (*Papilio demoleus* L.) and fruit fly (*Dacus* spp.). Citrus psylla which is a serious pest of citrus also acts as a vector of bacterial and viral diseases like canker and greening disease (Bindra, 1966).

The studies were carried out at the research farm of Rainfed Research Substation for Subtropical Fruits, Raya, Sher-e-Kashmir University of Agricultural Sciences Technology, Jammu located at a distance of 20 km away from Jammu city, during 2006-2007 to determine the major insect pests, disease and their natural enemies with a view to develop suitable biocontrol based Integrated Pest Management programme. For this purpose, 20 citrus trees of uniform age, vigor, and size were selected, tagged and were left unsprayed to allow maximum population buildup of pests and their natural enemies. The observations were recorded at weekly interval on randomly selected and tagged plants all along the periphery (Table 1). Pest status was determined on the basis of percent damage. More than 10 percent damage was considered as a major pest and those causing damage between 5-10 percent were categorized as minor. Natural enemies were selected on the basis of relative abundance. Relative abundance was determined with the help of formula Total population ÷ Population at date of sampling x 100.

The field surveys revealed that psylla (*Diaphorina citri*) leaf miner (*Phyllocnistis citrella*), black fly (*Aleurocanthus woglumi*), lemon butterfly (*Papilio demoleus*) and fruit fly (*Dacus* spp.) are the major pests and gummosis (*Phytophthora palmivora* Butler), Anthracnose (*Colletotrichum gloeosporioides* Penz) and canker (*Xantomonas axonopodis* p.v. *citri* Hase) is the major disease in this region. Study also revealed the presence of four species of coccinellid predators *i.e. Coccinella septempunctata, Coccinella transversalis, Hippodamia dimidiata* and *Menochilus sexmaculatus*. Syrphid fly was also recorded as a major predator. It was interesting to note that the predator population significantly coincided with the peak population of major pest, citrus psylla, which is a vector of greening disease and citrus canker in citrus.

Table 1 Insect-Pest, disease and natural enemies complex of citrus under rainfed area of Jammu region

Insect- Pest	Scientific Name	Phenology of the crop	Status
Citrus psylla	*Diaphorina citri* Kuwayama	Buds and leaves active new flush	Major
White fly	*Dialeurodes citri* Ashmead	Tender leaves, active vegetative stage	Minor
Leaf miner	*Phyllocnistis citrella* Staint	Tender leaves, active emergence of new flush	Major
Mealy bug	*Pseudococcus filamentous* Cockrell	Leaves, tender shoots and fruits	Minor
Lemon butterfly	*Papilio demoleus* L.	Nurseries and young trees and active new flush	Major
Citrus black fly	*Aleurocantheus woglumi* Ashby	New leaves and active vegetative stage	Minor
Aphid	*Myzus persicae* Fulz	Tender portion of the plant	Major
Fruit fly	*Dacus* spp.	Fruits	Major
Diseases			
Gummosis	*Phytophthora palmivora* Butler, *P. parasitica* Dastur	Root and rootlets, trunk	Minor
Brown fruit rot	*P. nicotianae* var. *parasitica* Dastur	Fruits	Minor
Anthracnose	*Colletotrichum gloeosporioides* Penz	Leaves, twigs and immature fruits	Major
Melanose or leaf spot	*Phomopsis citri*	Leaves and twigs	Minor
Canker	*Xanthomonas axonopodis* p.v. *citri* Hase	Leaves, twigs, branches and fruits	Major
Natural Enemies			
Lady bird beetle	*Coccinellid* spp.	Soft bodied insects	Major
Hover fly	*Syrphid* spp.	Soft bodied insects	Major
Lace wing bug	*Chrysoperla carnea* Stephans	Soft bodied insects	Minor

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Acridoidea (Orthoptera) biodiversity of Western Uttar Pradesh

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All the economically important species belonging to the Acridoidea are commonly known as locusts and grasshoppers. Sometimes they are called short-horned grasshoppers. Acridoidea possess short antennae, usually shorter than the body and a short ovipositor and their tarsi are three-segmented. Acridoidea has shown maximum diversity and divided into five families of which family Acrididae, Catantopidae and Pyrgomorphidae are widely distributed in India. Locusts and grasshoppers constitute an economically important group that infest a number of cultivated and non-cultivated crops. They cause considerable damage to agricultural crops, pastures and forests and are well reputed for their destructiveness all over the world.

Uttar Pradesh is bounded by Nepal on the North, Uttrakhand on the north-east, Himachal Pradesh on the north-west, Haryana on the west, Rajasthan on the south-west, Madhya Pradesh on the south and south-west, and Bihar on the east. Situated between 23°52'N and 31°28'N latitudes and 77°3' and 84°39'E longitudes, this is India's fifth largest and most populous state, located in the north-western part of the country. A notable taxonomic work on Acrididae was made by Kirby (1914) in the series 'Fauna of British India'. Henry (1940) made a major contribution to Indian fauna of Acrididae. An extensive and intensive survey to study the speciation and distribution of the locusts and grasshoppers belonging to the superfamily Acridoidea was undertaken in Western Uttar Pradesh during the period 2006-2008. Systematic study of the material collected from various habitats and localities was made to understand the diversity. The new material (250 specimens) of adult grasshoppers collected during 2006-2008 from various localities of Western Uttar Pradesh served the basis for the present critical study. A complete record was also maintained indicating the reference number, locality, data of collection and name of host plants. The specimens were first relaxed, stretched and later, they were pinned and labelled. For a detailed study of the various components of genitalia, the permanent slides were prepared and examined under the microscope in order to make a detailed study of the genitalic structures.

Table 1 Fauna of Acridoidea of Uttar Pradesh

Superfamily Acridoidea	
Family Pyrgomorphidae **Subfamily Pyrgomorphinae**	**Family Acrididae** **Subfamily Acridinae**
1. *Pyrgomorpha conica* Olivier, 1791	14. *Acrida exaltata* Walker, 1859 Subfamily Chrotogoninae
2. *Atractomorpha crenulata* Fabricius, 1793	15. *Phlaeoba infumata* Brunner von Wattenwyl,1893
Subfamily Poekilocerinae	**Subfamily Oedipodinae**
3. *Poekicerus pictus* Fabricius, 1775 4. *Chrotogonus trachypterus* Blanchard, 1836	16. *Locusta migratoroides* (Reiche & Fairmaire,1847)
Family Catantopidae **Subfamily Oxyinae**	17. *Trilophidia annulata* Thunberg, 1815
Subfamily Oxyinae 5. *Oxya hyla intricate* Stal, 1860	18. *Acrotylus humbertianus* Saussure, 1884
6. *Oxya japonica japonica* Thunberg, 1824	19. *Aiolopus simulatrix* Walker, 1870
Subfamily Hemiacridinae	20. *Oedaleus senegalensis* Krauss, 1877
7. *Hieroglyphus banian* Fabricius, 1798	21. *Oedipoda miniata* Pallas, 1771 **Subfamily Gomphocerinae**
8. *Hieroglyphus nigrorepletus* I. Bolivar, 1912 9. Spathosternum prasiniferum Walker, 1871	23. *Ochrilidia geniculata* I. Bolivar, 1913
Subfamily Eyprepocnemidinae	24. *Chorthippus Indus* Uvarov, 1942
10. *Eyprepocnemis alacris* Serville, 1839 12. *Tylotropidius varicornis* Walker, 1870	25. *Leva indica* I. Bolivar, 1902
Subfamily Catantopinae 13. *Catantops pinguis innotablis* Walker, 1870	26. *Aulacobothrus luteips* Walker, 1871

Except for some sporadic reports there is no systematic study on the locusts and grasshoppers belonging to the superfamily Acridoidea from North India, a hot spot of biodiversity. Keeping in view the above fact, the present work is aimed at studying one of the superfamilies of Orthoptera which is most widely distributed and show a very high degree of biological diversity. Further, it has revealed interesting observations on their destitution, biology and pest-plant relationships. Each sample collected and all specimens are recorded with bio-ecological observations and other relevant data. This makes the collected material extremely valuable. In terms of published documentation, Acrido-fauna of Uttar Pradesh, in particular and North India, in general are poorly known. In the present work, 250 specimens of locust and grasshoppers from various localities in Western Uttar Pradesh belonging to three families, ten subfamilies, twenty three genera and twenty six species have been recorded (Table 1).

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Population dynamics of insects visiting *Citrus jambhiri*

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Although citrus is essentially a crop of the subtropical regions, it is also grown under arid regions. This fruit ranks third among the subtropical fruits and in India with 10 percent of total area. A rough estimate shows about 5.27 hectares under various citrus species with approximately 40.51 lakh tonnes production. Among citrus species, *Citrus jambhiri* Lushington, commonly known as rough lemon (*Jamiri nimbu*) is highly polyembryonic with medium to large and spreading tree. Its flower secretes copious nectar and some pollen which attract the insects for their food. It appears that no work have been done in Bihar so far on population dynamics of insects visiting flowers of rough lemon. Therefore, the present investigation was undertaken.

The climate of the region is mild-tropical. The temperature varying from 40°C (May) to 7°C (January). The study was conducted in the citrus orchard of main campus, Rajendra Agricultural University, Bihar, Pusa (Samastipur). To find out the population dynamics of insect visitors and their abundance on citrus blooms, one citrus tree of 8-9 years old was selected. Observations on number of insect visitors was recorded from one twig at two places (replications) on flowering branches visually, as sweeping was inconvenient, for five minutes on alternate day at hourly intervals (0600-1700 h). Thus, there were 55 treatment combinations (11 days x 5 insect spp.) with two replications (twigs). The data so obtained were subjected to statistical analysis following randomized block design factorial (RBDF). Simultaneously weather parameters viz. maximum and minimum temperature (°C) and relative humidity (at 0700 and 1400 h) were also recorded prevailing at Crop Research Programme, Regional Station, Pusa within the main campus of R.A.U., Pusa from flowering to fruit set of citrus i.e., from 21.02.2002 to 14.03.2002 daily. The direct and indirect influences of weather components together and individual on insect visitors on citrus blooms were also computed.

Apis mellifera predominated and outnumbered (171.5) varying from 22nd February to 14th March. Its number gradually and significantly increased during first day of observation (22nd February) to 7th observation (6th March) and significantly decreased thereafter. Similar trend was observed in case of *A. c. indica*, with total of 29.0. *A. dorsata* (78.0) maintained its position next to *A. mellifera*. The number of visitors varied significantly. The percent share of different visitors were 8.07, 47.71, 21.69, 5.70 and 16.82 for *A. c. indica, A. mellifera, A. dorsata, A. florae* and others, respectively. The bees constituted 83.18 percent over total population. The maximum temperature showed non-significant but negative correlation with *A. dorsata* and *A. mellifera* while positive with *A. c. indica* and *A. florea*. Similar influence was observed in case of minimum temperature. Relative humidity 0700 h exerted positive correlation with *A. c. indica*, others and *A. florea* while negative with *A. dorsata*. The similar trend was noticed in case of relative humidity at 1400 h. Insect visitors included all the *Apis* species and others were mainly flies, butterflies, sharing 78 and 22 per cent, respectively. Desh Raj and Rana (1993) reported that *A. c. indica* and *A. mellifera* species had highest number among the foragers on rapeseed and mustard.

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Taxonomic details of *Phytoscaphus* Schoenherr (Coleoptera: Curculionidae)

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The weevils or snout beetles of the superfamily Curculionoidea are the most important insect herbivores. Curculionidae or the "True Weevils" is the largest of these groups and its diversity has been well documented. In the world catalogue of genera of Curculionoidea (Alonso-Zarazaga and Lyal 1999) 22 families have been recognized. There are approximately 60,000 species under 6000 genera making it currently the largest family. Broad nosed weevils of the subfamily Entiminae are one of its largest groups distributed throughout the world particularly in tropics. 55 tribes, 1340 genera (Nikolai *et.al.*, 2006) and 12,000 species are known of this group (Alonso-Zarazaga and Lyal, 1999).

Phytoscaphus is one such entimine group first described by Schoenherr (1826), and this stands currently under subtribe Phytoscaphina of the tribe Cyphicerini. Persual of literature reveals that it is known from Indian subcontinent, south East Asian countries (Cambodia, Vietnam, Laos, Taiwan, Philippines and Indonesia), China, Szetschwan, Japan and Afghanistan showing that it is largely Oriental. Myanmar and India are the regions from where more than half of the species (46 species) has been reported. From India alone 17 species are known contributing to more than one-third of the total species diversity known from different areas like Punjab, Uttar Pradesh, Uttarakhand, West Bengal, Meghalaya, Assam and Sikkim.

Economic importance of this group reveals that it infests a number of crops viz., sugarcane, mulberry and cotton. It is a serious defoliator of sugarcane in India particularly in Uttar Pradesh and Bihar (Varma, *et al.*, 1988; Mukunthan and Sardana, 1989; Varma and Tandan, 1996); and as root weevil on rice in India (Nayar *et. al.*, 1975); Butani & Jotwani (1984) reported it as a pest on sweet potato; *P. gossypii* infests mainly cotton, legumes and maize in China though it has a range of more than 20 food plants species (Zhou and Zhou, 1989; Ding *et.al.*, 2000) (Table 1). In view of its economic importance, taxonomic studies are imminent. As a prelude to such studies efforts were made to prepare an annotated checklist of the species of the genus *Phytoscaphus*. Information on the distribution and coleopterists who contributed to this genus was also gathered. These studies have revealed the following significant findings:

There are 56 species (Table 2) of *Phytoscaphus* known from India, Myanmar, Sri Lanka, Nepal, Bangladesh, Afghanistan, China, Szetschwan, Taiwan, Vietnam, Cambodia, Japan, Philippines and Indonesia (Fig. 1) showing that it is entirely Oriental. Myanmar and India are the regions from where majority of the species has been reported. From India alone 17 species are known contributing to more than one-third of the total. Different states like Punjab, Uttar Pradesh, Uttarakhand, West Bengal, Meghalaya, Assam, and Sikkim are the areas from which many species are known. *Phytoscaphus* was studied by coleopterists namely Schoenherr, Faust, Marshall, Voss and Motschulsky (Fig. 2) which are significant towards its taxonomic information. Marshall along with Schenkling (1931) catalogued 35 species, of which 3 species had been transferred to other genera.

Phytoscaphus is distinguished from other weevils with their mentum having 2 setae; interscrobal area not raised in form of plate; dorsolateral carinae of rostrum diverging towards apex; epistome short with hind margin transverse or curved or forming an obtuse angle, its apex not exceeding a line between bases of antennae; prothorax transverse, shallowly bisinuate at base; rostrum longer than broad, prothorax much narrower at apex than at base; corbels of hind tibiae variable. Its taxonomy needs to be worked out in detail, in particular in the context of the studies by Pajni (1990).

India being one of the biodiversity hotspots of the world studies on the taxonomic diversity of the weevils has become imminent. Being agriculturally most important, these weevils play a major role in the agro ecosystems as defoliators in their adult stage and root feeders in their larval stages. Especially in the present scenario of the climate change with increasing temperature, loss of natural habitats, melting of glaciers and increasing mean sea levels studies on the taxonomic diversity of these herbivorous insect groups gains significance.

Table 1 Economic Importance

Host	Reference
Sugarcane, rice, sweet potato and *Dalbergia*	Varma and Tandan, 1996; Mukunthan and Sardana, 1989; Varma, *et.al.*, 1988; Butani and Jotwani, 1984; Nayar *et.al.*, 1975; Lefroy, 1909
Maize, legumes, cotton and mulberry	Ding, J *et.al.*, 2000; Zhou and Zhou, 1989

Table 2 Contributions by periods

Periods	Number of species given
1826-1850	06
1850-1900	22
1900-1950	05
1950-1989	06
1990-2000	17
Total	56

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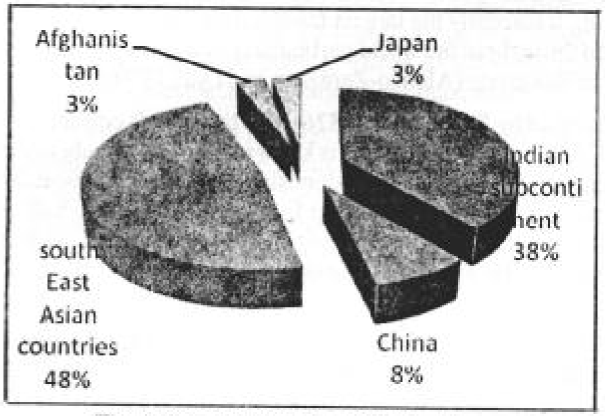

Fig. 1 Zoogeographical distribution

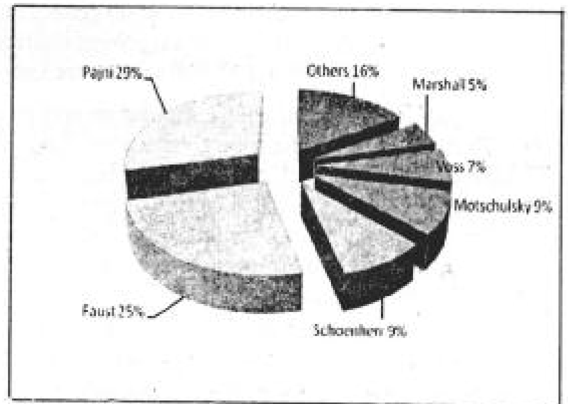

Fig. 2 Contributions by different coleopterists

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Pest succession in cabbage at Raipur, Chhattisgarh

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Cabbage is an important cruciferous vegetable grown throughout the world and it is attacked by a number of insect pests, which not only cause qualitative and quantitative losses but also result in pesticide residue problem. Among the most important insect pests the diamond back moth, *Plutella xylostella*; cabbage leaf webber, *Crocidolomia binotalis* and aphid, *Lipaphis erysimi* are important (Krishnaiah and Jaganmohan, 1983)

Table 1 Pest succession in cabbage var Golden acre along with natural enemies

Name of insect	Scientific name	Mean popl^n range	Period of activity	Max^m activity period	Crop stages attacked
Diamond back moth	*Plutella xylostella*	0.82-1.38	3rd week of October to 1st week of February	3rd week of November	All Stages
Aphids	*Myzus persicae*, *Brevicoryne brassicae*, *Lipaphis erysimi*	0.82-1.44	3rd week of October to 1st week of February	4th week of December	All Stages
Web worm	*Crocodolomia binotalis*	0.73-0.76	3rd week of October to 1st week of February	2nd and 4th week of January	All Stages
Flea beetle	*Phyllotreta cruciferae*	0.72-0.73	3rd week of November to 1st week of February	3rd week of November	Vegetative Stage
Tobacco caterpillar	*Spodoptera litura*	0.71-0.73	3rd week of October to 1st week of February	1st, 2nd and 4th week of January	All Stages
Bihar hairy caterpillar	*Spilosoma obliqua*	0.71-0.73	3rd week of October to 1st week of January	1st week of November and 1st week of December	Vegetative Stages
Natural enemies					
Spider	(unidentified)	0.72-1.14	3rd week of October to 1st week of February	4th week of December	Feeds on aphids
Ladybird beetles	*Coccinella septumpunctata* and *Menochilis sexmaculata*	0.72-0.74	3rd week of October to 1st week of February	3rd week of October to 1st week of January	Feeds on aphids
Rove beetle	*Paederus* spp.	0.71-0.72	3rd week of October to 4th week of December	3rd week of October to 4th week of December	Larvae of insects

Studies on pest succession in var. Golden acre were conducted during 2005-06 at the horticultural field, IGAU, Raipur. To study the pest succession, weekly observations were recorded on insect population and natural enemies on ten randomly selected plants from germination to harvesting stage.

Six insect pests were recorded at various stages, among these diamond back moth was recorded in the first week of February, with a maximum population of 1.38 larvae/plant during third week of November. In remaining season the population was comparatively low. Aphids appeared at the vegetative stage during third week of October with 0.92

aphids/plant. Peak population was recorded in the fourth week of December with a maximum population of 1.44 aphids/plant. The larval population of web worm, *Crocidolomia binotalis* was very low. It was noticed in the third week of October with 0.73 larvae/plant and continued up to 0.74 larvae/plant up to first week of February. The flea beetle, *Phyllotreta cruciferae,* incidence started in the third week of November and continued till first week of February although the population was low ranging from 0.72 to 0.73 beetles/plant. The population of tobacco caterpillar, *Spodoptera litura* was again very low and appeared from third week of October to first week of February with 0.72 larvae/plant. Bhatia and Verma (1995) reported the incidence and sequence of appearance of major pests on cabbage, which are in agreement with the present study.

Among the natural enemies recorded spiders (unidentified) were noticed preying on soft-bodied insects like aphids, from October to February with an average population of 0.72 to1.14 spider/plant. Two species of ladybird beetles, *Coccinella septumpunctata* and *Cheilomenes sexmaculata* were observed as major bioagents from third week of October to first week of February feeding on nymphal stages of aphids.

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Biosystematical differentiation of a pest and its predatory species (Hemiptera: Pyrrhocoridae)

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Cotton is the most economically important natural fiber and about 1.67 million hectares are under cotton in Indian North Zone states of Haryana, Punjab and Rajasthan (Anonymous, 2007). One of the major factors limiting cotton cultivation is the insect pests. Amongst the sucking pests, the cotton stainers, *Dysdercus* spp. (Heteroptera: Pyrrhocoridae) particularly, cause damage by feeding on both the developing cotton bolls and ripe cotton seeds and transmitting disease organisms thus, causing primary and secondary losses (Scheafer and Panizzi, 2000). In addition, four heteropterous species of Pentatomoidea were found occurring on cotton in Haryana and adjoining areas (Khokhar and Khokhar, 2004). *Dysdercus koenigii* (F.) has been observed more dominating than its closely related species *D. cingulatus* in the North Zone. From this region, nymphs and adults of *Antilochus coqueberti* (F.) have been recorded predating on all the life stages of *D. koenigii* .This predatory species of the same family (Pyrrhocoridae), shares the same niche as that of its prey. Since both occur simultaneously and look quite similar are frequently confused as pest, by the field workers. Hence, here we differentiate them on the basis of their external morphological characters, body colorations (Fig. A-D), and the male and female genitalia so that predator *A. coueberti* can be protected and further augmented to control *Dysdercus* spp. in IPM programmes.

Dysdercus koenigii **(Fabricius):** Body subelongated and punctate, general colouration dull sanguineously-ochracecus (reddish); head, tylus , juga reddish, bucculae very small pale-whitish, eyes dark-brown to dark; antennae black except base of segment I; pronotal collar with narrow creamy white band, remaining pronotum, ventro-lateral sclerites of thorax and metathoracic scent gland lobes sanguineous; spots near coxae creamy white; scutellum black, triangular with light colored pointed apex; corium of hemelytron sanguineously-ochraceous, with a black spot, membrane black in both sexes (Fig. A&B); legs black with femora pale sanguineous,anterior femora not incrassated with short spines beneath, near apex; abdominal sterna sanguineous with posterior margins creamy white.

Head declivent, as long as width across eyes 2.14±0.06 (1.90-2.35), tylus slightly convex, longer than juga; eyes medium sized, interocular distance 1.15±0.08 (1.00-1.35); antenniferous tubercles prominent, antennal segment I slightly longer (2.30± 0.25) than II (2.05± 0.5), III shortest (1.30±0.08) and IV longest (3.25±0.04); labium long, extending upto third abdominal segment, labial segment I longest (2.35±0.26), followed by II (2.10±0.45) while III & IV subequal (1.50±0.18& 1.50± 0.15). Pronotum punctuate, wider (3.75±0.28) than long (2.56±0.08), anterior callosity impunctate, lateral margins laminated and reflexed; scutellum impunctate , almost as long as width at base (1.30-1.90). Abdomen more than four times longer (8.25-11.25) than head length, abdominal width (4.80±0.08) more than pronotal width. Total body length 14.35±1.05 (12.30-15.65). Male pygophore (Fig.1) with convex median lobe (ML) covered with hairs, median vertical projections near pygophoral caudal orifice, small, stout and bifurcated apically (Fig.2), claspers (Fig.3) sickle-shaped and hooked at apex, broad subapically with finger-like dorsal lobe; spermathecal duct (Fig.4) narrow, more looped (SD), bulb spherical (SB), spermathecal pump (SP) with distinct flanges.

Antilochus coqueberti **(Fabricius):** Body oblong, heavily built; general coloration bright sanguineous; head, tylus, juga , bucculae sanguineous; eyes black; antennae black except base of segment I; pronotum, ventro-lateral sclerites of thorax, bases of coxae and metathoracic scent gland lobe sanguineous; scutellum triangular, dull sanguineous with pointed apex; corium of hemelytron sanguineous without black spot, membrane black in both sexes (C,D); anterior femora slightly incrassated with short spines beneath, near apex, tibiae and tarsi fuscous, femora and abdominal sterna sanguineous, ventral incisures black. Head moderately declivent; head length 2.13±0.31 (1.70-2.50), less than width across eyes 2.28±0.25 (2.00-2.50); tylus more convex, longer than juga; eyes large, interocular distance, 0.93±0.08 (0.90-1.05); antenniferous tubercles prominent, antennal segment I slightly shorter (2.50±0.18) than II (2.55±0.26), III shortest (2.14±0.02) and IV longest (3.12±0.04); labium short, extending upto mid-coxae, labial segment I slightly longer (1.85±0.07) than II(1.81±0.08), followed by III (0.82±0.08) and IV (0.54± 0.05), shortest. Pronotum with two transverse series of punctures, wider (4.42±0.24) than long (3.28±0.18), anterior callosity impunctate, lateral margins laminated but not distinctly reflexed; scutellum punctuate, broader (2.27±0.21) than long (1.94± 0.16). Abdomen almost five times longer (9.80-11.30) than head length, abdominal width (7.05±0.33) more than pronotal width. Total body length 16.40±0.86 (14.45-18.25).Male pygophore (Fig.5) with long median bifurcated lobes covered with hairs, median vertical projections near pygophoral caudal orifice (Fig.6), large and bifurcated apically; claspers (Fig.7) hooked at apex, dorsally straight and with small tooth-like process subapically blade narrow but shaft quite broad; spermathecal duct (Fig.8) narrow, less looped, bulb spherical and spermathecal pump without distinct flanges.

Table 1 Comparative morphometrics of important taxonomic characters of *Antilochus coqueberti* (F.) and *Dysdercus koenigii* (F.)

Body Regions	Characters	*Antilochus coqueberti*		*Dysdercus koenigii*	
		Morphometerics(mm)			
		$\overline{X}$±SD	Range	$\overline{X}$±SD	Range
Head	Head Length	2.13±0.31	1.70-2.50	2.14±0.06	1.90-2.35
	Head Width	2.28±0.25	2.00-2.50	2.14±0.06	1.90-2.35
	Inter-ocular Distance	0.93±0.08	0.90-1.05	1.15±0.08	1.00-1.35
	Antennal Length Segment-I	2.50±0.18	2.10-2.60	2.30±0.25	2.05-2.75
	Antennal Length Segment-II	2.55±0.26	2.50-3.00	2.05±0.15	1.90-2.30
	Antennal Length Segment-III	2.14±0.02	2.10-2.20	1.30±0.08	1.20-1.50
	Antennal Length Segment-IV	3.12±0.04	3.00-3.20	3.25±0.04	2.95-3.55
	Labial Length Segment-I	1.85±0.07	1.60-1.95	2.35±0.26	2.00-2.75
	Labial Length Segment-II	1.81±0.08	1.50-1.75	2.10±0.45	1.90-2.35
	Labial Length Segment-III	0.82±0.08	0.80-0.90	1.50±0.18	1.35-1.80
	Labial Length Segment-IV	0.54±0.05	0.50-0.60	1.50±0.15	1.40-1.70
Thorax	Pronotal Length	3.28±0.18	3.10-3.50	2.56±0.08	2.20-3.10
	Pronotal Width	4.42±0.24	4.10-4.80	3.75±0.28	3.70-4.45
	Scutellar Length	1.94±0.16	1.70-2.10	1.56±0.24	1.30-1.90
	Scutellar Width	2.27±0.21	1.90-2.50	1.68±0.26	1.30-1.90
Abdomen	Abdominal length	10.83±0.62	9.80-11.30	9.82±0.15	8.25-11.25
	Abdominal Width	7.05±0.33	6.20-7.50	4.80±0.08	5.00-5.25
Total Body Length		16.40±0.86	14.45-18.25	14.35±1.05	12.30-15.65

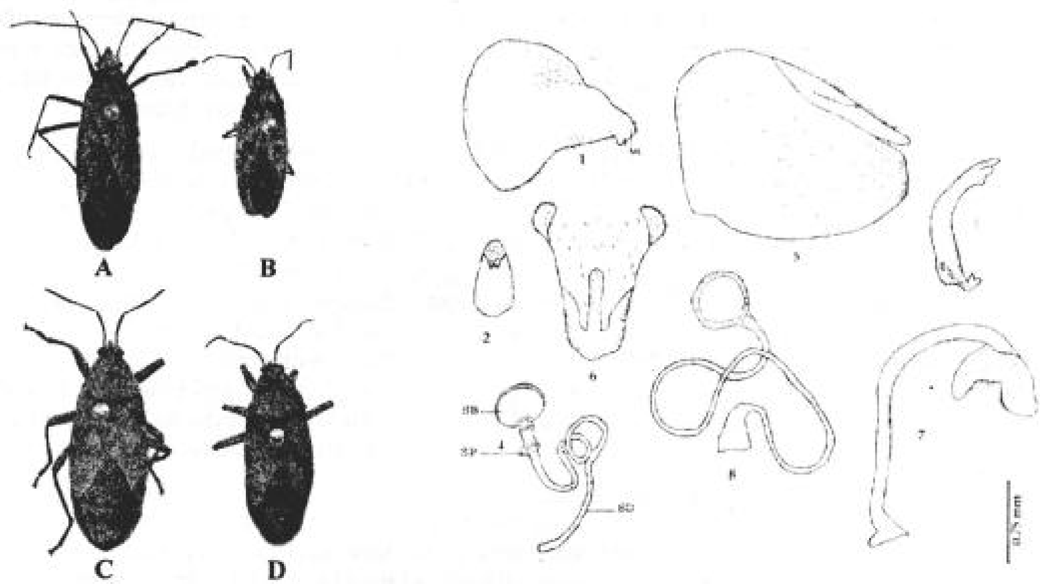

Fig (1-8, A-D): *Dysdercus koenigii*: 1, Pygophore (lateral view); 2, Caudal orifice of Pygophore; 3 Clasper; 4, Spermatheca; A, Female (Adult); B, Male (Adult); *Antilochus coqueberti*: 5, Pygophore (lateral view); 6, Caudal orifice of Pygophore; 7, Clasper; 8, Spermatheca; C, Female (Adult); D, Male (Adult); ML: Median lobe; SB: Spermathecal bulb; SD: Spermathecal duct; SP: Spermathecal pump.

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Proceedings of the National Symposium on IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh

Phycodes radiata (Lepidoptera: Brachodidae) as an emerging pest of ornamental fig, *Ficus benjamina* var. *nuda* in New Delhi

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The fig leaf roller, *Phycodes radiata* has earlier been reported as a minor and sporadic pest of fig from Myanmar, Sri Lanka and some parts of India (Fletcher, 1917; 1919). Beeson (1941) recorded this on various species of *Ficus* in India. Wadhi and Batra (1964) reported *P. radiata* and. *P. minor* as sporadic pests of *F. carica.* Simwat and Sidhu (1974) studied the biology of *P. minor* and observed heavy infestation on fig, resulting in 92 % of leaves being damaged. Nair *et al.,* (1976) also mentioned *P. radiata* and *P. minor* webbing and feeding on leaves of *Ficus* sp. in South India. It was observed on the leaves of ornamental fig, *F. benjamina* var. *nuda* at the Indian Agricultural Research Institute, New Delhi. Hence, realizing the significance, preliminary studies on the biology and nature of damage were undertaken and the results presented herein.

Studies were done by collecting full-grown caterpillar along with infested leaves and reared individually in plastic jars for adult emergence. Adults thus obtained were paired in glass tubes and were provided with 10 % honey solution on cotton swab. These adults after processing were studied for their taxonomic characters. These indicated that the important taxonomic characters are head smooth; ocelli present; tongue developed; labial palpi short, curved, ascending, second joint laterally compressed, much dilated beneath with dense appressed scales, terminal joint very short, obtuse; maxillary palpi obsolete. Middle and posterior tibia smooth, with groups of spines above on origin of spurs, tarsi spinose beneath. These were elaborated by Meyrick (1912-22) which was used and further compared with specimens in the National Pusa Collection, Division of Entomology, Indian Agricultural Research Institute, New Delhi.

The larval development studied under field conditions reveals that it remained active between July to October, with two generations. Adult emergence started in the last week of August, synchronized with new flush of leaves which starts in second week. The perusal of literature indicates its occurrence at Kullu (Himachal Pradesh), Gurdaspur (Punjab), Pusa (Bihar), Guwahati (Assam), Nagpur (Maharashtra) and Hagari (Karnataka) in India, and Peshawar in Pakistan. It has been reported to breed on *F. religiosa, F. glomerata, F. indica, F. tisela* and *F. carica.* The eggs are observed on the under surface of leaves preferably on new flush (Fig.1). Early instars fed gregariously on the under surface of the leaves targeting the mesophyll tissue while later instars fed individually, mostly under the silken webs spun by them along the veins (Fig.2). These disperse in their second instar and spun individual webs made of white fine threads on both surfaces of leaves. Larvae feed on chlorophyll along with the epidermis of the under surface, leaving the epidermis of other side. Infested leaves turn yellow, dry and gradually wither away (Fig.3). In some cases the leaf petiole is also damaged. Earlier instars are bicoloured with head and thorax brown and abdomen yellowish white which later turns dark green (Fig.4). Later instar only the head remains brown, while the rest of the body has alternate black and yellow markings dorsally.

The full grown larva is about 2 to 2.5 cm long, which usually gets stretched longer while feeding (Fig.5). The larva generally feeds within the web and gets into it even at slight disturbance. The larva makes many wriggling movements if disturbed outside the web. Pupation takes place on or in between the leaves under the shelter of webs in dirty brown cocoons resembling pine seeds (Fig.6). The pupa is brown, measures 1.5 to 2 cm long, enclosed in a cocoon, half of which is pushed out anteriorly at the time of emergence (Fig.7). Adults measure a wingspan of 2.5-3 cm with forewing blackish with darker markings across, hind wing are dark brown with yellow markings on the margins and centre (Fig.8). Abdomen black with five fine yellow bands across the dorsum making it more distinct (Fig.9).The observations reveal that the *P. radiata* has migrated towards ornamental plants grown in the urban areas too. This shift in the temporal/spatial variations can be attributed to climate change. This is the first report of the appreciable damage by *P. radiata* to the ornamental fig plants from Delhi. It was however, reported as a minor and sporadic pest of fig from Myanmar, Sri Lanka and some parts of India and a serious pest in the Punjab. It can be concluded that such migrations and shift in the host plant can be used as indicators of climate change.

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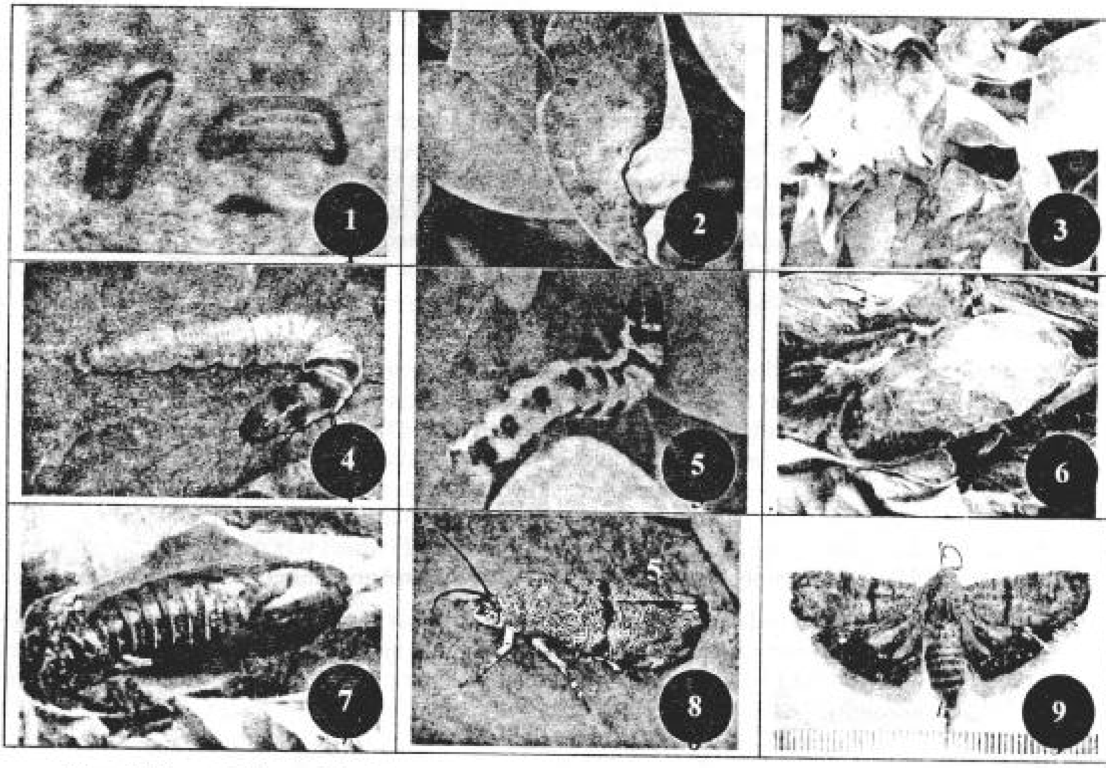

Figs. 1. Eggs, 2. Larval feeding within leaf, 3. Damage, 4 – 5. Larva, 6 – 7. Pupa, 8. Adult in resting position 9. Habitus

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Checklist of genus *Eublemma* Hubner (Lepidoptera : Noctuidae)

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The genus *Eublemma* was erected by Hübner (1818) (Hampson, 1894) with one species *Eublemma* raspersa from Europe. The genus was characterized by palpi upturned, and reaching just above vertex of head, the 3rd joint short; antenna minutely ciliated in male; thorax and abdomen smoothly scaled; legs short, the tibiae moderately hairy. Forewing with the apex somewhat produced and depressed; veins M1, R5 from angle of cell; R2, R3, R4 stalked from before the angle. Hindwing with veins Cu1a, Cu1b and M2, M3 from angle of cell. It was described under Family Noctuidae with the characteristic feature of tympanum present on metathorax and subfamily Acontinae with the following characters: eyes naked and without lashes; proboscis fully developed; tibiae without spines. Hindwing with vein 5 slender, depressed at origin, the outer margin not produced at its termination. Almost all the species are of small size and live amongst low herbage. Larvae usually with the four pairs of abdominal prolegs fully developed but sometimes with but three or two pairs. The 298 species were recorded from the world over. Among these species only 30 species were described in India. In India, it had been reported in the states / union territories i.e. Andaman & Nicobar, Assam, Bihar, Delhi, Himachal Pradesh, Jharkhand, Maharashtra, Meghalaya, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal (Fig. 1).

Fig. 1 Distribution of species of *Eublemma* in India

These species were described by 62 lepidopterists from 1775 to 1989. The authors and described species in brackets i.e. Berio (6), Bethune-Baker (7), Bienert (1), Bradley (1), Brandt (11), Butler (5), Bytinski-Salz & Brandt (2), Candéze (1), Christoph (6), Culot (1), Distant (2), Draudt (2), Druce (1), Duponchel (1), Dyar (1), Eversmann (3), Fabricius (3), Felder & Rogenhofer (4), Fletcher (2), Freyer (3), Gaede (5), Guenée (4), Hampson (92), Herrich-Schäffer (4), Holloway (2), Hübner (5), Joannis (2), Krüger (3), Le Cerf (1), Lederer (1), Lower (1), Lucas (1), Mabille (2), Meyrick (2), Milliére (1), Moore (6), Möschler (2), Oberthür (1), Osthelder (1), Poole (2), Prout (1), Rambur (2), Rebel (4), Rothschild (20), Saalmüller (3), Schaus (2), Schiffermüller (1), Snellen (2), Staudinger (12), Strand (1), Swinhoe (4), Turati (5), Turner (4), Viette (2), Walker (3), Wallengren (2), Warren (1), Warren & Rothschild (1), Wileman (1), Wileman & West (2), Wiltshire (14) and Zerny (1). The most of the species were described by Hampson.

The genus is a taxonomically and biologically diverse. On the biodiversity point of view it is a large group of small to very small, but often robust. Usually, the larvae are semilooper with greatest diversity in the tropics, particularly in open habitats and savanna. The genus *Eublemma* is economically important and taxonomically ill defined (Kitching, 1984). E. amabilis is predaceous and major insect pest of Indian lac insect Laccifer lacca (Pramanik and Choudhury, 1963; Bhattacharya et al., 2006), thus harmful, but one is predator on Coccidae i.e. E. scitula thus beneficial. E. silicula had reported major insect pest of pearl millet (Mittal *et al.*, 2006) and E. olivacea reported as a moderate pest of egg plant (Singh and Singh, 2002).

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Checklist of biodiversity of assassin bugs from north India (Hemiptera : Reduviidae)

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Reduviidae is the largest family of predaceous terrestrial Heteroptera (Hemiptera), globally distributed and comprised of 6250 species and subspecies under 913 genera and 25 subfamilies (Maldonado, 1990). Distant (1904, 1910) classified reduviid fauna, from the then British India including Myanmar and Sri Lanka, into 12 subfamilies containing 106 genera and 342 species. Since then several changes have taken place in the taxonomic status of several taxa. There is an urgent need to have a comprehensive and consolidated catalogue on Indian Reduviidae stating the distribution of the species throughout the country. Recently, Ambrose (2006) has published a checklist of 14 subfamilies with 144 genera and 464 species of Reduviidae from India. However, scrutiny of his document indicates that the majority of the enlisted species are from different areas of South India and very few places are covered from North India, although, in this region many species are existing in different agroclimatic conditions. I am engaged with the collection and subsequent taxonomic investigations of reduviid bugs from different states of this region for more than three decades. I initiated the taxonomic work in 1973, described and illustrated 24 species under six subfamilies from Haryana. Further, added 5 species and one subfamily to the list as well as 4 new species to the science *viz., Acanthaspis hisarensis, A. maculatus, A. niger* and *Sirthenea bharati* (Sucheta and Chopra, 1988a,b; 1989). The importance of male and female genitalia as tools to trace the phylogeny of Reduviidae has also been established (Sucheta and Khokhar, 2003; 2004).

The efforts have been made to prepare a checklist of North Indian assassin bugs from seven major states, namely, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Uttrakhand and Uttar Pradesh (Table 1).

Table 1 Checklist of biodiversity of assasin bugs (Hemiptera : Reduviidae) from north India

States	Biodiversity of Assassin bugs
Delhi	I. Ectrichodiinae: *Haematorrhophus nigroviolaceous* (Reuter); II. Emesinae: *Ploiaria anak* Distant; III. Harpactorinae: *Coranus spiniscutis* Reuter, *Coranus* sp., *C. wolffi* Lethierry & Severin; *Epidaus famulus* Stal; *Lophocephala guerini* Laporte; *Rhynocoris lapidicola* Samuel & Joseph; *R. marginatus* (Fabricius), *R. nysiiphagus* Samuel & Joseph, *Rhynocoris* sp.; *Sycanus reclinatus* (Dohrn); IV. Holoptilinae: *Holoptilus sp.*; V. Peiratinae : *Ectomocoris elegans* (Fabricius); VI. Reduviinae: *Acanthaspis flavipes* Stål, *A. rugulosa* Stål; *Reduvius delicatula* Distant; VII. Salyavatinae: *Lisarda annulosa* Stål ;VIII. Stenopodainae: *Caunus farinator* Reuter; *Pygolampis foeda* Stål; IX. Triatominae: *Triatoma rubrofasciata* (DeGeer); X. Tribelocephalinae: *Tribelocephala indica* (Walker).
Haryana	I. Ectrichodiinae: *Haematorrhophus nigroviolaceous* (Reuter); *Scadra fuscicrus* Stal, *Scadra sp.*; II. Harpactorinae: *Coranus spiniscutis* Reuter; *C. obscurus* Kirby, *Coranus* sp., *C. wolffi* Lethierry & Severin; *Lophocephala guerini* Laporte; *Rhynocoris marginatus* (Fabricius); *Rhynocoris* sp.; III. Holoptilinae: *Holoptilus sp.*; IV. Peiratinae: *Ectomocoris cordiger* Stål; *E. elegans* (Fabricius); *Lestomerus affinis* Serville; *Peirates atromaculatus* Stål, *P. sanctus* Fabricius; *Phalantus* sp.; *Sirthenea bharati* Sucheta & Chopra; V. Reduviinae: *Acanthaspis flavipes* Stål; *A. hisarensis* Sucheta & Chopra; *A. maculatus* Sucheta & Chopra; *A. niger* Sucheta & Chopra; *A. rugulosa* Stål; *Acanthaspis* sp.; *Gerbelius ornatus* Distant; *Reduviu knyvetti Distant*; *Reduvius* sp., *R. transnominalis* Distant; VI. Salyavatinae: *Lisarda annulosa* Stål ;VII. Stenopodainae: *Caunus farinator* Reuter; *Oncocephalus annulipes* (Stål); *Oncocephalus* sp.; *Pygolampis foeda* Stål; *Sastrapada baerensspprungi* (Stål); *Staccia sp.*; *Thodelmus falleni* Stål; VIII. Triatominae: *Triatoma rubrofasciata* (DeGeer); IX. Tribelocephalinae: *Tribelocephala indica* (Walker).
Himachal Pradesh	I. Ectrichodiinae: *Scadra annulipes* Reuter; *Vilius melanopterus* Stal; II. Harpactorinae: *Coranus spiniscutis* Reuter; *Endochus nigricornis* Stål; *Epidaus atrispinns*; Distant; *Euagora plagiatus* (Burmeister); *Irantha armipes* (Stål); *Isyndus heros* (Fabricius); *Polididus armatissimus* Stål; *Rohirbus trochantericus* Stål; *Rhynocoris costalis* (Stål), *R. marginatus* (Fabricius); III. Peiratinae: *Ectomocoris apimaculatus* Distant, *E. atrox* (Stål), *E. cordiger* Stål; *Lestomerus affinis* Serville; *Peirates femoralis* Walker; *P. flavipes* (Walker); IV. Reduviinae: *Acanthaspis flavipes* Stål; *A. fulvipes* (Dallas); *A. quinquespinosa* (Fabricius); *Pasira perpusilla* (Walker); V. Salyavatinae: *Lisarda annulosa* Stål; VI. Stenopodainae: *Canthesancus helluo* Stål.
J & K	I. Ectrichodiinae: *Scadra annulipes* Reuter; II. Harpactorinae: *Endochus nigricornis* Stål; *Epidaus atrispinns* Distant; *Rohirbus trochantericus* Stål; *Rhynocoris costalis* (Stål), *R. marginatus* (Fabricius); *R. reuteri* Distant; *Sphedanolestes* sp.; *Sycanus collaris* (Fabricius); *S. pyrrhomelas* (Walker); III. Peiratinae: *Peirates* sp.; IV Reduviinae: *Acanthaspis flavipes* Stål, *A. fulvipes* (Dallas); V. Salyavatinae: *Lisarda annulosa* Stål ; VI. Stenopodainae: *Canthesancus helluo* Stål.
Punjab	I. Ectrichodiinae: *Haematorrhophus nigroviolaceous* (Reuter); II. Harpactori nae: *Coranus spiniscutis* Reuter, *C. wolffi* Lethierry & Severin; *Lophocephala guerini* Laporte; *Rhynocoris marginatus* (Fabricius); *Rhynocoris* sp.; III. Holoptilinae: *Holoptilus sp.* IV. Peiratinae: *Ectomocoris cordiger* Stål; *E. elegans* (Fabricius); V. Reduviinae: *Acanthaspis flavipes* Stål; VI. Salyavatinae: *Lisarda annulosa* Stål;VII.

Stenopodainae: *Caunus farinator* Reuter; *Pygolampis foeda* Stål; *Sastrapada baerensprungi* (Stål); *Thodelmus falleni* Stål; VIII. Triatominae: *Triatoma rubrofasciata*(DeGeer); IX. Tribelocephalinae: *Tribelocephala indica* (Walker).

UP I. Ectrichodiinae: *Scadra annulipes* Reuter; *Scadra sp.*; II. Harpactorinae: *Endochus nigricornis* Stål; *Epidaus atrispinns* Distant; *Euagora plagiatus* (Burmeister); *Irantha armipes* (Stål); *Isyndus heros* (Fabricius); *Rohirbus trochantericus* Stål; *Rhynocoris costalis* (Stål), *R. marginatus* (Fabricius), R. *reuteri* Distant; *Sphedanolestes funeralis* Distant, *S. mendicus* Stal; *Sycanus collaris* (Fabricius), *S. indagator* Stål, *S. reclinatus* (Dohrn); *Vesbius sanguinosus* Stål; III. Peiratinae: *Catamiarus brevipennis* (Serville); *Ectomocoris atrox* (Stål), *E.cordiger* Stål; *Lestomerus affinis* Serville; *Peirates atromaculatus* Stål; *P. femoralis* Walker; *P. flavipes* (Walker); *P. sanctus* Fabricius; *Peirates* sp.; IV. Reduviinae: *Acanthaspis flavipes* Stål; *A.fulvipes* (Dallas); *A. rama* Distant; V . Salyavatinae: *Lisarda annulosa* Stål ;VI . Stenopodainae: *Canthesancus helluo* Stål; *Oncocephalus annulipes* (Stål).

Perusal of the data indicate that the maximum number of reduviid subfamilies (10) are represented from Delhi followed by Haryana , Punjab and Uttar Pradesh with 9,9 and 8 subfamilies, respectively while Himachal Pradesh, Jammu & Kashmir, and Uttra Khand, each with representatives of 6 subfamilies. The maximum number of genera (24) and species (38) have been recorded from Haryana, followed by Uttrakhand(19&32), Himachal Pradesh (18&24), Delhi (16&22),Uttar Pradesh (16&19), Punjab (14&17) and Jammu & Kashmir (11&15).The species of Harpactorinae are more abundant in all the aforesaid states except Haryana where Reduviinae outnumber Harpactorinae.

There is every need to explore the biodiversity of Reduviidae more extensively in Eastern, Western India and other unexplored areas of different Indian zones, so as to conserve and utilize these predatory bugs in IPM programmes by crop entomologists and growers.

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Observation on mites associated with gall on *Cordia* sp. in Delhi

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Galls are the result of abnormal growth of plant cells in response to stimulus from causative agents like insects, mites, nematodes, bacteria and fungi. These do not usually damage the plant, as they are gall inducers, although some may change plant architecture and physiology. Also these provide food and shelter to the insects or mites lodged inside them. Some galls are also used commercially for extracting resins and tannic acids used for dyeing, tanning, making permanent ink and astringents. Though insect galls are most common, eriophyids or gall-mites make a variety of plant galls with characteristic size, shape and colour. The structure varies from plant to plant ranging from small finger-like outgrowths, pocket-shaped galls to leaf-erineums. Each species of eriophyid mite has a particular association with its host plant, and their feeding activities are concentrated on the plant's fleshy tissues. The galls serve as special sites that mites develop to provide protection for their brood and to supply themselves with additional food made available through the extra tissues in the gall. Some of the commonly infested plants belong to families Rosaceae, Asteraceae, Salicaceae, Fagaceae and Boraginaceae.

Of these, several instances of mite-induced galls have been reported from *Cordia* sp. (Boraginaceae). *Cordia* is a moderate-sized deciduous tree found in tropical and subtropical regions. The plant has great economic value in terms of providing fodder, cattle feed, timber, fruit and medicine. Some of the eriophyids reported on *Cordia* sp. are *Aceria cordiae, A. neocordiae, A. boraginae, A. dichotomae, A. gallae, A. pobuzii, Aculodes* sp. unknown, *Calepitrimerus cordiae, Neodichopelmus cordiae, Paraphytoptella arnaudi, P. secunda, Tegolophus cordis and Tegonotus cardiavagrans.* (Chakrabarti and Pandit,1997; Flechtmann and Etienne, 2001; Gupta, 1985; Huang, 1996; Wilson, 1970).A similar mite-induced erineum galls were observed on *Cordia* sp. at IARI, New Delhi during 2008. The galls were seen as white patches of no particular shape, mostly on the under surface of leaf with corresponding dimpling of its dorsal surface. The patches eventually became reddish brown as the erineum matured (Fig. 1-3). Periodic inspection of infected leaves revealed presence of eriophyids and occasional instances of predatory phytoseiids and tarsonemids. Taxonomic studies on the eriophyids revealed the presence of *Aceria* sp. The phytoseiid was identified as *Phytoseius (Phytoseius) intermedius* and the tarsonemid as *Tarsonemus* sp.

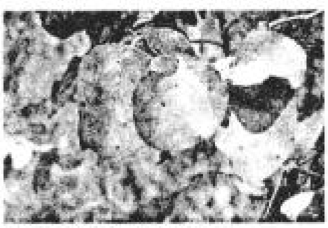

Fig.1 infected leaves

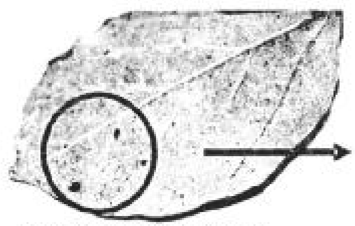

Fig.2 leaf with erineum

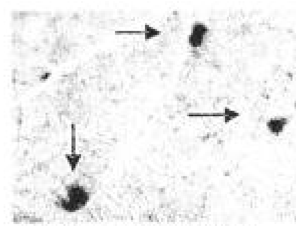

Fig.3 bronzed erineum

The galls and gall-inducers were recorded throughout the year and it was found that their population fluctuated with season. Although galls were present during January, the mites became apparent with fading winter (mid February), gradually increasing with the onset of summer (March-April). This was followed by a recess during hot summer season (mid May-June), and rainy season (July-September), showing a resurgence in early winter (October-mid November). The phytoseiids were observed throughout the year, though their population dwindled during rainy season. Tarsonemids showed no specific seasonal occurrence pattern and were seen in negligible numbers.The eriophyids and tarsonemids were seen mostly hidden deep amongst the hairy outgrowths in the erineum. Phytoseiids were found actively probing inside the erineum for predation and egg laying. Though the erineum patches became very evident and widespread when eriophyids' population was high, no damage to the overall health of the tree was observed. It was interesting to note that the erineum mites thrived best during mild winter conditions, when they were also found as vagrants on leaf in close vicinity to their erineum. As the temperature rose, the erineum bronzed, the hairy outgrowths becoming more brittle, less supple and dry. During this season very few eriophyids were seen only towards the core of the erineum. The population staggered back during pre-monsoons but again showed a dip in the rainy season, probably owing to mites being washed away by rains. Thus weather conditions play a vital role in the sustenance of mites. As is evident, the population dynamics of eriophyids showed variation with fluctuation in climatic conditions. However, these mites were able to maintain themselves through adverse conditions, showing adaptability to withstand climatic changes by initiating gall formation for food and shelter. Hence, eriophyid mites can be taken as good example for Darwin's theory of natural selection. Their capacity to induce galls on host plant to tide over unfavorable conditions exhibit their flexibility to adapt to nature's vagaries confirming sustenance rainy season, probably owing to mites being washed away by rains. Thus weather conditions play a vital role in the sustenance of mites. As is evident, the population dynamics of eriophyids showed variation with fluctuation in climatic conditions. However, these mites were able to maintain themselves through adverse conditions, showing adaptability to withstand climatic changes by initiating gall formation for food and shelter. Hence, eriophyid mites can be taken as good example for Darwin's theory of natural selection. Their capacity to induce galls on host plant to tide over unfavorable conditions exhibit their flexibility to adapt to nature's vagaries confirming sustenance.

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Record of male of invasive eucalyptus gall wasp *Leptocybe invasa* Fisher & Lasalle (Hymenoptera: Eulophidae) and gall biology

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In India, species and clones of eucalyptus have commercial acceptability, being grown for various purposes, as a major source of pulp for paper industries, timber and firewood. Eucalyptus with its 300 species is one of the fastest growing trees and many species attain greater heights. It occupies nearly 8 million ha and has a potential productivity of around 5 tons of biomass/ ha/yr on an average. The gall wasp *Leptocybe invasa* Fisher & La Salle (Eulophidae: Hymenoptera) is a regular invasive and serious pest of eucalyptus affecting seedlings in the nursery and young plantations (Mendel *et al.*, 2004). Its infestation causes major injury to young foliage by inducing a typical bump shaped gall, mainly on growing shoots resulting in growth reduction and deformation of leaves and shoots. Details about the outbreak of this pest have been reported recently for the first time from India. The extensive studies on this pest had revealed its potential to spread faster and inflict serious damage to eucalyptus plantations all over India. Intensive and extensive surveys have already shown that it has spread as a serious pest at several locations in Madhya Pradesh, Uttar Pradesh, Rajasthan and Delhi (Akhtar *et al.*, 2008). In spite of its invasive nature and economic importance, its taxonomy, biology and occurrence of male have not been studied in detail in India. So far the description of its female only from Israel and a male from Turkey are available. With the aim of filling this gap, laboratory and field investigations have been carried out.

As far as gall development is concerned the oviposition scars on both sides of the midrib, particularly on tender leaves is the first stage. This stage is characterized by a small change in the morphology of the attacked tissue, the oviposition scar becomes bigger and the section of the midrib that carries the eggs often gets discolored from green to pink. Second stage is characterized by development of the typical bump shape and the galls reach their maximum size of about 2.7 ± 0.5 mm wide. The third stage is characterized by the fading of the green colour on the surface that tends to change to pink while retaining its typical gloss. Fourth stage is characterized by the loss of glossiness of the gall surface, with colour changes to light or dark red. Fifth and final stage is characterized by emergence holes of the wasps where the colour changes to light brown on the leaf and red on the stem. Gall collected from Aligarh (Uttar Pradesh) and Pusa (Delhi) showed variation in size; size of gall in stem, midrib and petiole (±SD) was 0.32±0.26 cm (44%), 2.50±1.47 cm (22%) and 1.09±0.58 cm (76%) in Aligarh and 0.10±0.14 cm (15%), 0.52±0.57 cm (5%) and 0.54± 0.62 cm (34%) in New Delhi, respectively. The feeding by the adult under laboratory conditions when evaluated indicated that survival distribution of adult wasps differed significantly. Wasps fed with honey + water solution had the longest mean life span (±SD) (6.73 ± 0.33d), followed by sugar + water (5.70 ± 0.45 d), water (2.73 ± 0.44 d), fresh young foliage (2.17 ± 0.43 d) and no food (2.03 ± 0.43 d) (Table 1).

Table 1 Survival pattern of *Leptocybe invasa* on different food sources

Survival (No.) Food source	1st Day	2nd Day	3rd Day	4th Day	5th Day	6th Day	7th Day	8th Day	9th Day
No food	10.00	9.33	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Sugar + water	10.00	10.00	10.00	10.00	8.67	6.67	1.67	0.00	0.00
Water	10.00	10.00	6.33	1.00	0.00	0.00	0.00	0.00	0.00
Honey + water	10.00	10.00	10.00	10.00	9.33	7.67	5.33	3.67	1.33
Fresh young foliage	10.00	10.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00

Male: Sex ratio 1 male: 140 female. Length 0.8-1.2 mm. Similar to female except for the following: Head and mesosoma blue to distinct metallic green shine; metasoma brown with slight metallic tinge dorsally, leg pale yellow except mid, hind coxa and claws with brownish black. Fore coxa 1.25x of length of mid coxa, 1.66x as long as broad, Hind coxa 1.67x of mid coxa and 1.33x of fore coxa; antenna with scape yellow, darkened dorsally at apex; pedicellus yellow, darkened dorsally on its base, funicle and club yellow. Wing hyaline, veins brownish. Head 1.20x as broad as high, about twice as wide as long. Antenna with scape 2.87x as long as broad; pedicellus 2x as long as broad, 0.92x of anelli plus F1; flagellum filiform 1.50x of club; F1 about 1.14x of its width, 0.89x of length of F2, distinctly transverse, F2 to F4 subequal in length, each nearly quadrate; club 1.22x longer than F3 plus F4, about 2.20x as long as broad, with C1 1.28x of C2, C2 slightly longer than C3, setae long; funicular segments with some additional long setae and 2-3 linear sensillae; club with one row of long setae on each of C1 and C2, and two rows on C3. Forewing without post marginal vein, area between stigmal vein and costal margin almost bare, apical margin with short ciliae.

The occurrence of these wasps in different parts of the world indicates the invasiveness of the species with quick adaptations. The parthenogenetic reproduction and absence of natural enemies enable its quick spread and it has been observed that it can survive under wide range of climate. Research towards natural enemies and effect of climatic change on this invasive pest are required to be done.

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Studies on the biology of bruchids *Callosobruchus chinensis*

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The insects causing damage to stored pulses are pulse beetle (*Callosobruchus chinensis* L.), Khapra beetle (*Trogoderma gramarium* Everts.), lesser grain borer (*Rhizopertha dominica* Feb.). Among these pulse beetle is most important as it infests pigeonpea both in field and storage. The bruchids are most degraded stored grain pest, causing loss of nearly 0.21 million tones, costing 6.85 million rupees. The bruchids (*Callosobruchus chinensis* L.) breeds exclusively on variety of pulses having a very short life span with high degree of reproductive potential. The pest developed during storage and detected only when adult beetles comes out from seeds. Although, this insect remains active throughout the year but its infestation is maximum from July to September causing 40-50 % loss. The present investigation was carried out in Entomology Laboratory of Seed Technology section of Narendra Dev University of Agriculture (Kumarganj) Faizabad during 2006-2008.

Mating of insect was observed in tail to tail position. Lasted for on an average 7.3 minutes. The average pre-oviposition, oviposition, post oviposition periods were 6.8 (hrs.), 6.3 and 3.98 days respectively. Single female lays on an average 83.6 eggs. The larval and pupal periods were 15.15 & 7.43 days respectively. The average longevity of male & female beetle were 7.79 & 6.77 days respectively. The sex ratio of male and female was worked out and it was from to be 1:1.22. Female bears serrate type of antenna and male bears pectinate type (Table 1). The average size of head capsule of adult was 1.321, length of antennae was 3.261 mm. The average length of prothoracic, mesothoracic, metathoracic, legs was 3.064, 4.017 & 4.514 mm respectively. The length & width of fore wing was 3.402 & 1.485 mm respectively and hind wing was 7.56 & 3.33 mm respectively. The average length of male & female was 3.235 & 3.576 mm, respectively. 1000 number of adult beetles of *C. chinensis* were collected from infested grains at seed processing plant of N.D. University of Faizabad and released in the plastic jar of 5 kg capacity containing 2 kg fumigated grains of pigeonpea. Then mouth of jar was covered with muslin cloth and tied with rubber band. The female lays eggs either on maturing pods in field or on seeds in godowns. A female lays around 50-100 eggs. These hatch in 4-5 days. The grub bores into grain immediately after hatching. It moults four times and completely develops in two to three weeks, then transforms into the pupa. The adults normally emerge in four days but in winter it may take up to 28 days. Complete cycle from egg to adult takes around 25-30 days in summer and 50-60 days in winter. The adult normally survive for 10 days. Seven to eight generations were recorded in a year.

Table 1 Mating duration, pre-oviposition, post oviposition periods and fecundity of *C. Chinensis*

Generation	Year		Mating duration (Min.)	Preoviposition period (hours)	Oviposition period (days)	Fecundity (egg/ female)	Post oviposition period (days)
I	2006	Range	6.00-8.00	5.1-8.15	5-7	65-90	3.1-5.01
	June	Mean	7.3	6.81	6.3	83.60	3.98
II	2006	Range	5.00-8.00	5.14-8.15	5-7	65-92	3.5-5.00
	July	Mean	6.900	6.62	6.5	81.90	4.2

In case of morphometric study of the first instar larva, the size of head capsule varied from 0.513 to 0.567 mm, width varied from 1.026 to 1.134 mm and length varied from 1.755 to 1.134 mm, respectively with an average of 0.534, 1.061 and 1.825 mm. In case of second instar larva head capsule varied from 0.621 to 0.675 mm, width varied from 1.323 to 1.485 mm and length varied from 2.646 to 2.70 mm, respectively with an average of 0.658, 1.387 and 2.686 mm. In case of third instar larva size of head capsule varied from 0.765 to 0.813 mm, width varied from 1.836 to 1.890 mm and length varied from 3.645 to 3.780 mm, respectively with an average of 0.789, 1.582 and 3.731 mm. In case of fourth instar larva the size of head capsule varied from 0.864 to 0.918 mm, width varied from 2.403 to 2.484 mm and length varied from 4.725 to 4.860 mm, respectively with an average of 0.893, 2.446 and 4.795 mm. The width of pupae varied from 4.05 to 4.08 mm with an average 4.059 mm and length varied from 5.32 to 5.40 mm with an average of 5.348 mm. The width of male varied from 2.565 to 2.70 mm with an average of 2.648 mm and length of male varied from 3.186 to 3.294 mm with an average of 3.234 mm. The width of female varied from 2.808 to 2.889 mm with an average of 2.840 mm and length of female varied from 3.56 to 3.60 mm with an average of 3.576 mm.

The length of antennae ranges from 2.97 to 3.45 mm with an average of 3.26 mm. The length of prothoracic legs varied from 2.997 to 3.132 mm, mesothoracic leg varied from 4.482 to 4.536 mm and metathoracic legs varied from 4.482 to 4.536 mm, respectively with an average of 3.064, 4.017 and 4.514 mm. The length of fore wing varied from 3.075 to 3.483 mm and width varied from 1.385 to 1.585 mm, respectively with an average of 3.402 to 1.485 mm. The length of hind wing varied from 7.425 to 7.696 mm and width varied from 2.295 to 3.376 mm, respectively with an average of 7.56 and 3.32 mm. The length of eggs varied from 0.706 to 0.891 mm and width varied from 0.985 to 1.215 mm respectively with an average of 0.785 and 1.088 mm.

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Molecular identification of *Bracon hebetor* Say (Hymenoptera: Braconidae) a biocontrol agent in cotton crop

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The family *Braconidae* comprises of parasitoid species of many major pests of agriculture in both field and storage. These play a major role as important biocontrol agents in cotton against many lepidopteron pests. For effective and successful biological control authentic identifications are essential. Identification of many braconids is complicated by physiological and morphological differences over species and populations. To simplify these complexities DNA based approaches have been proposed leading to genetic or DNA fingerprinting. Sequence comparison of the ITS region is widely used in taxonomy and molecular phylogeny because it is easy to amplify even from small quantities of DNA and has high degree of variation even between closely related species. It has typically been useful for molecular systematics at the species level and within the species (Atanas and Nazar, 1999). This approach has been used for molecular characterization of *Lepidoptera, Hymenoptera* and *Hemiptera* (Silva *et al.*, 1999). George *et al.*, (2002), studied reproductive isolation and genetic variation between two strains of *Bracon hebetor* using mitochondrial markers. There are no studies on the populations of *Bracon hebetor* Say available in India. The results obtained using ribosomal DNA markers and the detail of the study is presented herein.

B. hebetor collected from the cotton fields of Indian Agricultural Research Institute, New Delhi were subjected to molecular characterisation. The DNA from single individual was isolated using DNA easy Tissue Kit (Quiagen). The internal transcribed spacers (ITS) were amplified by PCR using the primers, ITSa and ITSd. Amplification parameters were, denaturation at 94°C for 2 min in the first cycle, and 1min for subsequent cycles, primer annealing was at 55°C for 1 min, and primer extension at 72°C for 10 min. Amplification products were separated by electrophoresis in 8% polyacrylamide, non denaturing gel, stained with ethidium bromide and viewed under UV transilluminator. The size estimates of the amplicons were done by comparison with a molecular weight marker (Fig. 1). The primers ITSa and ITSd amplified the entire internal transcribed spacer regions, (1197bp length) 18s ribosomal RNA gene, ITS1, 5.8S Ribosomal RNA gene, ITS2 and 28S ribosomal RNA gene.

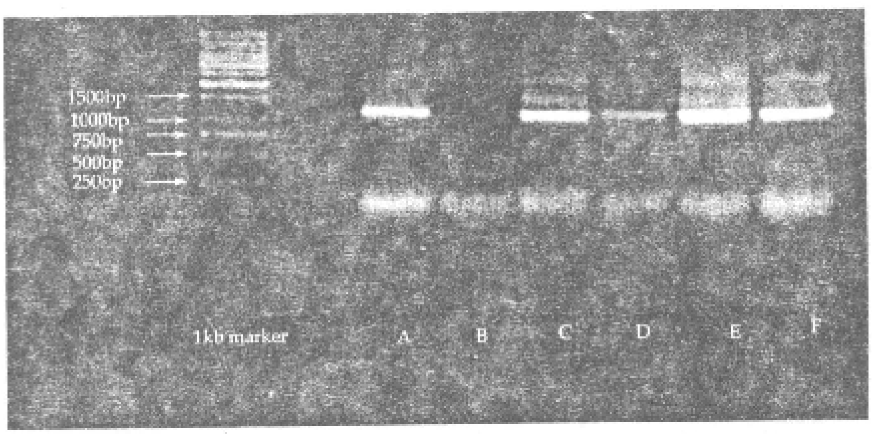

Fig.1 Gel electrophoresis of PCR amplicons obtained with PCR primers, ITSa and ITSd (TCCGTAGGTGAACCTGCGG and TCCTCCGCTTATTGATATGC respectively). Lanes A-F is amplicons from DNA extracted from different isolates of *Bracon hebetor* Say collected from cotton field. 1 kb ladder used as molecular weight marker

PCR product ligated with PGEMT easy vector and transformed into the *Escherichia coli* cells. Selected clones were sequenced in an automatic sequencer and sequences were aligned and analysed in BLAST. Multiple nucleotide alignment of ITS region of different isolates of the *Bracon hebetor* showed less percentage identity with other *Braconidae* and the nucleotide sequence obtained was deposited in GeneBank under Accession No. EF491261. The ITS sequence of five Braconids species, *Peristenus stygicus, Dasymutilia paenulata, Peristenus pallipes, Peristenus digoneutis* belonging to different geographical situations available in the GeneBank were compared.

Multiple sequence alignments were performed using CLUSTALW to elucidate the phylogenetic relationships. There is considerably less conservation in the populations among the different geographical location observed in silico analysis. It can be concluded that ribosomal DNA markers can be used as a simple and potent tool for molecular and phylogenetic study.

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Insect pest scenario of *Jatropha curcas* at Raipur, Chhattisgarh

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Studies conducted on *Jatropha curcas* at Raipur, Chhattisgarh, during 2008 revealed four insect pests of which three are major. These are blue bug, *Chrysocoris purpureus* (Westwood), webber, *Pempelia morosalis* (Saalmuller), and coccids (unidentified); however, thrips, *Retithrips syriacus was* a minor pest. Some natural enemies like Chrysopa, *Chrysoperla carnea*, coccinellid, *Mireaspis vineta,* mantids, *Mantis religiosa*, and spider, *Oxyopes lineatipes* were also observed. (Table 1). *C. purpureus* attacked mainly the fruits, both nymphs and adults suck the sap of fruits, due to which the colour changed from green to yellow; in case of severe infestation the fruits turned brown. The infestation adversely affected the quality of seed and oil and ultimately reduced the fruit and oil yield.

The larvae of webber, *P. morosalis* caused damage to the leaves, inflorescence, fruits and apical stem by making webs along with excreta, causing economic damage. It also fed on the inflorescence inhibiting flower and fruit set and in later stages bore into capsules, which leads to loss of fruit and oil. The nymphs and adults of coccids suck the plant sap from the leaves and young shoots leading to yellowing, browning and curling, affecting the growth. It also secretes honey dew on which sooty mould develops. Thrips, causes discoloration and white speckles. Four species of natural enemies were recorded. Chrysopa, *C. carnea* was recorded as a predator feeding on soft bodiel insects, the red coccinellid *Mireaspis vineta,* was observed feeding on soft bodied insects such as coccids, spider, *Oxyopes lineatipes* preys upon moths and play an important role by killing 2-3 moths and mantid, *M. religiosa* as a predator feeding various insects.

Table 1 Insect pests and natural enemies on *Jatropha curcas*

S.N	Name of insect pest	Status	Target	Period of peak activity
1	Blue bug, *Chrysocoris purpureus*	Major	Fruits	October 2nd fortnight
2	Webber, *Pempelia morosalis*	Major	Inflorescence, leaves and apical stem	October 2nd fortnight
3	Coccids (unidentified)	Major	Leaves and young shoots	September1st fortnight
4	Thrips, *Retithrips syriacus*	Major	Leaves	November2nd fortnight
Natural Enemies				
1	Chrysopa, *Chrysoperla carnea*	Predator	Soft bodied insects	September2nd fortnight
2	Red Coccinella, *Mireaspis vineta*	Predator	Soft bodied insects	September1st fortnight
3	Preying mantis, *Mantis religiosa*	Predator	Many species of insects	September1st fortnight
4	Spider, *Oxyopes lineatipes*	Predator	Lepidopterous insects	September1st fortnight

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Population dynamics and diversity of myrmicine ants associated with rice

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Ants have a major influence on other organisms in many tropical habitats (Carrol and Risch, 1983). Studying the ant community can also help us understand an important component of any ecosystem. The myrmicines are most common and found everywhere in large numbers. The population dynamics and diversity of myrmicine ants associated with the rice agroecosystem, was studied for two successive crop seasons, *viz.*, 2006-2008 at the farm of Indian Agricultural Research Institute, New Delhi. Baiting was used for collecting the ground dwelling ants. Baits were laid on the bunds in the field, the baits consisted of a yellow plastic sticker of 10cm x 10cm size coated with sugar solution. Twenty baits were placed randomly for a period of about 90 minutes and were observed at intervals of 30 minutes. The specimens removed from the traps were sorted, counted, identified to species level and data on abundance recorded.

The population fluctuation data of different Myrmicinae collected by baiting were subjected to correlation analysis *vis-à-vis* various weather parameters like rainfall, maximum and minimum temperature, sunshine hours and relative humidity. (Fig.1). The data were also used to calculate the standard biodiversity indices like Shanon-weiner diversity index (H), Simpson Yule diversity index (b), Berger-Parker dominant index (d), species richness (s) and evenness (E) to ascertain the species richness, composition, relative abundance and evenness of myrmicine ants. For both the crop seasons of 2006 and 2007, the diversity of myrmicine ants comprised of four different species, *viz.*, *Pheidole indica*, *Monomorium scabriceps*, *Meranoplus bicolor* and *Monomorium indicum*. The analysis of the population data for *P. indica* and *M. scabriceps* showed correlation to be insignificant with all the weather parameters (Table 1). The population of *M. bicolor* showed significant correlation with rainfall (r= 0.48) while it was insignificant with maximum temperature and minimum temperature, sunshine hours and relative humidity (Table 1). *Monomorium indicum* population showed significant correlation with minimum temperature (r = 0.49) but was rainfall (r=-0.13), maximum temperature (r= -0.17), sunshine hour (r= -0.02) and relative humidity (r=0.029) did not affect it in any way (Table 1). Species richness fluctuated between 2 and 4 throughout the sampling period. The Shannon-Wiener index fluctuated between 0.15 and 0.54 coinciding with the 43rd and 29th standard week during the first season while it was 0.10 and 0.56 during 40th and 25th standard week respectively during second season. The range of dominance indices, Simpson-Yule (D) varied from 1.23 and 3.14 coinciding with 43rd and 29th standard week in first season, while in the second, values varied from 1.33 to 3.43. Berger-Parker index was between 0.44 and 0.89 during the first season and 0.38 and 0.93 during the second season; evenness varied from 0.48 to 0.91 in first season while it was 0.35 and 0.93 in the crop second season.

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Table 1 Correlation coefficient (r) for different species of ants in the rice agroecosystem

S.N.	Name of Species	Rainfall	Temp. Max	Temp. Min.	S.S.	R.H.
1	*Pheidole indica*	0.065	- 0.002	0.247	- 0.124	0.053
2	*Monomorium scabriceps*	- 0.158	- 0.30	0.177	0.311	0.029
3	*Meranoplus bicolor*	0.478*	0.358	0.401	- 0.240	0.03
4	*Monomorium indicum*	0.149	- 0.173	0.493*	- 0.025	- 0.029

* significant

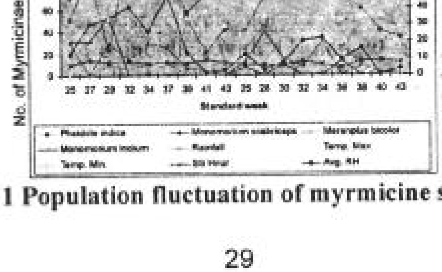

Fig. 1 Population fluctuation of myrmicine species

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Record of elaterid *Agrypnus fuscipes* (Fabricius) predator on white grubs of *Holotrichia rustica* (Burm.)

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White grubs, amongst other pests of the forestry and agricultural crops, are considered the most serious (Yadav and Sharma, 1995; Kulkarni *et al.*, 2007). The serious incidence of the white grub complex (*Holotrichia rustica, H. mucida* and *Schizonycha ruficollis*) on teak seedlings in the Ramdongari Forest Nursery of Forest Development Corporation of Maharashtra, Nagpur (Kulkarni *et al.*, 2006) prompts continuous chemical treatments of the nursery beds. The paper reports elaterid grubs of *Agrypnus fuscipes* predating the white grub complex.

Predatory grubs of *A. fuscipes* were first accidently collected from the affected teak nursery beds. Later collections were made by random surveys and digging the pits sized 1m x 1m in beds with maximum wilting. The collected grubs were reared in plastic containers, fed daily with white grubs of *H. rustica*. To evaluate predatory potential, the single grub of *A. fuscipes* was kept in plastic container half filled with moistened soil and maintained in B.O.D. set at $27\pm1\,^{0}C$. The counted number of white grubs were released daily. The live white grubs in the container were counted after every 24 hrs. The arrangement was replicated 5 times daily consumption of white grubs was calculated and analyzed.

The record of *A. fuscipes* grubs is an indicator of its association with white grubs of *H. rustica*. *A. fuscipes* had been reported as predator of white grubs earlier by Beeson (1941). There are no reports available particularly on their feeding potential. Present study indicates its potential with per day consumption ranging from 8 to 17- 1st instar with mean consumption of 11.04 ± 0.85, 4 to 12- 2nd and 3rd instar with mean consumption of 7.53 ± 0.95 and 2 to 8 mature grubs with mean consumption 4.05 ± 0.26 (Fig. 1).

This is the first record of occurrence and experimental evidence of feeding potential. The results indicate that if the species is mass-multiplied for planned biological control could prove successful component of the Integrated Pest Management (IPM) against the white grubs.

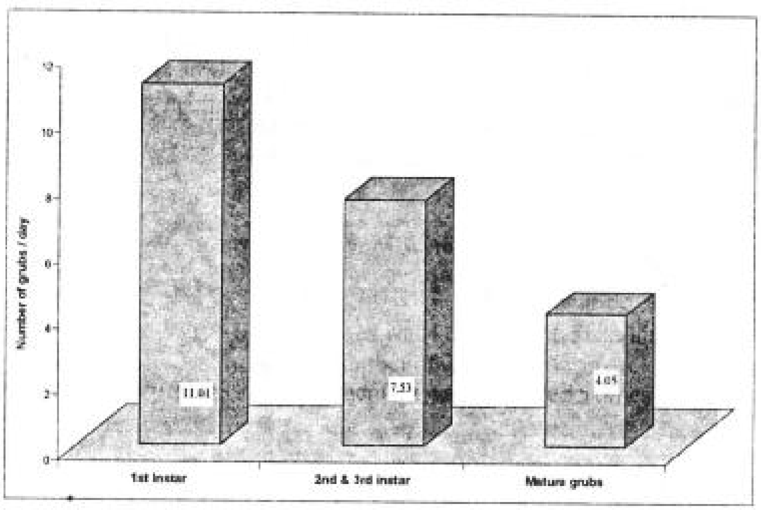

Fig. 1 Predatory potential of mature grub of *A. fuscipes* under laboratory conditions

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Records of *Apanteles* spp. (Braconidae: Microgastrinae) from Chhattisgarh

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Braconidae is the most diverse and largest hymenopteran family, comprising approximately 40,000 species, divided into 45 subfamilies. *Apanteles* is the most familiar genus of Braconidae, under subfamily Microgastrinae. Most of its species are solitary endoparasitoids of lepidopterous pests, and characterized by thick-set, small, black appearance, reduced wing venation and 18-segmented antennae. 66 species were reported from India, of which 15 species are recorded from Chhattisgarh (Table 1).

Table 1 *Apanteles* spp. from Chhattisgarh

S.N.	*Apanteles* spp.	Host-range	Distribution (Recorded by earlier workers)	Material Examined (New distribution)
1.	*A. agilis*	*Hidari irava* & *Diaphania pulverulentalis.*	Manila, Java, Sumatra & India: Karnataka (Bangalore, Mandya).	Bastar (Ghora gaon) 1 F, 19.viii.2007.
2.	*A. antipoda*	*Agrotis* sp., *Naranga diffusa, Hypsipyla robusta, Perigea capensis* & *Spodoptera mauritia.*	Australia; Taiwan & India: Uttrakhand (Dehra Dun) & Bihar (Pusa).	Durg (Agari) 1 M, 17.viii.2007.
3.	*A. bambusae*	*Cosmopteryx bambusae*	India; Bihar (Pusa).	Korea (Baikunthpur) 1 F, 25.xii.2007.
4.	*A. cajani*	Unknown	India: Bihar (Pusa)	Kawardha (Ponri) 1 F 1 M,22.xi.2006
5.	*A. caniae**	*Cania bilinea*	Java	Dantewara (Geedam) 1 F, 8.iii.2007.
6.	*A. flavipes*	*Amsacta albistriga, Argyria sticticraspsis, Chilo partellus, Chilo infuscatellus, Chilo suppressalis, Chilo tumidicostalis, Chilo zonellus, Corcyra cephalonica, Diacrisia obliqua, Diatraea venosata, Proceras indicus, Sesamia inferens, Sesamia uniformis, Spodoptera mauritia, Tryporyza incertulas* & *Tryporyza nivella.*	Australia, Pakistan,Taiwan & India: Bihar (Pusa), Delhi, Tamil Nadu (Coimbatore & Gudiyattam); Karnataka (Bangalore) .	Bastar (Ghora gaon) 1 F 19.viii.2007.
7.	*A. hyblaeae*	*Hyblaea puera* & # Blotch of *Pongamia pinnata*	Java & India: Uttarakhand (Dehra Dun)	Bastar (Ghora gaon) 3 M M 19.viii.2007; Mahasamund (Seetla Naka) 1 F 11.iii.2007; Raipur (Kendri) 2 M M & 2 F F. Ex. *Pongamia pinnata* leaf Blotch 22.viii.2007.
8.	*A. javensis**	*Parnara conjuncta*	Java	Durg (Jagtara)1 F, 29.vii.2007; Raipur (Cheri Kheri) 1 M, 14.x.2006.
9.	*A. lamprosemae**	*Lamprosema diemenalis*	Malaysia	Bastar (Dahi Konga) 1 F, 19.viii.2007.
10.	*A. machaeralis*	*Agrotera basinotata, Diaphania bicolor, Glyphodes conclusalis, Hyblaea puera* & *Eutectona machaeralis.*	India: Bihar (Pusa), Kerala (Nilambur); M.P. (Hoshangabad, Rahat gaon, Seoni); Maharashtra (Thana); Karnataka (Mysore); Uttarakhand (Dehra Dun); U.P. (Saharanpur)	Kawardha (Bametra) 1 F, 17.viii.2007.
11.	*A. platyedrae**	*Platyedra gossypiella* & *Decadarchis heterogramma*	Fiji	Durg (Sikosa) 1 F, 26.ix.2006.
12.	*A. significans**	Unknown	Sri Lanka	Raipur (Kendri) 1 M, 15.x.2006.
13.	*A. tachardiae*	*Eublemma amabilis, Holcocera pulverea* & *Laccifer lacca*	India: Jharkhand (Ranchi), Uttarakhand (Dehra Dun)	Bastar (Ghora gaon) 2 M M, 19.viii.2007; Dhamtari (Dhamtari) 3 F F 23.xi.2006; Raipur (Kendri) 1 M, 15.x.2006.
14.	*A. taprobanae*	*Stauropus alternus* & *Selepta celtis*	Sri Lanka;Taiwan; Java & India: Jharkhand (Ranchi), Karnataka (Bangalore & Mysore)	Rajnand gaon (Somni) 1 F 16.vi.2008.
15.	*A. tiracholae**	*Tirachola plagiata* & *Euproctis* sp.#	Sri Lanka	Bastar (Metwada) 1 M 24.xi.2006; Dantewara (Karni) 1 F, 20.viii.2007; Bastar (Ghora gaon 2 M M 3 F F, 19.viii.2007,Ex larvae of *Euproctis* sp.

* F- Female, M- Male, First record from India, # New host record

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Lepidoptera diversity of Andaman and Nicobar Islands

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The Andaman and Nicobar Islands comprised of an arcuate chain of more than 500 islands, islets and rocks spreading in more than 1100 km in Bay of Bengal. These islands cover an area of 8239 sq. km. and a coast line of 1962 km. The islands have undulating terrain and intervening valley mostly covered with dense tropical rain forests. These islands have more than 86% of the land under forest cover and 35% of the area is allotted to tribal reserves.

Table 1 Number of species in different families of Lepidoptera

Suborder Family	No. of Genera	No. of Species	A Is	N Is	Else where	Endemic
RHOPALOCERA						
Papilionidae	6	22	15	11	6	16
Pieridae	12	29	18	17	13	16
Danaidae	7	27	11	19	12	15
Satyridae	5	13	7	7	3	10
Amathusiidae	2	2	2	--	--	2
Riodinidae	1	1	1	--	--	1
Nymphalidae	26	51	36	20	16	35
Lycaenidae	39	86	59	38	40	46
Hesperiidae	24	43	38	14	29	15
HETEROCERA						
Gracillaridae	3	3	3	--	3	--
Immidae	1	1	1	--	1	--
Cosmopterygidae	1	1	1	--	--	1
Momphidae	2	2	2	--	2	--
Oecophoridae	1	1	1	--	1	--
Xyloryctidae	1	1	1	--	1	--
Gelechiidae	5	6	6	--	6	--
Cossidae	3	5	4	1	4	1
Zygaenidae	5	6	5	3	6	--
Limacodidae	7	7	7	--	5	2
Psychidae	2	2	2	--	1	1
Tortricidae	10	10	10	--	10	--
Phyllocnistidae	1	1	1	--	1	--
Pyralidae	92	165	142	54	162	3
Pterophoridae	2	2	2	--	2	--
Lasiocampidae	6	6	5	1	6	--
Saturniidae	5	7	7	--	1	6
Bombycidae	3	3	3	--	3	--
Callidulidae	2	2	2	--	2	--
Geometridae	55	70	67	12	67	3
Epiplemidae	1	3	2	1	3	1
Uraniidae	5	6	5	1	5	1
Sphingidae	19	33	32	10	30	4
Lymantridae	8	16	16	--	15	1
Notodontidae	3	7	7	--	6	1
Agaristidae	2	2	2	--	2	--
Hypsidae	3	7	7	--	6	1
Amatidae	4	7	7	--	3	4
Arctiidae	21	49	42	17	36	13
Noctuidae	127	183	160	38	176	6
Drepanidae	2	2	1	1	2	--
Grand Total	**529**	**896**	**750**	**268**	**690**	**206**

This archipelago supports a unique biodiversity due to their geographical position, tropical climate and isolation from Indian subcontinent. These islands with 0.25% of the geographical area of India harbour about 4.2% of all known species of insects (Chandra, 2000). While carying out the detailed study on insect diversity by the Zoological Survey of India, Kolkata and Port Blair station, 896 species belonging to 529 genera under 39 families were reported from Andaman and Nicobar Islands (Table 1). Of these 750 species are recorded from Andaman Islands and 268 species are known from Nicobar Islands and 206 species are endemic.

It has been observed that inspite of the rich wealth of tropical forests on these islands, insects are poorly investigated. During last one decade, more than 500 species of different insect orders are recorded for the first time from these islands and several new species indicating the scope of discovery.

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Status of mealy bug *Phenacoccus solenopsis* Tinsley at Faridkot, Punjab and its management

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The cotton belt of Punjab was seriously threatened by *Phenacoccus solenopsis* (Homoptera: Pesudococcidae) covering larger areas and causing huge losses in 2007-08 (Dutt, 2007). The same pest has emerged as serious threat to the cotton cultivation in Pakistan also during 2005 (Abbas *et al*, 2005). The studies were conducted in twenty villages (Tehna, Chahal, Chaina, Kiriwali, Chack Kalyan, Fiddekalan, Baja Khana, Sirewala, Fiddekhurd, Dhimanwali, Khuwarwala, Wanderjathana, Machaki Malsinghwala, Jalalaniana, Warradherakha, Khara, Arayanwala Kalan, Bhurjamasta, Sadhuwala, Doad) of Faridkot district of Punjab state during the cotton season (2008) at PAU, Regional Station, Faridkot. Two cotton fields, at least one acre size were selected per village to collect the data on incidence, and time to time interventions made by the farmers for managing the pest were also taken into consideration. One hundred plants were selected randomly at weekly intervals to record the data by using the four scale grading method i.e. 0 (no mealy bug incidence), 1 (mealy bug scattered on the whole plant), 2 (one twig fully loaded with mealy bug), 3 (two or more than two twigs fully loaded with mealy bug), and 4 whole plant fully loaded with mealy bug.

Intensive surveys were carried out to educate the farmers about the effective management of the mealy bug. The per cent infested plants and the intensity was calculated. The important management practices were eradication of the weed such as congress grass, Lantana, *Trianthema monogyna, Calotropis gigantean, Bathu* and common grass, burial of the infested weed in the soil and not to dispose it in the water source such as canal, regular monitoring of the field, spot treatment of the infested plants with recommended insecticides in rotation, washing of the implements to avoid dispersal. This programme had a great impact on the mealy bug incidence as compared to the previous year. A total of 34,400 cotton plants were observed from the 40 fields with per cent of infested plants were 8.06 per cent and the intensity of the infested plants was only 1.07 per cent . The total number of the plants that reached the 4th grade of infestation was only 37. The village wise data of incidence reveal the lowest per cent of the infested plants at village Fiddekhurd and maximum at Bhurjamasta (Table 1). However the intensity of the infested plants remained between 0.73 and 1.44. It was observed that besides all these practices adopted the rains also had great impact on the population which was initially high and lowered with the initiation of the rains. The impact of the various management practices and the rains on the population has been studied.

Table 1 Status of mealy bug in different villages of Faridkot

Village	Infested plants (%)	Intensity of infested plants	No. of 4th grade plants	Village	Infested plants (%)	Intensity of infested plants	No. of 4th grade plants
Tehna	5.20	1.00	0	Khuwarwala	3.28	1.01	0
Chahal	5.09	1.00	0	Wanderjathana	3.10	1.00	0
Chaina	17.45	1.24	0	Machaki Malsinghwala	7.50	1.17	0
Kiriwali	16.94	1.24	0	Jalalaniana	7.50	1.17	0
Chack Kalyan	5.40	1.09	2	Warradherakha	4.83	1.00	0
Fiddekalan	2.71	0.88	0	Khara	6.22	1.01	0
Baja Khana	16.68	1.44	25	Arayanwala Kalan	18.96	1.09	1
Sirewala	7.32	0.97	1	Bhurjamasta	18.31	1.09	0
Fiddekhurd	1.94	0.95	0	Sadhuwala	7.19	0.73	8
Dhimanwali	2.36	0.90	0	Doad	3.13	0.75	0

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Study on biology of mealy bug, *Phenacoccus solenopsis* Tinsley on cotton in Punjab

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Biology of cotton mealy bug, *Phenacoccus solenopsis* Tinsley was studied on cotton. The pest was observed to be viviparous with three nymphal instars preceding the adult stage. In case of male, after second instar cocoon is formed, this is composed of cottony white wax and male exhibit a radical change during their life cycle and changed to wasp like flying adult. The tip of the abdomen of adult female was protruded with long setae. Various body appendages were measured. Lifecycle ranged from 27-38 days including adult longevity in warmer conditions. The lifecycle of male varies from 16-23 days. The fecundity varies from 270- 340 young ones/female.

The mealy bug, *P. solenopsis* Tinsley is a pest of ornamental and fruit trees world wide and it is known to be cryptic in nature. It was described originally from the U.S. in 1898 and subsequently reported in Central America, the Caribbean and Ecuador on different ornamental plants. In the USA, *P. solenopsis* was first time reported on cotton (Fuchs *et al.*, 1991). *P. solenopsis* was recorded on *Solanum muricatum* in Chile and on tomato in Brazil. This mealy bug has been found previously on a relatively wide variety of host plants including species of economically important families such as Cucurbitaceae and Fabaceae as well as Solanaceae. This mealy bug is very similar in appearance to *P. solani* Ferris and *P. defectus* Ferris. In 2005, a new species *Phenacoccus gossypiphilious* Stanley severely infected the cotton crop in the cotton growing provinces of Pakistan (Abbas *et al.*, 2005). During 2006, in Punjab, *P. solenopsis* appeared on cotton crop in some pockets of Ferozepur (Abohar), Muktsar (Malout) and Bathinda (Sangat) districts. Subsequently, mealy bug also spread to Ferozepur, Bathinda and Muktsar districts during 2007, and caused 30 to 40% loss to cotton yield (Dhawan *et al.*, 2007). This is a first record of mealy bug *P. solenopsis* infesting cotton crop in Punjab. On cotton, there were reports of the pink mealybug *Maconellicoccus hirsutus* (Green) in Punjab (Dhawan *et al.*, 1980). The purpose of this study is to describe this species which has not been reported in India on cotton before, while this research is however, part of wider study of mealy bug types in the particular ecological zone of Punjab. Each developmental stage was mounted on slide. Body length and width, length of prothoracic, mesothoracic and metathoracic legs, and antennae length and no of segments were taken. *P. solenopsis* adults and nymphs were collected from fields of cotton belt and reared on potted cotton plants in cage house at entomological farm of PAU, Ludhiana. The adult female was individually reared on cotton leave to obtain the first instar nymphs, leaves were put on agar medium in a plastic petri dish to prevent desiccation and maintained under laboratory conditions.

Newly hatched nymphs (<24hrs) coming out from ovisac were individually placed on a cotton leaf on the agar medium in a dish, for life cycle observations. Ecdysis of nymphs was observed to determine the instar durations (stadia). After adult emergence, pre-oviposition and ovipositional period, and fertility was monitored. Offspring were counted and removed daily and the cotton leaf and agar medium were changed after every three days. Means and standard error were calculated. For each 10 observations were taken and all measurements are in mm.

Eggs are pale yellow oval very minute varying from 0.34 to 0.40 ($X=0.37\pm0.03$) in length and width from 0.16 to 0.20 ($X=0.17\pm0.02$) n=10.

1st instar is oblong, yellow devoid of mealy scale and hence conspicuously yellowish, body length range from 0.71 to 0.75 ($X=0.73\pm0.01$) and width from 0.43 to 0.49 ($X=0.47\pm0.03$). The head has a pair of 6-7 segmented filiform antenna having a length of 0.19 to 0.21 ($X=0.20\pm0.01$). The mesothoracic pair being the longest with an average length of 0.34 to 0.39 ($X=0.36\pm0.02$), prothoracic and metathoracic legs range 0.28 to 0.31 ($X=0.29\pm0.01$) and 0.20 to 0.25 ($X=0.21\pm0.01$), respectively. Two caudal filaments are present at the tip of abdomen.

2nd instar oblong, pale yellow, body lacked mealy waxy secretions. The body length between 1.0 to 1.5 ($X=1.3\pm0.29$). its body width between 0.51 to 0.55 ($X=0.53\pm0.02$). Two eyes are very clear at this stage, conspicuous like red spot. The head has a pair of 6-7 segmented antennae and antennal length between 0.26 to 0.28 ($X=0.27\pm0.01$). The thorax had 3 pairs of legs with mesothoracic legs being the longest i.e. with a range of 0.39 to 0.41 ($X=0.40\pm0.01$), prothoracic and metathoracic legs length range varies 0.30 to 0.40 ($X=0.36\pm0.04$) and 0.27 to 0.30mm ($X=0.29\pm0.01$) n=10, respectively. The tip of abdomen is protruded and has two caudal filaments.

3rd instar can be distinguished by a white fluffy waxy coating which begins to form over the dorsal surface, except for a slightly darker stripe on dorsal side. Body is dark yellow and oblong. The body length between 2.1 to 2.6 ($X=2.4\pm0.20$), while the body width range between 1.1 to 1.3 ($X=1.2\pm0.10$). The antenna is straight, filiform and 7 to 8 segmented, pointing forward with a mean length of 0.43 ± 0.05 and range between 0.37 to 0.49, mouth conspicuous. The thorax had 3 pairs of legs i.e. prothoracic, mesothoracic and metathoracic with the length 0.31 to 0.45 ($X=0.45\pm0.13$), 0.54 to 0.69 ($X=.62\pm0.07$) and 0.29 to 0.31 ($X=0.30\pm0.01$), respectively.

Prepupal instar of male pale yellow, elongate, covered with white fluffy covering, characterized by its sluggishness. The body length between 2.2 to 2.9 ($X=2.7\pm0.29$), while the body width between 1.0 to 1.3 ($X= 1.17\pm0.12$). The antenna straight, filiform and 9 segmented. The male nymph formed a cocoon prior to third cocoon composed of cottony whitewax, and about 1mm long.

Adult female oblong, oblong, light to dark yellow, and wingless, yellowish body is largely obscured by the powdery white wax with which the mealy bug covers itself, except slightly darker stripes on dorsal side. 18 pairs of short waxy filaments exist around the body, pair present at the posterior end somewhat longest. Adult female has body length ranging between 4.1 to 4.7 (X=4.4±0.24) and the body width between 2.8 to 3.0 (X=2.9±0.1). The head also has a pair of 9 segmented filiform antenna having a length from 0.49 to 0.54 (X=0.51±0.02). The thorax and abdomen form the largest part of the body. The mesothoracic pairs being the longest with an average length of 1.7 to 2.0 (X=1.8±0.13); prothroacic and metathoracic legs 1.3 to 1.6 (X=1.4±0.13) and 1.2 to 1.3 long (X=1.3±0.05).

Adult male smaller than the female and has pale brown coloration. Body delicate elongated and their body length varies from 0.99 to 1.1 (X=1.0±0.01) and the body width 0.25 to 0.26 (X=0.25±0.01). The head also has one pair of 9 segmented antenna having a length ranging between 0.75 to 0.77 (X=0.76±0.1). Male has a one pair of mesothoracic wings and its length varies from 1.0 to 1.2 (X=1.1±0.06) and the wing expanse varies from 0.43 to 0.45 (X=0.44±0.01).

Life cycle Adult female has five life stages-egg, first instar (crawler), second instar (nymph), third instar (nymph) and adult; and adult male has five stages-egg, first instar (crawler), second instar (nymph), third instar (Pre-pupal and cocoon) and adult. Details of these stages are provided in Table 1 and 2. Eggs hatched to crawlers in the ovisacs, there were no variations in first instar of male and female. 3rd instar of female can be distinguished by white waxy covering on the entire body and appearance of short waxy filaments at the peripheral region of the body.

Prepupa and cocoon In case of male, after second instar it starts forming cocoon and male exhibit a radical change, changing from wingless ovoid nymph to wasp like flying adult. This stage of male lasted for 6-8 (7.0±1.0) days. Akintola and Ande (2008) reported the adult recovered from fields were female and the total number of days from egg to adult (longevity) was 37 days. In present study also the life cycle of adult female varies from 27-38 (32.4±4.4) days and adult male 16-23 (20.5±2.9) days. The morphological variations observed were suspected to be due to some morphological ecological reasons. The second instar male nymphs at the end of this stage migrated to congregate in a shady place and each secreted a small, loose mass of cottony fibers cocoon instead of puparium like other mealy bugs, namely *Planococcoides bengalensis* and *Planococcus lilacinus* (Mukhopadhyay and Ghose, 1999). Weather conditions like temperature, minimum R.H. and rainfall showed positive effect on the insect biology and their incidence in field.

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Table 1 Development period of different instars of *P. solenopsis*

Stage	Development period of different instars in days (Mean±SD)					
	Egg	I instar	II instar	III instar	Adult longevity	Total
Female	1.4±0.5 (1-2)	4.6±1.1 (4-6)	4.8±1.1 (4-6)	6.2±0.9 (5-7)	14.8±1.6 (13-17)	32.4±4.4 (27-38)
Male	1.4±0.5 (1-2)	4.8±1.1 (4-6)	4.7±0.6 (4-5)	7.0±1.0 (6-8)	1.6±0.5 (1-2)	20.5±2.9 (16-23)

Table 2 Mean fecundity of adult female

Stage	Duration in day(Mean±SD)
Pre-ovipositional	4.4±04 (3-5)
Ovipositional Period	8.2±0.8 (8-9)
Post ovipositional Period	2.6±0.6 (2-3)
No of young ones/female	308.6±26.25 270-340

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Mealy bug (*Phenacoccus solenopsis*) - a new threat to cotton production in Marathwada region of Maharashtra

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Mealy bug (*Phenacoccus solenopsis* Tinsley) on cotton had emerged as a new threat to cotton production in India. The farmers are suffering huge losses in yield and quality of cotton crop due to attack of various insect pests and diseases and this has further added to their damage. It is yellowish green, oval in shape, somewhat rounded in lateral view, legs red, body covered by thin, white mealy wax with dark dorso-medial bare spots on inter segmental areas of thorax and abdomen forming one pair of dark longitudinal line on dorsum, ovisac ventral with lateral wax filaments.

A roving survey was carried out in major cotton districts (Parbhani, Nanded, Hingoli, Jalna and Aurangabad) of Marathwada region of Maharashtra during 2007-08 crop season to observe the severity of the infestation. Observations were recorded on 10 plants from each field. The observations on number of mealy bugs per 2.5 cm apical shoot, per cent infested plants, per cent infested leaves and per cent infested bolls were recorded. The grading of infested plants was done in 0 - 4 scale ('0' for no mealy bug infestation, '1' for 1-10 mealy bugs scattered on plant, '2' for one branch infested, '3' for two or more branches infested and '4' for whole plant infested.)

The results revealed that the mean number of mealy bug / 2.5 cm apical shoot ranged from 8.88 to 20.41 % (Table 1). In Parbhani district, the number was highest (20.41 %). The percentage of infested plants was highest in Parbhani (52.08 %) and lowest in Hingoli district (11.14 %). The infested leaves ranged from 11.37 to 49.95 %. The severity of infested bolls ranged from 10.10 to 35.77 %. The highest grade of infested plants was recorded in Parbhani (2.74), followed by Jalna (2.39), Aurangabad (2.03), Nanded (1.86) and Hingoli (1.12). Survey revealed that the incidence was severe all over in Marathwada and it may prove as a major biotic constraint in ensuing years. Dhawan (1980) reported 58-73 % reduction in seed cotton yields due to pink hibiscus mealy bug. Jhala and Bharpoda (2008) had also reported 50% reduction in yields in Gujarat during 2006 due to severe mealy bug infestation.

Table 1 Mealy bug incidence on Bt cotton in districts of Marathwada (2007-08)

Village	No. of mealybugs per 2.5 cm apical shoot	No. of plants infested (%)	No. of leaves infested (%)	Grading of infested plants	No. of bolls infested (%)
Parbhani	20.41	52.08	49.95	2.74	35.77
Nanded	17.80	49.07	25.14	1.86	25.94
Hingoli	8.88	11.14	11.37	1.12	10.10
Jalna	18.22	32.63	37.62	2.39	25.99
Aurangabad	13.9	29.99	27.18	2.03	22.39

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Mealybug *Phenacoccus solenopsis* Tinsley an emerging pest of bidi tobacco in Gujarat

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The production of bidi (*Nicotiana tabacum* L.) and chewing (*Nicotiana rustica* L.) tobacco is largely concentrated in middle Gujarat. Tobacco being a long duration crop, it passes through various biotic stresses like insect pests causing quantitative and qualitative damage. Recently, tobacco has been also found to be attacked by mealy bug, *Phenacoccus solenopsis*. Tinsley; a major species occurring on cotton in middle Gujarat (Jhala *et al.*, 2008). It has short to medium sized waxy filaments around the body; two dark stripes on either sides of middle "ridge" of the body and absence of long tail. *P. solenopsis* being a polyphagous pest, feeds on number of cash crops, ornamental crops, medicinal plants, vegetable crops and others. It harbors throughout the year on weed hosts and spread after preferred host crop appear in field. Ant distributes crawlers within field. In tobacco, at initial stage mealy bug attach themselves to underneath of lower leaves and suck the cell sap. Under severe infestation pest is found on all parts of plant and even on parasitic weed broomrape (*Orobanche cernua*). The infested leaves show sickly appearance, dry out before maturity and quality of leaf also is deteriorated. An experiment was carried out at Tobacco Research Farm AAU Anand during 2007-08. Treatments were replicated thrice under Randomized Block Design. Three leaves of five plants were randomly selected and tagged from each plot. The number of mealy bugs was recorded before and 3, 7, 14 days after insecticide application. The data obtained were statistically analysed and presented in Table 1.

These data indicate that there was uniform population of pest prior to insecticide application. All insecticidal treatments has significantly reduced the population (49.15% to 89.41%) over control. Amongst the treatments methomyl 0.8% (6.1 / leaf) was found significantly superior and at par with profenophos 0.1% (6.7 / leaf) and carbaryl 0.2% (6.8 / leaf); these findings are in agreement with Jhala *et al.* (2008) on cotton.

Table 1 Bioefficacy of various insecticides against mealy bug, *Phenaccocus solenopsis* infesting tobacco

Treatment	No. of mealy bug/leaf					Per cent reduction over control	Yield (kg/ha)
	Before spray	Spray after indicated days			Pooled		
		3	7	14			
Carbaryl (0.2 %)	55.2^{a}	13.2^{f}	3.8^{i}	3.4^{f}	6.8^{ef}	88.19	2454^{a}
Profenophos (0.1 %)	52.4^{a}	10.7^{f}	7.3^{gh}	2.1^{f}	6.7^{ef}	88.36	2465^{a}
Trizophos (0.01 %)	53.6^{a}	13.6^{f}	8.5^{fg}	8.4^{e}	10.2^{e}	82.29	2396^{a}
Methomyl (0.08 %)	55.2^{a}	10.3^{f}	5.0^{hi}	3.2^{f}	6.1^{f}	89.41	2500^{a}
Methyl-O-dematone (0.05 %)	49.2^{a}	34.2^{b}	29.9^{bc}	21.9^{b}	28.7^{b}	50.17	2080^{a}
Phenthoate (0.1 %)	48.7^{a}	29.2^{bcd}	19.6^{d}	17.0^{cd}	21.9^{c}	61.98	2222^{a}
Phosphamidon (0.05 %)	53.2^{a}	30.8^{bc}	30.8^{b}	23.9^{b}	28.5^{b}	50.52	2249^{a}
Chlorpyriphos (0.05 %)	50.1^{a}	26.0^{e}	16.0^{e}	17.0^{c}	19.7^{cd}	65.80	2199^{a}
Acephate (0.075 %)	53.0^{a}	35.5^{b}	27.5^{c}	25.0^{b}	29.3^{d}	49.13	1987^{a}
Imidaclopride (0.005 %)	54.6^{a}	26.2^{cde}	10.9^{f}	13.5^{d}	16.9^{b}	70.65	2299^{a}
Control	53.9^{a}	58.6^{a}	58.5^{a}	55.6^{a}	57.6^{a}	-	1863^{a}
Mean	-	26.2	19.8	17.4	-		
S.Em.	7.1	2.4	0.8	1.3	1.1	-	159
CV %	23.5	15.6	6.8	13.2	12.3	-	12.2

Note : Means with the letter (s) in common are not significant by DMRT at 5% level of significance.

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Impact of weather factors on cotton mealy bug, *Phenacoccus solenopsis* Tinsley

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The wide scale commercialization of Bt cotton led to a change in pest scenario, which resulted in the emergence of minor pests into a major one. Mealy bug (*Phenacoccus solenopsis*) is one such pest, after introduction of Bt varieties it was observed during 2002 and became serious in 2006-07 in Gujarat (Jhala and Bharpoda, 2008) and then in Punjab in traces during 2006 and as epidemic during 2007 season. The minimum estimated loss caused is about Rs.159 crores to cotton growers of Punjab during *kharif* 2007 (Anon., 2008a). The information on different factors leading to their populations build up and dispersal in India is very limited. Keeping this in view the present investigation was carried out to study the impact of weather factors on dispersal of mealy bug in cotton in Punjab.

An intensive surveillance was carried out in 32 cotton-growing villages in Faridkot district of Punjab from June to September 2008. In each village two fixed fields and two random fields were selected for weekly surveillance. In the selected fields 100 plants were selected at random for observations and which was expressed as per cent incidence. In the same fields 10 plants were selected at random, in which the mealy bug grade was worked out using the following scale.

Mealy bug grade (0 -4):

0 No mealy bug
1 Scattered appearance of few mealy bugs on the plant
2 Severe incidence of mealy bug on any one branch of the plant
3 Severe incidence of mealy bug on more than one branch or half portion of the plant
4 Severe incidence of mealy bug on the whole plant

The average grade was expressed as mealy bug intensity. The weekly weather parameters were collected from the observatory of Punjab Agricultural University, Regional Station, Faridkot. The correlation analysis indicated that both maximum as well as minimum temperature are negatively correlated with incidence (%) and intensity (grade). Relative humidity (morning and evening) shows a positive correlation; correlation of morning RH with incidence was low (0.23 0.42) compared to that of evening RH (0.51 0.60) (Table 1). The same trend was observed with that of intensity. In Pakistan the increase in incidence of mealy bug is positively correlated with the increase in humidity (Anon., 2008b). The negative correlation with that of rainfall was found to be for higher incidence (-0.43 to -0.49) than that of intensity (-0.37 to -0.38). The 103.8 mm rainfall received during 32nd Standard Meteorological Week (SMW) might have decreased the infestation in the later part of the crop season. It appeared that high rainfall had washed away all the small crawlers. Moreover the high rainfall has favoured the growth of entomopathogens, and it was confirmed by the samples collected from Bhatinda (Punjab) of October / November, 2008. It is evident that though humidity favours the multiplication, but the intense rainfall adversely affects the spread and reduces the intensity.

Table 1 Correlation coefficient of mealy bug incidence and intensity with weather parameters

Weather	Mealy bug incidence (%)			Mealy bug intensity (Grade)		
	Fixed	**Random**	**Average**	**Fixed**	**Random**	**Average**
Max. Temp.(°C)	-0.71	-0.76	-0.77	-.91	-0.88	-0.90
Min. Temp.(°C)	-0.51	-0.67	-0.62	-.83	-0.84	-0.85
Morn. RH (%)	0.23	0.42	0.38	0.66	0.65	0.66
Even. RH (%)	0.51	0.58	0.60	0.73	0.68	0.70
Rainfall (mm)	-0.49	-0.43	-0.44	-.38	-0.37	-0.38

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Population dynamics of mango fruit fly, *Bactrocera* spp. (Tephritidae: Diptera) in West Bengal

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Fruit flies are found in almost all mango growing areas of the world (Singh, 1991). The common species reported on mango include Queensland fruit fly *Bactrocera tryoni*, *B. zonata*, Oriental fruit fly *B. dorsalis*, *B. neobumeralis*, *B. jarvisi*, and *B. fravenfeldi* (Umeya and Hirao, 1975). The damage caused by fruit fly ranged from 30-35% as reported by Mohyuddin and Mahmood (1993).

The population dynamics of mango fruit fly in relation to change in weather condition was investigated at Malda district of West Bengal. Population was recorded by using methyl eugenol trap; trap was prepared by using a plastic jar and a couple of funnels in such a way that the fruit fly can enter in the trap but cannot escape. Three drops (0.042 ml) of methyl eugenol was dropped on the sponge in a small glass petridish placed inside the plastic jar. The traps were under the tree with a rope, keeping 30-meter distance. Observation for number of fruit flies trapped was recorded at fortnightly interval and weather data were correlated.

Population build up in 2004 started from February (i.e., 5.33 fruit flies trapped) and then its population was found in an increasing manner upto the month of June. From July upto December its population declined (i.e., 72.33 to 0.00 fruit flies) with little fluctuation (Table 1). The maximum number trapped during June (*i.e.*, 383.33) and minimum was observed during December to January. Maximum number of fruit flies was trapped during May 2005 (*i.e.*, 104). population then declined. No fruit fly was found during November January. Among all the weather parameters and periodicity, heat sum pertaining to previous fortnight showed maximum correlation (r = 0.69%*) (Table 2). While, studying across weather parameter and periodicity, weather parameters other than DV were almost positively and significantly correlated. Multiple linear regression equation showed that population variability to the extent of 47% can be explained by the selected significant weather parameters. Mohyuddin and Mahmood (1993) reported that mango fruits are attacked in central Punjab in July with a maximum in August.

Table 1 Incidence of fruit fly in Malda and weather parameters (2004-2005).

Month of observation	Number of fruit fly /Trap		Temperature (°C)				Relative humidity (%)				Rainfall (mm)	
			2004		2005		2004		2005			
	2004	2005	Tmax.	Tmin.	Tmax.	Tmin	RH-I	RH-II	RH-I	RH-II	2004	2005
January	0 *(0.71)h	0 (0.71)e	20.8	10.2	22.8	10.7	98	66	98	58	24.7	14.7
February	5.33 (2.38)gh	12.33 (3.49)d	26.4	13.1	27.5	14.2	96	45	91	47	0	3.7
March	32.67 (5.70)d	35.67 (5.98)c	33.0	18.7	31.6	19.0	92.4	49	93	50	4.6	54.7
April	72.00 (8.47)c	70.33 (8.40)b	32.7	21.7	32.2	21.8	89	57	89	53	48.4	21.9
May	237.67 (15.43)b	104.00 (10.19)a	35.8	24.2	33.9	23.6	89	52	90	57	59.4	91.6
June	383.33 (19.36)a	44.33 (6.67)c	32.8	27.7	35.9	25.9	93	73	90	60	313.7	51.4
July	72.33 (8.36)c	46.00 (6.70)c	32	25.8	32.0	25.9	95	79	93	76	356.2	718.7
August	22.67 (4.77)de	19.00 (4.40)d	32.5	26.2	32.6	26.6	93	76	94	78	207.2	204.0
September	11.33 (3.42)efg	11.67 (3.48)d	31.3	25.3	33.4	25.9	95	80	92	72	117.5	144.1
October	19.00 (4.29)def	15.00 (3.87)d	29.9	21.9	28.6	22.5	95	70	96	83	522.3	161.8
November	8.00 (2.84)fg	0 (0.71)e	28.2	16.2	27.6	16.2	95	53	92	74	0	0
December	0 (0.71)h	0 (0.71)e	25.3	18.6	25.0	12.3	98	59	89	51	0	0

SEm=0.601 SEm=0.415

*Figures in the parentheses are the square root transformed values: Fortnightly data are pooled and is presented here as monthly. Means with the same alphabets are statistically at par by DMRT

Table 2 Correlation between incidence and weather parameters

Meteorological parameter	Bored Shoot/sapling					
	Annual			Seasonal		
	Fortnight	PW	WBP	Fortnight	PW	WBP
Rainfall	0.48*	0.76*	0.18	0.20	0.45	0.03
Tmax	0.43*	0.45*	0.35	0.63*	0.57*	0.62*
Tmin	0.47*	0.48*	0.44*	0.66*	0.64*	0.63*
Taverage	0.47*	0.49*	0.43*	0.68*	0.63*	0.68*
DT	0.47*	0.49*	0.42*	0.67*	0.62*	0.68*
NT	0.48*	0.49*	0.44*	0.68*	0.64*	0.68*
DV	-0.29	-0.15	-0.32	-0.13	-0.17	-0.19
Heat Sum	0.48*	-0.06	0.43*	0.69*	-0.10	0.68*

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Incidence of mealybug, *Phenacoccus solenopsis* Tinsley and its parasitoids on cotton

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Severe incidence of the mealybug *Phenococcus solenopsis* (Pseudococcidae: Hemiptera) was first reported on cotton from Punjab (Dhawan, 2007). Subsequently it has been reported across cotton growing belts of north and central India. A drastic change in the pesticide usage pattern brought about by the introduction of Bt cotton is believed to be one of the reasons for severe outbreak of mealybug. There is no information available on the status of *P. solenopsis* on cotton in Andhra Pradesh. Hence field surveys were undertaken to assess the severity in the Warangal district of Andhra Pradesh.

In the project villages of CRIDA, a total of 18 intensive cotton-cultivating villages in the Shayampet mandal were selected, covering 36 farmers during the four months period from August to November 2008. The incidence was recorded on 100 plants per acre sampled diagonally across the field. Samples along with host material were collected from each village kept in one liter plastic jars by closing the mouth of the jar with cotton (Kora) cloth and observed for the emergence of parasitoids. Parasitized cocoons identified by reddish brown colour were held separately in glass vials with cotton plugs and observed for emergence.

Though sporadic incidence was noticed during the second fortnight of August 2008, heavy infestations was observed only during the second week of October and continued till the end of November. In 8 out of 18 villages surveyed, the percentage of plants infested during October last week was in the range of 21 and 61 (Table 1). There were no significant differences in the incidence between Bt and non-Bt cotton cultivars. Natural parasitoids on *P. solenopsis* in the field were identified by the presence of reddish brown cocoons of *Aenasius* sp. (Hymenoptera: Encyrtidae), a solitary endoparasitoid. Minute adults (< 0.4 mm in size) of another hymenopteran species (yet to be identified) emerged from the mummified bodies. Percent parasitization by both the above parasitoids was in the range of 8 to 26. However, the dominant parasitoid was the encyrtid. Mealybug assumed pest status during the 2008 *kharif* as the infestation was moderate to severe across 18 villages sampled in the Warangal district. The survey reports for the first time the extent of natural field parasitization in Andhra Pradesh. It is hoped that the information on the natural regulation of the pest which is likely to keep it under check will lead to less reliance on pesticide application.

Table 1 Incidence of cotton mealybug in Warangal district (October 2008)

S.No.	Village	% plant infestation
1	Pragathisingaram	44.8
2	Koppula	30.9
3	Nizampalli	38.6
4	Gangireni Gudem	61.0
5	Thaharapur	35.9
6	Shayampet	25.5
7	Pathipaka	38.8
8	Hussainpalli	31.1
9	Jogampalli	28.9
10	Katrapalli	41.1
11	Noorjahanpalli	33.9
12	Rajupalli	33.2
13	Sadanpalli	36.5
14	Neredupalli	35.1
15	Appaiahpalli	35.0
16	Gollapally	28.0
17	Vasanthapur	36.5
18	Jaffergudem	21.0

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Incidence and management of *Scirtothrips dorsalis* Hood and *Empoasca flavescens* F. - sucking pests of tea in North Bengal

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One of the most important beverages and commercial crops covering an area of 4.35 lakh hectares of plantation in India is tea. Twenty three percent of this foliage crop is produced annually from North Bengal (Roy *et al*., 2008a). Climate change, deforestation and over reliance of chemical pesticides during last five decades are supposed to have a significant impact on incidence and abundance of pest scenario (Rahman *et al*., 2007; Roy *et al*., 2008b). The thrips (*Scirtothrips dorsalis* Hood) and the green fly (*Empoasca flavescens* F.), which were previously considered as minor pests or occasionally as serious in particular localized areas of tea plantations, are now established as serious and regular pests in tea plantations of North Bengal. Therefore, our study was focused on the influence of the weather factors on incidence and abundance of tea thrips and green flies in the foot hill region of North Bengal with possibility of their integrated management. The population incidence study in correlation with weather parameters (temperature, rainfall, RH and sunshine) was conducted between 2005 and 2007 in the terai plantation in and around the North Bengal University campus, Darjeeling, using pruned section of TV1 clone. Direct count method was adopted using 30 young shoots. The green fly was counted on lower surface of the first 5 leaves, and nymphs and adults of thrips were sampled from first 3 leaves and the bud. The trend suggested that thrips and green flies were abundant throughout the year in the North Bengal tea plantations. Population abundance was highest, 6.3-10.37 thrips/shoot in the months of April to June, and 4.34-10.1 for green flies/shoot from March to May ; during December to March, it was lowest (1.40-5.40 thrips/shoot and 1.07-3.15 green flies/shoot) respectively (Fig. 1). Thus, the buildup of population for both the pests was highest during the flushing season. In a period of continuous three seasons (2005-2007), population peaks generally occurred during April- May for thrips and March-May and September for green flies. Within the first and third flushing periods, conspicuous high population (6.3-3.39 thrips per shoot and 4.34-10.1 green flies per shoot) could be seen. This provides an indication that at least during first fortnight of February and March monitoring the population in the range of 1.87-2.02 insects/shoot on any of the sampled tea bushes should be viewed critically for deciding upon the necessary insecticidal control (Fig. 1). Seasonal incidence of both the sucking pests revealed that the outbreaks were frequent, regular and followed a patchy distribution across a region. In such cases a farm level monitoring/ forecast strategy should be appropriate.

Various correlation analyses made for thrips and jassids population with the various abiotic factors (Table 1) indicated that population abundance of thrips and jassids was influenced by maximum and minimum temperature, rain fall, sun shine hours and RH afternoon hours (and not forenoon RH). Therfore, population growth was largely dependant of weather factors. In spite of these, other additional factors appeared to influence the population incidence of tea thrips and green flies resulting in low R^2 value in multiple regression equation (for thrips $R^2 = 0.450$ and for green flies $R^2 = 0.282$). One such factor may be the harvesting / removal of the plucking shoots harbouring a significant number of eggs laid by these pests. Minimum and maximum temperature between 26.5-30.9°C, RH afternoon between 49- 65 %, rainfall 49- 65 % and sunshine hours between 6.0-7.7 h, were reported optimum for triggering the population build up of thrips and jassids respectively. These pests have shown capacity to multiply very quickly in a short period during favourable conditions and for proper management of these pests on tea, tea plantation should be economically yielding and field level monitoring of thrips and green fly from February onwards. For easier monitoring of the population abundance at field level, use of yellow colour sticky water traps will be appropriate and economically feasible at farm level.

Table 1 Relation between weather and thrips and greenfly populations in tea plantations.

Pest	Regression coefficient of independent variable						
	Rainfall mm	Temperature °C		Relative humidity %		Sunshine hours	R^2 value
		Max	Min	Forenoon	Afternoon		
Thrips	0.2856**	0.3916**	0.3803**	-0.3959NS	0.4626**	0.2283**	0.450**
Greenfly	0.0504**	0.2467**	0.2312**	-0.4826NS	0.2632**	0.0533**	0.282**

n= 252; df = (n-2)=250; **Significant at 1% level; NS – Not Significant.

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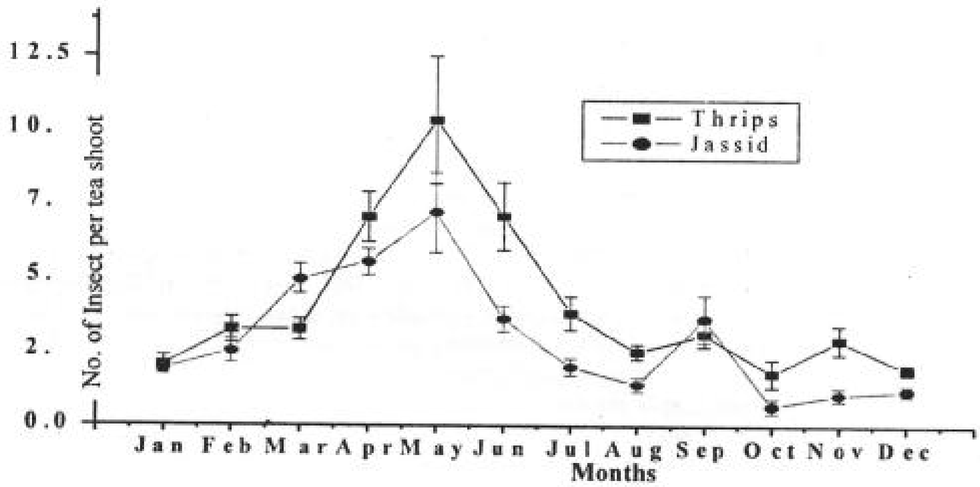

Fig. 1 Seasonal incidence of trhrips and jassids in tea (Dooars of North Bengal 2005-2007)

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An insight into the looper complex of tea from Darjeeling terai

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The perennial foliage crop tea is attacked by a number of lepidopteran pests among which looper caterpillars are one of the most damaging in Darjeeling Terai, the Dooars and Assam plantations. The looper *Buzura suppressaria* was recorded in the past (Anonymous, 1994). However, recent studies revealed existence of *Hyposidra talaca* (Basu Majumdar and Ghosh, 2004) causing extensive damage. Very recently another looper species *Hyposidra infixaria* is also recorded.

A study on the occurrence of these species showed that *H. talaca* and *H. infixaria* were much prevalent than *B. suppressaria* in most tea estates of Terai and Dooars. *B. suppressaria* with an average post embryonic development period of 60 days in summer months could only complete four broods (generations) whereas the *Hyposidra* spp. with a shorter post-embryonic development period of about 31 days could produce numerous (about eight) broods. Further, a difference in diapause during winter months was quite evident among these species. While *B. suppressaria* is reported to enter winter diapause as sub-soil pupae, caterpillar stages of *Hyposidra* spp. were recorded on tea even during winter months of December and February. In cold foggy days of winter the *Hyposidra* spp. were even observed to mate at ground level, an unusual practice to remain reproductively active even at low temperature.

All these looper species had chiefly migrated from forest plants to tea. Several forest plants and even weeds served as the host of *Hyposidra* spp. (Das and Mukhopadhyay, 2008). In an experiment designed to study the feeding cycle of *H. talaca* on tea, a clear hour wise difference was evident. Maximum feeding took place in afternoon hours (12-18 hrs.) and the minimum in the late evening (18-0 hrs.). In the first (0-6 hrs.) and the second quarter (6-12 hrs.) intermediate but sustained feeding activity without much difference was noted. A significant increase in the feeding activity in the afternoon hours (12-18 hrs.) appears to be dependant on higher ambient and in turn higher body temperature to support enhanced activity of the loopers. As *B. suppressaria* is almost of negligible occurrence in the Terai tea estates visited for sampling, hence a detailed comparison of the two *Hyposidra* spp. based on morphology and isozyme patterns is considered in Table 1. Morphological, developmental, behavioral and biochemical studies provide an insight on the two most destructive looper species in the tea plantations of Darjeeling Terai and Dooars. A further study on their life traits would enable planning of better IPM programme of tea. \

Table 1 Morphological and biochemical differences between *H. talaca* and *H. infixaria*

	H. talaca	*H. infixaria*
Larva	5th instar grayish brown in colour. Paired lateral black mark on 1st abdominal segment.	Characteristic paired lateral oblique black stripes extend from 1st abdominal segment to thoracic legs III, which is blackish than 1st and 2nd pair of legs.
Pupal anal process	Process at the abdominal end either single or bifurcated. Single process may or may not be forked; bifurcated ones are not forked. Apex of both types of processes never recurved.	Process may be either single or bifurcated. The apex of the processes in both types forked and recurved.
Adult wing pattern	A distinct sub marginal notch present on the fore wing. Wing colour grayish to blackish brown. Diffused and wavy dark patch present.	Sub marginal notch not prominent. Colour is as *H. talaca* on which sharp and dark lines are present
Phosphoglucose isomerase banding pattern	RF value 0.35	RF value 0.42

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Studies on the life cycle of the bamboo lesser leaf roller, *Pyrausta bambucivora* Moore at Raipur, Chhattisgarh

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The annual loss caused by the insects to forest products has been computed to be about 10% of the total revenue of the forests (David, 2001). Chhattisgarh is the second densely forested state in India after Assam with 46% of forest cover (Kumar *el al.*, 2003). Among the forest trees, bamboo is most important and it is heavily infested by the lesser leaf roller, *Pyrausta bambucivora*. At Chhattisgarh its infestation is recorded from July to November (Ganguli *et. al.* 2003). Its life cycle was studied under laboratory conditions, for two generations, in the Department of Entomology, IGAU, Raipur. Larvae collected from the plantations were reared in petri dish and fresh leaves were provided as feed. Length and width of the larvae and pupae along with the duration of larval and pupal period were recorded. The lengths of the adult moth along with the wing expanse were measured.

The results in Table 1, will reveal that the mean length of the full-grown larvae was 24.0mm, while that of pupa was 12.0 mm. The larvae were light greenish in their early instars, which later changed to pink. The average total larval and pupal period was 17.0 and 9.0 days, respectively. The pupae were dark brown while the adult was yellowish brown with dark brown markings and silvery white underside.

Table 1 Details of larvae, pupae and adult of *Pyrausta bambucivora*

S.No.	Observation	Generation		Mean
		I	II	
1.	Length of full grown larvae (mm)	23.0	25.0	24.0
2.	Width of full grown larvae (mm)	3.0	3.5	3.25
3.	Total larval period (days)	16.0	18.0	17.0
4.	Length of pupae (mm)	12.0	12.0	12.0
5.	Length of pupae (mm)	3.0	4.0	3.5
6.	Pupal period (days)	9.0	9.0	9.0
7.	Length of adult moth (mm)	16.0	16.0	16.0
8.	Wing span (fore wing) (mm)	26.2	27.0	26.6
9.	Longevity (days)	8.0	10.0	9.0

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New records of scutellerid bugs (Hemiptera) on jatropha in and around Delhi

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Jatropha is an economically important plant which belongs to the family Euphorbiacae. The name is derived from two Greek words i.e. iartos= physician and trophe= nutrition, hence the common name is physic nut. It is a native of tropical America. Jatropha is a multipurpose, drought resistant, large, erect shrub or small tree. Generally alkaline soil is more suitable for its cultivation but it can be easily grown on other types of soils. Its oil is used as fuel along with petrol or diesel in the vehicles. Jatropha fulfills many human needs but nowadays it is getting more attention because of its oil producing capability, henceforth is frequently termed as biodiesel. Besides the seeds of jatropha contain (50% by weight) viscous oil, which is useful for manufacturing of candles, soaps, cosmetics etc. Its bark contains tannin, the flower attracts bees and thus the plant has honey production potential.

Jatropha is being cultivated as biodiesel crop in IARI farms, New Delhi and at farmer's field around Delhi. The crop was surveyed periodically to record insect pests. Taxonomic studies on these insects revealed that two species of bugs were more abundant on jatropha viz., *Chrysocoris stollii* Wolff and *Scutellera perplexa* (Fabricius) belonging to the family Scutelleridae (Hemiptera: Heteroptera). These bugs are reported first time as a pest of jatropha from Delhi and adjoining areas. Due to infestation of these bugs the quantity and quality of seeds is affected enormously. These bugs are large sized, bright and metallic green coloured. Morphologically these can be differentiated on the basis of body size, shape and spots/pattern on the dorsum. *C. stollii* is small and dorsally more convex as compared to *S. perplexa* (=*nobilis*), and size of spots varies (Fig. 1, 2)

Fig. 1 ***Chrysocoris stollii***

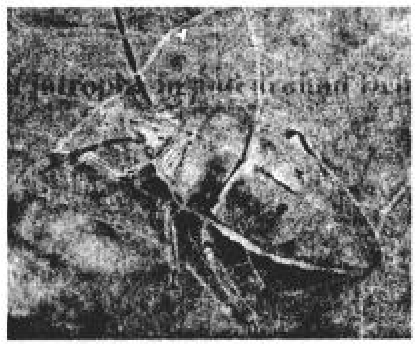

Fig. 2 ***Scutellera perplexa***

To record seasonal activities of *C. stollii* and *S. perplexa* on jatropha ten plots were selected. The observations were recorded twice a week on ten randomly selected plants per plot. These bugs remained active on the crop from July to March and activity declines during hot months. The population was less during July, and number of eggs and adults were recorded during September-October. Different instars of nymphs were observed from second week of July to fourth week of August. As the temperature declines bugs start hibernating. Both species are gregarious and prefer to remain on both surfaces of leaves and growing tips of branches. Batches of eggs were seen on leaf surfaces, fruits and stems. The gravid females laid the eggs in two rows. Freshly laid eggs were light yellow which changed to bright red before hatching. Generally females laid 35-45 eggs in a batch with variation of 27-75 per batch. Eggs are barrel shaped, but dorsally they appear round. Though oviposition was on both sides of leaves, fruits and stem, with leaf shedding stage approaching, eggs were observed on the leaf litter and adjoining weeds.

Adults and nymphs caused damage by sucking the sap of leaves, tender petioles, stem and fruits. Due to excess sap sucking the leaves turned yellowish and fruits became brownish which dried up ultimately. Similar symptoms were observed by Shankar and Dhyani (2006) in Madhya Pradesh due to the infestation of *Scutellera perplexa* in *Jatropha curcas*. *S. perplexa* had been also reported as a serious pest. They could not sustain against extreme climatic conditions. With emerging implications of climate change and energy crisis the biofuels have a great scope and the plants like Jatropha will have a large economic and environmental importance. It is not only necessary to record such important insect pests but also monitor their infestation and relate with abiotic and biotic factors. It will also be necessary to document the bionomics, behaviour and other ecological details so as to exploit these towards their management.

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Seasonal incidence and assessment of losses due to insect pests of temperate vegetables

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Temperate vegetable crops include cabbage, cauliflower, knolkhol, broccoli, Brussels sprout, turnip, radish and carrot and these are known for their biennial nature. Depending upon the crop, low to high chilling is needed for their transformation from vegetative to reproductive stages. During the last quarter of 20[th] century insect pests have increased alarmingly on these crops (Barwal, 2005).

Experiments were conducted during 2006-07 and 2007-08 to study the seasonal incidence, activity periods and losses caused by the major insect-pests of temperate vegetable crops. Nurseries were raised during July in the case of cabbage, Brussels sprout and broccoli followed by their transplanting in August; nursery of knollkhol was raised in August followed by its transplanting in September, whereas cauliflower nursery was raised in September followed by its transplanting in October. On the other hand, radish, turnip and carrot were sown in ridges and their transplanting was done after uprooting in November. The crops were replicated thrice in insecticide treated and untreated plots. Observations on insect pests were made at fortnightly interval followed by the need based sprays of the recommended insecticides in the treated plots. Recommended applications of irrigations, fertilizers and disease management were undertaken uniformly. Plant survival and losses in seed yield were calculated and analysed by the randomized block design.

Insect pests and number of their generations in the vegetative and reproductive stages have been recorded in the temperate environment (Barwal, 2001). However, in the present studies, seasonal activity of only the major insect pests were recorded. In the vegetative stages damages were recorded from September to November due to green peach aphid (GPA), *Myzus persicae* Sulz., diamondback moth (DBM), *Plutella xylostella* L., cabbage butterfly (CB), *Pieris brassicae* L., green caterpillar (GC), *Helicoverpa armigera* Hubn., cabbage cutworm (CC), *Agrotis ipsilon* Huf., and tobacco caterpillar (TC), *Spodoptera litura* L. On attaining vegetative maturity by January, these crops were damaged by cabbage aphid (CA), *Brevicoryne brassicae* L. from January to May and major damage was recorded in the case of broccoli, cauliflower, radish, turnip, knolkhol and Brussels sprout (Table 1). It caused damage to cabbage during April and May, whereas carrot remained free. Another major pest was CB in April when its peak adult emergence coincided with the peak flowering in the cabbage in the second week of April. In May, thrips (CT), *Thrips tabaci* L. became the major pest and affected inflorescence and seed setting. Maximum loss due to insect-pests in plant stand (80.63 %) and the seed yield (87.95 %) was recorded in the case of cabbage, whereas it was minimum in the case of carrot (Fig. 1).

Table 1 Losses in the seed yield of temperate vegetable crops due to insect damage

Crop	Plant Survival (%)			Seed wt. (g plant-1)		
	Treated	Untreated	Survival	Treated	Untreated	Loss (%)
Cabbage	56.07	10.87	19.37	16.60	2.00	87.95
Cauliflower	32.07	17.80	45.50	10.62	1.45	86.35
Knolkhol	74.40	67.64	90.91	67.00	15.52	76.84
Broccoli	64.28	43.84	68.20	17.67	13.55	23.32
Br. Sprout	78.60	78.14	99.41	30.72	9.40	69.40
Radish	60.80	49.47	81.37	27.33	7.52	72.48
Turnip	42.65	32.50	76.20	17.82	4.80	73.06
Carrot	65.90	59.12	93.22	65.95	60.70	7.92
	CD (P= 0.05)			CD (P= 0.05)		
	T = 16.87			T = 16.87		
	D = 8.43			D = 4.62		
	T x D = 23.85			T x D = 16.06		

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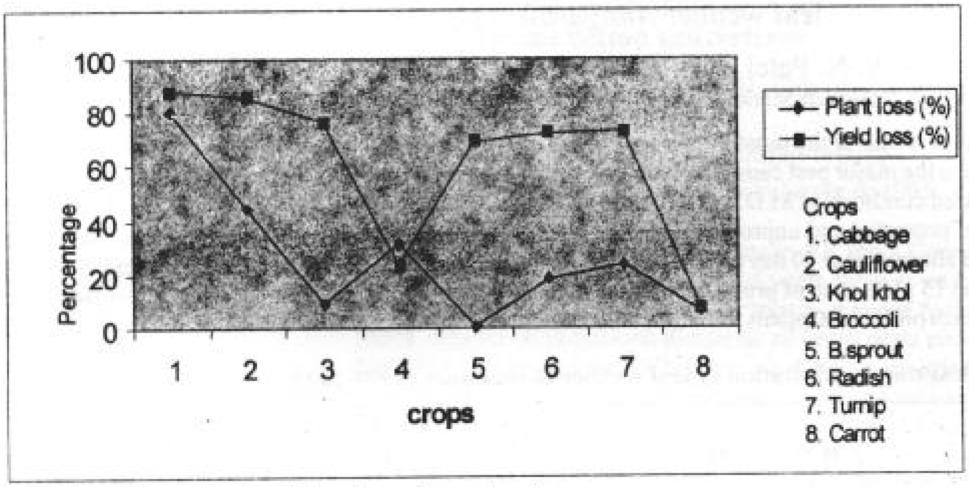

Fig. 1 Losses in temperate vegetables due to insect-pests

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Estimation of yield losses in rainfed sesamum due to leaf webber *Antigastra catalaunalis* Duponchal

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Sesamum is one of the most important oilseed crop grown in North Saurashtra agroclimatic zone of Gujarat. The leaf webber is the major pest causing heavy loss in the yield. Attempts were therefore made to estimate the losses of yield under rainfed condition at M.D.R.S., Targhadia (Rajkot) during from *Kharif,* 1999 to 2005. The trial consisted of two treatment of protected and unprotected plot. In protected plots, endosulfan 0.07 per cent and monocrotophos 0.04 per cent sprayed alternative at 10 day interval starting from commencement of the pest. Unprotected plots kept free from insecticide. Total 15 plots each of protected and unprotected kept in ABBA design. The population of leaf webber\plant recorded from each plots on 10 plants randomly selected, before one day and after 3 day of each insecticidal application.

Table 1 Yield loss due to infestation of leaf webber in sesamum (1999-2005)

Treatment	Yield Kg/ha							
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Pooled**
Treated	359	1231	1157	1187	717	1262	752	952
Untreated	310	1130	1068	997	640	985	494	804
Yield loss %	13.65	8.20	7.69	16.01	10.74	21.95	34.31	15.85
Calculated "T"Value	6.69	7.35	4.38	8.10	2.15	6.14	11.23	14.06
Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

Table "T" Value=2.145 for year data

Table "T" Value=1.985 for year pooled data

Table 2 Number of leaf webber *A. catalaunalis* in sesamum (1999-2005)

Sr.No.	Treatment	No.of larvae/plant							
		1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Mean**
1	Treated	0.03	0.02	0.07	0.07	0.06	0.01	0.19	0.06
2	Untreated	0.34	0.19	0.20	0.25	0.32	0.36	0.67	0.33

The data given in Table 1 and 2 reveal that the losses in yield was maximum 34.31 percent with 0.67 larvae/plant in untreated plots during 2005. While the yield loss was minimum 7.69 per cent with 0.2 larvae/plant during 2001. Average 15.85 per cent yield was lost due to the leaf webber over seven years (*Kharif,* 1999 to 2005) Avoidable yield loss of 6.2 to 43.1 per cent due to the sesamum leaf webber was also reported in Madhya Pradesh (Gupta *et. al.* 2002) and yield loss of 22.27 to 34.3 per cent due to major pests including leaf webber was reported in Maharashtra (Thakur and Ghorpade 1998).

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Development of databank for population dynamics of insect pests in different cotton ecosystems

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The data on insect pests and natural enemies are recorded by experts in All India Coordinated Research Improvement Project (AICRP) in major crops. These data sets collected over the years serve as an important asset in establishing pest forewarning models. Loss of these data sets due to various factors is a major problem. In All India Coordinated Cotton Improvement Project (AICCIP) data on population dynamics of insect pests under untreated crop condition is being recorded in 23 centres throughout the crop season. This data set is being recorded for more than a decade in AICCIP system, but there is no mechanism put in place for establishing a uniform data entry and retrieval system. Keeping this in view, efforts were made to develop a data bank for the population dynamics of insect pests as well as the weather parameters. The population dynamics and weather data of the year 2006-07 was obtained from AICCIP report (Anon., 2007) and a computer software was developed in MS-Access for data entry and generating reports.

The main menu of the software provides option for addition / edition of crop, location, pest and weather parameters and variables (Fig. 1). Once the master menu is prepared, the survey data entry option allows for easy and fast feeding of the data into this programme. The cotton pest population dynamics and weather data for the year 2006-07, from different centres has been fed in to this programme. This programme will be used to feed the subsequent years data for the same set of centres and pest and weather variables. The data entry option allows feed either date wise or week wise data. The date wise data will be clubbed and converted to show the weekly average data automatically in the reporting menu.

The reports can be generated for year wise / week wise for different locations for a single pest or for multiple pests along with the weather variables depending upon the requirement. Reports can be obtained either in tabular form or in chart form. Charts can also be generated for a particular pest against various weather parameters for any location (Fig. 2). The software is user-friendly, which requires very basic knowledge of computing for entering survey data and generating reports. The data entry and retrieval system, when enriched with the historic pest data available with the various centres of AICCIP will serve as a data bank of cotton insect pests and natural enemies, which can be accessed by the experts for various uses.

Fig. 1 Main menu of the software showing various options for data entry and retrieval

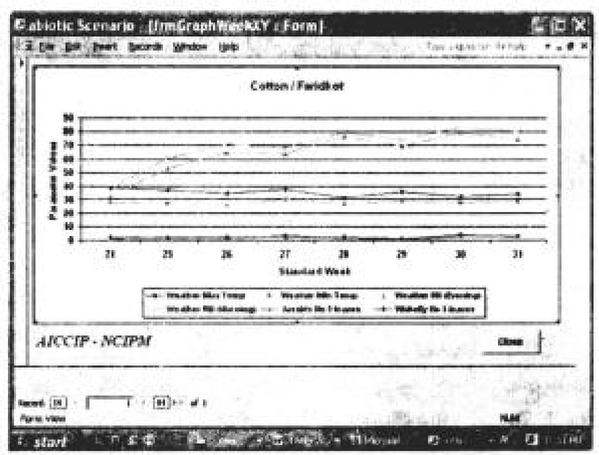

Fig. 2 Data retrieval of sucking pests with weather parameters from the software in the form of chart

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Insecticide resistance in tobacco caterpillar *Spodoptera litura* (F.) in Jammu region

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The tobacco caterpillar, *Spodoptera litura,* earlier known to be a sporadic pest has emerged as major polyphagus pest. It is reported to attack a wide range of vegetables, cash and fiber crops and has developed resistance to various groups of insecticides (Ramakrishnan et al., 1984.) Various conventional and newer insecticides were evaluated against 5-day old larvae collected from fields in and around Jammu to determine the level of resistance if any, against certain conventional insecticides. These insecticides were also evaluated against the laboratory reared susceptible population of *S. litura* to have the LC_{50} values of susceptible strain. On the basis of LC_{50} values against field collected strains (Table 1), the newer insecticide, indoxacarb was highly effective with a least LC_{50} value of 0.0068, followed by fenvalerate (LC_{50} 0.0071). However, when compared to the laboratory reared population, field populations showed slight degree of resistance to fenvalerate (resistance ratio 1.24). Pyrethroid resistance has been reported among few major insect pests of cotton (Kranthi et al.,2002). Spinosad was also effective and showed a lesser resistance ratio in the field population (LC_{50} 0.241; resistance ratio 1.03) indicating its potential in the IPM module. Remaining all conventional insecticides *viz.,* cypermethrin, quinalphos, bifenthrin, endosulfan and betacyfluthrin showed certain degree of resistance with the resistance ratio of 1.50, 1.30, 1.36, 1.15 and 1.15 respectively. It is evident that the third instar larvae of *S. litura* obtained from various parts of Jammu showed resistance to the pyrethroids and some organophosphates. The LC_{50} values obtained would serve as ready reckoner for the selection of insecticides for field strains. Also, such base line data could be used as critical inputs in insecticide resistance management programmes.

Table 1 Relative toxicity of various insecticides against laboratory and field population of *S. litura*

Insecticides	Lab population			Field population		
	chi square	LC50 (%)	Fiducial limits	chi square	LC_{50} (%)	Fiducial limits
Fenvalerate 20 EC	1.48	0.0057	0.0043-0.0074	1.49	0.0071	0.0053-0.0084
Indoxacarb 15 EC	7.73	0.0064	0.0048-0.0086	6.62	0.0068	0.0058-0.0086
Cypermethrin 10 EC	2.96	0.0104	0.0078-0.0138	2.33	0.0156	0.0098-0.0178
Quinalphos 25 EC	5.84	0.0154	0.0119-0.0199	5.54	0.0200	0.0110-0.0239
Bifenthrin 10 EC	10.17	0.0203	0.0167-0.0247	9.88	0.0276	0.0177-0.0299
Spinosad 48 EC	1.40	0.0233	0.0168-0.0324	2.51	0.0241	0.0168-0.0324
Endosulfan 35 EC	6.08	0.0366	0.0267-0.0501	6.25	0.0422	0.0367-0.0522
Betacyfluthrin 2.5 SC	1.41	0.0444	0.0364-0.0543	1.56	0.0524	0.0364-0.0593

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Development of resistance to insecticides in *Helicoverpa armigera* Hubner on cotton

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Over the past two decades, *Helicoverpa armigera* has emerged as one of the most destructive pests in the history of pest management. Management of *H. armigera* became more and more difficult due to the development of insecticide resistance. Existence of resistance to pyrethroids, organophosphates, carbamates and cyclodines has been recorded in India (Kranthi *et. al.*, 2002). In present investigations studies on development of resistance to insecticides in *H. armigera* population on cotton from Amravati district of the Maharashtra were carried out at Department of Entomology, Marathwada Agricultural University, Parbhani during 2006-07.

The insecticide resistance monitoring bioassay was conducted with most commonly used insecticides. The discriminating doses used for resistance monitoring were cypermethrin 0.1 µg/µl, fenvalerate 0.2 µg/µl, deltamethrin 0.0125 µg/µl, quinalphos 0.75 µg/µl, chlorpyriphos 1.0 µg/µl, profenophos 2.0 µg/µl, endosulfan 10.0 µg/µl, methomyl 1.2 µg/µl and spinosad 1.2 µg/µl. The sublethal concentrations of insecticides were used for bioassay to study the development of resistance level. *H. armigera* eggs were collected from cotton fields and reared on semisynthetic diet in laboratory. The insecticides were applied to the thoracic dorsum of each third instar larva (30-40 mg) with Hamilton microsyringe @ 1.0 µl/larva and mortality of larva was recorded daily upto 6 days.

The results revealed that synthetic pyrethroids have shown high resistance frequencies (Table 1). Among synthetic pyrethroids, the *H. armigera* population showed highest resistance to deltamethrin (99.47 %), followed by cypermethrin (98.95 %) and fenvalerate (97.90 %). Mean resistance frequencies were medium to organophosphates and carbamates. The per cent survival was 45.32 %, 42.75 %, 38.05 % and 29.20 % for chlorpyriphos, methomyl, quinalphos and profenophos, respectively. *H. armigera* showed low resistance to endosulfan (25.00 %). The population was not resistant to the new molecule, spinosad. The LD_{50} values of cypermethrin, fenvalerate, deltamethrin, chlorpyriphos, quinalphos, profenophos, methomyl, endosulfan and spinosad were 1.694, 1.980, 0.170, 0.817, 0.573, 0.101, 0.877, 2.710 and 0.050 µl/larva, respectively. The *H. armigera* had developed highest resistance to cypermethrin (338.80 fold), followed by fenvalerate (330.00 fold), deltamethrin (170.00 fold) and chlorpyriphos (40.85 fold). The resistance against quinalphos, profenophos, methomyl and endosulfan was 5.07, 1.98, 6.74 and 4.91 fold, respectively (Table 2).

The results of present investigations are in conformity with that of Surilivelu *et.al.*, 2004 and Chavan and Nimbalkar (2003) who showed high level of resistance to synthetic pyrethriods, moderate to above moderate levels and fluctuating trends to organophosphates, and low to moderate levels to carbamates and cyclodiene compounds.

Table 1 Level of resistance in *Helicoverpa* to insecticides

Insecticide	LD 50 µg/larva		RF
	Susceptible strain	Amravati strain	
Cypermethrin	0.005	1.694	338.80
Fenvalerate	0.006	1.980	330.00
Deltamethrin	0.001	0.170	170.00
Chlorpyriphos	0.020	0.817	40.85
Quinalphos	0.113	0.573	5.07
Profenophos	.051	0.101	1.98
Endosulfan	0.551	2.710	4.91
Methomyl	0.130	0.877	6.74
Spinosad	0.062	0.050	0.80

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Table 2 Resistance of *H. armigera* in cotton, 2006-07 (% larval survival)

Insecticide	%RP* + SE**				
	September IInd fortnight	October Ist fortnight	October IInd fortnight	November Ist fortnight	Mean (% RP + SE)
Cypermethrin 0.1 µg/µl	97.90 + 2.09	97.90 + 2.09	100.00 + 0.00	100.00 + 0.00	98.95 + 1.48
Fenvalerate 0.2µg/µl	95.80 + 2.92	97.90 + 2.09	97.90 + 2.09	100.00 + 0.00	97.90 + 2.09
Deltamethrin 0.0125µg/µl	97.90 + 2.09	100.00 + 0.00	100.00 + 0.00	100.00 + 0.00	99.47 + 1.05
Quinalphos 0.75ug/µl	31.30 + 6.76	37.50 + 7.06	41.70 + 7.19	41.70 + 7.19	38.05 + 7.08
Chlorpyriphos 1.00 µg/µl	37.50 + 7.06	43.80 + 7.23	47.90 + 7.28	52.10 + 7.28	45.32 + 7.26
Profenophos 2.00µg/µl	27.10 + 6.48	29.20 + 6.63	29.20 + 6.63	31.30 + 6.76	29.20 + 6.63
Endosulfan 10.00µg/µl	22.90 + 6.12	25.00 + 6.31	25.00 + 6.31	27.10 + 6.48	25.00 + 6.31
Methomyl 1.20µg/µl	41.70 + 7.19	41.70 + 7.19	43.80 + 7.23	43.80 + 7.23	42.75 + 7.21
Spinosad 1.20µg/µl	0.00 + 0.00	0.00 + 0.00	0.00 + 0.00	0.00 + 0.00	0.00 + 0.00

*RP - Resistant population**SE - Standard error

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Efficacy of insecticides against brinjal shoot and fruit borer

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Brinjal (*Solanum melongena* L.) is one of the most popular vegetable in India. It is longely grown in almost all parts of the country, like other vegetables it is attacked by a number of insects-pests which directly or indirectly infest serious damage at different stages of the crop growth. Among the insect pests, brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee is one of the most serious and regular pest. Causing heavy loss to brinjal grower in North Bihar. It causes extensive loss to the *kharif* crop. The damage starts soon after transplanting and continue till harvest of the fruits. Insecticidal treatment is a potential tool for the management of brinjal shoot and fruit borer. At this stage it is essential to evaluate the bioefficacy of synthetic pyrethroids and some new insecticides against brinjal shoot and fruit borer and the extent of residues of these insecticides *viz.*, cypermethrin and deltamethrin in/on its fruit in Bihar.

The experiment was carried out to evaluate the efficacy of insecticides against *Leucinodes orbonalis* in brinjal and residues of cypermethrin and deltamethrin in/on brinjal fruits at Research Farm of TCA, Dholi, Muzaffarpur during kharif 2007. Brinjal cv. Rajendra Baigan-II was chosen for experimental purpose. For the efficacy, commercial formulations of fenvalerate @ 0.075 and 0.150 kg a.i. ha^{-1}, endosulfan @ 0.500 kg a.i. ha^{-1}, imidacloprid @ 0.025 kg a.i. ha^{-1} were aprayed twice, the first at 50 per cent flowering and the second 15 days after first spray. Whereas, carbofuran @ 1.000 kg a.i. ha^{-1} was applied at the time of earthing up. For quantitative estimation of the residues, cypermethrin @ 0.025 and 0.050 kg a.i. ha^{-1} and deltamethrin @ 0.012 kg a.i. ha^{-1} were sprayed twice.

Field experiments were laid out at the research farm of TCA, Dholi. Brinjal cv. Rajendra Baigan-II was chosen for experimental purpose. For the efficacy, commercial formulations of fenvalerate @ 0.075 and 0.150 kg a.i. ha^{-1}, cypermethrin @ 0.025 and 0.050 kg a.i. ha^{-1}, deltamethrin @ 0.012 kg a.i. ha^{-1}, endosulfan @ 0.500 kg a.i. ha^{-1}, imidacloprid @ 0.025 kg a.i. ha^{-1} were sprayed twice, the first at 50 per cent flowering and the second 15 days after first spray. Whereas, carbofuran @ 1.00 kg a.i. ha^{-1} was applied at the time of earthing up. For quantitative estimation of the residues, cypermethrin @ 0.025 and 0.050 kg a.i. ha^{-1} and deltamethrin @ 0.012 kg a.i. ha^{-1} were sprayed twice. On 15th day after first and second application, imidacloprid treatment at 0.025 kg a.i. ha^{-1} recorded minimum shoot damage, followed by fenvalerate at 0.150 kg a.i. ha^{-1}. On per cent fruit damage (number and weight basis), imidacloprid was found most effective in reducing the damage. On the basis of larvae per 100 fruits, imidacloprid was again found most effective followed by fenvalerate at @ 0.150 kg a.i. ha^{-1} and cypermethrin at 0.050 kg a.i. ha^{-1}. On the basis of healthy fruits yield, imidacloprid treatment gave maximum yield (290.25 q ha^{-1}) followed by fenvalerate at 0.150 kg a.i. ha^{-1} (268.50 q ha^{-1}). Quantitative estimation of the residues of cypermethrin and deltamethrin in/on brinjal fruits was done. The half-life values of cypermethrin at 0.025 and 0.050 kg a.i. ha^{-1} and deltamethrin at 0.012 kg a.i. ha^{-1} on brinjal fruits were found as 3.04, 3.14 and 2.98 days, respectively. The safe waiting period for cypermethrin at 0.050 kg a.i. ha^{-1} was found as one day. The initial deposits due to application of cypermethrin at 0.025 kg a.i. ha^{-1} and deltamethrin at 0.012 kg a.i. ha^{-1} were less than their MRL (0.2 ppm), therefore, no waiting period is required.

It is evident from the data presented in table 1 that on 15th day after first and second application, imidacloprid treatment at 0.025 kg a.i. ha^{-1} recorded minimum shoot damage, followed by fenvalerate at 0.150 kg a.i. ha^{-1} and endosulfan at 0.500 kg a.i. ha^{-1} as compared with the rest of the treatments. All the insecticidal treatments were found significantly superior over control in reducing the shoot damage by *L. orbonalis.* (Table 1). However, on per cent fruit damage (number and weight basis), imidacloprid was found most effective in reducing the damage. All insecticidal treatments were significantly superior to control in most of the observations.

Table 1 Effect of insecticidal treatments on *L. orbonalis* in brinjal

Tr. No.	Treatments	Dose (kg a.i. ha^{-1})	Per cent shoot damage 15 DA 1st S	15 DA 2nd S
T_1	Fenvalerate	0.075	14.15 (22.08)	12.05 (20.29)
T_2	Fenvalerate	0.150	13.14 (21.24)	11.63 (19.92)
T_3	Cypermethrin	0.025	16.31 (23.81)	13.79 (21.79)
T_4	Cypermethrin	0.050	15.05 (22.81)	13.03 (21.14)
T_5	Deltamethrin	0.012	16.37 (23.85)	13.88 (21.86)
T_6	Endosulfan	0.500	14.11 (22.05)	12.03 (20.27)
T_7	Imidacloprid	0.025	9.16 (17.61)	7.20 (15.56)
T_8	Carbofuran	1.000	18.40 (25.39)	14.70 (22.54)
T_9	Control	-	22.83 (28.52)	27.78 (31.80)
	SEm±		(0.570)	(0.462)
	CD (P=0.05)		(1.664)	(1.350)

Figures in parentheses are angular transformed value ; 15 DA 1st S - 15 days after first spraying ; 15 DA 2nd S - 15 days after second spraying

The biomass estimation reveals that (larvae per 100 fruits) imidacloprid was again found most effective followed by fenvalearate at @ 0.150 kg a.i. ha^{-1} and cypermethrin at 0.050 kg a.i. ha^{-1}. On the basis of healthy fruits yield, imidacloprid treatment gave maximum yield (290.25 q ha^{-1}) followed by fenvalerate at 0.150 kg a.i. ha^{-1} (268.50 q ha^{-1}). Residue estimation showed that the cypermethrin and deltamethrin in/on brinjal fruits can be done by gas liquid chromatographic method. The mean inititial deposits of cypermethrin on brinjal fruits after application at 0.025 and 0.050 kg a.i. ha^{-1} were 0.135 and 0.205 ppm, respectively. The residues in lower dose degraded to 0.109 and 0.082 ppm showing dissipation of 19.26 and 39.26 per cent after 1 and 3 days of treatment, respectively. The residues further reduced to 0.041 ppm with a loss of 69.63 per cent and became non-detectable on 10^{th} day. The initial deposit of 0.205 ppm in higher dose reduced to 0.160, 0.115, 0.061 and 0.023 ppe causing a loss of 21.95, 43.90, 70.24 and 88.78 per cent on 1^{st}, 3^{rd}, 5^{th}, and 10^{th} day, respectively (Singh *et. al.*, 1992 ; Gajbhiye *et.al.*, 1985).

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IPM package for brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.)

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Shoot and fruit borer (ESFB, *Leucinodes orbonalis* Guen.) is the key pest of brinjal. Traditionally pesticides having high toxicity and persistence are being used despite the availability of several new insecticides with much acceptable qualities. Therefore, there is a need to evaluate new insecticides. To minimize use of pesticides and to maintain natural enemy population, alternative approaches like cultural control, mechanical control and botanical insecticides were used. Botanical pesticides like NSKE, Nimbo Bas™ (azadirachtin based formulation) and two Bt based bio-insecticides, namely PUSA Bt and Biolep™ were also evaluated.

The study was conducted at Indian Agricultural Research Institute New Delhi. Analytical methodologies for the estimation of indoxacarb and thiacloprid were developed and their dissipation patterns were studied. Thiacloprid was sprayed @ 30 and 60 g active ingredient per hectare (ai ha^{-1}), indoxacarb at 75 and 150 g ai ha^{-1} and methyl parathion at 100 and 200 g ai ha^{-1} (fluid rate 500 L ha^{-1}). Biopesticides like Biolep™ and PUSA Bt were applied in two concentrations i.e., 1 and 2 kg ha^{-1}. NSKE was applied at 5% and 10% and Nimbo Bas™ at 1 and 2 Lha^{-1}. The parameter observed was the hole made by ESFB larvae on the fruit in terms of number of fruits and weight of fruits. Each insecticide was applied individually and in combination. The data was analyzed using SPSS version 14.0.

Table 1 Efficacy of biopesticides against brinjal shoot and fruit borer

Insecticide	Treatment	Percent fruit damage First year Weight basis	First year Number basis	Second year Weight basis	Second year Number basis
Indoxacarb	75	11.47	24.24	12.29	28.54
(g ai ha-1)	Control	28.68	41.35	31.54	47.28
	CD @ 5%	3.45	8.22	5.81	11.43
Thiacloprid	30	14.23	34.48	12.74	32.76
(g ai ha-1)	Control	17.38	37.74	15.78	35.28
	CD @ 5%	1.24	2.88	1.39	2.67
Methyl parathion	100	13.45	26.35	11.98	31.43
(g ai ha-1)	Control	31.78	36.46	27.46	34.35
	CD @ 5%	5.43	11.24	4.37	16.88
BiolepTM	1.0	15.86	29.79	14.63	24.34
(kg formulation ha-1)	Control	22.82	34.68	24.89	36.73
	CD @ 5%	2.54	6.46	1.38	2.62
PUSA BtTM	1.0	16.34	22.59	13.54	23.21
(kg formulation ha-1)	Control	19.62	29.78	25.44	28.43
	CD @ 5%	5.98	6.77	4.86	9.18
NSKE	5	19.65	23.93	18.23	24.34
(Percent)	Control	22.87	26.73	24.90	36.72
	CD @ 5%	4.87	7.62	8.84	6.43
Nimbo BasTM	100	17.65	21.23	18.24	22.34
(mL formulation ha-1)	Control	20.88	22.74	21.98	23.84
	CD @ 5%	1.56	2.34	2.271	2.12

It was found that indoxacarb was effective against ESFB where as thiacloprid was not effective and left high residues. Methyl parathion was effective but it is not recommended against ESFB as it left toxic residues. Among the biopesticides Bt based WDP formulation PUSA Bt was significantly effective than the commercial Biolep ™ (Table 1). Also neem (NSKE) seed kernel extract was found significantly superior. An IPM package is being proposed to reduce the cost of cultivation which would be beneficial for both farmers as well as consumers

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Evaluation of newer molecules of insecticides for management of major insect pests of rice

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Rice (*Oryza sativa* L.) is the most important crop of Jharkhand which is grown in different ecologies viz. upland, medium and low land as well. Some major insect pest fauna cause moderate to severe injuries to the crop plants which in turn found responsible for loss in yield usually ranging from 20 to 35 per cent (Prasad *et al*., 2007). In order to search out alternative and effective insecticides for management of insect pests of rice, some newer molecules of insecticides were evaluated in the field conditions on rice var. Jaya. A field experiment was conducted in the randomised block design (RBD) comprising of 7 treatments and four replications in the sub plot size of 4.0 x 4.0 sq. meters (Table 1) Seeds of rice (var. Jaya) were sown on 16.07.2007 and seedlings were transplanted on 11.08.2007. Harvesting was made on 28.12.2007. First application of the respective insecticides were applied at 10 days after transplanting (DAT) as foliar spray in the required dose. Then need based foliar sprays with respective insecticides were provided at 35, 60 and 95 DAT in the respective treatments. Granules of carbofuran 3G were broadcasted in the standing water @ 33 kg/ha at 10 DAT in the respective treatments. Observations were recorded periodically on the pest incidence viz. gall midge, green leaf hopper and rice hispa. Grains yield after harvest was recorded on per plot basis and then converted into q/ha (Table 1). Statistical analysis was made for data interpretation and drawing conclusions.

Results revealed that all the treatments proved significantly effective against three major insect of rice viz. gall midge, GLH and hispa. The combination product comprising of imidacloprid 40% EC plus ethiprole 40 % WG applied @ 125g a.i./ha proved to be most effective against all the three major insect pests of rice which in turn realized the highest grains yield (34.56 q/ha). The standard insecticide i.e. monocrotophos 36 WSC @ 1300 ml/ha could also be effective in suppressing the incidence of the pest fauna and enhancing the grains yield (25.26q/ha). Prasad *et.al.* (2007) also found that monocrotophos remained effective. Dani and Jena (2007) also found promising control of hispa (*Dicladispa armigera* Oliver) through foliar application of thiamethoxam 25 WG, imidacloprid 200 SL, bifenthrin 10 EC and indoxacarb 14.5 EC each applied @ 30g a.i./ha at the right time. /Ha).

Table 1 Effect of application of some newer molecules of insecticides on insect pest complex of rice and its yield

Treatments	Gall midge:SS (%)	GLH No. per 10 hills	Rice hispa, HDL/10 hills	Yield (q/ha)
	50 DAT	63 DAT	70 DAT	
Bifenthrin 10 EC @ (Talster) 500 ml/ha	4.80 (12.64)**	15.25 (3.26)*	14.50 (3.86)*	22.91
Flubendamide 36 % EC + Fipronil 30% 66 WG @ 50g /ha	4.44 (12.00)	11.00 (3.37)	9.75 (3.19)	28.59
Imidacloprid 40% EC + Ethiprole 40% 80 WG @ 125 g/ha	1.85 (7.30)	5.00 (2.48)	7.50 (2.77)	34.56
Monocrotophos 36 WSC (Monocrown) @ 1300 ml/ha as check	6.89 (13.10)	17.50 (4.24)	20.00 (4.52)	25.26
Imidacloprid 17.8 SL confidor @ 100ml/ha	6.93 (15.19)	15.75 (4.00)	21.00 (4.63)	31.56
Carbofuran 3 G (Furadon) @ 33 kg/ha	6.81 (12.53)	44.50 (6.68)	48.50 (6.99)	25.60
Untreated Control	12.04 (20.27)	57.75 (6.78)	65.00 (8.08)	19.67
CD at 5%	2.68	1.29	0.54	6.35

Square root transflormed values : ** Angular transformed values; GLH = Green leaf hopper, SS= Silver shoot, DAT = days after transplanting, HDL= damaged leaves by hispa

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Efficacy and of Rynaxypyr 20SC (Coragen) against pod borer complex infesting pigeon pea·

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Pigeonpea, is one of the important pulse crops of Madhya Pradesh. and its average productivity of the state is very low, at 9.21q / ha (Anonymous, 2000). One of the major constraints limiting the yield potential is the damage caused by pod borer complex, which mostly includes gram pod borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) and pod fly, *Melanagromyza obtusa* (Malloch) (Diptera: Agromyzidae).

Several workers have tested the efficacy of various formulations of conventional insecticides and synthetic pyrethroids against pod borer complex. Considering the seriousness of the pod borer complex and the desired level of efficacy of insecticides, a new insecticide *viz*. Rynaxypyr 20SC (Coragen) was tried in different doses and was compared with spinosad 45SC, indoxacarb 14.5 SC and endosulfan 35EC. Further, Economic Threshold Level was also computed for pod and grain damage caused by pod fly and gram pod borer.

Table 1 Efficacy of Rynaxypyr 20SC (Coragen) against pigeon pea pod borer complex (2006-07, 2007-08)

Treatments	Dose g *a.i.* / ha	Period	% damage by *-				Yield (Kg/ha)
			Pod fly		*H. armigera*		
			Pod	Grain	Pod	Grain	
Spinosad 45 SC	56	06-07	20.20(26.71)	8.93 (17.39)	16.23(23.76)	6.10(14.51)	1567.67
		07-08	30.67(33.62)	20.67(13.01)	5.07(27.04)	2.33(7.39)	1586.33
		Pooled	25.43(30.17)	14.80(18.39)	10.65(22.22)	4.22(10.95)	1577.00
Spinosad 45 SC	73	06-07	16.27(23.78)	8.07 (16.50)	15.33(23.05)	4.27(11.92)	1572.00
		07-08	29.50(32.89)	19.20(25.99)	4.17(11.77)	1.87(7.85)	1665.63
		Pooled	22.88(28.34)	13.63(17.42)	9.75(21.25)	3.07(9.89)	1618.82
Coragen 20 SC	30	06-07	17.23(24.53)	8.67(17.12)	11.30(19.64)	3.30(10.47)	1753.33
		07-08	29.83(33.10)	19.87(26.47)	4.20(11.82)	1.93(7.99)	1633.57
		Pooled	23.53(28.82)	14.27(15.73)	7.75(21.79)	2.62(9.23)	1693.45
Coragen 20 SC	40	06-07	14.10(22.05)	6.37(14.61)	10.03(18.47)	2.20(8.52)	1755.67
		07-08	25.23(30.15)	17.33(24.60)	2.77(9.57)	1.13(6.11)	1712.33
		Pooled	19.67(26.11)	11.85(14.02)	6.40(19.60)	1.67(7.32)	1734.00
Indoxacarb 14.5 SC	60	06-07	22.30(28.18)	10.03(18.46)	19.30(26.06)	7.37(15.75)	1356.33
		07-08	32.47(34.73)	22.53(28.34)	6.37(14.61)	3.63(10.98)	1446.13
		Pooled	27.38(31.46)	16.28(20.34)	12.83(23.40)	5.50(13.37)	1401.23
Endosulfan 35 EC	700	06-07	26.63(31.07)	13.07(21.18)	23.10(28.73)	9.67(18.11)	1115.00
		07-08	35.43(36.53)	25.57(30.37)	9.10(17.56)	5.03(12.96)	1247.40
		Pooled	31.03(33.80)	19.32(23.14)	16.10(25.78)	7.35(15.54)	1181.20
Control	-	06-07	40.17(39.33)	23.33(27.50)	26.32(30.85)	12.23(20.47)	988.33
		07-08	46.40(42.93)	32.40(34.69)	13.50(21.55)	7.07 (15.42)	677.30
		Pooled	43.28(41.13)	27.87(26.20)	19.91(31.10)	9.65(17.95)	832.82
SEm±		06-07	(0.11)	(0.34)	(0.16)	(0.19)	2.64
		07-08	(0.17)	(0.17)	(0.16)	(0.23)	9.82
		Pooled	(0.10)	(0.15)	(0.21)	(0.16)	5.21
CD at 5%		06-07	(0.34)	(1.05)	(0.50)	(0.60)	8.14
		07-08	(0.53)	(0.53)	(0.48)	(0.70)	30.27
		Pooled	(0.29)	(0.45)	(0.66)	(0.49)	16.04

*=Figures in parentheses are arcs in-transformed values

Field experiments were conducted in RBD with three replications during *Kharif* 2006-2008 on medium maturing pigeon pea variety JKM-7 in the experimental field of Department of Entomology, College of Agriculture, J. N. Agricultural University, Jabalpur Madhya Pradesh. Two sprayings of insecticide treatments were applied, initiating at 50% flowering stage and repeated at 10 days interval. The data on efficacy and grain yield are presented in Table 1.

Pod and Grain damage: The data on pod fly damage indicated that the difference in pod and grain damage was significant and all the treatments were significantly superior over untreated control; *M.obtusa:* The pod and grain damage significantly ranged from 19.67 and 11.85% (Coragen 20 SC @ 40g *a.i.* / ha) to 43.28 and 27.87% (Control) respectively; *H.armigera:* The pod and grain damage significantly ranged from 6.4 and 1.67% (Coragen 20 SC @ 40g *a.i.* / ha) to 19.91 and 9.65% (Control), respectively.

Grain yield: Highest grain yield was registered by Coragen 20 SC @ 40g *a.i.* / ha (1734 Kg / ha), followed by Coragen 20 SC @ 30g *a.i.* / ha (1693.45 Kg / ha) whereas lowest yields were recorded in untreated control (832.82 Kg / ha). Increase in grain yield over control varied from 348.38 Kg / ha (endosulfan 35 EC) to 901.18 Kg / ha (Coragen 20 SC @ 40g *a.i.* / ha); Economics: The economics of different treatments revealed that maximum net of profit of Rs. 15664=17 per ha was obtained from treatment, Coragen 20 SC @ 30g *a.i.* / ha followed by Coragen 20 SC @ 40g *a.i.* / ha (Rs. 15476=55 per ha) respectively; Economic Threshold Level: The ETL computed was 5.37% pod and 3.43% grain damage by *M. obtusa* and 4.81% pod and 2.3% grain damage by *H. armigera* at harvest respectively.

From the above it can be concluded that two sprayings, initiating at 50% flowering stage and repeated at 10 days interval of Coragen 20 SC @ 30-40g *a.i.* / ha was quite effective in controlling pigeon pea pod borer complex. The ETL worked out was 3.43% and 2.3% grain damage by *M. obtusa* and *H. armigera* at harvest, respectively.

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Action of biolep and endosulfan on Spotted bollworm, *Earias vittella* (Fabricius)

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Spotted bollworm, *Earias vittella* (Fabricius) [Lepidoptera:Noctuidae] is a major insect pest of okra (Kumar and Urs, 1988). *Bacillus thuringiensis* can be compounded with insecticides for controlling this insect pest in a low dose. Therefore, joint effect of endosulfan and biolep was studied. The nucleus culture of *E. vittella* was maintained in the BOD incubator at 30°C temperature and 60-70 per cent relative humidity on fresh okra leaves and fruits. Okra fruit was dipped in the desired aqueous concentration of biolep, endosulfan mixture and dried at room temperature and were offered to 2[nd] instar larvae of *E. vittella*. The impregnated fruits were changed after 24 hrs and then fresh fruits were provided to the larvae. Three sets of experiment were made for each treatments and mortality counts were made at 12, 24, 48 and 72 hrs after treatment. A control was also run parallel to each sets of experiment to obtain corrected mortality. The moribund were treated as dead. The data was analyzed statistically (Finney, 1952). Results revealed that endosulfan is an effective insecticide, causes a well marked mortality even at a concentration of 0.00312 per cent while biolep was most effective at higher concentration like 1.0 per cent and cause higher mortality at 72 HAT (Hours after treatment) (Table 1). Result of joint effect showed an additive action with endosulfan. It may be concluded that a combination of endosulfan and biolep may substantially increase the toxicity (Table 2)

Table 1 Alone and joint effect of biolep and endosulfan on larvae of *E. vittella*

Concentrations	Mortality (%) after 12 Hrs	Mortality (%) after 24 Hrs	Mortality (%) after 48 Hrs	Mortality (%) after 72 Hrs
		A. Biolep		
1 %	18.00 (4.24)	64.33 (8.02)	77.67 (8.81)	94.33 (9.71)
0.5 %	12.00 (3.46)	51.67 (7.19)	66.67 (8.16)	82.33 (9.07)
0.25 %	6.67 (2.58)	44.33 (6.65)	60.00 (7.75)	71.33 (8.45)
0.125%	6.33 (2.51)	33.00 (5.74)	51.67 (7.19)	65.67 (8.10)
Untreated Control	3.33 (1.05)	5.00 (1.79)	0.00 (0.00)	0.00 (0.00)
SEm ±	1.612	1.633	0.894	1.398
C.D. at 5%	5.079	5.145	2.817	4.405
C.V.	30.14	7.130	3.026	3.861
		B. Endosulfan		
0.025%	37.67 (6.14)	73.00 (8.54)	77.67 (8.81)	91.67 (9.57)
0.0125%	31.67 (5.63)	58.33 (7.63)	65.33 (8.08)	93.00 (9.64)
0.00625%	27.00 (5.19)	27.00 (5.19)	37.67 (6.14)	58.00 (7.62)
0.00312%	12.33 (3.51)	12.33 (3.51)	26.33 (5.13)	54.00 (7.35)
Untreated Control	3.33 (1.05)	1.67 (0.75)	4.33 (1.69)	0.00 (0.00)
SEm ±	1.738	1.000	1.542	0.869
C.D. at 5%	5.476	3.150	4.857	2.738
C.V.	13.442	5.025	6.319	2.537
		C. Mixture of Biolep and Endosulfan		
1%B+0.025%E	44.00 (6.63)	84.00 (9.16)	91.33 (9.56)	97.67(9.88)
1%B+0.0125%E	30.00 (5.47)	78.00 (8.83)	90.33 (9.50)	97.00 (9.85)
1%B+0.00625%E	27.00 (5.19)	71.33 (8.45)	86.00 (9.27)	96.00 (9.79)
1%B+0.00312%E	17.33 (4.16)	71.33 (8.45)	83.00 (9.11)	95.00 (9.74)
Untreated Control	3.33 (1.05)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SEm ±	2.171	1.201	0.761	1.349
C.D. at 5%	6.837	3.786	2.395	4.253
C.V.	15.449	3.416	1.877	3.016
		D. Mixture of Biolep and Endosulfan		
0.5%B+0.025%E	37.67 (6.14)	79.00 (8.89)	86.00 (9.27)	98.33 (9.92)
0.5%B+0.0125%E	24.00 (4.88)	66.67 (8.16)	79.33 (8.91)	94.33 (9.71)
0.5%B+0.00625%E	18.67 (4.30)	59.00 (7.68)	78.67 (8.86)	90.00 (9.48)
0.5%B+0.00312%E	17.33 (4.15)	56.33 (7.51)	66.67 (8.16)	89.00 (9.43)
Untreated Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SEm ±	6.657	0.667	2.828	2.044
C.D. at 5%	2.113	2.100	8.909	6.438
C.V.	18.740	2.212	7.885	4.763
		E. Mixture of Biolep and Endosulfan		
0.25%B+0.025%E	36.00 (6.00)	78.33 (8.85)	91.67 (9.57)	95.33 (9.76)
0.25%B+0.0125%E	28.33 (5.32)	67.67 (8.16)	84.00 (9.16)	90.00 (9.48)
0.25%B+0.00625%E	18.33 (4.27)	50.33 (7.09)	63.00 (7.94)	91.67 (9.57)
0.25%B+0.00312%E	15.00 (3.87)	44.67 (6.68)	63.33 (7.96)	90.67 (9.52)
Untreated Control	0.33 (0.57)	1.67 (0.75)	4.33 (1.69)	0.00 (0.00)
SEm ±	1.983	4.992	1.983	1.653
C.D. at 5%	6.247	5.742	6.247	5.208
C.V.	17.118	1.586	5.607	3.894
		F. Mixture of Biolep and Endosulfan		
0.125%B+0.025%E	32.67 (8.71)	76.33 (8.74)	90.33 (9.50)	94.33 (9.71)
0.125%B+0.0125%E	24.00 (4.89)	56.33 (7.50)	77.67 (8.81)	90.33 (9.50)
0.125%B+0.00625%E	17.67 (4.19)	47.67 (6.90)	65.33 (8.08)	88.33 (9.39)
0.125%B+0.00312%E	12.33 (3.49)	37.56 (6.14)	61.00 (7.81)	87.00 (9.33)
Untreated Control	0.00 (0.00)	1.67 (0.75)	0.00 (0.00)	1.67 (0.75)
SEm ±	1.571	1.667	1.367	1.639
C.D. at 5%	4.947	5.250	4.304	5.165
C.V.	14.731	6.492	4.019	3.926

*figure in parentheses are square root transform value B = Bioleop, E = Endosulfan

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Table 2 Bioefficacy of biolep and endosulfan on larvae of *E. vittella*

Insecticide	Heterogeneity	Regression Equation	LC_{50}	Fiducial Limits Low	Fiducial Limits Up	Slop ± S.E.	Relative Toxicity
		After 12 hours					
Biolep	0.464	Y= 0853x+4.138	10.229	1.484	70.467	0.853±0.427	1.00
Endosulfan	1.674	Y= 0.598x+4.806	2.112	0.623	7.160	0.598±0.271	4.84
		After 24 hours					
Biolep	0.576	Y= 0.932x+5.420	0.354	0.253	0.496	0.932±0.068	1.00
Endosulfan	2.649	Y= 2.029x+8.952	0.011	0.009	0.013	0.035±2.029	3.22
		After 48 hours					
Biolep	0.814	Y= 0.806x+5.764	0.112	0.059	0.221	0.806±0.141	1.00
Endosulfan	1.241	Y= 1.689x+8.570	0.008	0.006	0.009	1.689±0.039	14.0
		After 72 hours					
Biolep	1.164	Y= 1.170x+6.434	0.059	0.030	0.117	1.170±0.149	1.00
Endosulfan	11.57	Y= 1.725x+9.351	0.003	0.002	0.004	1.725±0.065	19.7

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IPM modules against fruit fly, *Bactrocera cucurbitae* (Coquillett) on round gourd

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Cucurbits are an important group vegetables and these are extensively cultivated in Rajasthan because of greater suitability of climate and land. Round gourd (*Citrullus vulgaris* var. *fistulosus*) commonly known as *tinda* is one of the most popular summer and rainy season vegetable. The introduction of new high yielding hybrids has also resulted in dramatic changes in the pest scenario. It has become vulnerable to the attack of several pests of which melon fruit fly, *Bactrocera cucurbitae* (Coquillett) is the serious pest and farmers resort to frequent spraying. This tends to leave high pesticide residues. Hence, a field study comprising eight treatments was conducted at research farm of Agricultural Research Station, Durgapura, Jaipur during kharif 2004 and 2005. The experiment was laid out in randomized block design with three replications in the plots measuring 4.5 x 3.0 m, each of which was separated by 0.80 cm wide irrigation channel. A row spacing of 1.5 m and plant to plant distance of 0.60 and recommended agronomical practices were followed. Acephate, malathion and endosulfan, neem seed kernel extract, *Datura* leaf extract, neem oil, neem gold and repeated soil raking were the treatments evaluated (Table 1). Pre-calibrated foot sprayer was used for spaying the insecticides with spray @ 500 l/ha. Each treatment except first comprised three sprays made at an interval of 10 days starting from fruit set stage. The observations were started from flower bud initiation stage and subsequently three days interval after the spray. Number of infested (ovipositor punctures and feeding holes) and non infested fruits were picked up and per cent infestation was calculated both on number and weight basis.

Table 1 Ecofriendly IPM modules against fruit fly, *Bactrocera cucurbitae* in round gourd (Pooled, 2004, 2005)

Treatment	IPM Modules	Percent infestation of fruit		Fruit Yield* q/ha.	Economic Return over Control (Rs./ha.)	Benef it cost ratio
		Based on number of fruits	Based on weight of fruits			
1	Repeated soil racking after every ten days in the early stage of the crop upto one month-NSKE 10%-DLE 10%	1.67 (34.20)	31.05	67	14674	4.99
2	Acephate 0.03% - Acephate 0.03% - Acephate 0.03%	14.41 (22.34)	13.95 (21.93)	94	42840	33.20
3	NSKE 10% - Malathion 0.05% - NSKE 10%	22.47 (28.29)	21.96 (27.93)	80	28976	21.72
4	DLE 10% - Acephate 0.03% - DLE 10%	24.07 (29.27)	21.73 (27.61)	82	29624	21.37
5	Endosulfan 0.07%-Malathion 0.05%-Acephate 0.03%	11.32 (19.61)	11.22 (19.57)	103	51394	37.08
6	Neem oil 1% - Neem gold 2.5 l/ha -NSKE 10%	29.25 (32.71)	27.27 (31.46)	75	22246	7.58
7	DLE 10% - NSKE 10% - Endosulfan 0.07%	27.15 (31.42)	27.54 (31.73)	76	24556	16.00
8	Acephate 0.03% - NSKE 10% - Malathion 0.05%	11.88 (20.22)	11.65 (19.99)	99	47914	37.25
9	Malathion 0.05%-Malathion 0.05% - Malathion 0.05%	16.35 (24.07)	16.37 (23.81)	87	36486	32.17
10	Control (Untreated check)	41.56 (40.16)	41.22 (40.00)	50	-	-
	CD at 5%	1.135	0.997	5		

* Picking obtained in entire season; ** Figures in parentheses are angular transformed values NSKE - Neem Seed Kernel ExtractDLE - *Datura* Leaf Extract

Minimum fruit damage 11.32% on number and 11.22% on weight basis with highest marketable fruit yield of 103q/ha was observed in treatment comprising sequential spray of endosulfan 0.07%, malathion 0.05% and acephate 0.03% which gave maximum net return of Rs. 51394/ ha. However, it was at par with module comprising acephate 0.03% - NSKE 10% - malathion 0.05% sprays damage being 11.88% on number and 11.65% on weight basis with fruit yield 98.93 q/ha and also gave highest benefit cost ratio 1:37.25. Thus spray of synthetic insecticide such as endosulfan could be replaced by neem based formulation. More (2007), Varghese *et. al.* (2006) and Prem Chand *et al.*(2003) have also reported application of NSKE , acephate and malathion for management of fruit fly.

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Evaluation of bioefficacy of biopesticides, chemical insecticides against blister beetles, *Mylabris pustulata* and *Epicauta* sp. in black gram

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Blister beetles are hypermetamorphic going through several larval stages, the first of which is typically a mobile triungulin. The adults feed on flowers and leaves of plants of such diverse families like Amaranthaceae, Asteraceae, Fabaceae and Solanaceae. The adults feed on leaves but are especially attracted to flowers where they feed on nectar and pollen. It is the most serious pest of pulse crop and groundnut and it can cause yield loss up to 25 per cent in black gram (Pathak, 2003; Shylesha *et al.*, 2006). New chemicals alongwith the conventional insecticides, if used judiciously and in rotation can be help in control of blister beetles. Hence, Field trials were conducted during kharif 2007-08 at ICAR Research Complex for NEH Region, Mizoram Centre, to evaluate the efficacy of biopesticides, and common insecticides in blackgram. The trial was laid out in randomized block design (RBD) with plot size of $20m^2$. The variety used was local planted with a spacing of 60 × 30 cm. One spray was given based on ETL (Economic Threshold Level) starting from 45 and 60 days after sowing. Ten plants were randomly selected and tagged in each plot. Observations were made on plant prior to the spray and 1, 7 and 15 days after each spray. The 7^{th} or 15^{th} day count assumed as the pre-treatment count in respect of succeeding spray when it crossed ETL. The total numbers of adults were recorded.

The results from the Fig. 1 reveal that all the treatments were significantly superior of endosulphan 35% EC, imidacloprid 17.8% SL, chlorpyriphos 20% EC, deltamethrin 2.8% EC and dimethoate 30% EC were more effective. Spray with neem oil 1% EC, neem oil 0.03% EC, malathion 50% EC, endosulphan 35% EC, monocrotophos 36% SL, cypermethrin 5% EC, chlorpyriphos 20% EC and dimethoate 30% EC was found more effective after 15 days.

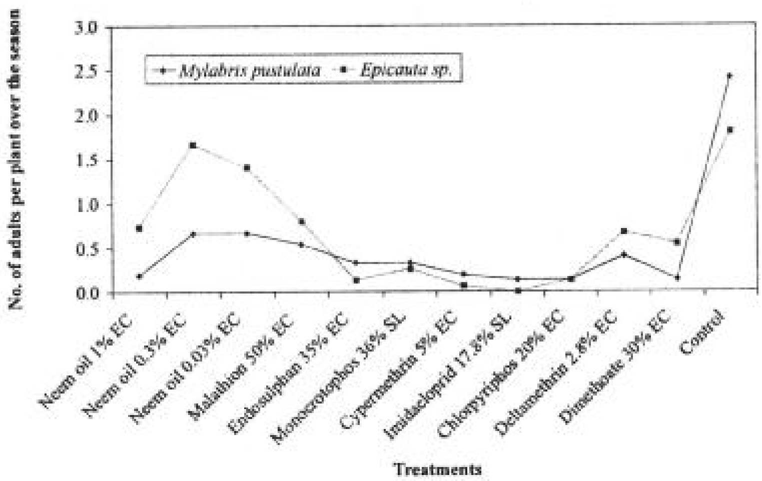

Fig. 1 Bioefficacy of biopesticides against blister beetles

Among all the treatments spraying of monocrotophos 36% SL and imidacloprid 17.8% SL was found more effective against *Epicauta* sp. with cent per cent reduction in the adult population one day after spray followed by neem oil 1% EC, cypermethrin 5% EC and chlorpyriphos 20% EC (0.2 adult per plant). Spray with neem oil 1% EC, malathion 50% EC, endosulphan 35% EC, monocrotophos 36% SL, cypermethrin 5% EC, imidacloprid 17.8% SL, chlorpyriphos 20% EC and dimethoate 30% EC were found more effective after 15 days spray. Spraying of imdacloprid 17.8% SL was found more effective 1, 7 and 15 days after spray. *Epicauta* sp. adult population over the season (Fig. 1) indicated that the spraying of imdacloprid 17.8% SL noticed most effective. Boopathi *et.al.* (2008) and Ward (2001) reported that monocrotophos 36% SL caused reduction of blister beetles.

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Toxicity of novel chemicals to diamond back moth, *Plutella xylostella* (L.)

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The Diamond back moth (DBM), *Plutella xylostella* (Linnaeus)(Lepidoptera: Yponomeutidae) is a major pest of cabbage and cauliflower and other cruciferous crops, can thrive under extremely varied climatic conditions (Sarfraz *et. al.*, 2005). The destructiveness of DBM, coupled with capacity to develop resistance to synthetic insecticides as well as Bt, has made this pest the focus of IPM research in cruciferous crops. In view of this, bioassays were conducted to evaluate different insecticides with diverse modes of action. The test-larvae were reared on cabbage curd in laboratory (temp. 27±1°C, RH 65%±5%, 16: 8 hour scoto/ photophase regime). Five day-old larvae of F_2 generation of DBM were used to ensure genetic homogeneity for bioassay study by "leaf-disc dip bioassay method", an ideal method for such study (Vastrad *et. al.*, 2004). Leaf-discs of approximately 4 cm diameter were cut from the cabbage curds and were dipped in test concentrations of different insecticides for 20 seconds and then air-dried. The treated leaf-discs were then transferred to clean crystal vials (6 cm diameter) and five larvae (5-day old) were released in each vial. For control, the leaf-discs were dipped in the sterile water. Larval mortality was recorded at 24, 48, 72 hour after treatment. Moribund insects were counted as dead.

Based on LC_{50} values, spinosad 45%SC was found to be highly toxic (LC_{50} 0.336ppm), followed by emamectin benzoate 5%WSG (LC_{50} 2.185ppm), chlorpyriphos 20%EC (LC_{50} 5.214ppm), cartap hydrochloride 50%SP (LC_{50} 8.238ppm). Indoxacarb 14.5%SC was least toxic (i.e., LC_{50} 111.895ppm) (Table 1). Spinosad is easily absorbed into leaf tissues as demonstrated by Gray and Osborne (2001), probably this is the reason for the maximum larval-mortality. It is therefore suggested that spinosad 45%SC can be used to control *Plutella xylostella.* Further field trials may be undertaken to check the bioefficacy before recommending to farmers.

Table 1 Comparative toxicity of insecticides against *Plutella xylostella*

Test-insecticides	Heterogeneity		Regression equation Y=	LC_{50} (ppm)	Fiducial limits	Relative Toxicity
	χ^2	df				
Spinosad 45% SC	3.124	7	5.780+1.647x	0.336	0.249 - 0.452	15.51
Emamectin benzoate 5%WSG	3.070	7	4.401+1.763x	2.185	1.651 - 2.892	2.38
Cartap hydrochloride 50% SP	1.951	7	3.905+1.195x	8.238	5.729 - 11.855	0.63
Indoxacarb 14.5%SC	4.266	7	1.774+1.574x	111.895	85.297 - 146.788	0.04
Chlorpyriphos 20%EC	8.046	7	2.551+3.414x	5.214	4.574 - 5.948	1.00

Df: degree of freedom, χ^2 : chi square, LC: lethal concentration

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Toxicity against predators limits the use of microbial insecticides in terai region of West Bengal

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Microbial10s tend to be highly selective and established as an alternative to eco-destabilizing chemical insecticides especially against lepidopteran pests. The main limiting factor in large scale use of *Bacillus thuringiensis kurstaki* and avermectin is their high toxicity to beneficial insects like silk worm and other non-target species. In view of this, adverse effects of some commercial biological insecticides were investigated under field condition against two important natural enemies. These included *Menochilus sexmaculatus*, *Micraspis* sp. and *Harmonia octomaculata* and spiders, *Lycosa psedudoannulata*, *Oxyopes* spp. and, *Argiope* sp. The experiment was conducted simultaneously in cabbage field with 5 treatments. Tested microbials were *B.t.k.*- 55000 S.U. / mg (Halt), *B.t.k.*- 32000 I.U. / mg (Biolep), Avermectin-1.8% w/v (Vertimec) and *Beauvaria bassiana*- $1x10^7$spore / ml (Bassina) which obtained from Biostadt Agri Sciences, Wockhardt ; Biotech International Ltd, New Delhi; Novartis, Mumbai and Agro Evo India Ltd, Mumbai, respectively. Spraying was done when moderate populations of the two predators were noticed, synchronized with the infestation of cabbage aphid, cabbage lopper, cabbage butterfly and diamond back moth. Pre-count observation based on actual number present in ten plants / plot at one day before spraying and subsequent post count data on 3, 7 and 14 days after spraying (DAS) were recorded, 3 species each of coccinellids and spiders taken together and considered as coccinelid and spider predator respectively. Data thus obtained were subjected to two factors RCBD analysis.

All the microbials were found toxic to cocconellid and there was variation in toxicity. Avermectin was found most toxic causing 37.11% overall reduction in beetle population followed by *Btk*-32000 IU/mg (34.62%), *Btk*-55000 SU/mg (28.8%) and *B. bassiana* (25.61%). Regarding persistent toxicity, the maximum reduction of coccinellid population was observed on 7 days after spraying. A similar trend was noticed on 14 days after spraying. Decrement in appearance of coccinellid beetles also may be attributed to the mortality of their prey populations immediately after application of biopesticides as observed on 3 DAS. While, the percentage of reduction with respect to control plot were recorded as avermectin (36.57%) > Btk-32000 IU / mg (35.23%) > Btk-55000 SU / mg (30.68%) an 7 DAS whereas, *Beauvaria bassiana* exerted a maximum 28.58% mortality of coccinellids sometime latter on 14 DAS (Fig.1). Present investigation is very similar to those of Zuo *et al.* (1994) where *B.t.* was found to suppress the population of ladybird beetles and chrysopids after 3-7 days. Among the microbials avermectin again emerged as most toxic compound to spider species reducing 34.45% average population. The next order of toxicity was found as *Btk*-55000 SU/mg (28.08%)> *Btk*-32000 IU/mg (22.11%)> *B. bassiana* (15.15%). There was a direct effect of microbials on spider population rather than indirect effect by eliminating host species as observed in case of coccinellid beetles.

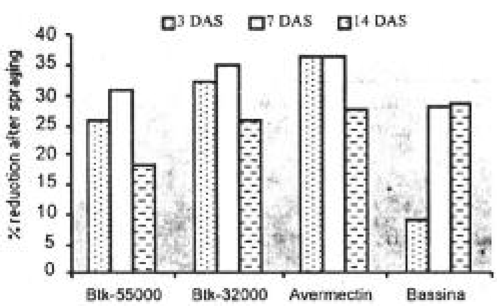

Fig. 1 Effect of microbials against *coccinellid* beetles over control

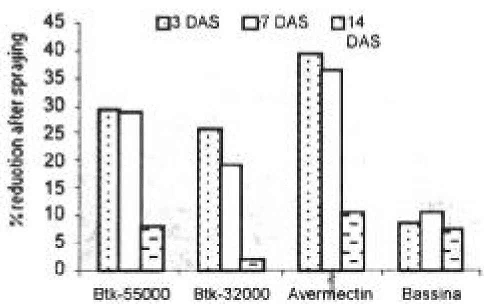

Fig. 2 Effect of microbials against *spider species* over control

When the effect was compared with the control plot it was noticed that 39.31% reduction in spider population was due to avermectin followed by 29.14% and 25.56% in *Btk*-55000 SU/mg and *Btk*-32000 IU/mg respectively on 3 DAS (Fig.2), whereas the fungus affected 10.81% reduction on 14 DAS. However, the population gradually increased afterwards and analogous pattern of decreasing toxicity were also recorded for the rest microbials. The results are in accordance with the findings of Ghosh (1999) where avermectin and *B.t.*k. showed 38.16% and 27.97% reduction in spider population respectively.

It can be concluded that though avermectin was considered as most potent microbial toxin towards lepidopteran pests and proved to be safer against non-target arthropods (Lasota and Dybas, 1991) present study establishes that it is highly toxic to natural predatory fauna even at very low doses, and might be restricted its use in large scale.

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Lambda-cyhalothrin induced alterations in cuticular biochemistry of mutant *Drosophila melanogaster*

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Insects destroy our crops and cause food scarcity. Many insecticides have been used for their control. These could play a role in chitin metabolism. Chitin synthesis is regulated by chitin synthase and chitinase enzymes which help in polymerization and degradation respectively. An attempt has been made to assess modulation in chitin synthesis by the experimental compound, lambda-cyhalothrin in mutant *Drosophila melanogaster.* Adult white mutants were reared and maintained at 25°C and 50% relative humidity. Males and females were crossed for each biochemical estimation, consisting of six sets for statistical accuracy, first three as control sets (UT♀ X UT♂) and another three as treated sets (T♀ x T♂). The experimental flies were divided into five sets, each consisting of randomly selected 10 individuals. The stock solution of test compound was prepared in acetone and serially diluted to 8 µl, 4 µl, 2 µl, 1 µl, and 0.5 µl per 100 ml food. Same amount of diluent was given to the control groups and the flies were released in culture bottles. The mortality and survival were recorded for each dose after 48 hours. Moribund flies were considered as dead. The data were analyzed statistically by log-dose/probit regression line method. Biochemical estimations were done with standard laboratory methods. The observations were analyzed using student's 't' test.

Table 1 Alterations in cuticular components of white mutant *Drosophila melanogaster*

S.No.	Parameters	Control set (Mean±S.Em.)	Treated set (Mean±S.Em.)
1.	Total proteins (mg/dl)	13.13±2.76	16.26±3.70*
2.	Glucosamine (mg/dl)	1.23±0.086	1.6±0.173*
3.	N-acetylglucosamine (mg/dl)	4.63±0.29	5.6±0.34*
4.	Chitinase activity (Unit)	6.28±0.32	8.01±0.153***
5.	Chitin content (mg/gm)	1.053±0.014	0.9±0.089***

S.Em. Standard Error of Mean *(P>0.05) **(P<0.05) ***(P<0.01)

LC_{50} value for white mutant *Drosophila melanogaster* was 2.12µl/100ml of food and the sublethal concentration for experiment was 0.2µl/100ml of food. Under stress condition, the biochemical components may vary. Chitinase activity has been increased after treatment which induces degradation of chitin into its simpler units *i.e.* glucosamine and N-acetylglucosamine (Kramer *et al.,* 1995) as revealed by their increased level. Total protein content has been increased due to breakdown of chitin-protein complex by the action of protease and chitinase enzymes collectively (Karaiyan and Thangraj, 1999). The chitin content has been decreased following lambda-cyhalothrin treatment, reveals its modulatory action in *Drosophila melanogaster*. The active moulting fluid has been observed to penetrate the layers of chitin and protein complex (Brookhart and Kramer, 1990). This fluid contains two major enzymes, one, the protease which unmasks the cuticular chitin for the action of chitinase and the two, chitinase which act on the unmasked cuticular chitin to degrade it into simpler units, glucosamine and N-acetylglucosamine (Karaiyan and Thangraj, 1999). However, it is also possible that the chitin synthase which helps in amino sugar polymerization, decreases following treatment with lambda-cyhalothrin, resulting in decreased chitin content as chitin synthase and chitinase are the main enzymes to regulate chitin synthesis (Merzendorfer and Zimoch, 2003). The possibility of involvement of chitin synthase cannot be ruled out and has been considered an important regulatory step. It is thus concluded that lambda-cyhalothrin, a type II synthetic pyrethroid has the potentiality to modulate chitin synthesis.

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Response of plant lectin, erythroagglutinin on tobacco caterpillar, *Spodoptera litura* (F.)

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Tobacco caterpillar, *Spodoptera litura* (Fabricius) (Noctuidae: Lepidoptera), is a polyphagous and economically important pest in India, and has emerged as a major pest in first generation Bt cotton too (Janakiraman and Gupta, 2002) by occupying the niche left by other bollworms owing to its refractory nature to most of the Cry proteins. Lectins (Erythroagglutinin), the plant defensive proteins are among the effective and affordable natural molecules that have been reported to act as insecticides and bound strongly which caused severe disruption, disorganization and elongation of the brush border membrane and stimulate the division of midgut epithelial cell nuclei of target cohort (Fitches *et al.*, 2001). Keeping in view, an attempt has been made to investigate the response of Erythroagglutinin against *S. lityra* in our laboratory during 2007-2008. Culture of the test insect was maintained in the laboratory in environmental simulation walk-in chamber (27±1°C, 60±5%RH, 16:8 scoto/photophase). The lectin Erythroagglutinin was tested following 'artificial diet surface incorporation' technique with neonates of the test insect as suggested by (Gupta *et al.*, 2007). Studies show that Erythroagglutinin lectin was found effective to the target pest, *S. litura* (LC_{50} 0.0014%). Consequence of feeding lectin intoxicated diet by the larvae, the pupal weight was adversely affected (341.3 mg) in higher concentration of Erythroagglutinin, whereas in untreated control it was 435.5 mg. The effect of the lectin was quite different on survival and mortality of the test insect, which varied from 53.33 to 10.00% in treatment (Erythroagglutinin) as compared to untreated control (80.00%). It is evident from the data that lectin intoxicated diet prolonged the larval period and also adversely affected the various biological parameters of the test insect (Table 1). The outcome of the studies will be of practical value to the entomologists and molecular biologists involved in developing transgenic crops.

Table 1 Effect of Erythroagglutinin lectin on the growth and development of *Spodoptera litura*

Biological attribute	Concentration (%)							CD (P≥0.05)
	Control	0.0001	0.0007	0.001	0.005	0.01	0.05	
11-day old Larval weight (mg)	248.02±18.20	151.57±14.59	120.44±15.01	98.62±14.33	63.46±10.05	20.88±5.99	19.51±6.49	22.48
Larval mortality (%)	6.67±2.99 (14.70)	26.67±9.92 (30.82)	46.67±10.26 (43.06)	53.33±10.44 (49.94)	63.33±9.92 (52.85)	73.33±5.53 (59.98)	80.00±6.43 (63.63)	9.29
Larval period (days)	17.28±3.02	19.49±3.29	20.86±2.89	22.00±3.10	23.33±4.21	23.70±3.89	25.75±4.52	6.32
Pupal weight (mg)	435.5±30.16	420.4±29.56	411.5±13.31	401.2±27.76	383.66±27.92	358.0±30.54	341.3±25.66	50.86
Adult emergence (%)	85.71±5.54 (69.09)	72.72±5.55 (58.57)	68.75±6.54 (56.09)	64.29±5.83 (53.35)	54.54±6.69 (47.62)	50.00±4.43 (45.00)	50.00±5.40 (45.00)	6.39
Survival (%)	80.00±6.67 (63.64)	53.33±3.34 (46.91)	36.67±3.33 (37.25)	30.000±3.33 (33.19)	20.00±3.34 (26.52)	13.33±3.33 (21.32)	10.00±3.33 (18.27)	5.11
Total Developmental period (days)	26.44±2.09	29.38±2.33	30.92±2.04	32.10±2.44	34.08±3.05	34.07±2.99	36.94±3.01	4.55

Data in parentheses are arcsine- transformed values; ±: standard deviation, CD: critical difference

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Persistency effect of different insecticides on *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae)

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Inspite of several credentials, indiscriminate and over use of insecticides leads to several ill effects such as environmental pollution, development of resistance in insects against insecticides, resurgence and outbreak of pests and harmful side effects on non-target species including natural enemies. Hence, entomologists are advocating to avoid the use of insecticides or it should be kept at bare minimal level because, insecticides are important tool of IPM and should be used judiciously. In IPM programmes only those insecticides should be incorporated which are eeofriendly and have no adverse effect or very little effect on non-target organisms. According to Van den Bosch and Stern (1962) identification of insecticides, which can kill the pest species effectively without adversely effecting natural enemies has been recognized as an important prerequisite for effective integrated pest management. The efficiency of any bioagent is greatly influenced by the use of insecticides. On many occasions the insecticides used are of long residual actions and can cause adverse effects on natural enemies for longer periods. The predator, *Chrysoperla carnea* Stephens has been recommended for controlling aphids, jassids, whiteflies, mealy bugs and eggs and young larvae of lepidopterous pests on various crops, including mustard. Hence, the present study was conducted to assess the persistent toxicity of some commonly used insecticides sprayed at recommended dosages on mustard so as to identify safer insecticides for *C. carnea*.

Mustard crop was raised in pots in a net house and sprayed with selected insecticides at recommended doses with a high volume sprayer. Water sprayed control was also maintained for comparison. The leaves were brought in laboratory at 24 h intervals up to 5 days after treatment and placed inside the petridishes separately in such a way that entire inner surface of the petridish was covered with treated leaves. In each petridish 10 larvae of *C. carnea* (2nd instar, two days old) obtained from laboratory culture were released. The experiment was replicated 5 times and observations on mortality of larvae were recorded separately for each treatment after 24h of release. The petridishes were placed in a B O D. incubator at $28 \pm 2^{\circ}C$ and 65 ± 5 % RH. Every day a control with leaf collected from water sprayed plant were also maintained. The processes were continued till mortality of *C. carnea* on treated leaves was about equal to the mortality observed in water spray control plants (5 days). The data thus generated on per cent mortality after the respective time intervals were transformed to arc sine values for statistical analysis.

The persistencies of all the tested insecticides (Table 1) revealed that the toxicity of all the tested insecticides reduced gradually over period of time. The maximum per centage of mortality of *C. carnea* was observed one day after treatment (1st DAT) and followed significantly decreasing trend till 5 days after treatment. The persistency of different insecticides differed. Among the tested insecticides, Nimbecidine and NSKE have no persistent toxicity however, oxydemeton methyl was found with maximum persistency followed by Imidacloprid > Dimethoate > Endosulfan > Cypermethrin with significant mortality over untreated control.

On the basis of mortality, selected insecticides were categorized (Table 2&3) as described by the International Organization for Biological Control, 1985. Residues of oxydemeton methyl were moderately harmful for 1-2 days after treatment (DAT), slightly harmful on 3 days after application, and onwards it could be categorized as harmless. Nimbecidine and NSKE has no persistent toxicity against *C. carnea* as the per cent mortality observed at any days after treatment did not differ significantly from the mortality observed in untreated control. The maximum persistent toxicity was observed with Oxydemeton methyl and the minimum with NSKE followed by Nimbecidine.

The finding is in conformity with of Balasubramani and Swamiappan (1997) and Patil and Lingappa (2001). Among all the tested insecticides, botanical insecticides like NSKE 5% and Nimbecidine have no persistent toxicity on *C. carnea* and similar reports were also made by Deol *et al.* (2000). These clearly demonstrate that under mustard ecosystem only botanical insecticides (i.e. Nimbecidine and NSKE) should be incorporated in IPM programs for the management of mustard aphid, as these have no persistent toxicity on *C. Carnea*, an important bioagent of aphids. If at all it becomes necessary to apply other insecticides like Oxydemeton methyl, Imidacloprid, Dimethoate, Endosulfan and Cypermethrin, then the release of *C. carnea* larvae should be done after four days after the application of these chemicals

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Table 1 Persistent toxicity of different insecticides to *Chrysoperla carnea*

Insecticides	Per cent* mortality of *C. carnea* at different days after treatment					Mean
	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	
Oxydemeton methyl	64.00 (53.13)	52.00 (46.15)	28.00 (31.95)	10.00 (18.43)	4.00 (11.54)	31.60 (34.20)
Imidacloprid	54.00 (47.29)	40.00 (39.23)	26.00 (30.66)	14.00 (21.97)	4.00 (11.54)	27.60 (31.69)
Dimethoate	56.00 (48.45)	40.00 (39.23)	26.00 (30.66)	8.00 (16.43)	0.00 (0.00)	26.00 (30.66)
Endosulfan	34.00 (35.67)	22.00 (27.97)	10.00 (18.43)	6.00 (14.18)	2.00 (8.13)	14.80 (22.63)
Cypermethrin	22.00 (27.97)	12.00 (20.27)	8.00 (16.43)	12.00 (20.27)	0.00 (0.00)	10.80 (19.19)
Nimbecidine	6.00 (14.18)	0.00 (0.00)	4.00 (11.54)	2.00 (8.13)	2.00 (8.13)	2.80 (9.63)
NSKE	4.00 (11.54)	4.00 (11.54)	0.00 (0.00)	0.00 (0.00)	2.00 (8.13)	2.00 (8.13)
Control	0.00 (0.00)	4.00 (11.54)	0.00 (0.00)	4.00 (11.54)	6.00 (14.18)	2.80 (9.63)
Mean	30.00 (33.21)	21.75 (27.80)	12.75 (20.92)	7.00 (15.34)	2.50 (9.10)	

Sources of variation

C.D. at	5 per cent	1 per cent
Treatment (T)	1.050	1.386
Days (D)	0.656	0.866
T x D	5.251	6.932

*Average of five replications Figures in parentheses are arcsine-transformed values

Table 2 Insecticides categories following IOBC 1985

S. No.	Categories	Per cent mortality	Name of insecticides
1.	Harmless	< 25	Endosulfan, Cypermethrin, Nimbecidine and NSKE
2.	Slightly harmful	25-50	Oxy-demeton methyl, Imidaclorprid and Dimethoate
3.	Moderately harmful	51-75	-
4.	Harmful	> 75	-

Table 3 Lasting period of insecticides on the basis of persistent toxicity

Insecticides	Lasting period of insecticides in different categories in DAT			
	Harmful	Moderately harmful	Slightly harmful	Harmless
Oxydemeton methyl	-	1-2	3	4-5
Imidacloprid	-	1	2-3	4-5
Dimethoate	-	1	2-3	4-5
Endosulfan	-	-	1	2-5
Cypermethrin	-	-	-	1-5
Nimbecidine	-	-	-	1-5
NSKE	-	-	-	1-5

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Effects of plant lectin on growth and development of Helicoverpa armigera (Hubner)

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Helicoverpa armigera (Hubner) is one of the most devastating pest worldwide (Arora *et al.*, 2005). It has defied conventional methods of control and has developed resistance to almost all groups of insecticides. There is fear that it may soon develop resistance to Bt cotton. It has prompted scientists to seek alternatives such as enzyme inhibitors and secondary metabolites. Our interest has been to identify effective inhibitors of insect gut proteinases from different plant sources that might be an alternative or complimentary to Bt strategy. The effectiveness of plant lectin, caster bean, was tested against neonates of *H. armigera* following '*artificial diet surface incorporation*' method (Gupta *et al.*, 2004). Laboratory culture was maintained in environmental simulation walk-in chamber (27±1°C, 65±5% RH, 16:8 h scoto: photophase regimes) on the artificial diet in laboratory of the Division of Entomology, Indian Agricultural Research Institute, New Delhi. Different concentrations of lectin (castor bean) (Sigma Aldrich) were prepared by serial dilution technique.

A complete randomized block design was used to test the lectin. Data showed that plant lectin (castor bean) inhibited the growth and development and affected the larval and pupal survival and adult emergence in a dose dependent manner. The larval mortality till pupation in untreated control was maximum (11.11 %), it ranged from 40.00 to 63.42 % in caster bean treated diet. The larval weight was adversely affected and was less than the untreated control. It is evident from the data that lectin intoxicated diet prolonged the larval period and also adversely affected the various biological parameters (Table 1). The LC 50 value for lection in the bioassay was 0.377%.

Table 1 Effects of plant lectin (caster bean) on growth and development of *Helicoverpa armigera*

Biological attribute	Concentration 0.1	0.05	0.01	0.005	0.001	Control	SEm ±	CD (P≥0.05)
Larval weight (mg) 9 DAT	91.36±6.07	95.48±7.17	113.86±5.64	115.78±5.80	122.94±6.17	151.05±5.38	3.51	10.79
Pupal weight (mg)	270.00±14.08	266.31±4.35	266.00±12.44	265.33±8.97	260.15±15.03	265.29±5.74	6.29	19.37
Pupation (%)	36.59±4.26 *(37.20)	44.44±7.25 (41.79)	53.33±4.35 (46.91)	55.56±7.31 (48.22)	60.00±5.02 (50.79)	88.89±3.20 (70.66)	1.91	5.88
Larval period (days)	15.69±1.64	15.36±1.16	15.29±1.09	14.96±1.86	14.81±1.17	14.60±1.04	0.79	2.42
Adult emergence (%)	60.00±5.67 (50.81)	65.00±5.60 (53.78)	66.67±8.56 (54.85)	68.00±8.35 (55.67)	70.37±5.72 (57.10)	90.00±2.61 (71.60)	2.38	7.35
Survival (%)	21.95±2.65 *(27.91)	28.89±4.9 (32.46)	35.56±3.61 (36.59)	37.78±2.13 (37.92)	42.22±2.57 (40.52)	80.00±12.31 (63.83)	2.57	7.93
Fecundity (eggs/female)	408±43	594±184	778±153	860±115	937±127	1375±320	102.97	317.29
Fertility (% hatching)	20.34±3.78 *(26.75)	31.31±4.78 (33.98)	34.70±3.58 (36.07)	35.81±3.61 (36.74)	38.31±4.65 (38.22)	88.07±6.49 (70.30)	1.95	6.02
Total Developmental period (days)	27.37±5.77	26.82±2.70	26.72±2.62	26.18±3.98	25.81±0.80	25.56±2.80	2.00	6.15

* Data in parentheses are arcsine- transformed values; SEm±: standard error of mean; CD: critical difference; ±: standard deviation, DAT: Day after treatment

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Bioefficacy of various seed protectants against pulse beetle in eastern parts of Uttar Pradesh

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The insects causing damage to stored pulses are pulse beetle (*Callosobruchus chinensis* L.) khapra beetle (*Trogoderma granarium* Everts) and lesser grain borer (*Rhizopertha dominica* F.). Among these pulse beetle is most important as it infests pigeonpea both in field and storage, causing loss of nearly 0.21 million tonnes, costing 6.85 million rupees. Many workers have reported that mixing of plant products with grain repeal insects. A lot of work have been carried out in different parts of India, but little work on management of this pest under the condition of eastern U.P. The investigations were carried out in the entomology laboratory of Seed tech section of N.D.U.A&T Kumarganj, Faizabad during 2006-07. Deltamethrin 2.5W.P. @40 mg/Kg seed proved most effective against *C. chinensis* infesting stored pigeon pea up to 9 month. Neem oil @ 10 ml/kg seed was most effective in reducing percent infestation and weight loss caused by *C chinensis*. It also reduced the oviposition on grain. Neem India 10 ml/kg seed Neem dry leaf powder 10g/kg seed, lufeneuron 10ml/kg seed, spinosed 10ml/ kg seed and coconut oil 10 ml/kg seed were also effective in controlling the population of *C. chinensis*.

Fifteen kg freshly harvested insect free, healthy grain of pigeonpea variety NDA-1 was used for testing the efficacy of various protectant against *C. chinensis*. Experiment was conducted in CRD with 10 treatments and 3 replications from July2007 to March 2008. Required amount of neem dry leaf powder was weighed and neem oil, mustard oil, coconut oil, neem India, spinosad and lufeneuron were measured and mixed in 500g of grains separately. Deltamethrin 2.5 w.p. was weighed and diluted in 10 ml of water and mixed in 500g pigeonpea seed. Then 5 pairs of *C. chinensis* were taken from already maintained culture and release in each container. Deltamethrin 2.5 WP @ 40 mg/kg seeds proved most effective infesting stored pigeonpea upto 9 months. These observations are supported by Rahman and Yadav (1987). Neem oil @ 10 m/1kg seed was effective in reducing per cent infestation, and weight loss caused by *C. chinensis*. It also reduced the oviposition on grains. The next effective treatment was mustard oil @ 10 ml/kg seeds. Neem India 10 ml/ kg seed, Neem dry leaf powder 10 g/ kg seed, Lufenuran 10 ml/ kg seed, spinosad 10 ml/ kg seed and coconut oil 10 ml/ kg seed were also found effective (Table 1). In case of botanicals the results have been supported by various workers (Yadav and Bhatnagar, 1987).

Table 1 Effects of seed protectants against pulse beetle in pigeonpea

S.No.	Treatments doses/ kg of seed	Per cent infestation		
		3 months	6 months	9 months
1.	Neem dry leaf powder (10g)	3.40	6.45	10.41
2.	Neem oil (10 ml)	2.58	5.78	8.75
3.	Mustard oil (10 ml)	2.65	5.85	9.85
4.	Coconut oil (10 ml)	4.33	3.93	12.01
5.	Neem India (10 ml)	3.12	6.25	10.32
6.	Spinosad (10 ml)	3.76	6.03	10.65
7.	Lufenuron (10 ml)	3.45	5.87	10.48
8.	Deltamethrin (40 mg)	2.48	4.85	6.95
9.	Water (10 ml)	15.36	29.21	44.83
10.	Control	15.30	30.18	45.31
C.D. at 5%		0.040	0.040	0.040
SEm±		0.013	0.013	0.013

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Feeding responses to organic chickpea by *Helicoverpa armigera* (Hubner)

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Chickpea (*Cicer arietinum* L.) is a premier pulse and more than 65% is produced from India. Damage caused by *Helicoverpa armigera* (Hubner) on chickpea may be 75-90% . Organic crops have shown higher tolerance to insect attack due to thicker cell wall and lower levels of free amino acids. Host plant nutrition influence the larval mortality, decreased larval and pupal weight, prolonged periods, inhibit pupation and reduced fecundity. Udai variety of chickpea was used for experiment. Fertilizer and manure for treatments of NPK @ 20, 60 and 40 kg / ha; FYM @ 8 tonnes / ha, vermin- compost @ 37.5 q / ha and seeds inoculated with rhizobium culture @ 20 mg / Kg were applied for the treatments T_1, T_2, T_3 and T_4 respectively. No fertilizer was applied for treatment T 5 i.e. control. The larvae reared in the laboratory by feeding of raised chickpea (*C. arietinum* L.) under treatments (T_1-T_5).

Amino acids extracted with hot ethanol (80% v/v) from fresh larval samples and two dimensional ascending paper chromatography with solvents phenol: water: ammonia (80:20:3, v/v) and butanol: acetic acid: water (4:1:5, v/v) were used. Ninhydrin positive substances were detected and measured quantitatively with sprectrophotometer at wavelength 510nm. Proline quantified separately. Protein was estimated by Lowry *et al.* (1951). Larval protein and amino acids were estimated on fresh weight basis.

Length, weight and protein content of the 5[th] instar larvae of the treatment of NPK were highest. In the treatment of vermi-compost weight of the 5[th] instar larva was lowest. Lowest protein content was recorded in the treatment FYM. Total concentration of essential amino acids in the treatments of the T_3 (Vermi compost) and T_5 (Control) were 298.59 and 240.30 μg /100 mg fresh weight larvae, which were also 1.38 times and1.71 times lesser than NPK respectively. Essential amino acids lysine and histidine concentration were lowest (26μg /100 mg fresh weight) of the treatment vermicompost. Lower concentration of essential amino acids of the treatment vermicompost resulted lesser protein and weight of larva, while its higher concentration of the treatment NPK resulted highest larval protein and weight. Consequently, feeding of vermicompost treated chickpea inhibited larval growth. Similarly, 6[th] instar larva of vermicompost treatment was deficient of lysine and histidine. Vermicompost application in chickpea may be useful for lowest concentration of larval lysine and histidine of *H. armigera*.

Table1 Impact of chickpea feeding on length, weight, protein and essential amino acids of 5[th] larval instar of *H. armigera*

Treatments	T1 NPK	T2 FYM	T3Vermi Compost	T4 Seed Inoculation	T5 Control	SEM+-	CD at 5%
Length mm	22.18	22.35	21.80	21.20	20.20	0.46	1.36
Weight gm	0.0810	0.0800	0.0625	0.0805	0.0775	0.0025	0.0073
Protein μg/ 100mg fresh weight	4592	1109	4520	4524	4590	106.69	315.8
Essential Amino acids μg/100mg fresh weight							
Leucine and Isoleucine	107.22	187.50	152.77	176.78	115.31	1.97	5.84
Valine	57.69	89.84	59.72	103.54	69.07	1.06	3.15
Lysine and Histidine	100.96	158.85	26.38	296.42	55.92	1.45	4.3
Arginine	107.22	14.32	22.22	66.07	-	1.20	3.56
Threonine	39.66	31.25	37.50	53.57	-	0.76	2.24
Total	412.75	481.76	298.59	696.40	240.30	2.98	8.85
Number	7	7	7	7	5	0.32	0.96

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Interrelationships amongst the larval, pupal and adult weights of *Helicoverpa armigera* Hubner

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Characterization and quantification of different stages of test insects may be useful for understanding the test insects biology. The test-insect taken is the most common lepidopteran pest *Helicoverpa armigera* Hübner (Noctuidae). In scientific investigations related to entomological experimentations, this is the most widely used test insect to be reared in the laboratory on natural and/or artificial diet. Despite its wide usage, still some facts are unknown to us. The last larval- weight, pupal- weights (first-day of pupation, last-day of pupation) and the adult-weight after emergence may have some definitive relationship(s) with/without gender bias. On this hypothesis, an experiment was undertaken taking wheat germ based artificial diet (Gupta *et al*,.2005) under controlled laboratory conditions (temperature 27±1°C, RH 65±5%, and 16: 8 hours scoto/photo-phase regime). Fifty larvae were selected, weighed on 6-day larval age, reared individually in borosil vials (5.5 x 2 cm; 20cc). till adult-emergence. Body-weights on 6th day to last-day of larval-stage, first and last-day of pupal-, and first-day adult-stage; were recorded. Sexual segregation was done in the pupal-stage, confirmed in adult-stage; and tabulation was prepared on this sex-determination.

Larval weights were recorded on 6-day (61.39 mg per male, 60.65 mg per female; and 61.07 mg average). The larval weight gain from this 6th day to last-larval stage (maximum) was 7-8 folds. The body weight conversion in various life-satges is presented in a two-way matrix (Table 1). The weights of last-day of larvae recorded were averaged out (465.07 and 494.52 mg), first-day of pupa (346.67 and 360.26 mg); last-day of pupa (293.62 and 310.20 mg); and first-day of adult-moth (156.7 and 179 mg); respectively for male and female individuals. It can be concluded that sex has no role in this existing variation between male and female Such types of studies are being continued for other important test-insects also, for generalizing any possible trend in the interrelationships amongst the body-weights of larval-, pupal- and adult-weights. This may provide more meaningful insight that may help in basic physiological investigations on insect-biology and bionomics.

Table 1 Relationships amongst the larval-, pupal- and adult-weights of *H. armigera* (two-way matrix, related from X to Y)

Y / X	Body-weight conversion percentage at various life-stages			
	Last-day of larval-stage	First-day of pupal-stage	Last-day of pupal stage	First-day of adult-stage
Male	465.07 mg	346.67 mg	293.62 mg	156.7 mg
Last-day of larval-stage	100%	74.54%	63.13%	33.69%
First-day of pupal-stage		100%	84.70%	45.20%
Last-day of pupal stage			100%	55.29%
Female	494.52 mg	360.26 mg	310.20 mg	179.0 mg
Last-day of larval-stage	100%	72.85%	62.73%	36.19%
First-day of pupal-stage		100%	86.10%	49.69%
Last-day of pupal stage			100%	57.74%
Average	477.69 mg	352.49 mg	300.72 mg	166.28 mg
Last-day of larval-stage	100%	73.79%	62.95%	34.81%
First-day of pupal-stage		100%	85.31%	47.17%
Last-day of pupal stage			100%	55.29%

Body-weights are mean of 50 test-insects, N=50

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Effect of chemicals on the incidence of *Tropilaelaps clareae* in *Apis mellifera* colonies

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Modern keeping with *Apis mellifera* encounters the problem caused by infestation with mites. The mite, *Tropilaelaps clareae* Delfinado and Baker (Mesostigmata: Laelapidae), is parasite of honey bee and severely affects it. Feeding on bee larvae and pupae causes brood malformation, death of bees and subsequent colony decline or abscond. An infestation by *Tropilaelaps* can be recognized either visually on bees or by examining hive debris. Irregular brood pattern, dead or malformed immatures, bees with malformed wings that crawl at the hive's entrance, and especially the presence of fast-running, large, red-brown, elongated mites on the combs, are diagnostic for the presence.

Present study was undertaken to determine best suitable chemicals for management of *T. clareae* in colonies. Experiments were carried out at university apiary at RAU, Pusa during 2006-07 and 2007-08. The experiment comprised of eight treatments and three replications. The hive (colony) may be treated with various chemicals that cause the mites to drop off combs and bees. Sticky boards on the bottom of the colony can be used to examine hive debris and mite. The first sign of an infestation by *T. clareae* is often the occurrence of large (almost 1 mm in length), red-brown, elongated mites on the combs or on adult bees. The infestation of mite was recorded by the method suggested by Mishra (1997). Different chemicals were tested for their efficacy during dearth period (July to September).

The observations recorded are presented in Table 1, all the colonies were infested and there was no significant variation in initial infestation. However, the infestation severity ranged from 42.33 to 52.33%. After application of chemicals, there was reduction in infestation. In control colonies infestation increased and it was recorded 51.67% and 52.67%, respectively, during 2006-07 and 2007-08. Among different treatments when oxalic acid (35g) and 200 g sugar dissolved in warm water was applied @ 2 ml per frame there was 48.96% and 44.54% reduction followed by Bayticol @ 0.25 ml showing 45.86% and 41.72% reduction, respectively in 2006-07 and 2007-08. There was 9.66% and 16.19% increase in infestation, respectively, during 2006-07 and 2007-08 in the control colonies. All the treatment decreased the mite infestation in the hive, chemicals having fumigant action were found better in reducing infestation. The above findings are in conformity with those of Atwal and Goyal (1971) and Garg *et al.* (1984).

Table 1 Effect of chemicals on *Tropilaelaps clareae* in colony of *Apis mellifera*

Treatment	Dose	2006-07			2007-08		
		Initial Infestation	Final infestation	% reduction	Initial Infestation	Final infestation	% reduction
T_1 – Sulphur dust	50 g/ colony	52.00	41.33	20.51	50.00	42.33	15.34
T_2 – Formic acid	5 ml / colony	51.33	33.67	34.42	49.33	34.67	29.72
T_3 – Spray of Formic acid (500 ml in 2 l water	2 ml / frame	44.33	25.67	42.09	42.33	26.67	36.99
T_4 – Fumigation (Tobacco)	5 minutes	51.33	31.22	39.17	49.33	30.22	38.37
T_5 – Oxalic acid (35g) + 200 g Sugar + 1 l warm water	2 ml / frame	47.67	24.33	48.96	45.67	25.33	44.54
T_6 – Bromopropylate	1 strip / colony	50.00	31.00	38.00	48.00	30.00	37.50
T_7 – Bayticol	0.25 ml / colony	52.33	28.33	45.86	50.33	29.33	41.72
T_8 – Control	-	47.33	51.67	-9.66	45.33	52.67	-16.19
S.E.M (±)		-	1.24	-	-	0.72	-
CD (p=0.05)		NS	3.60	-	NS	2.08	-

Data are mean of three replication, each 500 bees (100 bee / frame). Observation at 10 days interval after treatment, mean of 5 observations.

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Case study of socioeconomic impact of cotton IPM on Punjab farmers

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Due to the success of the green revolution in India, agricultural sector showed tremendous progress. There was a quantum jump in the production of different crops, especially wheat and rice. This increase was made possible by high yielding varieties and by the use of fertilizers especially in irrigated areas. But intensive cultivation has caused environmental degradation (Singh *et al.*, 2002). The same problem was observed in Punjab. In these adverse conditions cotton is best option for crop diversification especially for southwestern districts of the states. But since mid nineties, the area under cotton crop has shown rapid fall in yield mainly due to serious attack of insect-pest and diseases. The Integrated pest management is the best approach for the revival of cotton crop. Considering the importance Punjab Agricultural University Ludhiana initiated several projects for dissemination of IPM technology with the help of ICAR, New Delhi and Sir Ratan Tata trust, Mumbai.

Table 1 Impact of adoption of IPM strategies

S. No.	Village	District	Total Area	Area Under Cotton	No of Sprays against				Yield Kg/ha	COC	Average Profit
					SP	MB	TC	BW			
IPM Villages											
1.	Daula	Muktsar	509	360	1.9	2	1	0	2500	21980	48020
2.	Bodi wala	Muktsar	432	305	1.5	2.1	0.7	0	2485	22040	47540
3.	Rajpura	Ferojpur	1045	806	1.3	1.8	0.9	0	2540	22770	48350
4.	Bhagu	Ferojpur	980	775	1.3	2	0.2	0.7	2478	23400	45984
5.	Saharna	Mansa	497	342	1.7	1.2	1.1	0	2575	21750	50350
6.	Ghurkani	Mansa	908	289	1.6	1.8	0.7	0	2435	21945	46235
7.	Bhagwangharh	Bathinda	840	582	1.6	1.1	0.4	0	2515	22118	48302
8.	Pakka Khurd	Muktsar	509	360	1.9	2	1	0	2500	21980	48020
		Average			1.6	1.7	0.7	0.1	2496.9	22297.9	47614.6
Non-IPM Villages											
1.	Maha Badhar	Muktsar	479	378	2.9	3.5	1.9	0.4	2240	28270	34450
2.	Usman Khera	Ferojpur	1042	823	3.2	4.1	1.5	1	2123	27980	31464
3.	Chainewala	Mansa	570	482	3.6	3.7	1.6	0.2	2145	28285	31775
4.	Gehri Butter	Bathinda	795	574	3.8	3.5	1.8	0.2	2035	28720	28260
		Average			3.4	3.7	1.7	0.5	2135.8	28313.8	31487.3

A study was carried out in villages Rajpura and Bhagu (Distt. Ferojpur) Daula and Bodiwala (Distt. Mukatsar), Saharna and Ghurkani (Distt. Mansa) and Bhagwangharh and Pakka Khurd (Distt. Bathinda) to access the impact of IPM practices on socioeconomic condition of farmers. IPM technology was transferred by Department of Entomology, PAU Ludhiana with the help of Sir Ratan Tata trust, Mumbai. A typical comparison was carried out between villages covered under IPM and those not covered. Scouts (Trained persons form same village) were employed to coordinate meetings, training camps, field days, and field visits of experts. Need based information was also provided through pamphlets and public address system.

The study revealed that there was increase in the yield to 20-25 per cent and reduction in cost of cultivation by 30 -35 per cent. Indiscriminate use and higher doses of pesticides were reduced with the advice of experts. The population of insects pests was 10-15 per cent lower and friendly insects has increased significantly in IPM fields as compared to non IPM fields. There was 12,000 to 17,000 increase in average income per hectare in villages selected under IPM which provide a positive economic impact of the project along with good environmental impact due to reduced sprays. The benefits of IPM practices has also been reported earlier (Dhawan, 2006) and (Peshin, 2005). The inclusion of Bt cotton will further prove as useful component in Integrated pest management programme (Hillocks, 2005).

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Biorational approach in the management of tomato fruit borer, *Helicoverpa armigera* (Hubner)

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The major constraint in the production of tomato is the fruit borer, *Helicoverpa armigera* (Hubner) leading 18 to 55 per cent yield loss in different parts of the country. A field experiment was conducted at the Vegetable Research Farm, College of Agriculture, CAU, Imphal during *Rabi*, 2007-08 to develop biorational approach of IPM Tomato variety 'Best of All' was grown at 60 x 45 cm spacing in 3 x 2 m^2 plots and the experiment was laid-out in RBD with three replications. The treatments comprised four bioproducts, one neem formulation, one conventional insecticide and untreated control. Three sprays of these treatments were given at 10 days interval commencing from the fruit initiation stage. Observations on number of damaged and healthy tomato fruits from each treatment plot were recorded and weighed at each picking for computing fruit infestation on number and weight basis.

All the insecticidal treatments were effective against *H. armigera* with infestation of 4.06 to 5.35% on number basis and 3.68 to 5.20% on weight basis against 15.44 and 14.37%, respectively in untreated control (Table 1). Spinosad @ 250 ml/ha proved to be the most effective against the pest with minimum fruit damage of 4.06% on number basis and 3.68% on weight basis, closely followed by HaNPV (Heliokill) @ 250 LE/ha and B.t.k. (Delfin) @ 1000 g/ha. Highest fruit yield of 32.48 t/ha was recorded in spinosad treated plots with 47.23% increase in yield over treated control and highest cost benefit ratio 1:51.86. The effectiveness of spinosad obtained in the present studies is in confirmation with the results of Dhonde *et al.* (2005) and Raghvani and Poshiya (2006), who observed reduction in larval population of *H. armigera* and increase in chickpea yield.

In consideration of higher yield, and safety to natural enemies prevalent in the tomato ecosystem in one hand and the problem of chemical insecticides in environmental pollution and residual toxicity in foods on the other hand, it is advisable to use effective microbial pesticides like spinosad, HaNPV and B.t.k. for management of tomato fruit borer.

Table 1 Field efficacy of five biorational insecticides and endosulfan against *H. armigera* (Rabi, 2007- 08)

Treatment	Dose	[1]Average (%) fruit infestation		Yield (t/ha)	Increase yield over control (%)	Cost benefit ratio
		Number basis	Weight basis			
Endosulfan 35 EC	1,000 ml/ha	4.93 (12.64)	4.76 (12.53)	29.33	32.95	1:41.58
Delfin (*Bacillus thuringiensis* var. *kurstaki*)	1000 g/ha	4.90 (12.77)	4.08 (11.43)	30.72	39.25	1:22.68
HaNPV (Heliokill)	250 LE/ha	4.58 (12.15)	4.53 (12.04)	31.71	43.74	1:47.08
Spinosad	250 ml/ha	4.06 (10.78)	3.68 (10.06)	32.48	47.23	1:51.86
Larvocel (*Beauveria bassiana*)	2000 g/ha	5.27 (12.83)	4.66 (12.13)	26.85	21.71	1:21.50
Neemexcel	1,000 ml/ha	5.35 (12.94)	5.20 (12.79)	31.22	41.52	1:28.44
Untreated Control	-	15.44 (23.12)	14.37 (22.24)	22.06	-	-
S.E.m (±)	-	1.74	1.73	2.05	-	-
CD (P=0.05)	-	5.36	5.32	6.32	-	-

Figures in parentheses are angular transformed values.
[1]Average per cent fruit infestation of three replications based on total fruit number/weight of seven harvestings

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Evaluation of ecofriendly approaches against major insect pests of mustard

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Indian mustard, *Brassica juncea* is one of the principal cruciferous crops cultivated all over India. Among the various factors responsible for the low yield of mustard, damage inflicted by various insect pests is an important factor. Among these the mustard aphid, *Lipaphis erysimi*, (Kaltenbach) the mustard sawfly *Athalia lugens proxima* (Klug.), the painted bug, *Bagrada hilaris* (Kirk.) and the leaf miner *Phytomyza horticola* (Goureella) are major pests. A field experiment on the comparative effectiveness of different combination of treatments against major insect pest of mustard and their natural enemies was conducted at RCA. Udaipur during rabi 2004-05 and 2005-06 in RBD with three replications. The details of the treatment: T_1 NSKE 5% + *Chrysoperla carnea* @ 50,000 grubs/ha + NSKE 5%; T_2 NSKE 5% + *Coccinella septempunctata* @ 5000grubs/ha + NSKE 5%; T_3 Custard apple seed extract 5% + *C. carnea* @ 50,000 grubs/ha + Custard apple seed extract 5%; T_4 Custard apple seed extract 5% + *C. septempunctata* @ 5000 grubs/ha + Custard apple seed extract 5%; T_5 Jatropha seed kernel extract 5% + *C. carnea* @ 50,000grubs/ha + Jatropha seed kernel extract 5%; T_6 Jatropha seed kernel extract 5% + *C. septempunctata* @ 5000 grubs/ha + Jatropha seed kernel extract 5%; T_7 Methyl-oxy-demeton 25 EC @ 0.025% -Three applications; T_8 Untreated control. Observations were taken weekly on five randomly selected and tagged plants/ plot on 10cm central twig for aphid and on whole plant basis for mustard sawfly larvae and painted bug (nymph and adult). First application of insecticides and botanicals was made when crop was 25 to 30 days old crop and third application was made when the crop was 90 days old crop. Release of 2[nd] instar larvae of *C. carnea* and *C. septempunctata* was made when the crop was 60 to 70 days old and the aphid population was sufficient on the plant. For natural enemies of aphid their population was also recorded at weekly interval. Benefit cost ratio was calculated.

Studies reveal that three sprays of methyl oxydemeton 25 EC @ 0.025% was effective from the view point of insect pests' suppression, which recorded minimum mean population of aphid i. e. 10.59 and 9.33 aphids per 10 cm twig length per plant; painted bug 2.96 and 2.41 bugs per plant and mustard sawfly 0.41 and 0.53 grubs per plant during 2004-05 and 2005-06, respectively but it reduced natural enemies population greatly. The natural enemies populations recorded in this treatment were 0.34 and 0.28 coccinellids, 0.13 and 0.11 *C. carnea*, 0.12 and 0.10 *Xanthogramma scutellrae* and per cent parasitization by *Diaeretiella rapae* was 5.92 and 6.12 only in 2004-05 and 2005-06, respectively (Fig. 1). Treatment (comprising NSKE 5% + *C. septempunctata* @ 5000 grubs/ha + NSKE 5%) was the best effective biointensive treatment against aphid and painted bug with mean population of 15.23 and 12.42 and 4.56 and 4.66 during 2004-05 and 2005-06, respectively (which was at par with treatment comprising NSKE 5% + *C. carnea* @ 50,000 grubs/ha + NSKE 5%) with respective mean population of aphid 16.52 and 13.84 per plant and painted bug 4.63 and 4.50, during 2004-05 and 2005-06, respectively. Whereas, in case of mustard sawfly, (NSKE 5% + *C. carnea* @ 50,000 grubs/ha + NSKE 5%) was the next best treatment in order of effectiveness with mean population of 1.12 and 1.21 larvae per plant during 2004-05 and 2005-06, respectively. All the biointensive treatments were relatively safer to the natural enemies and helped in building up their population. The treatments comprising NSKE 5% + *C. septempunctata* + NSKE 5% and was in order of superiority giving a net profit of Rs. 9870 and Rs. 9144/ha and with respective B: C ratio of 1.44 and 1.40 during 2004-05 and 2005-06, respectively (Table 1).

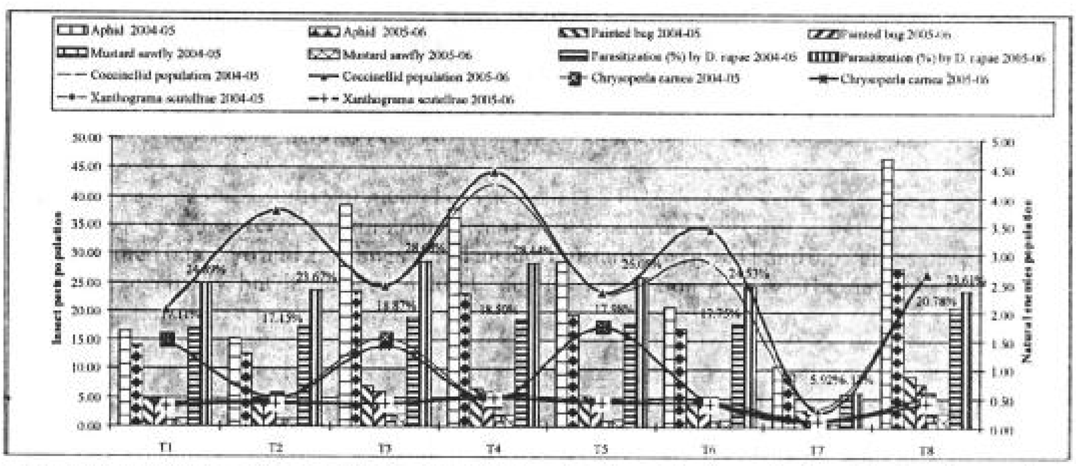

Fig. 1 Effectiveness of insecticides against major insect pests of mustard and natural enemies

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Table 1 Effectiveness of different treatments on the seed yield of mustard and their economics during 2004-05 & 2005-06

Treatments	Yield (kg/ha)		Gross return (Rs./h a)		Increased yield over control (kg/ha)		Cost of increased yield over control		Cost of treatments (Rs./ha)		Net profit (Rs./ha)		B:C ratio return over control	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
T_1	1694.44	1701.38	31770	31900	625.00	598.61	11719	11223	6210	6210	5509	5014	1.21	1.19
T_2	1713.88	1708.33	32135	32031	644.44	605.55	12083	11354	2210	2210	9873	9144	1.44	1.40
T_3	1448.61	1437.49	27161	27057	379.17	334.72	7109	6380	6210	6210	899	170	1.03	1.01
T_4	1458.33	1461.11	27343	27395	388.89	358.33	7292	6719	2210	2210	5082	4509	1.23	1.20
T_5	1531.94	1533.33	28723	28750	462.50	430.55	8672	8073	5710	5710	2962	2363	1.12	1.09
T_6	1643.33	1614.99	30812	30281	573.89	512.22	10760	9604	1710	1710	9050	7894	1.42	1.35
T_7	1819.11	1837.49	34114	34452	750.00	734.72	14062	13775	1410	1410	12652	12365	1.59	1.56
T_8	1069.44	1102.77	20052	20677	-	-	-	-	-	-	-	-	-	-
SEm ±	62.30	58.57												
CD at 5 %	188.79	177.67												

Cost of insecticides/bioagents:

Neem seed kernel	- 40/- per Kg.
Jatropha seeds	-20/- per Kg.
Custard apple seeds	- 40/- per kg
Chrysoperla carnea	- 100/- per 1000 eggs.
Coccinella septempunctata	-20/- per 100 1st instar g

Labour charges: Rs. 70 per application
Seed yield: 18.75/- per Kg.
Oxy- demeton- methyl: 400/- per 500 ml

Integrated pest management in vegetables for safer environment of Andaman

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The Andaman and Nicobar group of Islands forms an arched string of 572 Islands and islets stretching from Burma in the north to Sumatra in the south. Andaman and Nicobar group of Islands are located in the Bay of Bengal and falls under the island ecosystems. The climate is unique with humid tropical (temp 28-32°C and RH 75-95%), endowed with the occurrence of both South-West and North-East monsoon and the rainy season is of more than eight months in a year with an average rainfall of 3100mm. In Andaman and Nicobar Islands the total available land for Agriculture is limited to 50,000 ha. i.e. 6% of the total geographical area only.

Congenial climatic and weather condition coupled with intensive cultivation causes heavy pest incidence in vegetable crops. In the Bay islands, vegetable crop ranks second position, next to the plantation crops in fetching more income to the farmers. So farmers trying to save their crops from pest and disease attack at any cost, which ultimately lead to the indiscriminate use of chemical pesticides. Almost all types of vegetables except potato and onion are being grown in the Bay Islands. Earlier the vegetable crops were grown as inter or subsidiary crop rather than sole crop. But due the intensive and participatory effort of CARI, Port Blair, farmers started to grow and cultivate vegetables as sole crops.

The adoption of modern technology, comprising of introduction of high yielding varieties, use of chemical fertilizers and improved agronomic practices has enabled the farmers in increasing the crop production two to three folds, but such intensive cropping system have also paved the way for emergence of pests, diseases problems, necessitating the unilateral use of pesticides. The indiscriminate use of pesticides has resulted into several risk factors such as health hazards, ecological imbalance, and resistance in pests to pesticides, resurgence of pests and environmental pollution. Besides the destruction of natural enemies of pests increased level of pesticides residues in soil, water, food and fodder crops have also been noticed above the prescribed limit of tolerance. Though the usage of pesticides is still a dominating tool to combat pests, it is conceded that the use of pesticides alone is not a satisfactory solution to the pest problem and some suitable alternative methods should be developed to minimize the disease and pest incidence for sustainable production of vegetables in Bay Islands.

Six plant species namely *Alpinia manii* King ex Baker, *Orophea katschallica* Kurz, *Amomum aculeatum* Roxb., *Amomum fenzlii* Kurz, *Pseudouvaria prainii* King, *Zingiber squarrosum* Roxb. were found to be effective against rock bee (Chakrabarty *et al.*, 2006). These plants having repellent and tranquilizing effect may eventually serve as natural insecticides or insect repellent. In our studies, *Amomum aculeatum* was proved as a strong repellent and tranquilizing agent against housefly (*Musca domestica*) under controlled laboratory conditions. No reports till now have been published with regard to such use of this plant. It has also been tested in a fish shop and same results have been obtained. It has to be tested for other species of parasites. Combining all these information if suitable technology developed and farmer are trained, some of these plants can be used for pest management. The preliminary studies have shown that the fungal antagonists are naturally occurring in these Islands in abundant and they have been proved to be highly parasitic on some soil borne plant pathogens *in vitro* (Bhagat *et al.*, 2006). These fungi are opportunistic, avirulent plant symbionts (Harman *et al.*, 2004), and functions as parasites and antagonists of many phytopathogenic fungi, thus protecting plants from disease. Similarly, many species of entomopathogenic fungi have been used to manage various pests of vegetables.

The native strains of biocontrol agents are supposed to be more effective in management of plant diseases and pests than introduced one, as they are well adapted. Plant origin insecticides also have a great advantage by being compatible with other low risk options which are acceptable for insect management, such as pheromones, oils, detergents, entomopathogenic fungi, predators and parasitoids, among others, which greatly increase probabilities of being integrated in IPM programs. With this, Islands can move one step forward towards organic farming. This will reduce the use of dangerous chemicals which may cause health hazards and also reduce cost of cultivation.

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Management of diamond back moth through chemicals and ecofriendly insecticides

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Cabbage (*Brassica oleraceae* var. *capitata*) is one of the most important cruciferous vegetables of Ranchi region of Jharkhand. One of the major constraints in the successful cultivation of the crop is pest menace. Diamond back moth, DBM (*Plutella xylostella* L.) is the most injurious insect pest. On account of repeated and over use of chemical insecticides, the pest becomes resistant. More over, cabbage is a green vegetable crop, and hence, there is need to evolve some ecofriendly management. Some chemical and ecofriendly insecticides were evaluated against DBM infesting cabbage. A field experiment was conducted in RBD with 7 treatments and 4 replications. The biopesticides / insecticides (Table 1) were applied as foliar spray using hand compression sprayer during evening hours. The population count of larvae was recorded on 5 randomly selected plants from each plot at 1, 5 and 7 days after spraying. The yield of marketable heads was recorded on per plot basis. Data were statistically analysed.

The results (Table 1) revealed that all the treatments were effective in sppressing the incidence. The best performance was achieved by foliar application of imidacloprid suppressing the larval population to the extent of 86.03 per cent, followed by cartap hydrochloride, which reduced the pest incidence upto 79.10 per cent. Reduction in larval population to the extent of 78.53, 78.53, 71.50 and 68.94 per cent were recorded with two foliar applications of Btk, Vanguard, garlic plus chilli extracts and cow urine respectively. Efficacy of cartap hydrochloride and Btk against DBM was earlier reported by Peter (1961) and Krishnaiah *et al.* (1981).

The highest yield (225 q/ha) of edible and marketable curds was obtained with the application of imidacloprid with 157.64 per cent more yield followed by cartap hydrochloride and Btk where 141 per cent gain in yield was obtained. Asokan *et al.* (1986) also opined almost similar views. Application of Vanguard, extract of garlic + chilli and cow urine resulted to average yield of 180,170 and 160 q/ha, respectively.

Table 1 Effect of biopesticides and insecticides on cabbage diamond back moth

Treatment	Number of Larvae / plant Days after treatment 1	5	7	Yield of healthy curds (q/ha)
Cow Urine (Home made)	4.00 (2.12)	3.38 (1.97)	3.27 (1.94)	160
Garlic + Chilli (Home made)	3.87 (2.09)	3.18 (1.92)	3.00 (1.87)	170
Vanguard (5ml/L water)	3.07 (1.89)	2.53 (1.74)	2.26 (1.66)	180
B.T.K. (1 g/L water)	3.07 (1.89)	2.50 (1.73)	2.26 (1.66)	210
Imidacloprid (1ml/L water)	2.47 (1.72)	1.87 (1.54)	1.47 (1.40)	225
Cartap hydrochloride (1g/L water)	3.07 (1.89)	2.40 (1.70)	2.20 (1.64)	211
Untreated control	9.50 (3.16)	10.00 (3.24)	10.53 (3.32)	87
CD at 5%	0.076	0.079	0.065	4.96

Data transformed into $\sqrt{x + 0.5}$ for statistical analysis. Figures in parentheses correspond to transformed values.

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Evaluation of safer insecticides against bioagents in rice

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The ecological situations under which rice is grown in Bihar are primarily irrigated mid land, rain-fed lowland, semi-deep and deep water. Investigations have revealed that rice ecosystem is very rich in natural enemies which are very useful in reducing the yield loss (Singh and Dhaliwal, 1994). But indiscriminate and injudicious use of chemicals insecticide leads to the large scale killing of their natural enemies. Since the insecticides are not likely to be a abandoned completely in foreseeable future, their use needs to be rationalized both from economical and ecological points of view. It becomes absolutely essential to study the effectiveness of some insecticides against the natural fauna. As such efficacy of different insecticides were evaluated under field conditions during Kharif 2003 in paddy block of Pusa farm, Rajendra Agricultural University in a randomized block design with thirteen treatments replicated thrice. The leading rice variety 'Rajshree' was grown with the recommended package of practices. The size of each plot was kept as 3.7 x 4 m. Population fluctuations of spiders in the experimental plots were counted by net sweeping per unit area method. The collected predators were studied and its impact on pest populations estimated. The observations were recorded at weekly intervals with the help of quadrate 1m x 1m. The quadrate was thrown randomly by moving across the field, diagonally at four places and biotic fauna counted and brought to laboratory. Different insecticides were selected for evaluation of effectiveness against the bioagents. Data were processed for statistical analysis.

Tabe 1 Evaluation of safer insecticides in rice against bioagents

Treatments	Conc.	No. of spider/m²				
		I DBT	I DAT	7 DAT		
Beta cyfluthrin (5%)	30	4.219	2.846	3.834	3.633	1.88
+ Imidacloprid (5%)		(17.300)	(7.600)	(14.200)	(13.033)	(3.06)
Imidacloprid	25	4.139	3.638	3.027	3.601	2.05
		(16.633)	(12.733)	(8.667)	(12.618)	(3.86)
Beta cyfluthrin	12.5	4.123	3.329	3.605	3.786	4.54
		(16.500)	(12.667)	(12.500)	(13.898)	(20.28)
Ethiprole	50	4.103	3.587	3.493	3.727	2.68
		(16.333)	(12.367)	(11.700)	(13.467)	(6.93)
Profenofos	500	4.017	3.737	3.873	3.867	3.12
		(45.633)	(13.467)	(14.500)	(14.533)	(9.48)
Profenofos (4%)+	440	4.177	3.449	3.724	3.782	3.57
Cypermethrin (4%)		(16.900)	(11.400)	(13.367)	(13.889)	(12.88)
Neonicotinoid	25	4.195	3.564	2.811	3.523	1.96
		(17.100)	(12.200)	(7.400)	(12.233)	(3.59)
Neem oil	1.5%	4.207	3.440	3.701	3.783	4.79
		(17.200)	(11.333)	(13.200)	(13.911)	(22.96)
Deltamethrin	12	4.147	3.605	4.037	3.930	4.48
		(16.700)	(12.500)	(15.800)	(15.000)	(19.88)
Cypermethrin	25	4.215	3.624	4.155	3.998	4.37
		(17.267)	(12.633)	(16.767)	(15.556)	(19.28)
Fenvalerate	12	4.179	3.568	4.004	3.917	4.47
		(16.967)	(12.233)	(15.533)	(14.911)	(19.73)
Monocrotophos	500	4.131	3.396	4.359	3.962	3.25
		(16.567)	(11.033)	(18.500)	(15.367)	(10.45)
Untreated control		4.568	4.785	5.666	5.006	7.06
(Water spray)		(20.367)	(22.400)	(31.600)	(24.789)	(49.76)
SEm±		0.0164	0.0154	0.0153	0.1205	0.0354
CD at 5%		0.0478	0.0450	0.0447	0.1771	0.0520

It is evident from the data that the population of spider fauna in different treatment varied from 22.5/m² in control plot, to 7.6/m² in betacyfluthrin + imidacloprid treated plot when data recorded 1 DAT (Table 1). After control plot highest no. of spider population 13.46 was recorded in profenofos treated plot. After 7 days of treatment, again maximum spider population 31.6 was recorded in control plot which is followed by monocrotophos treated plot (18.5) and minimum (7.4) in neonicotinoid treated plot. It is concluded that among the twelve different insecticide tested against the spider cypermethrin was found to be the safest. The present finding is also supported by the result of Mohan *et al.* (1992) also observed that neem products had less effect on spiders.

The data pertaining to the inf uence of insecticide on mirid bug population recorded indicate that the population varied from 3.' 6/m² to 22.96/m² in betacyfluthrin + imidacloprid and neem oil treated plot respectively whereas, in control maximum 49.76 bug was recorded. Neem oil treatment was found to be safest (22.96/m²) among different insecticidal treatments, which was followed by betacyfluthrin (20.28/m²), cypermethrin (19.21/m²) and deltamethrin (19.85) which were statistically at par and superior. Most detrimental (3.06/m²) insecticide was betacyfluthrin + imidacloprid followed by neonicotinoid (3.59/m²). It is concluded that neem oil was the safest whereas betacyfluthrin + imidacloprid and neonicotinoid were detrimental. The finding is supported by Peter (1988), who stated the *Cyrtorhinus lividipennis* was the most abundant predator reaching to the tune of 18.65 nymphs per hill at 50 DAT but due to application of chemical insecticide their population declined to 7.45 nymph per hill.

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Taro insect pests and their management with particular reference to colocasia corm borer, *Apolosonyx chalybeus* Hope in the north eastern region

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Taro, *Colocasia esculenta* is the major tuber crop of tropics and its cultivation extends up to sub temperate environments. Its corms, cormels, petioles and leaves can be consumed fresh and their storage also is possible for off-season and marketing. Northeastern region is the centre of origin of various aroids and is known for both wild and cultivated types, due to long rainy season and high humidity. Number of insect pests including some new species was found associated with this crop in the Khasi Hills of Meghalaya, the world highest rainfall area.

Colocasia corm borer, *Apolosonyx chalybeus* Hope was recorded as the most serious pest of taro. Among the aphids, melon aphid, *Aphis gossypii* L. was the major pest during dry and hot periods, while leafhopper (*Tarophagus* sp.), hornworm (*Hippotion* sp.), whitefly (*Bemisia tabaci* L.), tobacco caterpillar (*Spodoptera litura* L.), leaf roller (*Myrioblephara simpalaria* Swin.), chrysomelid (*A. scutellatus* Baly), white grubs (*Anomala* sp., *Maladera* sp. and *Gonocephalum* sp.) were the minor pests. In the storage, corm caterpillar, *Palpifer murinus* (Moore) was found to be the major pest.

Colocasia corm borer had not so far been recorded as a pest of crops anywhere in the world. In the north eastern region too, it was found destructive in Meghalaya only at an elevation ranging from 1000 to 2000 m msl, the highest rainfall area of the world, e.g., Mawsynram (Cherrapungi) with an average 11430 mm annual rainfall. Adults of this pest emerged in May and fed upon taro leaves on the lower surface, until August. Thus, maximum number of beetles i.e., 92.05 on 15 June and maximum leaf damage on 1 July i.e., 1207.42 leaf holes 1000^{-1}plants were recorded (Fig. 1). On disturbance due to agricultural operations, rainfall and wind and also during the dry period and high temperature the adults migrated to leaf sheath, unweeded plots, grassy bunds and cracks and crevices in the soil. Mating took place in June. As a result the females increased in weight, could not fly and preferred to lay eggs at the plant base in July. Feeding of the corms by the grubs became known in August, which continued up to October. Grub feeding resulted in the flow of corm mucilage, which protected the pest from parasites, predators, rainfall and even the insecticide sprays. Maximum plant damage by the grubs i.e., 17.89 per cent was recorded on 15 November, and 24.11 per cent damage was recorded during August to October.

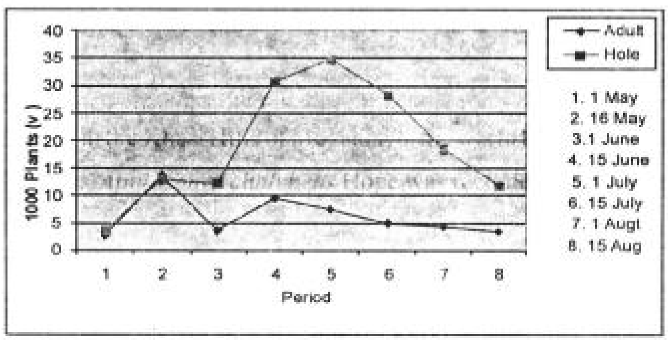

Fig. 1 Colocasia corm-borer adults and their damage

Melon aphid, became the major pest during hot and dry periods of May. Therefore, late crop sown in May was not found to suffer from the damage. The aphid colonized on the under surface of the leaf and was found associated with coccinellid predators and the fungal pathogens. Therefore, spraying of fungus, *Verticillium lecanii*. was preferred instead of systemic insecticides safety of very effective coccinellid predators. In order to manage the colocasia corm borer, hand picking of adults and their destruction during May and June, before their mating and egg laying, was found safe and economical. All the management practices viz., synthetic insectides, biopesticides, parasites and predators failed after the entry of the grubs of this chrysomelid into the corms. Therefore, on the first appearance of the corm damage, the application of insecticide dusts viz., carbaryl-5D and quinalphos-5D @ 5 g $plant^{-1}$ and spraying of endosulfan (0.05 %) malathion (0.05 %) and deltamethrin (0.001 %), was found promising. Application of entomogenous fungi, *Beauveria bassiana* @ 10^9 spores ml^{-1} water was also found effective against the grubs when applied at the root-zone in July. During storage of the corms, corm caterpillar was recorded as the third major pest. Changing of the storage pit and storage site after every two years alongwith proper hygiene was found to keep this pest at bay until the next sowing season. Seed corms could also be kept free from when dipped overnight in 0.1 % chlorpyriphos.

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Field screening for resistant genotypes of teak against major insect pests

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Teak (*Tectona grandis*) is an undisputed global leader of high quality tropical timbers. Madhya Pradesh, the heartland of India, is one of the most important states with extensive teak forests, highest number of superior teak clones, teak seed orchards (TSOs) both clonal seed orchards (CSOs) and seedling seed orchards (SSOs) and famous for its high quality wood (Tewari *et al*., 1992). Surprisingly, teak is always under a serious threat of insect pests. Among all, *Hyblaea puera* Cramer (Lepidoptera : Hyblaeidae) and *Eutectona machaeralis* (Walker) (Lepidoptera : Pyralidae) are considered as key pests of teak, causing serious damage in nurseries, man-made and natural forests. The present study is an attempt to explore the resistant genotypes of teak of Madhya Pradesh against its major insect pests, through field screening. Teak clones of MP origin planted in Teak Seed Orchard (TSO) located at Ghisi, Behrai, Seoni, Madhya Pradesh, were considered as a source.This seed orchard is an assemblage of 123 superior teak clones collected from 8 forest divisions of Madhya Pradesh, viz., Balaghat, Betul, Chhindwada, Hardha, Hoshangabad, Khandwa, Mandla and Seoni and planted during 1977-1985 with a total area of 50 ha (Comp.No 54, with RBD and 8 x 8 m spacing in 10 plots).

The screening for resistance was made by quantitative assessment of the severity of the damage by rating infested leaves through ocular estimation on the basis of percentage of affected leaves of branches in four directions of the tree as a whole. The observations on the damage intensity were recorded once in a year after completion of outbreak when the population of target pests was negligible during the first week of September and November for *H. puera* and *E. machaeralis*, respectively. Observations were recorded for all the clones separately, minimum for 10 ramets of a clone in, a plot and the degree of damage worked out on the basis of average of three years from 2002-2004. The data were subjected to ANOVA (RBD) and categorization of clones for degree of resistance done based on mean and CD values.

Table 1 Highly resistant MP teak clones against *H. puera* and *E. machaeralis* TSO, Behrai, Seoni

MP teak (Code)	Locality from where plus tree selected	Clone	Total
C	Seoni Kurai	C – 2, 3, 4, 8, 9, 11, 54	7
F	Betul	F-1	1
G	Betul	G-1	1
K	Khandwa	K-1	1
PT	Seoni Rukhar	PT – 1, 26, 41, 45, 46, 47	6
BHC	Bori Hoshangabad	BHC-19	1
CSC	Chhindwada Sillewani	CSC-9	1
Total			18

The assessment of larval damage by *H. puera* and *E. machaeralis* on 123 MP teak clones indicated that significant ($P<0.05$-$P<0.01$) variations existed in defoliation impact within the clones and over the years. These teak clones were categorized (ranked) in to 4 groups based on their grand total average value and CD over the years, for both the target pests, which are as follows: highly resistant (HR), resistant (R), susceptible (S) and highly susceptible (HS). In case of *H. puera*, 34 clones were found to be highly resistant, followed by 15 clones as resistant, 48 clones as susceptible and 26 clones as highly susceptible. Similarly for *E. machaeralis*, 45 clones were noticed to be highly resistant, 4 clones as resistant, 4 clones as susceptible and 70 clones as highly susceptible. Based on the damage intensity 18 clones were considered and found to be common for both *H. puera* and *E. machaeralis*, recorded to be least preferred and ranked as highly resistant (HR) (Table 1).

Existence of resistance in teak to *H. puera* and *E. machaeralis* has been suggested by many field and laboratory observations. The cause of resistance could be the result of escape from insect attack due to difference in flushing time, which in turn may have been caused by chemical, environmental or genetic factors (Roychoudhury, 2007). But, no such information is available on insect resistance in teak of Madhya Pradesh origin, which has been achieved now.

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Antifeedant activity of medicinal plant extracts against *Spodoptera litura* (F.)

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Biointensive IPM or ecology based pest management is the need of present day agriculture. The interest in botanical insecticides resulted from the need to provide alternatives for the synthetic insecticides whose adverse effects on agroecological systems are well known. Most plant defensive chemicals discourage insect herbivory either by deterring feeding and oviposition or by impairing larval growth rather than by killing insect outright; hence these attractants, repellants and growth regulators are proved to be effective weapons in IPM. Keeping this in view, attempt has been made to screen antifeedant activity of twelve medicinal plant extracts against *Spodoptera litura* (F.). Laboratory culture of *S. litura* was maintained on castor leaves at 27±1°c and R.H. 75±5 % in BPNP laboratory of Department of Entomology, GBPUA&T., Pantnagar. Each of the twelve plant species *viz., Bacopa monnieri, Plumbago zeylanica, Andrographis paniculata, Rauvolfia serpentina, Withania somnifera, Aloe barbadensis, Bixa orellana, Mucca pruriens, Elatteria spp., Cryptolepis buchananii, Cinnamomum camphora* and *Centella asiatica* were extracted in water and then diluted to make 50%.Twelve treatments (each replicated thrice with n=10 larvae) excluding control were taken. Data were recorded on mean leaf area consumed (MLAC), mean feeding (%), feeding inibtion (%), antifeedant activity (%) and preference index (C-value).

Table 1 Antifeedant activity of medicinal plant extracts against *Spodoptera litura*

S. No	Scientific name	Common Name	Conc.	MLAC (cm^2)	Mean Feeding (%)	Feeding Inhibition (%)	Antifeedant activity (%)	C-Value
1	*Bacopa monnieri*	Brahmi	50	15.017	41.714	32.096	48.595	0.679
2	*Plumbago zeylanica*	Chitrak	50	16.943	45.814	27.83	43.542	0.722
3	*Andrographis paniculata*	Kalmegh	50	13.093	36.369	30.067	55.181	0.619
4	*Rauvolfia serpentina*	Sarpgandha	50	23.387	64.964	9.972	19.943	0.889
5	*Withania somnifera*	Ashwgandha	50	7.79	21.639	57.485	73.334	0.421
6	*Aloe barbadensis*	Aloe vera	50	17.273	47.981	25.685	40.872	0.743
7	*Bixa orellana*	Sinduri	50	25.27	70.194	7.237	13.498	0.928
8	*Mucca pruriens*	Kaunch	50	18.153	50.425	20.3	37.86	0.796
9	*Elatteria spp.*	Elaichigrass	50	26.68	74.111	4.532	8.683	0.955
10	*Cryptolepis buchananii*	Dudhibael	50	24.093	66.925	9.604	17.526	0.904
11	*Cinnamomum camphora*	Camphor	50	7.493	20.814	59.173	74.35	0.408
12	*Centella asiatica*	Mandokparn i	50	29.45	81.806	-0.404	-0.812	1.004
	Control	-	-	29.213	81.147	-	-	1
	SEm±	-	-	1.099	-	-	-	-
	CD at 1%			4.319				
	CD at 5%			3.195				

It is revealed from the results of table 1 that none of the plant extracts showed extreme antifeedant activity (i.e C-value 0.10-0.25). The extracts of *C. camphora* and *W. somnifera* proved to be strong antifeedant with their C-value in between 0.26-0.50 i.e., 0.408 and 0.421, respectively. *C. asiatica* was observed to be the preferred plant extract with -0.802% antifeedant activity and preference index more than 1.0. Out of twelve medicinal plant extracts used in screening five plant extracts *viz., P. zeylanica* (43.542%), *B. monnieri* (48.595%), *R. serpentina* (55.181%), *W. somnifera* (73.334%) and *C. Camphora* (74.350%) showed antifeedant activity more than 40%. Behra and Satapathy (1997) reported 1.25,2.5,5.0 and 10.0% of neem seed kernel extract was found to be the most toxic against 4th instar larvae of *S. litura*. Medicinal plant extracts caused reduction in feeding in comparison to control (MLAC=81.147cm^2) except *C. asiatica.* Ramangouda (2007) also concluded that aqueous extracts of nine medicinal plants caused reduction in feeding (6.70cm^2) except *S. cumuni* (6.78 cm^2). Hence, these plants could be the best alternative and ecofriendly strategy for managing this polyphagous pest.

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Growth inhibition effect of *Annona squamosa* crude extracts on the larvae of teak skeletonizer, *Eutectona machaeralis* (Walk.) (Lepidoptera : Pyralidae)

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The hazardous environmental implications of excessive chemical uses past have given impetus to the biorational and ecofriendly methods for the management of insect pests. Same is also true for insect pests affecting forest tree species in India (Kulkarni *et al.*, 2008). Amongst these, forest nurseries require frequent monitoring and management of insect pests due to the agriculture like ecosystem (Kulkarni, 2006). Teak is the major forest crop in central India, which is attacked by a major defoliator, *Eutectona machaeralis* Walker. Although, chemical insecticides have been evaluated against this pest (Joshi *et al.*, 2001), evaluations of natural insecticides of botanical origin have not yet been taken up. The paper reports bioassay results of crude extracts of *Annona squamosa*.

The effect of feeding sublethal doses of serially extracted petroleum ether, ethyl acetate, acetone and water extracts by leaf treatment method (concentration range) on the larvae of teak skeletonizer was investigated. The initial larval weight, final larval weight, Pre-pupal weight and pupal weight were subjected to Analysis of Variance (ANOVA) using Genstat ver.2 statistical software. Values of final larval weights were adjusted with initial larval weight as covariate to avoid effect of difference in initial larval weights. Results revealed that petroleum ether and ethyl acetate extracts significantly inhibited the normal growth in terms of final larval weight, pre-pupal and pupal weights. Petroleum ether extract inhibited larval growth at and above 100 ppm with final larval weight of 0.036g ($F_{(0.031)}$=3.44, $LSD_{(P<0.05)}$=0.012) and prepupal weight of 0.032g ($F_{(0.001)}$=5.15, $LSD_{(P<0.05)}$=0.016) as against control with final larval and prepupal weight of 0.058g and 0.040g, respectively ($P<0.05$). There was significant reduction in larval and prepupal weight at maximum concentration of 3000 ppm tested. No larvae reached pupal stage as against the control. Similar results were available with the ethyl acetate extract. Effect with ethanol and water extracts were not statistically significant ($P>0.05$).While there are some preliminary reports on the antifeedant effect of botanicals including *A. squamosa* on teak skeletonizer (Kulkarni, et al., 1996; Kulkarni, 2001; Kulkarni *et al.*, 2008), growth inhibitory effect of *A. squamosa* has not been reported earlier against the teak skeletonizer to compare the present results. The investigation is significant to develop plant-based biopesticide against the insect pests attacking forest nurseries.

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Bioefficacy of botanical insecticides against shield-backed bug, *Scutellera nobilis* (Fabricius) on *Jatropha curcus*

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Investigation on bio efficacy of botanical insecticides against *Scutellera nobilis* on jatropha was carried out at Anand Agricultural University, Anand (Gujarat) during 2006-07. Of the ten botanical insecticides evaluated against *S. nobilis*, azadirachtin based formulations Vanguard (0.4%), Gronim (0.4%), Neemazal-F (0.1%) and Achook (0.4%) performed better to protect the jatropha shrubs from infestation of *S. nobilis*. The application cost of these effective botanicals was 1550 to 3500 Rs/ha.

The jatropha, *Jatropha curcus* can be used as fuel, fertilizers, medicine and industrial material for soap, candle, cosmetics and oil as raw material. The oil can be converted into biodiesel by transesterification. Oil cake is used as organic manure. This industrial crop is cultivated in central and western parts of India. The crop is attacked by a few insect pests which cause severe reduction in production and quality. The important and common insect pests found are leaf webber, semi looper, shield-backed bug (*Scutellera nobilis*), bloch miner, termite, aphid, jassid and thrips. Among these shield-backed bugs is the key pest of the jatropha crop in Gujarat. The nymph and adult suck the cell sap from leaves and tender parts of the plant, flowers and capsules. Information on ecofriendly measures is lacking and henceforth study was carried out on bio efficacy of some botanical insecticides. The experiment was conducted at Agronomy farm, Anand Agricultural University, Anand in large plots. Raised jatropha crop having equal size and age with spacing of 2 m between plants were used. Three plants were allotted in each treatment and each treatment replicated thrice observations on number of nymphs per plant recorded before and 1, 3, 7, 10 and 15 days after application. The data obtained were statistically analyzed and to know the economics, total cost of insecticides per hectare was calculated.

Table 1 Effectiveness of various botanical insecticides against *S. nobilis* on jatropha and its economics

Botanicals	Mean population of Nymphs / plant				Cost for two sprays (Rs/ha)
	Before spray	After spray			
		First	Second	Pooled	
Neemazal-F 0.1%	3.34^{a} (11.15)	3.07^{bcd} (9.43)	2.66^{bcd} (7.07)	2.86^{bcd} (8.18)	1516
Econeem 0.1%	3.39^{a} (11.49)	3.27^{ab} (10.69)	2.91^{abc} (8.47)	3.09^{abc} (9.55)	1438
Gronim 0.4%	3.31^{a} (10.96)	2.94^{cd} (8.64)	2.51^{cd} (6.30)	2.73^{cd} (7.45)	3518
Vanguard 0.4%	3.33^{a} (11.09)	2.83^{d} (8.01)	2.38^{d} (5.66)	2.60^{d} (6.76)	2366
Azadex 0.4%	3.33^{a} (11.09)	3.20^{abc} (10.24)	2.83^{abc} (8.01)	3.01^{abc} (9.06)	3086
Achook 0.4%	3.43^{a} (11.76)	3.11^{bcd} (9.67)	2.71^{abcd} (7.34)	2.91^{bcd} (8.47)	3006
Niconeem 0.4%	3.40^{a} (11.56)	3.28^{ab} (10.76)	2.93^{abc} (8.58)	3.11^{ab} (9.67)	2526
Neem oil 0.5%	3.39^{a} (11.49)	3.35^{ab} (11.22)	3.00^{ab} (9.00)	3.17^{ab} (10.05)	1166
NSKE 5%	3.34^{a} (11.15)	3.15^{abc} (9.92)	2.78^{abcd} (7.73)	2.96^{abc} (8.76)	816
NLE 5%	3.43^{a} (11.76)	3.35^{ab} (11.22)	3.03^{ab} (9.18)	3.19^{ab} (10.18)	766
Control	3.44^{a} (11.83)	3.45^{a} (11.90)	3.15^{a} (9.92)	3.30^{a} (10.89)	--
S. Em. ±	0.07	0.09	0.13	0.11	--
C.D. at 5%	NS	0.28	0.37	0.33	--
C. V. %	13.82	13.08	14.32	12.32	--

* Figures in parentheses are retransformed values, those outside are $\sqrt{X+0.5}$ transformed values. Treatment means with letter (s) in common are at par by DNMRT

The mean results of first spray showed higher effectiveness of Vanguard by registering the lowest (8.01 nymphs/plant) population and it was at par with Gronim (8.64), Neemazal-F (9.43) and Achook (9.67) (Table 1.). Neem seed kernel extract (NSKE) and Azadex exhibited nymphal population of 9.92 and 10.24 per plant, respectively and these were as effective as the three azadirachtin based formulations. The highest (11.22) nymphal population was observed in neem leaf extract (NLE) and neem oil (NO) treated plots.

The mean population of the pest after second spray exhibited the higher effectiveness of Vanguard by recording lower (6.26) nymphal population and it was at par with Gronim, Neemazal-F, Achook and NSKE. Azadex, Econeem and Niconeem treated plots exhibited nymphal population 8.50, 8.68 and 9.11 per plant, respectively. These three azadirachtin based formulations were as effective as earlier four botanicals in reducing the pest. Among the evaluated botanicals, NO and NLE registered higher (9.00 and 9.18 nymphs/plant, respectively) population of *S. nobilis* on jatropha.

Pooled results (Table 1 and Fig. 1) revealed that Vanguard recorded significantly lower (6.76 nymphs/plant) population of *S. nobilis* than all other tested botanicals except Gronim (6.89), Neemazal-F (7.53) and Achook (7.91). The NSKE, Azadex and Econeem recorded 8.20, 8.50 and 8.68 nymphs per plant, respectively. The NLE recorded highest (9.68) nymphal population followed by NO and Niconeem (9.11). On the basis of overall results, it can be concluded that the neem based formulations Vanguard, Gronim, Neemazal-F and Achook proved more effective in reducing the *S. nobilis* incidence on jatropha. The effectiveness of Achook was reported against mango hopper and thrips (Kumara and Bhatt, 1999) and safflower aphid (Pal *et al*., 2004) by earlier workers. The NSKE, Azadex, Econim, neem oil and neem leaf extract fail to check the population of *S. nobilis* on jatropha. Amjad *et al*. (1998) reported less effectiveness of NSKE and neem oil against jassids on cotton.

The crude extact of neem leaf registered lowest (766.40 Rs/ha) cost of application for the control of *S. nobilis* on jatropha followed by crude extract of neem seed kernel (816.40) and neem oil (1166.40). Similarly, the cost of application of Econeem, Niconeem and Azadex were 1438.40, 2526.40 and 3086.40 Rs/ha, respectively. These six botanicals were proved less effective against shield-backed bug on jatropha. The cost of applicationof humidity. They could not sustain against extreme climatic conditions.

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Effects of *Eucalyptus* and *Callistemon* extracts against *Helicoverpa armigera* (Hubner)

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Cotton bollworm/legume pod borer, *Helicoverpa armigera* (Hubner), is one of the most devastating pest worldwide. The problem is magnified due to its direct attack on fruiting structures, voracious feeding habits, high mobility and fecundity, multivoltine, overlapping generation with facultative diapause, nocturnal behaviour, migration, host selection by learning and propensity for acquiring resistance against wide range of insecticides. There is need to develop management strategies based on botanicals. Keeping in view, the present study was conducted to assess the bioactivity of the ethanolic extracts of *Eucalyptus camaldulensis* and *Callistemon lanceolatus* under laboratory conditions using 'artificial diet surface incorporation technique'.

Laboratory culture of *H. armigera* was maintained in environmental simulation walk-in chamber (temperature $27\pm1^{\circ}C$, $65\pm5\%$ relative humidity, 16:8 h scoto : photophase regimes) on artificial diet in the Division of Entomology at the Indian Agricultural Research Institute, New Delhi. Different concentrations of leaf extracts of *Eucalyptus* and *Callistemon* (supplied by The Energy Research Institute, New Delhi) were prepared by serial dilution technique. A randomized complete block design was used mortality data were recorded daily till pupation and moribund larvae were treated as dead. Larval weights were recorded at 6 and 10^{th} day of the treatment. The values of AI_{50} and GI_{50} were estimated by using Indostat.

Table 1 Antifeedanty and growth inhibitior on effect of *Eucalyptus* and *Callistemon* extracts on *Helicoverpa*

Index	Plant Extract	Larval weight (mg)	Chi square	Regression equation Y=	AI_{50} / GI_{50} value (%)	Fiducial limits (%)
Antifeedant Index (AI_{50})	*Eucalyptus camaldulensis*	6-day old	0.966	8.416+2.780x	0.059	0.051-0.067
		10-day old	2.928	7.663+2.121x	0.055	0.045-0.068
	Callistemon lanceolatus	6-day old	1.919	6.641+1.533x	0.085	0.070-0.103
		10-day old	2.137	6.202+1.016x	0.065	0.047-0.092
Growth Inhibition Index (GI_{50})	*Eucalyptus camaldulensis*	6-day old	9.562	11.214+5.430x	0.072	0.054-0.094
		10-day old	25.649	13.041+7.270x	0.069	0.047-0.101
	Callistemon lanceolatus	6-day old	1.948	7.219+2.328x	0.111	0.097-0.127
		10-day old	20.460	7.124+2.239	0.112	0.042-0.301

It is evident from Table 1 that *E. camaldulensis* proved more potentd than the *C. lanceolatus* in terms of antifeedancy (AI_{50} 0.059%, 0.085%) even at 6 -day old larvae. Due to feeding of artificial diet-intoxicated with *Eucalyptus camaldulensis* less amount of food was consumed and its weight was adversely affected, and also it inhibited the growth (0.072% and 0.069%). However, in case of *C. lanceolatus*, GI_{50} was noted as 0.111% and 0.112%. Insecticidal, antifeedant and growth inhibitory activities of essential oils of *C. lanceolatus* and *Eucalyptus* spp. has been well documented against *Spodoptera litura* third instar larvae (Sharma *et al.*, 2001). Our results are in agreement with these studies. Leaf extract of *E. camaldulensis* and *C. lanceolatus* were effective in physiological and behavioral disruption of the test-insect while simultaneously preserving the balance and cleanliness of the agroecosystem. Such plant extracts can well be used as alternatives for developing IPM strategy against *Harmigera*

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Acaricidal activity of two neem formulations, against tea red spider mite

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Experiments were carried out in the Acarology Laboratory, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal to evaluate the effect of two neem formulations viz. Neemazal-F(azadirachtin 5%) and Neemazal-T/S(azadirachtin 1%) with or without additives against egg, nymph and adult stages of tea red spider mite, *Oligonychus coffeae*. Leaves of the tea clone -TV_{19} were used for the experiment. In the first set of experiment, ten treatments- T_1-Azadirachtin 5% alone @0.01%, T_2-T_1 + Silicon oil @ 0.3%, T_3 - T_1 +Oleic acid @1%, T_4 -T_1+ Cyclohexane @1%, T_5 - T_1 + Iso-amyl acetate @ 1%, T_6 - Silicon oil @ 0.3%, T_7 - Oleic acid @1%, T_8 - Cyclohexane @1%, T_9 - Iso-amyl acetate @ 1% and T_{10} - Untreated check (water spray), were maintained. In the second set of experiment, similar treatments were maintained instead of azadirachtin 5%, azadirachtin 1% was used. Hand atomizer was used for spraying. In all the treatments including control, APSA @ 0.33% ml/lit was added before spraying. All the treatments were replicated three times and each replica comprised of five leaf disc of 2 cm^2 sizes. Known number of three different life stages was released separately, in different treatments. Observations for the nymph and adult mortality were recorded in 24hrs (1 day), 72hrs (3days) and 120hrs (5 days) after treatment. In case of egg, mortality was recorded on the 8^{th} day after treatment observing the number of larvae hatch out. CRD method was applied for statistical analysis.

Table 1 Effect azadirachtin additives against red spider mite

Treatments	Dose (%)	Azadirachtin 5%			Azadirachtin 1%		
		Ovicidal effect (%)	% mortality at 5 DAT		Ovicidal effect (%)	% mortality at 5 DAT	
			Nymph	Adult		Nymph	Adult
Azadirachtin alone	0.01	75.83 (60.88)	62.93 (52.79)	60.33 (51.25)	54.26 (47.73)	48.98 (4.70)	44.47 (42.06)
Azadirachtin + Silicon oil	0.01+0.3	96.21 (79.54)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Azadirachtin + Oleic acid	0.01+1.0	90.18 (72.22)	96.08 (79.31)	97.60 (82.07)	95.86 (79.00)	98.32 (83.76)	98.30 (83.71)
Azad.+ Cyclohexane	0.01+1.0	91.08 (73.13)	64.37 (53.65)	63.16 (52.92)	93.60 (75.94)	58.24 (50.03)	56.74 (49.16)
Azad.+ Isoamyl acetate	0.01+1.0	61.29 (51.81)	58.88 (50.40)	55.30 (48.33)	65.78 (54.50)	38.57 (38.68)	47.19 (43.67)
Silicon oil	0.3	62.02 (52.25)	71.25 (57.89)	73.40 (59.27)	62.02 (52.25)	71.25 (57.89)	73.40 (59.27)
Oleic acid	1.0	53.26 (47.15)	69.52 (56.80)	70.10 (57.16)	53.26 (47.15)	69.52 (56.80)	70.10 (57.16)
Cyclohexane	1.0	48.91 (44.56)	51.19 (45.96)	52.02 (46.44)	48.91 (44.56)	51.19 (45.96)	52.02 (46.44)
Isoamyl acetate	1.0	28.74 (32.73)	28.67 (32.68)	27.65 (32.04)	28.74 (32.73)	28.67 (32.68)	27.65 (32.04)
Untreated check		8.27 (17.22)	3.01 (10.79)	4.35 (12.72)	8.86 (17.81)	3.68 (11.79)	3.68 (11.79)
C.D.0.05		3.55	4.65	3.78	3.13	3.27	2.49

Figures in parentheses are angular transformed values

Azadirachtin 5% alone gave 60.33 per cent adult mortality at 5 days after treatment (DAT) (Table 1). The additives- silicon oil, oleic acid, cyclohexane and iso-amyl acetate alone gave 73.40, 70.10, 52.02 and 27.65 per cent mortality at 5 DAT, respectively. When the azadirachtin 5% was mixed with the additives synergistic effect was observed. Azadirachtin with silicon oil gave 100 per cent adult mortality at 5 DAT and it was followed by azadirachtin + oleic acid with 97.60 per cent mortality. Against the eggs, combination of azadirachtin + silicon oil gave the highest mortality with 96.21 per cent. Azadirachtin + cyclohexane and azadirachtin + oleic acid gave 91.08 and 90.18 per cent egg mortality, however they were on par. Azadirachtin 5% alone also gave high ovicidal activity with 75.83 per cent mortality. Against the nymphal stage, azadirachtin 5%, silicon oil, oleic acid, cyclohexane and isoamyl acetate gave 62.93, 71.25, 69.52, 51.19 and 28.67 per cent mortality, respectively at 5 DAT. Highest nymphal mortality of 100 per cent was observed in azadirachtin + silicon oil and it was followed by azadirachtin and oleic acid (96.08 per cent). With respect to azadirachtin 1%, spraying at 0.01% gave 44.47 percent adult mortality at 5 DAT however when combined with silicon oil 100 per cent mortality was observed. Azadirachtin 1% + oleic acid could killed 98.30 percent *A*dult at 5 DAT. Similarly, azadirachtin 1% + silicon oil also gave highest mortality of eggs (100 per cent) and it was followed by azadirachtin + oleic acid (95.86 per cent). Azadirachtin + cyclohexane also gave high mortality of egg (93.60 per cent) and it was comparable with azadirachtin + oleic acid. Azadirachtin 1% alone recorded 54.26% egg mortality. Azadirachtin 1% + silicon oil and azadirachtin + oleic acid were also found highly effective against the nymphal stage with 100 and 98.32 percent mortality at 5 DAT, respectively. Azadirachtin 1% alone gave 48.98 per cent mortality. Increased in aphidicidal activity of Neemazal-T and Neemazal-T/S on *Aphis craccivora* with addition of synergists *viz*., ethyl oleate, sesame oil and dimethyl sulphoxide (DMSO) was observed by Dimetry and Hawary (1997). Walter and Stark (1996) and Ascher *et al*. (1996) reported the qualitative improvement of chemicals using additives against different insect pests.

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Botanicals against Bihar hairy caterpillar

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Botanicals are the means to sustainable pest-management in the changed and well-aware progressive farming sector. Many-a-times, botanicals though are not effective, are promoted for obvious reasons. However, it is high time that, we know better both the pros and cons of phyto-pesticides. One should not be complacent that his/her pest-management-strategy includes botanicals, but at the same time assures satisfactory control as well. In this context, a hardy test-insect, Bihar hairy caterpillar (*Spilarctia obliqua* Walker, Lepidoptera: Arctiidae) was taken as the test-insect which is pest of more than 20 cash crops in northern India (Prajapati *et al.*, 2002). Laboratory trials (temp. 27±2°C, RH 60-70%, 16:8-h scoot/photophase regime) were conducted investigating the bio-efficacy of few botanicals *viz.*, most important active ingredients of neem (Azadirachtin, Aza), *Pongamia*/ karanj (Karanjin); crude extractives of CNSL and Jatropha (aqueous) extractives. Two conventional insecticides (indoxacarb and bifenthrin) were also tested.

The 7-day old larve of *S. obliqua* were reared on castor leaves, subjected to bioassay by feeding method (leaf-treatment, table not given), and direct-spray by potter's tower method (Table 1). Larval mortality never exceeded 25% in botanicals in oral/feeding bioassay (maximum conc. of Aza-1000ppm, Karanjin, Jatropha and CNSL 1% crude). In contact-toxicity-bioassay (potter's tower), larval mortality till pupation were 20, 25, 30,. 35, 38 and 34 percent CNSL, *Pongamia*, Aza (100ppm), Aza (200ppm), Aza (500ppm) and Aza (1000ppm), respectively; as against zero mortality in control (blank). Though slightly higher mortality was observed in Aza-500ppm than 1000ppm; the abnormal adult-emergence was 20 and 24 per cent for these two treatments. Inconsistent and ineffective mortality *i.e.*, less than 50 per cent even in higher test-concentrations in laboratory screening depicts clearly that these phyto-pesticides are not suitable to take to field. Inconsistent outcome in the contact-toxicity (most probably due to the hairy nature of larvae) made the statistical analyses invalid, though the experiment was repeated thrice. Two synthetic insecticides were also bioassayed for their contact-toxicity by potter's tower. The regression equations are given as follows with LC_{50} values with fiducial limits (p=0.05%).

Table 1 effect of botanical son larval mortality and adult emergence of *S. obliqua*

Sl. No.	Treatments	Larval mortality till pupation (%)	Adult emergence (%)
1	Control	0	68
2	CNSL (1%)	20	35
3	Jatropha (1%)	20	50
4	Karanjin (1%)	25	35
5	Aza 100ppm	30	20
6	Aza 200ppm	35	25
7	Aza 500ppm	38	52
8	Aza 1000ppm	34	58

Mean of 3 replicates (N=30)

1. Indoxacarb $Y=7.5847+1.5244x$, $LC_{50}=0.0203\%$ (FL 0.0127 0.0324%)
2. Bifenthrin $Y=10.487+1.565x$, $LC_{50}=0.0003\%$ (FL 0.0002 0.0004%)

Bifenthrin was found superior than indoxacarb against *S. Obliqua*. Though negative in outcome, the message is alarming and warns the pest-control-operators not to rely on botanicals for control of *S. obliqua*. More detailed research should be directed in such trials to educate farmers about the negations of more botanicals also. Our approach ought not be just idealist, but also much more realistic and pragmatic in solving the pest-problems.

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Efficacy of *Bacillus thuringiensis* Berliner against Bihar hairy caterpillar, *Spilarctia obliqua* (Walker) (Lepidoptera: Arctiidae)

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Microbial products have a long history of safe use and most of these are compatible with other methods of pest control. Literature reveals that hundreds of toxicogenic strains of *Bacillus thuringiensis* Berliner exist. Each strain produces its own unique -endotoxin. The insecticidal activity of the toxins varies widely among strains. In addition to that there is often a considerable diversity in efficacy within a single strain. Moreover, the medium on which a strain is grown also affect the efficacy (Srivastava and Ramakrishnan, 1980). The present study evaluated the susceptibility of Bihar hairy caterpillar *Spilarctia obliqua* (Walker) (Lepidoptera: Arctiidae), a polyphagous insect pest causing severe damage to agricultural as well as horticultural crops.

Bioassays were done separately with each of five *B. thuringiensis* (*Bt*) subspp. *viz*., *Bt galleriae, Bt sotto, Bt entomocidus, Bt thuringiensis* and *Bt aizawai*, four *Bt* strains *viz*., *Bt kurstaki* (*Btk*) path-1, *Btk* HD-1, *Btk* HD-73 and untypified strain *Bt* N1C1 along with commercial formulation *Dipel*®8L to determine the bioefficacy of each microbial pathogen against third instar larvae of *S. obliqua* under laboratory conditions at 28 1°C and 70 5 per cent relative humidity. The test insect was collected from the fields of Indian Agricultural Research Institute, New Delhi. The different subspp./strains were multiplied as mentioned in Capalbo *et al*. (2001). The spore-crystal complex was recovered by the procedure of Dulmage (1970). A series of six concentrations (0.12, 0.10, 0.08, 0.06, 0.04, 0.02 per cent) was prepared for carrying out the bioassays. Castor leaf disks (5 cm diameter) were treated by leaf dip method. For control, the leaf disks were dipped in sterile distilled water only. Treated leaves were dried and twenty larvae at third instar, already starved for two hours were released in three replications for twenty-four hours and thereafter, untreated food was provided to them till pupation. Observations on mortality of larvae were recorded after every twelve hours till the pupation. Moribund larvae were also considered as dead.

The observations revealed that all the five *B. thuringiensis* subspp, four *B. thuringiensis* strains along with commercial formulation *Dipel*®*8L* were effective. The lowest LC_{50} value was observed in the case of *Btk* HD-73 (0.09505%), whereas, highest LC_{50} value was obtained in the case of *Btk* path-1 (0.12458%) (Table 1). *Btk* HD-73 was followed by *Bt sotto, Bt aizawai, Bt* N1C1 and *Btk* HD-1, respectively. However, *Bt thuringiensis*, Dipel®8L, *Bt entomocidus*, *Bt galleriae* and *Btk* Path-1, respectively register high LC_{50} values. Valicente and Fonseca (2004) found highest mortality by *B. thuringiensis* subsp. *tolworthi* and the lowest by *B. thuringiensis* subsp. *kurstaki*. It was concluded that the insecticidal activity of the toxins from each strain of *B. thuringiensis* varied widely hence it is imperative to screen a wide variety of strains to select more potential strains.

Table 1 Comparison of LC values of different *B. thuringiensis* sub spp. against *S. obliqua*

Treatments	Df	Regression equation =Y	LC_{50}	LC_{90}	LC_{95}	LC_{99}
Btk Path-1	6	Y= -2.163005 +3.418383x	0.12458	0.29536	0.37725	0.59699
Bt galleriae	6	Y= -2.139485 +3.423038x	0.12182	0.28848	0.36834	0.58253
Bt sotto	6	Y= -0.447012 +2.746005x	0.09630	0.28205	0.38250	0.67729
Bt entomocidus	6	Y= -1.991092 +3.374952x	0.11789	0.28262	0.36212	0.57643
Bt thuringiensis	6	Y= -0.690137 +2.813262x	0.10534	0.30072	0.40486	0.70716
Bt aizawai	6	Y= -2.088051 +3.569054x	0.09682	0.22134	0.27980	0.43428
Btk HD-1	6	Y= -1.125185 +3.038209x	0.10377	0.27408	0.36096	0.60497
Btk HD-73	6	Y= -0.864906 +2.965137x	0.09505	0.25715	0.34096	0.57877
Bt N1C1	6	Y= -1.734084 +3.372980x	0.09919	0.23793	0.30489	0.48547
Dipel®8L	5	Y= -0.740857 +2.798114x	0.11264	0.32338	0.43606	0.76396

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Efficacy of entomopathogenic fungus *Beauveria bassiana* (Balsamo) against second instar larvae of *Helicoverpa armigera* Hubner

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The green gram pod borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is one of the most destructive pests of field crops worldwide. Although, chemical control has been a successful tool excessive use has given birth to the high level of resistance and adverse impact on environment. This calls for an urgent need to develop other means of control. Biopesticides formulations based on the entomopathogenic microbials have gained a great success due to their low environmental toxicity and target specificity. *Beauveria bassiana* Balsamo is a wide host range insect pathogenic fungus which is being marketed and used in insect pest management programme (Butt *et al.*, 2001). The important hosts of this fungus are Lepidoptera, Coleoptera and Hymenoptera. In the present investigation, different dilutions of the fungal spores have been tested against the larval instars of *H. armigera*.

Freshly emerged II instar larvae were treated individually in plastic vials (4x4x2) using artificial diet (Nachiappan *et al.*, 1973). For each dilution three replicates each of 10 larvae and one set of 10 larvae for control were used. Fungal preparation was prepared by serial dilutions .0.1, 0.125, 0.2, 0.25ml of 10 spores/ml were applied topically on each larva. Treated larva was kept in vial having 1gm of diet. After 24 hours the first lot was discarded and fresh 1gm was given to each larva. The observations were taken till the completion of life cycle. Different dilutions revealed significant mortality which was dose dependent. The highest dose of 0.25x1x10 ml brought 83.3 percent mortality followed by 66.70, 50.00 and 33.33 percent at dose level of 0.2, 0.125 and 0.1 x10 spores/ml as compared to 30.00 percent in control. ANOVA test when applied revealed significant value of F (Table 1).

Table 1 Efficacy of *Beauveria bassiana* on II instar larvae of *Helicoverpa armigera*

S No	Dose	N	% Mortality	S D	S E
1	Control	3	30.0	1.00	0.58
2	0.100 ml	3	33.0	0.58	0.33
3	0.125 ml	3	50.0	1.00	0.58
4	0.200 ml	3	66.7	0.58	0.33
5	0.250 ml	3	83.3	0.58	0.33

ANOVA

Mortality	Sum of Squares	df	Mean Square	F	Result
Between Groups	60.93	4	15.23	25.39	**
Within Groups	6.00	10	0.60		

Note: ** - Significant at 1% ($p<0.01$); * - Significant at 5% ($p<0.05$).

The treated larvae also revealed some typical morphological abnormalities. Cuticle started rupturing at several places, thereby oozing out fungal spores and mycelium. Loss of skin pigmentation converting skin into pinkish color, swollen and putrefied body was significant at later stages (Fig. 4). At the end of larval life, extensive fungal growth covering the complete larvae was observed. Almost whole larval body has been utilized by the fungus. Heavy sporulation can be seen from mycelium showing the potential infectious source (Fig.3). The casted off excuviae was heavily loaded with fungal mycelium and attached with pupae. Delicate pupal skin about to rupture was also observed on pupal body (Fig.2). Larvae became dried and shrunk at later stages with white patches of fungal mycelium all over the body. Cephalice and abdominal legs became small and shrunk. Head is typically bent downwards with deformed mouth parts (Fig. 1). Bitondi *et al.* (1998) reported profound alterations in cuticular pigmentation and sclerotization during different developmental phase in *Apis mellifera* treated with pyriproxyfen, a juveline hormone analogue; further added that hormonal treatment induced earlier activity of phenoloxidase, an enzyme system is involved in both the processes of melanism and pathogen resistance.

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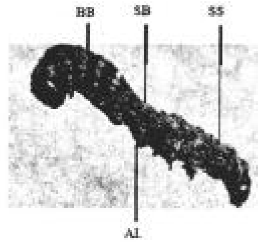


Fig. 1 at Dose 0.1 x 10^8 ml

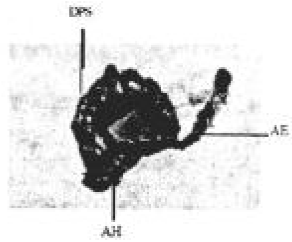
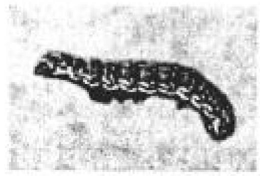


Fig. 2 at Dose 0.125 x 10^8 ml



Normal

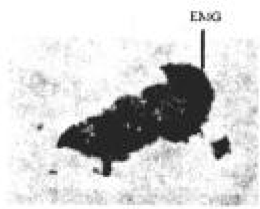


Fig. 3 at Dose 0.2 x 10^8 ml

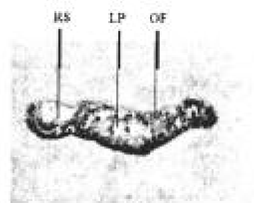


Fig. 4 at Dose 0.25 x 10^8 ml

Formation of blackening of body (BB), swollen basal part of appendages (SB) shrinkage of body skin (SS) and abnormal legs (AL) abnormal exuvial (AE) abnormal head (AH) and delicate pupal skin (DPS) extensive mycelial growth (EMG) ruptured skin (RS), Loss of pigmentation (LP), oozing of fungus (OF)

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Proceedings of the National Symposium on IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh

Studies on feeding behaviour of *Neochetina bruchi* and *N. eichhorniae*, biological control agents of water hyacinth

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Water hyacinth (*Eichhornia crassipes*) is a free-floating aquatic weed. It is a native of Amazon River Basin and has become a major problem in many countries. It is fast growing and difficult to eradicate and if unchecked it can threaten fresh water bodies by clogging them, increasing sedimentation and flooding. It reduces water quality by preventing light penetration and reducing oxygenation of water further threatening the aquatic life (Gopal, 1987). The weevils, *Neochetina bruchi* and *N. eichhorniae* have already established all over India as potential biocontrol agent of waterhyacinth (Jayanth and Visalakshi, 1989). To gain maximum from its biocontrol potential it is very essential to understand its feeding behaviour under the local climatic conditions. So an experiment was conducted under green house condition to understand its feeding behaviour.

Feeding behaviour of the waterhyacinth weevils was observed on small, medium and large growth stages. Five plants from each of the three growth stages were kept in tubs filled with water. On each plant, 2 pairs of weevils were released. All the scars on either surface of the leaves that were readily identifiable were counted. Compound scars were separated into component scars by noting any obvious discontinuities in the normally regular scar borders or on the differential depth of feeding. Feeding scars were counted by marking each counted scar using a marker pen. Marking of each scar prevented accidental recounting.

Neochetina spp. caused the characteristic feeding scars (Fig. 1), by feeding on the epidermal tissues of the laminae and petiole and removing the cuticle and part of the mesophyll tissue. The weevils preferred to feed on lower surface and upper petiole of the leaf, preferring to feed on younger leaves. They fed preferentially on the soft tissue of unfurled young lamina and upper portions of young petiole. The weevils, when given choice among the three growth stages, congregated in the centre most folded leaf of the small growth stages. Feeding declined with direct proportion to the leaf growth stage (Fig. 2). By the third day there was a mean of 23.0, 15.3 and 14.3 feeding scars on small, medium and large growth stages while by the 15th day there were 84.0, 60.7 and 54.7 feeding scars on the three growth stages respectively. There was no significant difference in the presence of weevils on medium and large growth stage of plants. Feeding scars could not be counted after day 10 on small growth stage plants as the scars were too dense and undifferentiated particularly at the leaf isthmus. Thus in water bodies with infestation of large growth stage plants more number of weevils shall be required as compared to small growth stage.

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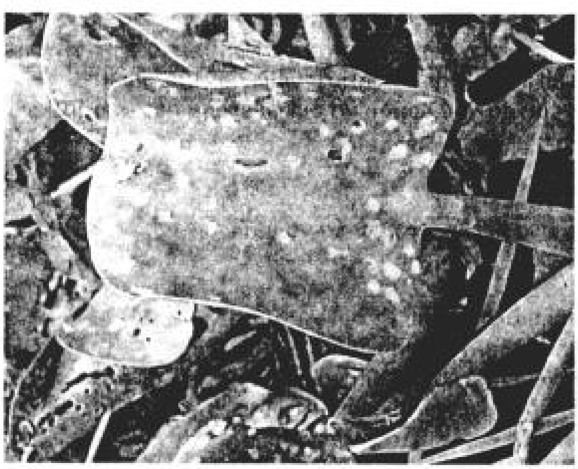

Fig. 1 Water hyacinth leaf showing characteristic feeding scars

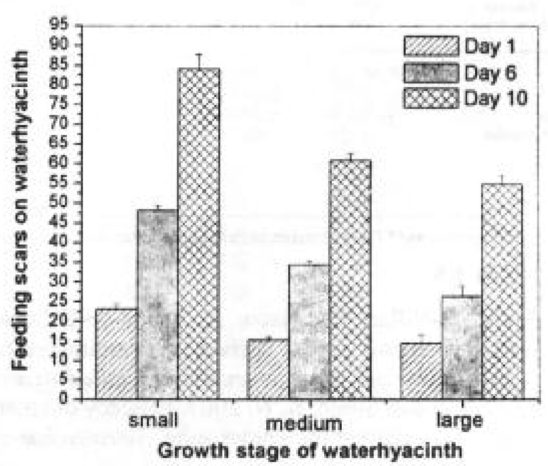

Fig. 2 Feeding scars by *Neochetina* spp. on three growth stages of water hyacinth

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Response of ecofriendly pesticides on spider mites, *Tetranychus urticae* Koch

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The spider mites are polyphagous attaining a major pest status on vegetables, particularly on brinjal. Among them, the spider mite, *Tetranychus urticae* Koch has been identified as a serious during summer Several acaricides to control this showed limited response. Response of biopesticides like azadiractin, neem oil and in combination with dicofol, sulphur and propargite could be a better replacement. Singh *et al.* (1996) studied ajoene against spider mite *Tetranychus urticae* which was found very effective and checked the resurgence also; affected the fecundity and juvenile survival even at lower concentration. A laboratory study was conducted to find out the responses of ecofriendly pesticides in combination with conventional acaricides. Various treatments of ecofriendly pesticides taken were azadiractin 0.03 in combination with dicofol (18.5 EC), sulphur (80 WP) and propargite (57 EC) as well as dicofol and propargite used alone. The mortality was observed at 1, 3, 7, 14 and 21 days intervals after the spray.

Perusal of the work done reveals that biopesticides are able to manage the spider mite. The present studies showed that azadiractin with dicofol performed better and showed maximum percent mortality (93.92 %). The fecundity recorded up-to 7 days were azadiractin (163.00 %), azadiractin + sulphur (68.87 %), neem oil (37.56 %) and water spray (control, 67.02 %). The adult survived in the same treatment with azadiractin (6.66 %), azadiractin + dicofol (2.30 %), azadiractin + propargite (2.50 %), neem oil (5.10 %) and propargite (2.50 %) at their recommended concentration. Maximum number of juveniles survived in azadiractin +sulphur (68.87 %) and sex ratio (M: F) was 1:2.8 (Table 1). Similar results were also obtained by Schauer and Schmutterer (1981), Yusof *et al.* (1986) and Elena Martinez-Villar *et al.* (2005).Though neem products alone could not gave better management in the present studies but Kumar and Singh (2007) found azadiractin gave significant control of *T. urticae* on okra .

Table 1 Influence of some pesticides on mortality, fecundity and sex ratio of *Tetranychus urticae* Koch

Pesticide	Concentration (ml ,%)	Mean percent mortality in days					Mean	Mean No. of adult survived	Mean fecundity/Six mites (days after treatment)			Juvenile Survival	Sex ratio M:F
		1	3	7	14	21			1	3	7		
Azadirachtin (0.03 EC)	5 ml	16.66* (24.04)**	23.33 (28.86)	40.00 (39.23)	40.00 (39.23)	50.00 (45.00)	33.99 (35.61)	6.66***	17.00	38.00	163.00	56.19	1:4
Azadirachtin + Dicofol (18. 5 EC)	(3+2) ml	79.60 (63.15)	91.00 (72.54)	99.00 (84.26)	100.00 (90.00)	100.00 (90.00)	93.92 (75.70)	2.30	-	-	-	-	-
Azadirachtin + Sulphur (80 %WP)	(3+1.5) ml	40.20 (39.35)	52.40 (46.38)	57.40 (49.26)	59.00 (50.18)	59.00 (50.18)	53.60 (47.06)	6.33	16.33	129.00	189.33	68.87	1:2.8
Azadirachtin + Propargite (57% EC)	(3 + .018) ml	75.88 (60.53)	80.55 (63.79)	96.99 (79.86)	80.78 (63.94)	81.72 (64.67)	83.18 (65.73)	2.50	-	-	-	-	-
Neem Oil (Pure)	2 ml	48.52 (44.14)	59.88 (50.65)	68.44 (55.80)	48.92 (44.37)	50.00 (45.00)	55.15 (47.93)	5.10	10.00	28.60	161.33	37.56	1:2.5
Propargite (57% EC)	0.228 %	90.66 (72.15)	94.88 (76.82)	68.77 (55.98)	50.55 (45.29)	52.00 (46.15)	71.37 (57.61)	2.50	-	-	-	-	-
Control (Water Spray)		0.00 0.00	10.00 18.44	0.00 0.00	0.00 0.00	0.66 0.8191	10.66 8.33	10.00	16.33	130.33	216.33	67.02	1:2.2
		C.D. at	5%		1%		S						
Days			0.6198		0.8191								
Pesticides			0.4427		0.8190		S						
Days X Pesticides			NS		NS		NS						
S.Em ±								0.7201	1.4105	4.4283	4.9900	2.8071	-
CD At 1 %								2.1034	4.4699	14.0333	15.8133	8.8957	-
5 %								1.5266	3.1428	9.8663	11.1177	6.2542	-

* Mean of three replications ** Figure in parenthesis Arc Sine % transformation *** No. of mites released on each leaf= 20

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Population of *Menochilus sexmaculatus* (F.) and its synchrony with *Aphis craccivora* koch on groundnut

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Among several natural enemies of groundnut aphid, coccinellids have a unique position. *Menochilus sexmaculatus* (F.) is very effective predator for suppression of the aphid on groundnut in Saurashtra region of Gujarat. An experiment was conducted at M.D.F.R.S. Targhadia (Rajkot) for 12 Years from *Kharif* 1996 to 2007 to know the seasonal abundance of the groundnut aphid and the predator. The groundnut plot of 20m x 20m kept free from insecticides and allowed natural population build up. The fifty plants selected randomly and weekly observation on number of predator (larvae + adults)/plant, no. of aphid\plant and aphid index (0 to 4.0) recorded. The data (Table 1) revealed that out of 12 years the predator *M. sexmaculatus* commenced on groundnut crop in std. week. 30 in 5 years followed by std. week. 31 in 4 years, std. week. 29 in 2 years and in std. week. 28 in 1 year. The predator population multiplied very fast during next week of its commencement and reached a peak in std. week 31st .Maximum population of the predator was during year 2000 (*i.e.*, 3.6 adult+larvae/plant).

Table 1 Population of coccinellid, *Menochilus sexmaculatus* on groundnut *kharif*, 1996 to 2007

Year	No. of the coccinellid / plant								Av.
	Std. Week no.								
	28	29	30	31	32	33	34	35	
1996	0.00	0.00	0.00	0.10	0.60	0.20	0.10	0.00	0.24
1997	0.00	0.00	1.25	2.70	0.80	0.15	0.00	0.00	1.23
1998	0.00	0.00	0.12	0.40	0.20	0.12	0.00	0.00	0.21
1999	0.00	0.00	0.60	0.99	0.20	0.04	0.00	0.00	0.60
2000	0.00	0.00	0.00	0.20	0.50	3.60	3.08	0.30	1.54
2001	0.00	0.00	0.20	1.48	1.16	0.10	0.00	0.00	0.74
2002	0.00	0.00	0.00	0.44	1.04	1.88	0.64	0.20	0.84
2003	0.00	0.00	0.00	0.12	0.16	0.00	0.00	0.00	0.14
2004	0.20	3.20	0.30	0.00	0.00	0.00	0.00	0.00	1.20
2005	0.00	0.20	0.60	1.20	1.35	0.40	0.30	0.50	0.65
2006	0.00	0.70	0.88	1.00	0.10	0.00	0.00	0.00	0.67
2007	0.00	0.00	1.10	1.20	0.32	0.00	0.00	0.00	0.87
Average	0.02	0.34	0.42	0.84	0.53	0.54	0.41	0.08	

Table 2 Population of aphid, *Aphis craccivora* on groundnut *kharif* 1996 to 2007

Year	Av. no. of aphid / twig								Av.
	std. week no.								
	28	29	30	31	32	33	34	35	
1996	0.0	00.0	24	59	64.0	02	0.0	0.0	31.3
1997	2.0	31.0	90	06	00.0	00	0.0	0.0	32.3
1998	0.0	02.0	18	125	00.0	00	0.0	0.0	48.3
1999	0.0	05.0	65	00	00.0	00	0.0	0.0	35.0
2000	0.0	00.0	00	23	56.0	156	4.0	0.0	59.8
2001	0.0	03.0	10	25	01.0	00	0.0	0.0	09.8
2002	0.0	00.0	02	26	56.0	22	0.0	0.0	26.5
2003	0.0	00.0	03	24	30.0	09	0.0	0.0	16.5
2004	8.0	28.0	0	00	00.0	00	0.0	0.0	18.0
2005	0.0	07.0	18	21	51.0	53	8.0	0.0	26.3
2006	0.0	26.0	87	22	00.0	00	8.0	0.0	45.0
2007	0.0	04.0	10	15	00.0	00	0.0	0.0	09.7
Average	0.8	08.8	27.3	28.8	21.5	20.2	1.7	0.00	

The data in Table 2 and 3 indicated that the *A. craccivora* commenced in std. week 29 in 6 years followed by std. week 30 in 3 years. Maximum 156 aphid\twig with 3.0index recorded during *kharif* 2000, while average of 28.8 aphid\twig with 1.44 index in 31st std. week was recorded. The data given in table 4 indicate that there was highly significant positive correlation between population of the predator and the prey. The data revealed that the predator population commenced one week later than its prey (aphid) on groundnut. After commencement both thepopulation (predator and prey) multiplied high. The peak population of the predator and the prey was in same std.week (31st) in majority years. When commencement of aphid and the cocinellids both was in same week (i.e. year 2000, 2004, 2005 and 2006) the pest(aphid) population was suppressed effectively and fall bellow E.T.L.(i.e. 1.5 aphid index). The predator population gave significantly positive response to the prey population on groundnut. Agrawal and Bardhanroy (2001) also reported the coccinellid to be efficient predator on *A. craccivora* and Mari *et. al.* (2005) worked out the per day predatory efficiency of 73 to 80 alfalfa aphid.

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Table 3 Aphid index on groundnut *Kharif* 1996-2007

Year	Av. Aphid index / plant								
	Std. week no.								Av.
	28	29	30	31	32	33	34	35	
1996	0.00	0.00	1.13	2.24	2.56	0.06	0.00	0.00	1.50
1997	0.23	1.92	3.30	0.63	0.00	0.00	0.00	0.00	1.52
1998	0.00	0.56	2.88	3.56	0.00	0.00	0.00	0.00	2.33
1999	0.00	0.15	2.01	0.00	0.00	0.00	0.00	0.00	1.08
2000	0.00	0.00	0.00	1.00	2.00	3.00	1.00	0.00	1.75
2001	0.00	0.70	1.70	2.20	0.10	0.00	0.00	0.00	1.18
2002	0.00	0.00	0.20	1.40	3.30	2.10	0.00	0.00	1.75
2003	0.00	0.00	0.30	2.10	2.40	1.40	0.00	0.00	1.55
2004	1.40	1.75	0.00	0.00	0.00	0.00	0.00	0.00	1.58
2005	0.00	0.20	1.22	1.30	1.40	1.27	0.70	0.00	1.02
2006	0.00	1.60	2.60	1.40	0.00	0.00	0.00	0.00	1.87
2007	0.00	0.20	0.75	1.40	0.00	0.00	0.00	0.00	0.78
Average	0.15	0.59	1.34	1.44	0.98	0.65	0.14	0.00	

Table 4 Correlation between population of the predator and prey and weather parameters 1996 to 2007

Sr. No.	Variable	Coccinellid	Aphid no. /twig
1	Aphid	0.481*	--
2	Rainfall	0.004	0.050
3	Rainy day	0.0048	- 0.048
4	Sunshine	0.004	- 0.021
5	Wind Velocity	0.010	0.091
6	Tem. Max.	0.043	- 0.119
7	Tem. Mini	0.067	0.172
8	Tem Mean	0.056	- 0.050
9	RH Max.	0.074	0.048
10	RH Mini	0.027	0.080
11	RH Mean.	0.043	0.070

*Critical Value (1 – Tail, 05) = ± 0.16896 ; Critical Value (2 – Tail, 05) = ± 0.20053

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Field evaluation of egg parasitoid, *Trichogramma* spp. against yellow stem borer and leaf folder in rice ecosystem

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Rice is attacked by more than 100 species of insects, 20 of them cause economic damage (Pathak and Khan, 1994). Yellow stem borer, *Scirpophaga incertulas* Walker and leaf folder, *Cnaphalocrocis medinalis* (Guenee) have been recorded as the major pest constraints in Manipur. A study was undertaken during *kharif*, 2006 and 2007 to evaluate the bioefficacy of egg parasitoids, *Trichogramma chilonis* Ishii and *T. japonicum* Ashmead against these at farmers' field at Bashikhong, Imphal East, Manipur in a total area of 5 ha with 20 subplots of 2500 m^2. Local high yielding rice variety 'Tamphaphou' was taken and there were 5 treatments including Farmers Practice and each treatment was replicated four times. The treatments were *T. chilonis* and *T. japonicum* released each @ 50,000/ha and 70,000/ha and Farmers Practice, where no parasitoids were released and insecticides were applied twice. The egg parasitoids were released 3 times at 15 days interval starting from 30 days after transplanting.

Incidence of yellow stem borer and rice leaf folder was found low in the plots where *Trichogramma* spp. were released (Table 1) Pooled mean data of two years showed that stem borer damage was significantly reduced in treatment with *T. chilonis* @ 70,000/ha with only 1.40% DH and 1.28% WEH as compared to 4.61% DH and 4.59% WEH observed in Farmers Practice plots. Similarly, significantly lower leaf folder damage of 1.29% FL was recorded in treatment with *T. chilonis* @ 70,000/ha against 5.58% FL in Farmers Practice. It was also observed that *T. chilonis* was more effective than *T. japonicum* in reduction of tiller damage caused by yellow stem borer and folded leaves by rice leaf folder and the effectiveness was superior at higher dose of 70,000/ha than lower dose of 50,000/- in both the species of *Trichrogramma*. Highest grain yield of 6.09 t/ha was recorded in *T. chilonis* released plots @ 70,000/ha with 20.23% increase in yield over Farmers Practice. The results obtained in the present studies corroborate the findings of Katti *et al.* (2001) who reported that 3 to 5 releases of *T. chilonis* @ 1,00,000/ha significantly reduced both stem borer and leaf folder damages resulting in significant increase (38 to 45%) in grain yield over Farmers Practice fields at Nellore district of Andhra Pradesh. Kumar and Khan (2005) also reported that effectiveness of *T. chilonis* and *T. japonicum* at higher dose of 1,00,000/ha was superior over lower dose of 50,000/ha against yellow stem borer and leaf folder of rice in farmers' field at Kashipur, Uttarakhand. It can be concluded that three releases of *T. chilonis* @ 70,000/ha at 15 days interval starting from 30 days after transplanting proved to be the most effective treatment for control of yellow stem borer and leaf folder of rice under agro climatic condition of Manipur and it can be incorporated in formulation of location specific IPM module of rice.

Table 1 Biocontrol agents on rice yellow stem borer and leaf folder *kharif*, 2006 and 2007

Treatments	Mean % Damage			Mean Grain yield (t/ha)	% yield increase over control
	DH	WEH	FL		
T_1- *T. japonicum* @ 50,000/ha	2.80 (9.50)	2.06 (8.22)	1.96 (7.60)	5.66	9.06
T_2- *T. japonicum* @ 70,000/ha	1.92 (7.94)	1.51 (7.06)	1.79 (7.24)	5.92	14.07
T_3- *T. chilonis* @ 50,000/ha	1.75 (7.56)	1.43 (6.78)	1.61 (6.79)	6.09	17.34
T_4- *T. chilonis* @ 70,000/ha	1.40 (6.67)	1.28 (6.12)	1.29 (6.13)	6.24	20.23
T_5- Farmers Practice	4.61 (12.39)	4.59 (12.34)	5.58 (13.25)	5.19	-
S.E.m (±)	0.76	0.51	1.23	0.08	
CD (P=0.05)	1.65	1.12	2.68	0.17	

Figures in parentheses are angular transformed values, DH=Dead heart; WEH=White ear head; FL=Folded leaf

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Bioefficacy of *Trichogramma japonicum* against *Chilo polychrysus* in the upland rice of Nagaland

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Trichogramma japonicum for management of dark headed rice stem borer, *Chilo polychrysus* was evaluated under laboratory condition during *kharif*, 2002 and under field condition during *kharif*, 2003 at School of Agricultural Science and Rural Development, Nagaland University, Medziphena, Nagaland. The variety 'Jaya' was used. In the laboratory experiment, eight different treatments release of 5 *T. japonicum*/pot (T1), 10 *T. japonicum*/pot (T2), 20 *T. japonicum*/pot (T3), 40 *T. japonicum*/pot (T4), 60 *T. japonicum*/pot (T5), 80 *T. japonicum*/pot (T6), 120 *T. japonicum*/pot (T7), and unreleased pot (T8) were maintained. The trichocard of respective treatments and fixed number of newly laid egg mass of *C. polychrysus* (obtained from the oviposition cage) were clipped in the leaf of the potted plants and the entire hills were covered with perforated polybags. After four days the clipped egg masses were collected and transferred individually in 15ml glass test tube and plugged with cotton swabs. The test tubes were then kept in room temperature for emergence of the parasitoids and stem borer larvae and the per cent paraeitization was worked out. For the field trail, nine treatments with first release of the split dosages were made on the 30th days after transplanting (DAT). The following releases of the split dosages made after 20 days of the first released. An isolation distance of not less than 100 meters was maintained between each release sites.

Observations were recorded at 15 days interval from the 30 DAT by randomly selecting 20 hills within 2 meters radius of the release site. Per cent infested tillers were worked out and DMRT method was applied for statistical analysis. In the laboratory experiment, a positive correlation between the number of parasitoid released and per cent paratization was observed. The highest parasitization of 81.18 per cent was highest number of *T. japonicum* released (120/pot). Barrion and Litsinger (1982) also reported parasitization of *C. polychrysus* by *T. japonicum*. In the field trail, incidence of stem borer was erratic at 30 DAT and average infestation was 4.41 per cent. At 45 DAT, no significant difference was observed between the treatments. Highest dead heart percentage (4.80) was observed in T8 and it was followed by T6 (4.16). Unreleased sites recorded 2.43 per cent dead heart. Higher dead heart per cent in the T6 and T9 may be the influence of stem borer larvae which hatch out before 30 DAT and also dead heart symptom persist for long period. At 60 and 75 DAT, T6, T2, T5 and T4 showed significant reduction in dead heart.

Table 1 Per cent dead heart and white ear with *Trichogramma japonicum*

Treatments	Dead heart% at 45 DAT	Dead heart% at 60 DAT	Dead heart% at 75DAT	White ear head % at 90DAT
T1- 50,000/ha as single release	1.20(1.30)	1.91(1.44)abc	2.01(1.55)ab	2.08(1.59)abcd
T2- 1,00,000/ha as single release	1.64(1.45)	1.31(1.61)c	1.46(1.30)abc	2.18(1.62)abc
T3- 2,00,000/ha as single release	1.77(1.50)	1.78(1.50)abc	1.12(1.29)abc	2.22(1.53)abcde
T4- 3,00,000/ha as single release	1.06(1.20)	1.69(1.33)bc	1.08(1.19)abc	1.80(1.40)abcdef
T5- 1,00,000/ha as 2 split release	1.69(1.33)	1.46(1.30)c	0.92(1.06)bc	2.21(1.65)ab
T6- 2,00,000/ha as 2 split release	4.16(2.00)	0.90(1.14)c	0.84(1.11)bc	1.59(1.34)abcdef
T7- 3,00,000/ha as 2 split release	2.24(1.48)	1.75(1.34)bc	0.43(0.91)c	0.91(1.14)bcdef
T8- .2,00,000/ha as 4 split release	4.30(2.15)	3.14(1.88)ab	0.39(0.90)c	0.43(0.91)f
T9- 0/ha	2.43(1.52)	3.65(1.93)a	2.54(1.76)a	3.20(1.85)a
C.V. (%)	26.62	20.68	24.3	19.4

Figures in the parentheses are (x +0.05) transformed values

Lowest number of white ear head (0.43 per cent) was recorded in T8 at 90 DAT and it was closely followed by T7 (0.91 per cent). Four split released of 2,00,000 /ha gave consistent check in stem borer infestation during the critical stages like booting, panicle initiation, flowering, and grain filling stage. From this observation it can be recommended that the release of the *Trichogramma* can be made before 30 DAT in late transplantations as the population was high by

30 DAT although initial infestation increases the number of tillering it delays the cropping period and is a risk in the regions like North-East Hill where the winter starts by late October. Split releases gave better results than inundative releases of once or twice. Borah (1994) reported that frequent inundative released of *T. japonicum* could reduce the stem borer infestation in Assam.

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Field parasitization, suitability of larval hosts and adult nutrition on the production potential of *Bracon* (*Habrobracon*) *hebetor*

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Bracon hebetor (Say) (Hymenoptera: Braconidae) is a gregarious, ecto parasitoid that attacks larvae of several species of Lepidoptera. *B. hebetor* females first paralyze their host larvae by stinging and then laying variable numbers of eggs singly on the surface of paralyzed hosts. The paralyzed host larvae are then used as food sources for developing wasp. For the past three years, the incidence of *B. hebetor* on *Helicoverpa armigera* was recorded in chickpea ecosystem (Saxena and Duraimurugan, 2008). In this study, we explore the field parasitization of *B. hebetor* and laboratory experiments on suitability of larval hosts and adult diets for the cost effective mass multiplication and utilization in biological control.

Various stages of *H. armigera* were collected from the chickpea fields of New Research Farm of Indian Institute of Pulses Research, Kanpur during March-April, 2006-2008. These larvae reared individually on semi-synthetic diet (Arms *et al*., 1992) in plastic vials and observed for the emergence of parasitoids. Experiments were conducted with last instar larvae of eight lepidopteran hosts *viz*., *Corcyra cephalonica*, *Galleria mellonella*, *Helicoverpa armigera*, *Spodoptera litura*, *Spilosoma obliqua*, *Eurema hecabe*, *Acherontia styx* and *Maruca vitrata* in the laboratory in a no-choice design to know the suitability of larval hosts for the production potential of *B. hebetor*. To know the influence of diets on the longevity of adult parasitoid, seven adult diets (25% honey, 50% honey, 100% honey, 25% glucose, 25 % sucrose, 25 % jaggery and distilled water) were tested with three replications.

The percent field parasitization of *B. hebetor* on *H. armigera* in chickpea ecosystem ranged from 0.24 to 1.59 %. (Table 1). *B. hebetor* females were able to parasitize and complete its life cycle (egg-to-adult survivorship) only on four hosts *viz*., *Corcyra cephalonica*, *Galleria mellonella*, *Helicoverpa armigera* and *Maruca vitrata*. The longevity of adults increased significantly with feeding. The highest longevity was 34.7 days and 22.0 days in females and males, respectively when fed with 50 % honey solution (Table 2). Thus, the gregarious ectoparasite *B. hebetor* is amenable for mass multiplication and it can be used as potential biocontrol agent against *H. armigera* in different cropping ecosystems.

Table 1 Field parasitization of *B. hebetor* on *H. armigera* in chickpea ecosystem

Year (Months)	No. of larvae collected	No. of larvae parasitized	% parasitization
2006 (March -April)	822	2	0.24
2007 (March -April)	710	3	0.42
2008 (March -April)	755	12	1.59

Table 2 Effect of diets on the longevity of adult parasitoid

Adult diet	Longevity of *B. hebetor* (days)	
	Female	Male
100% honey	33.3a	20.3b
50% honey	34.7a	22.0a
25% honey	25.0b	16.0c
25 % sucrose	23.3b	19.3b
25% glucose	15.7c	12.7d
25% jaggery	9.0d	6.3e
Distilled water	8.7d	5.0e
CD (at 5%)	2.45	1.67

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IPM package for onion thrips *Thrips tabaci*

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Onion is an important vegetable crop in India. Thrips is the most important insect pest attacking onion and garlic. Immature and adult thrips feed with a punch and suck behaviour that removes leaf chlorophyll causing white to silver patches and streaks. The effective check for this pest has so far been mainly through the use of chemical insecticides. Use of different IPM package were evaluated in the rabi seasons of 2005-06 and 2006-07. These are T1 (Verticillium lecani @ 0.4% + Verticillium lecani @ 0.4% + Neem seed Kernel extract @ 50gm/lit + Thimethoxam 25% @ 4gm/lit), T2 (*Beauveria bassiana* @ 0.4% + *Beauveria bassiana* @ 0.4% + Neem seed powder @ 60gm/lit + Ethopenprox 10EC 2ml/lit), T3 (Spinosad 45% SC @ 1ml/lit + Spinosad 45% SC @ 1 ml/lit + Neem oil @ 2ml/lit + Acetamiprid 10WP@ 1gm/lit), T4 (Econeem Azadirachtin 1% 2ml/lit + Lufenuron 5 EC @ 2.5 ml/lit Pongamia soap @ 1% + Fenpropathrin 30% EC @ 1 ml/lit), T5 (Neem Azal F @ 5%) + Novaluron 10EC @ 2ml/lit + Neem soap @ 1% + Diafenthiuron 50WP 1.5gm/lit), T6 (*Verticillium lecani* @ 0.4% + *Verticillium lecani* @ 0.4% + Econeem (Azadirachtin 1%) 2ml/lit + Acephate 75% SP 2 gm/lit) and T7 (Control - four spray of water). Pooled data of 3 consecutive year of Rabi 2005-06, 2006-07 and 2007-08 revealed that no thrips infestation was recorded in any of the treatment up to even seven day after 2[nd] spray. Before 3[rd] spray to till the last observation significantly lowest thrips population was recorded in treatment T3 package except the observation of 7 days after 3[rd] spray, where significantly lowest thrips population was recorded in T5, which was at par with T3 and T4. The data further revealed that significant highest gross yield (264.28q/ha) and marketable yield (252.57q/ha) were recorded in T3, which was at par with T5. The highest cost benefit ratio (1:35:59) was also recorded in T3 followed by T6 (1:33:98).

Tabel 1 Evaluation of IPM package for onion thrips *Thrips tabaci* (*Rabi*, 2005-06, 2006-07)

Treatment	Gross Yield (q/ha)	Market-table yield (q/ha)	Before 3rd spray		7 days after 3rd spray		Before 4th spray		7 days after 4th spray		Cost benefit ratio
			%	Nym/plant	%	Nym/plant	%	Nym/plant	%	Nym/plant	
T1	213.48	203.98	83.33	1.93	100.00	12.33	100.00	19.67	100.00	23.63	1:06
T2	230.56	219.50	48.89	1.49	100.00	7.99	100.00	16.64	100.00	17.09	1:18
T3	264.28	252.57	36.67	0.67	100.00	4.86	100.00	11.89	100.00	7.19	1.35
T4	235.61	224.03	55.56	1.19	100.00	6.28	100.00	15.03	100.00	15.70	1:13
T5	262.26	252.22	37.78	0.72	100.00	4.74	100.00	13.10	100.00	9.16	1:10
T6	242.04	232.68	67.78	2.27	100.00	11.08	100.00	19.49	100.00	17.00	1:33
T7	117.76	107.18	100.00	6.90	100.00	35.76	100.00	60.14	100.00	70.64	
S.Em	5.76	6.19	9.25	0.40	-	1.31	-	2.25	-	2.13	
C.D at 5%	12.54	13.48	20.15	0.80	-	2.86	-	4.91	-	4.63	

Incidence of thrips and average no. of nymphs/plant was nil from before first spray to 7 days after spray second spray

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Seasonal incidence of aphid *Brevicoryne brassicae* on cauliflower

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For the study of population dynamic of cabbage aphids, *Brevicoryne. brassicae* on cauliflower (var. snowball-16), the crop was sown in October and transplanted in November during two consecutive years (2002 and 2003) in four quadrates measuring 10 m in experimental field of Deptt. of Horticulture. M.A.U., Parbhani. The inter and intra row spacing of 60 x 45 cm was maintained. A gap of 1 m was maintained among the plot. The crop was raised without any insecticidal treatment so that population of pest and its natural enemies could build-up freely. Observations were made at weekly intervals right from 46[th] meteorological weeks and continue till 10[th] MW of second year. Number of larvae were counted from the randomly selected plants. Daily records of abiotic factors such as maximum and minimum temp., relative humidity, total rainfall, sunshine hours that prevailed during the period of field experimentation were collected from the meteorological Deptt. of M.A.U., Parbhani. The data thus collected were computed and subjected to correlation analysis in order to find out the relationship of environmental factors with the population density of insect pest.

The data on seasonal incidence (Table 1) indicated that during the first season 2002-03 incidence of aphid (1.32/3 leaves) was first noticed in the 46[th] MW(12-18 November). It markedly increased from 50[th] meteorological week and reached its peak (273.12 aphids/3 leaves) in 7[th] MW of 2003 (12-18 February). During 2003-04 incidence was first noticed in 47[th] MW (1.22 aphids/3 leaves). It increased from 50[th] MW and reached its peak (319.15 aphids/3 leaves) in 8[th] MW of 2004 (19[th] February). The similar result were reported by More and Mundhe, 2003. The aphid population was positively correlated with the maximum temperature (+0.323) and minimum temperature (+0.464). However, non-significant correlation was observed with maximum temperature. The aphid population was positively correlated with bright sunshine hours (+0.019). The correlation studies during 2003-04 indicated that the population was positively correlated with the bright sunshine hours (+0.116). Lakhanpal and Raj (2002) reported significant positive correlation with maximum temperature and minimum temperature. More and Mundhe (2003) also reported the positive correlation of aphid with maximum and minimum temperature. During the period of investigation, the results obtained varied and non-significant with some factors but the review of earlier workers gave some support to the findings of present investigation.

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Table 1 Incidence of aphids 2002-03 and 2003-04

MW	Population per ten plants		MW	Population per ten plants	
	2002-03	2003-04		2002-03	2003-04
46	1.32	0.00	3	131.05	219.22
47	8.70	1.22	4	164.85	150.50
48	22.30	3.15	5	97.70	145.35
49	20.22	23.17	6	90.35	286.17
50	60.15	80.17	7	273.12	317.05
51	72.80	51.40	8	192.22	319.15
52	84.77	76.42	9	85.27	74.07
1	110.85	161.67	10	120.32	31.32
2	140.92	82.07			

Table 2 Relationship between weather parameters and aphid population

Abiotic factors	2002-03	2003-04	Pooled
Rainfall (mm)	-0.021	-0.109	-0.079
Rainy days	-0.003	-0.109	-0.067
Temperature maximum (°C)	0.323	0.113	0.156
Temperature minimum (°C)	0.464**	0.021	0.167
Humidity (a.m.)	-0.301	-0.125	-0.172
Humidity (p.m.)	-0.060	-0.255	-0.133
Bright sunshine (hrs)	0.019	0.116	0.093
No. of observations	17	16	33

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IPM Modules for rice yellow stem borer and leaf folder

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The field efficacy of three IPM modules (Bio-intensive module, Adoptive module and Insecticidal module) against *Scirpophaga incertulas* and *Cnaphalocrocis medinalis* were carried out in the farmer's fields of Imphal West District, Imphal during *Kharif*, 2007 and 2008. The details of treatments are as follows:

M_1	(Biointensive Module)	Soaking of seeds in 0.5% solution of Neemcel (Azadirachtin 10000 ppm) for 6 hours + Judicious use of NPK @ 60:40:30 kg ha^{-1} + foliar spray with Neemcel @ 750 ml ha^{-1} at 20 DAT + Release of *Trichogramma chilonis* @ 50,000 eggs/ha/week for two weeks starting from 30 DAT + spray with Neemcel @ 750 ml ha^{-1} at panicle initiation stage.
M_2	(Adoptive Module)	Sprouted seed treatment with 0.2% solution of Chlorpyriphos 20 EC for 3 hours + Judicious use of NPK @ 60:40:30 kg ha^{-1} + foliar spray with Imidacloprid 17.8 SL @ 20 g a.i. ha^{-1} at 20 DAT + Installation of Pheromone trap for *S. incertulas* @ 15 traps ha^{-1} at 30 DAT+ spray with Imidacloprid 17.8 SL @ 20 g a.i. ha^{-1} at panicle initiation stage.
M_3	(Insecticidal Module)	Soaking of seeds in 0.2% solution of Monocrotophos 36 WSC for 6 hours + Judicious use of NPK @ 60:40:30 kg ha^{-1} + foliar spray with Monocrotophos @ 500 g a.i. ha^{-1} at 20, 45 and 75 DAT
M_4	(Farmer's Practice)	Check

The results based on pooled data revealed that the adoptive module (M_2) recorded significantly lowest incidence of *S. incertulas* with mean dead heart(DH) and white ear head (WEH) of 1.60 and 2.66 per cent, respectively as against 6.47 and 8.65 per cent in farmer's practice (M_4). It was closely followed by insecticidal module (M_3) with a record of 2.02 DH% and 3.89 WEH%, respectively, but differed significantly (Table 1).

Table 1 IPM modules on *S. incertulas* and *C. medinalis* (var. CAUR-1- *Kharif*, 2007, 2008 pooled)

Treatment	[1]Mean pest infestation in different treatments			Mean grain yield ($t\ ha^{-1}$)
	S. incertulas		*C. medinalis*	
	DH (%)	WEH (%)	DL (%)	
M_1=Biointensive Module	3.24 (10.31)	4.61 (12.39)	7.31 (15.63)	4.75
M_2=Adoptive Module	1.60 (7.15)	2.66 (9.12)	6.17 (14.33)	6.09
M_3= Insecticidal Module	2.02 (8.12)	3.89 (11.40)	5.38 (13.60)	5.13
M_4= Farmer's Practice	6.47 (14.61)	8.65 (17.09)	16.10 (23.55)	4.04
SE(m) ±	0.18	0.25	0.40	0.16
CD (P= 0.05)	0.54	0.74	1.15	0.45

Figures in parentheses angular transformed values; [1]Mean of pooled data, three observation periods, five replications; DH= Dead Heart; WEH= White Ear Head; DL=Damaged leaf

While, insecticidal module was found to be most effective against *C. medinalis* registering minimum incidence of 5.38%, followed by adoptive module (M_2) with 6.17% as against 16.10% in farmer's practice (M_4); these two modules had non-significant differences. The biointensive module (M_1) having no use of synthetic organic insecticides, although exhibited significantly better performance than the farmer's practice did not perform well in comparison to the other two modules. The highest grain yield (6.09 t ha^{-1}) was due to the adoptive module treatment as against 4.04 t ha^{-1} in farmer' practice (M_4). It was closely followed by insecticidal module (5.13 t ha^{-1}) but differed significantly. The lowest grain yield (4.75 t ha^{-1}) was from the biointensive module (Tables 1 & 2). The avoidable yield loss worked out to 33.66% in farmer's practice, which reduced to 15.76 (Insecticidal module)- 22.00% (Biointensive module) (Table 2).

Table 2 Avoidable yield losses (%)

Treatment	Mean grain Yield (t ha-1)	Increase of yield over check Farmer's Practice (FP)		Avoidable loss (%)
		Tonnes/ha	Per cent	
M1=Biointensive Module	4.75	0.71	17.57	22.00
M2=Adoptive Module	6.09	2.05	50.74	0.00
M3= Insecticidal Module	5.13	1.09	26.98	15.76
M4= Farmer's Practice(Check)	4.04	-	-	33.66

M_2 (Adoptive Module) accrued maximum grain yield of 6.09 t ha^{-1} on the basis of which the avoidable losses in check (FP) and in different treatments have been computed

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Field efficacy of indigenous plant extracts against aphid *Lipaphis erysimi* in rapeseed

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Mustard aphid, *Lipaphis erysimi* is one of the major constraints for profitable cultivation of rapeseed crop in Manipur causing considerable yield losses. Among the insect pollinators, honeybees play a vital role in boosting up the yield. In rapeseed, the aphid infestation is synchronised with the peak activity of bee pollinators. Pollination of rapeseed is seriously affected by repeated and indiscriminate use of many modern synthetic insecticides. Hence a field experiment was laid out during *rabi*, 2006 and 2007 at the Oilseed Research Farm of College of Agriculture, Central Agricultural University, Imphal to compare the efficacy of certain aqueous and cow-urine indigenous plant extracts with nimbecidine and endosulfan against *L. erysimi* and their toxicity to Indian hive bee, *Apis cerana indica* (a principal pollinator) in var. M-27. The investigation revealed that endosulfan @ 1000 ml ha^{-1} proved the most effective with lowest mean aphid population of 5.65 per 10 cm twig as against 67.35 in untreated control (Table 1).

Table 1 Effect of insecticides on the aphids, bees and seed yield (*Rabi*, 2006, 2007 (pooled))

Treatment	Dose/ha	[1]Mean population of		[2]Mean seed yield ($q\ ha^{-1}$)
		L. erysimi/ 10 cm twig	*A. ceran* / plant/5min	
T_1= Cow-urine + *Jatropha gossypifolia*	12,500 ml	9.56 (3.17)	5.03 (2.38)	9.85
T_2= Water + *Jatropha gossypifolia*	50,000 gm	10.64 (3.64)	4.63 (2.22)	8.00
T_3= Cow-urine + *Melia azedarach*	12,500 ml	8.64 (2.95)	5.42 (2.43)	10.03
T_4= Water + *Melia azedarach*	25,000 gm	10.49 (3.24)	5.30 (2.41)	8.76
T_5= Cow-urine + *Aralia armata*	12,500 ml	9.84 (3.21)	5.33 (2.16)	9.03
T_6= Water + *Aralia armata*	25,000 gm	10.56 (3.32)	4.89 (2.32)	7.97
T_7= Cow-urine + *Artemisia nilagirica*	12,500 ml	10.63 (3.32)	5.29 (2.40)	8.74
T_8= Water + *Artemisia nilagirica*	25,000 gm	11.18 (3.42)	5.07 (2.36)	7.93
T_9 =Nimbecidine 300 ppm	2000 ml	7.31 (2.78)	4.40 (2.21)	10.93
T_{10}=Endosulfan 35 EC	1000 ml	5.65 (2.47)	3.04 (1.86)	11.81
T_0= Control	Water	67.35 (8.17)	7.92 (2.90)	6.38
CD (P=0.05)	-	0.34	0.21	0.50

Figures in the parentheses are transformed values; [1]Mean of two years' pooled data of five observations and three replications; [2]Mean of two years' yield data

The mean population of nimbecidine was at par with cow-urine + *Melia azedarach* extract @ 12500 ml ha^{-1} registering mean aphid population of 8.64 per 10 cm twig. The mean aphid population recorded in the rest ranged from 9.56 (cow-urine + *Jatropha gossypifolia* extract @ 12500 ml ha^{-1}) to 11.18 per 10 cm twig (water + *Artemisia nilagirica* extract @ 25000 gm), but did not differ significantly.

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Present status of insect pests of soybean in Mewar-Vagar region of Rajasthan

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Soybean, *Glycine max* is a major oil seed crop and its production is affected insect pest problem. Bhattacharya and Rathore (1977) recorded two pests at seed and seedling stage, and at growing stage, six as stem borers, 43 as foliage feeders, 12 sucking in Uttar Pradesh, among these, *Spodoptera litura* (Fab.), *Plusia orichalcea* (Walker), *Melanagromyza sojae* (Zehniter) and *Oberia brevis* (Swed) were found to cause considerable damage. The field collection and survey to find out the present status of insect pest in these areas were made at 15 days interval in Mewar-Vagar region of Rajasthan. In order to assess the location specific losses, paired plot experiment were conducted at Agronomy Farm, Rajasthan College of Agriculture, Udaipur and Agricultural Research Station, Banswara during *kharif* , 2004 and 2005. The experiments were laid out in paired plot design as suggested by Le Clerg (1971).

A total of forty two species of insect pests were found associated at various growth stages. Out of these, six insects *viz*., girdle beetle, *Oberia brevis* (Swed.); tobacco caterpillar, *Spodoptera litura* Fab.; green semilooper, *Chrysodeixis acuta* (Walker); green cloverworm, *Plathypena scabra* (Fab.); grey weevil, *Myllocerus* spp. and jassids, *Amrasca* spp. were rated to be of major pests of soybean. Maximum infestation of girdle beetle, tobacco caterpillar, green semilooper and jassids was observed in Banswara district of Rajasthan. The mean number of pods per plant in protected and unprotected plots during 2004 were 60.31 and 48.51, respectively, whereas, during 2005 it was 62.03 and 47.85, respectively, which resulted into 19.51 and 22.85 per cent loss, respectively. The mean yield per plant in protected and unprotected plots during 2004 was 15.40 g and 12.72 g, whereas in 2005 it was 15.87 g and 12.28 g, respectively, which led to an estimate loss of 17.19 and 22.14 per cent, respectively. The mean yield in protected plots during 2004 and 2005 were 3.60 and 3.68 kg, whereas in unprotected plots were 2.70 and 2.66 kg, respectively. Similar type of results was also obtained in Pratap variety at Banswara. Average per cent loss in plant height, number of pods per plant, grain yield per plant, weight of 100 seeds and grain yield were 5.98, 21.46, 17.63, 10.94 and 29.28 per cent, respectively, during 2004 and 6.34, 24.74, 19.15, 10.67 and 31.64 per cent, respectively. Similar studies on losses caused by insect pests were made by Singh and Singh (1991) who reported yield losses due to semilooper, *C. acuta* 3-18 larvae/meter length at flowering stage ranged from 7.29 to 45.35 per cent at pod filling stage losses ranged from 9.43 to 46.49 per cent.

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