MONITORING AND MANAGEMENT OF THE PEST COMPLEX OF BITTER GOURD

(Momordica charantia **L.***)*

BY

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THESIS

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1999

DECLARATION

I hereby declare that this thesis entitled **"Monitoring and management of the pest complex of bitter gourd (*Momordica charantia* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
26-5-1999.

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CERTIFICATE

Certified that this thesis entitled **"Monitoring and management of the pest complex of bitter gourd (*Momordica charantia* L.)"** is a record of research work done independently by **Sri. Nandakumar. C.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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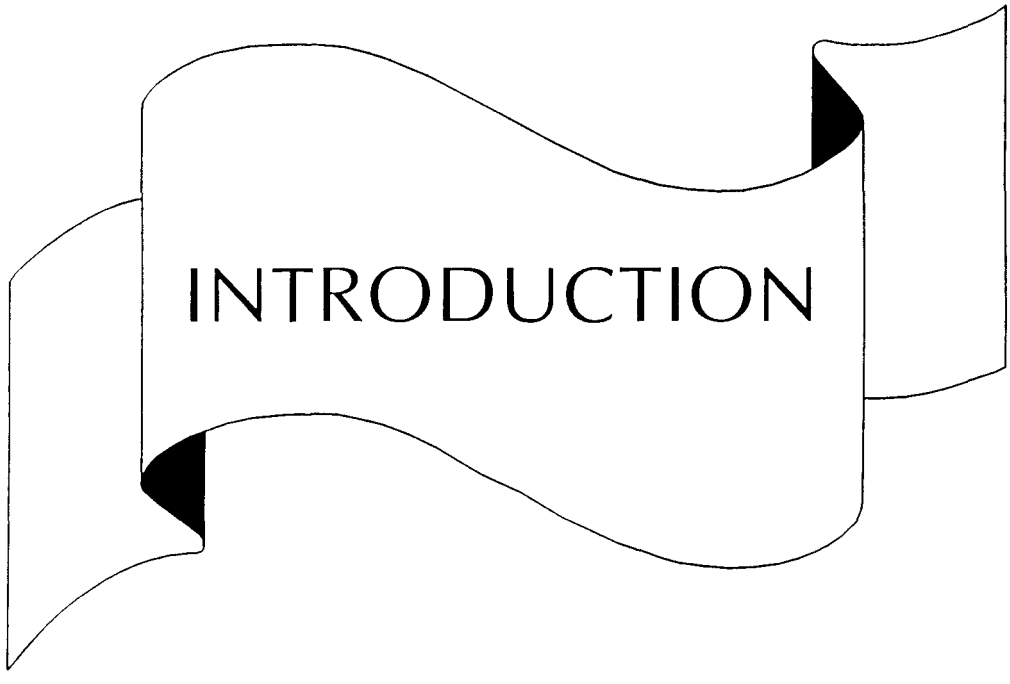

INTRODUCTION

INTRODUCTION

Vegetables constitute an important component in human nutrition and supply invaluable elements required by the human body. The average requirement of vegetables in a balanced diet is about 300 g per person per day. Though India is the second largest producer of vegetables in the world, the national consumption level is about 120 g per person per day and in Kerala, this level is below the national average. The production of vegetables in the State is hardly sufficient to meet even the current requirements. About 25 lakh tonnes of vegetables costing more than 1000 crore rupees are being brought annually from other States. Thus there is a peremptory need to improve vegetable production per unit area to achieve self sufficiency.

The increase in the domestic as well as export demand for vegetables has fuelled the interest of vegetable growers and as a result over the past decade, the area under vegetable cultivation especially in the wetlands and rice fallows has increased substantially in Kerala. The first phase of the Intensive Vegetable Cultivation Programme initiated by the Government of Kerala in November 1997 has yielded dividends and the second phase is in progress. This programme is implemented under the Peoples' Plan Programme with the active participation of the Department of Agriculture, Kerala Horticulture Development Programme, Kerala Agricultural University, State Farming Corporation, Plantation Corporation of Kerala and other organisations. The programme has opened up new vistas in vegetable production, income generation and employment potential.

Among the vegetables cultivated in Kerala, the bitter gourd (*Momordica charantia* L.) occupies a prominent place. This old world species of gourd is a native of tropical Africa and Asia. It is in a class of its own among the cucurbitaceae and matches well with other vegetables in nutritive qualities. It is a rich source of calcium and iron. The fruit juice is used to control diabetes mellitus by increasing the utilization of carbohydrates. The plant parts of bitter gourd are used to cure various ailments and the Chinese use extracts of bitter gourd against spider mites and other agricultural pests.

One of the major obstacles in the successful cultivation of bitter gourd is the attack of pests like the fruit fly, leaf and flower feeder, epilachna beetle, aphids, pumpkin beetles, mites and diseases like mildews and mosaic. The fruit fly *Bactrocera cucurbitae* Coq. causes more than 50 per cent loss in the yield of bitter gourd fruits (Narayanan and Batra, 1960). The pests are kept in check by biotic and abiotic factors. Among the biotic factors,the natural control exerted by natural enemies belonging to the insect orders of Hymenoptera, Diptera and Coleoptera has been well documented (Nayar *et al.*, 1976).

At present, the major strategy developed for plant protection against the pests of bitter gourd is chemical control. There are reports on the indiscriminate use of chemical pesticides (Rahiman *et al.*, 1986; Meera, 1995 and Kerala Agricultural University, 1996b) in vegetable pest control. There has been an increase of 200 per cent in the consumption of pesticides in the late eighties compared to the mid seventies in India (Vijayalaxmi and Babu, 1991). The unwarranted use of chemical pesticides has resulted in build up of minor pests, destruction of natural enemies of pests, pest resurgence, pesticide residues in food,

man and animals, contamination of the environment and related health hazards. High levels of pesticide residues (0.80 to 1.67 ppm of carbofuran) were detected in vegetables like bitter gourd, brinjal and amaranthus (Rajendran *et al.*, 1991). Analyses of market samples of bitter gourd fruits in Kerala have revealed residues of organophosphorus pesticides above the maximum residue limit (Kerala Agricultural University, 1993b and Mathew *et al.*, 1995). Apart from internal consumption in Kerala, bitter gourd fruits are also being exported. The presence of pesticide residues could affect the export of this vegetable. A survey conducted by the Kerala Horticulture Development Project has revealed that the use of high doses of pesticides and other unscientific crop management practices in vegetables add to the cost of cultivation (Kerala Agricultural University, 1996a).

Inspite of the problems, chemical pesticides will still continue to be the cornerstone of pest control strategies in India. The persistence, selectivity in action, biodegradability, toxicity and compatability with other components in Integrated Pest Management will have to be considered while selecting chemicals for use in vegetables like bitter gourd. Top priority should be given to monitoring of pesticide residues and environmental quality.

There is also an impetus for research and development of eco-friendly and biorational alternatives for pest control in bitter gourd. The development and use of botanical pesticides in plant protection especially in homestead or kitchen gardens is warrantable. A pest management strategy is related to the life systems of the pest involved. The pest status is determined by the interactions of the pests, its natural enemies, crop and climate. A strategy which is effective, economically and environmentally sound involving the use of different pest control

tactics is required in bitter gourd. This would go a long way in reducing pesticide contamination and related hazards.

The information on pests of bitter gourd, their status and pest control methods in Kerala is meagre and scattered. Hence the present investigation was taken up with the following objectives.

1. To monitor the incidence of insect pests in bitter gourd and their parasites and predators, to evaluate the present methods of plant protection, to find out the information sources on plant protection and to identify the constraints in bitter gourd cultivation in the major vegetable growing areas of Thiruvananthapuram district.

2. To assess the efficacy of parasites and predators on the pests of bitter gourd.

3. To ascertain the effect of synthetic chemical and botanical pesticides on the pests of bitter gourd and their parasites and predators.

4. To study the reaction of bitter gourd varieties to pests.

5. To evolve a suitable management strategy for the insect pests of bitter gourd.


REVIEW OF
LITERATURE

REVIEW OF LITERATURE

2.1 Plant protection related problems in bitter gourd in Kerala

Based on an extensive survey in the commercial vegetable growing areas in the panchayats surrounding the Vellayani lake in Thiruvananthapuram district, Rahiman *et al.* (1986) reported that there was indiscriminate use of pesticides on vegetables like bitter gourd, snake gourd and cowpea.

Rajendran *et al.* (1991) reported levels of 0.80 to 1.67 ppm of carbofuran residues in samples of bitter gourd, bhindi, brinjal, amaranthus and cucumber collected from local markets in Taliparamba, Kannur and Panniyoor. The residue levels were higher than the MRL of 0.20 ppm.

In a study conducted to monitor insecticide residues in vegetables collected from farmers' fields, cowpea and bitter gourd showed high residues of monocrotophos. The levels of residues ranged from 0.93 to 1.22 ppm which was above the MRL of 0.20 ppm (Kerala Agricultural University, 1993b).

Monocrotophos and phosphamidon were the major contaminants in vegetables exported from Thiruvananthapuram. High residues of monocrotophos was observed in farm gate bitter gourd fruits by Mathew *et al.* (1995).

Meera (1995) studied the differential adoption of plant protection technology in important crops like paddy and vegetables by the farmers of Thiruvananthapuram and Alappuzha districts. There was irrational use of plant protection chemicals by farmers due to lack of adequate knowledge and favourable attitude towards scientific plant protection measures.

In samples collected from major markets in Thiruvananthapuram district, 33.30 per cent of the bitter gourd fruits contained organophosphorus insecticides above MRL (Kerala Agricultural University, 1996b). However, Santhoshkumar (1997) obtained residues of methyl parathion, monocrotophos and quinalphos in all the 72 market samples analysed.

Surveys conducted under the Kerala Horticultural Development Programme (KHDP) revealed that farmers chose pesticides at their own discretion in vegetables. The farmers applied pesticides indiscriminately resulting in high cost and undesirable effects (Kerala Agricultural University, 1996a).

2.2. Pests of bitter gourd

Common name and family	Scientific name	Citations
Fruit flies (Tephritidae)	Melon fly *Bactrocera cucurbitae* Coq. (*Dacus cucurbitae*)	Lefroy (1909) Narayanan and Batra (1960) Nishida (1963) Lall (1964), Pradhan (1969), Darshan Singh *et al.* (1976), David and Kumaraswami (1978), Nair (1995), Thakur *et al.* (1996), Reddy (1997b)

Common name and family	Scientific name	Citations
	Dacus ciliatus Loew.	Pruthi (1941), Chaturvedi (1947), David and Kumaraswami (1978), Nair (1995)
	Bactrocera tau Walker	Gupta and Verma (1992)
Epilachna beetle (Coccinellidae)	*Epilachna* sp. *Epilachna septima* Deike	Basavanna (1954) Kapur (1966), Nayar *et al.* (1976), David and Kumaraswami (1978), Abbas and Nakamura (1985), Ahmed and Khatun (1996), Mahalya *et al.* (1996), Sreekala (1997)
	Epilachna vigintioctopunctata Fb.	Lily (1995), Nair (1995), Reddy (1997b)
	Epilachna implicata Muls.	Nayar *et al.* (1976)
	Epilachna dodecastigma Wied.	Lefroy (1909), Mandal *et al.* (1984)
Pumpkin caterpillar (Pyralidae)	*Diaphania (Margaronia) indica* Saund.	Patel and Kulkarny (1956), Shariff (1969), Peter and David (1990a), Nair (1995)
	Palpita indica Saund.	Nayar *et al.* (1976)
	Eudioptes indicus Saund. (Pyraustidae)	David and Kumaraswami (1978)
Stem gall fly (Cecidomyiidae)	*Lasioptera falcata* Felt.	Ayyar (1940), Rawat and Jakhmola (1975), David and Kumaraswami (1978), Nair (1995)
	Neolasioptera falcata Felt.	Reghupathy *et al.* (1997)
Jassids (Jassidae)	*Hishimonas (Eutettix) phycitis* Dist. *Empoasca binotata* Pruthi *Empoasca* (S.Str.) *motti* Pruthi *Amrasca biguttula biguttula* Ishida	Nair (1995) Nair (1995) Mathew (1995) Sabitha *et al.* (1994), Reddy (1997b)
Aphids (Aphididae)	*Aphis gossypii* Glov.	Nair (1995) Sandhu and Kaushal (1975), David and Kumaraswami (1978)
	Aphis malvae Koch.	Lefroy (1909), Nair (1995)
Pumpkin beetles (Chrysomelidae)	*Raphidopalpa (Aulacophora) foveicollis* Lucas	Thomas and Jacob (1994a)
	Aulacophora lewesi F.	Hussain and Shah (1926), Nair (1978)

Common name and family	Scientific name	Citations
	Aulacophora stevensi B. *Aulacophora cincta* Fb. *Aulacophora intermedia* Fb. (*A. atripennis* F.)	David and Kumaraswami (1978)
American serpentine leaf miner (Agromyzidae)	*Liriomyza trifolli* Burgess	Spencer (1973) Sreenivasan *et al.* (1995), Jeyakumar and Uthamaswamy (1998)
Fruit borer (Noctuidae)	*Heliothis armigera* Hb.	Nayar *et al.* (1976) Mathew *et al.* (1996)
Thrips (Thripidae)	*Thrips palmi* Karny	Kajita *et al.* (1996)
Yellow mite (Tarsonemidae)	*Polyphagotarsonemus latus* Banks	Saradamma *et al.* (1981) Sudharma (1996)
Spider mite (Tetranychidae)	*Tetranychus cucurbitae* Rah and Sap.	Rahman and Sapra (1946)
Mites (Eutetranychidae)	*Eutetranychus orientatis* Klein	Dhooria (1981)
Leaf footed bug (Coreidae)	*Leptoglossus australis* Fb.	Lyla *et al.* (1986), Hill and Waller (1988), Yasuda (1998)
	Fabrictilis australis Fb.	Reghupathy *et al.* (1997)
Shield bug (Pentatomidae)	*Aspongopus janus* F.	Nair (1978)
	Cordius janus F.	Nair (1989) Reghupathy *et al.* (1997)
Flower beetle (Meloidae)	*Mylabris pustulata* Tgn.	Nair (1978)
Cotton white fly (Aleyrodidae)	*Bemisia tabaci* Guen.	Nayar *et al.* (1976)
Flower thrips (Thripidae)	*Frankliniella sulphurae* Schm.	Nayar *et al.* (1976)
Onion thrips (Thripidae)	*Thrips tabaci* Lind.	Nayar *et al.* (1976)
Leaf roller (Pyralidae)	*Leucinodes orbonalis* Guen.	Nayar *et al.* (1976)

Common name and family	Scientific name	Citations
Common stalk borer	*Papaipema nabris*	Chowattakunnel and Cummings (1983)
Other pests on bitter gourd and other cucurbits include		
	Aspongopus observus Fb. (*Pentatomidae*)	
	Aspongopus orientalis Kirk. (*Pentatomidae*)	
	Hulys salcata Thunb. (Pentatomidae)	
	Pericallia ricini F. (Arctidae)	Nair (1989)
	Holotrichia insularis Brun. (Melolonthidae)	
	Apomecyna perotetti F. (Cerambycidae)	

2.3. Natural enemies of pests of bitter gourd

Natural enemy	Pest	Citations
Opius fletcheri Silv.	Fruit fly	Fullaway (1915), Clausen (1950), Batra (1954), Nishida and Bess (1957), Pradhan (1969), Nair (1995)
Opius compensatus Silv.	Fruit fly	
Opius incisus Silv.	Fruit fly	
Spalangia philippinensis Full.	Fruit fly	
Dirrhinus giffardi Silv.	Fruit fly	Nair (1995)
Dirrhinus luzonenisis Rohw.	Fruit fly	
Pachycrepoideus dubius Ashm.	Fruit fly	
Ipobracon sp.	Fruit fly	
Syntomosophyrum indicum Silv.	Fruit fly	
Spalansis sp.	Fruit fly	

Natural enemy	Pest	Citations
Pediobius foveolatus Craw.	Epilachna beetle	Lal (1946), Lall (1961), Usman *et al.* (1964), Flanders *et al.* (1984), Tewari (1986), Paik (1991), Shing and Wang (1992), Mehta *et al.* (1993), Sreekala (1997)
Chrysocharis johnsoni S. Rao.	Epilachna beetle	Subba Rao (1957), Usman *et al.* (1964), Mathew and Abraham (1973), Lily (1995), Hebsy Bai (1996)
Tetrastichus sp.	Epilachna beetle	Abbas and Nakamura (1985)
Tetrastichus ovulorum Ferr.	Epilachna beetle	Usman *et al.* (1964), Sreekala (1997)
Achrysocharis appanai	Epilachna beetle	
Pleurotropis epilachnae Roh.	Epilachna beetle	Usman *et al.* (1964), Nair (1995)
Solinderia vermai Bhat	Epilachna beetle	
Uga menoni Kerrich.	Epilachna beetle	Nair (1995)
Pediobius epilachnae Roh.	Epilachna beetle	Nair (1995)
Cantheconidae furcellata Wolff.	*H. armigera*	Nayar *et al.* (1976)
(*Eocanthecona furcellata* Wolff.)		
Apanteles machaeralis Wilk.	Pumpkin caterpillar (*D. indica*)	Bhatnagar (1948). Peter and David (1990a)
Apanteles sp.	*D. indica*	Patel and Kulkarny (1956), Nair (1995)
Apanteles taragamae Vier *Goniozus sensorius* Gordh	*D. indica*	Peter and David (1990b)
Tetrastichus lasiopterae Bhat.	Stem gall fly (*L. falcata*)	Bhatnagar (1952)
Misocyclops sp.	*L. falcata*	Ayyar (1963) Rawat and Jakhmola (1975)
Lestodiplosis sp.	*L. falcata*	Richards and Davies (1993)
Menochilus sexmaculatus Fabr.	Aphids	Lefroy (1909), Hagen (1962)
	A. gossypii	Jacob (1963), Rajamohan and Jayaraj (1974), Haque and Islam (1978), Anand (1983), Verma *et al.* (1983), Agarwala and Ghosh (1988), Singh and Singh (1994).

Natural enemy	Pest	Citations
	A. malvae	Rajamohan and Jayaraj (1974)
Coccinella septempunctata L.	Aphids	Lal and Singh (1947), Hagen (1962), Anand (1983), Singh and Singh (1994)
	A. gossypii	Chatenet and Zhu (1985), Matter *et al.* (1993)
Coccinella transversalis F.	*A. gossypii*	Veeravel and Baskaran (1996)
Coccinella maculatus F.	*A. gossypii*	Veeravel and Baskaran (1996)
Scymnus sp.	Aphids	Lefroy (1909), Kapur (1942)
Brumus sp.	Aphids	Kapur (1942)
Ischiodon scutellare Fabr.	Aphids	Deoras (1942), Sarala Devi (1967)
I. scutellare	*A. gossypii*	Patel and Patel (1969), Ghosh *et al.* (1985), Dahiya *et al.* (1988)
Syritta orientalis Macquart.	*A. gossypii*	Anand *et al.* (1967)
Ischiodon aegyptius Wied.	*A. gossypii*	Zeren and Duzgunes (1983)
Harmonia axyridis Pallas	*A. gossypii*	Choi and Kim (1985)
Paragus serratus Fabr.	*A. gossypii*	Dahiya *et al.* (1988)
Trioxys indicus Subba Rao and Sharma	*A. gossypii*	Subba Rao and Sharma (1958)
Lipolexis scutellaris	*A. gossypii*	Ng and Stary (1986)
Chrysopa sp.	Aphids	Ghosh (1980)
Chrysoperla carnea Stephens	Aphids *A. gossypii*	Narasimhan (1991) Chatenet and Zhu (1985)
Chrysoperla orestes Banks	Aphids	Bhagat and Masoodi (1986)
Hemiptarsenus varicornis Girault	American serpentine leaf miner (*L. trifolii*)	Krishnakumar *et al.* (1998)
Gonotoma sp.	*L. trifolii*	Srinivasan *et al.* (1995)
Phytoseiid mites	*P. latus*	Sudharma (1996)

2.4. Seasonal incidence of natural enemies of pests

Sitaraman (1966) reported that the incidence of *Xanthogramma scutellare* Fabr. was high during November to March and April and a reduction during December to February. The maggots and pupae of *Leucopis* sp. were found in small numbers during November and disappeared during December. They reappeared in February and were found in appreciable numbers upto April.

Mathew *et al.* (1971) indicated that the population of the *Aphis craccivora* Koch. and its predators were high during September to April at Vellayani. There was strong positive correlation between aphid population and predator groups like coccinellids, syrphids and hemerobids.

Patel *et al.* (1976) and Butani and Bharodia (1984) studied the seasonal abundance of aphids on groundnut and their natural enemies. There was a positive correlation between groundnut aphid population and population of active stages of their predators.

Studies on the safflower aphids and its predator coccinellids by Upadhyay *et al.* (1980) revealed that there was positive correlation between the population of predators and maximum, minimum temperature and sunshine hours whereas maximum and minimum relative humidity and rainfall were negatively correlated.

Multiple peaks of aphid abundance during each season matched the peaks of coccinellid predator abundance in egg plants (Baskaran and Veeravel, 1989).

Faleiro *et al.* (1990) reported that the number of *Brumus* sp. increased per unit area as daily temperature increased in summer whereas Araneae were significantly affected by maximum, minimum temperature and sunshine hours.

Hijam and Singh (1991) opined that eventhough predator populations closely followed those of aphids on cowpea, density independent factors had more influence on aphid populations. A pest dependant increase of predators of aphids was observed on cowpea and glyricidia by Reji Rani (1995).

Gupta and Verma (1992) observed that 60 per cent infestation by *D.cucurbitae* occurred around August - September and infestation was positively correlated with temperature and relative humidity.

2.5. Efficacy and consumption patterns of natural enemies of vegetable pests

2.5.1. Coccinellid predators

Lefroy (1909) stated that a single larva of *M. sexmaculatus* consumed 2400 aphids during its life time.

Chilomenes sp. and *C. septempunctata* had a feeding potential of 303 and 420 aphids respectively, the maximum number of aphids consumed by the former being 16321 and the latter, 22574 (Bagal and Trehan, 1949).

Jacob (1963) observed that the predator *M. sexmaculatus* consumed 272 aphids (*A. craccivora*) per day and Sarala Devi (1967) observed that the average feeding potential of the first, second and third instar larvae and adult of *C. sexmaculatus* as 7.11, 38.44, 70.78 and 27.22 respectively in the laboratory.

A total of 906.70 aphids was consumed during its lifetime whereas under field conditions, the consumption was 92.35 aphids per day and 5611 aphids during its life time.

Johnson (1972) observed that the grubs of *S. nubilis* consumed 50 to 63 aphids during its larval period of 8 to 11 days whereas the adult beetle consumed 6 to 11 aphids a day.

The total number of *A. craccivora* consumed by a single larvae of *C.transversalis* varied from 401 to 736 (Debaraj and Singh, 1990).

The average daily consumption of *M. sexmaculatus* larvae was 8.50 *A.craccivora* adults and 73.52 nymphs whereas the adult predator fed on 24.34 adults and 176.15 nymphs (Lokhande and Mohan, 1990). Das (1991) reported that the average consumption during the entire life stage of *M. sexmaculatus* was 270 to 367 aphids, whereas Reji Rani (1995) stated that the adult *M. sexmaculatus* lived upto 31 days and had a mean consumption of 24 aphids per day.

Singh and Singh (1994) reported that the first to fourth instar larvae and adult male and female *C. septempunctata* consumed an average of 22.78, 66.00, 72.50, 333.11, 119.80 and 140.68 *Lipaphis erysimi* Kalt. aphids respectively. The corresponding prey consumption for *Hippodamia variegata* Goeze were 21.83, 79.11, 162.95, 243.01, 91.56 and 115.30 aphids per day.

Studies on the feeding preference of *C. transversalis* and *C. maculatus* on *A. gossypii* stages by Veeravel and Baskaran (1996) revealed that there was significant difference among the predatory stages for various prey ages.

Syrphid and other predators

While describing some species of Syrphidae in India, Deoras (1942) stated that a single syrphid destroyed about 484 aphids in four hours.

Sitaraman (1966) reported that a single larva of the predator *X.scutellare* required on an average 123 *A. craccivora* per day. Sarala Devi (1967) stated that the feeding potential of *X.scutellare* maggot was 386.86 aphids during its larval period of 5.07 days. Sitaraman (1966) and Sandhu and Kaushal (1975) studied the feeding pattern of *Leucopis* sp. on aphids.

Ghosh *et al.* (1985) observed the feeding of *I.scutellare* on *A.craccivora* and *A.gossypii* in the N.W. Himalayas. *I. scutellare* and *P. serratus* consumed on an average 471 and 429 *A. gossypii* respectively during their larval period of six days (Dahiya *et al.*, 1988).

2.5.2. Parasites and parasitoids

Mathew and Abraham (1973) observed the parasitism of epilachna beetle by *C.johnsoni* in Kerala and reported that the mean number of parasites emerging from a single host grub was 20. Field parasitisation was the highest (6.50 per cent) during July - August and declined with lower pest population.

Rataul (1976) observed the biology of *Apanteles glomeratus* L., an endoparasite of *Pieris brassicae* Linn. larvae in Ludhiana. The parasite which had a life cycle of 17.00 to 18.50 days,passed through three to four generations during March to May.

The peak parasitism of *A. craccivora* by *T. indicus* of 64.60 per cent was observed in February resulting in suppression of the aphid (Pandey and Rajendra Singh, 1984).

Pathummal Beevi *et al.* (1988) revealed that the parasite *Eretmocerus* sp. and *Encarsia* sp. were able to lower the population of *B. tabaci* in brinjal. The natural parasitism was 20 per cent in April where adults were 100 to 150 per leaf and the extent of parasitism was 90 per cent in June reducing the pest to a level of five to ten per leaf.

2.6. Mechanical / cultural methods in pest control

Hutson (1940) reported that gourds covered with newspaper bags were completely protected from infestation by *D. cucurbitae*. Narayanan (1953) recommended ploughing of the field to destroy fruit fly pupae.

Patel and Kulkarny (1956) reported that *M. indica* could be controlled by hand picking of larvae and application of contact insecticides.

Pradhan (1969) opined that collection and destruction of infested fruits of cucurbits along with the larval stages of the fruit fly was very effective in dealing with the pest. He advocated the use of poison baits with attractants.

Shah and Patel (1976) reported that *Ocimum sanctum* which contained methyl eugenol attracted *Dacus* spp. in mango and chiku.

Lall and Singh (1960) and Eta (1985) disclosed that poison baiting with fermented palm juice or protein hydrolysate was effective against fruit flies in

cucurbits. Nakamori and Soemori (1985) adovated the use of traps of naled with either cue-lure or sliced pumpkin against fruit fly. However, Wen (1985) opined that cue-lure and isolan were more useful. The use of methyl eugenol and cue-lure to trap *D. cucurbitae* in cucurbits was recommended by Fang and Chang (1984), Su (1984) and Ramsamy *et al.* (1987).

Fruit flies of *Dacus* and *Anastrepha* sp were more attracted and caught in yellow coloured traps (Bateman, 1976 and Velasco-Pascal and Enkerlin, 1980), while Robacker *et al.* (1990), Vargas *et al.* (1991) and Stark and Vargas (1992) observed that yellow or white coloured traps were useful for trapping *Dacus dorsalis* Hendel. Shukla and Upadhyay (1985) reported that irrigation of the field minimised damage by *E. dodecastigma* on loofah.

Jalaja (1989) observed that one per cent honey and ripe banana fruits of palayankodan or poovan variety were effective and on par in luring *D. cucurbitae* adults. She recommended the bagging of developing fruits with polythene bags upto eight days from fruit set along with trapping of adults to control fruit fly.

Trials at Vellayani by Pillai *et al.* (1991) revealed that palayankodan banana fruit impregnated with carbofuran at the cut surface was the most effective trap against the melon fly. The palayankodan banana fruit with carbofuran trap is to be set at two metre distance and replenished once in seven to nine days to control fruit fly in snake gourd (Kerala Agricultural University, 1993).

A fishmeal trap with dichlorvos placed in perforated polythene bags is recommended against fruit flies in Tamil Nadu (Reghupathy *et al.*, 1997).

Reghunath and Indira (1993) developed a trap containing 20 g crushed *O.sanctum* leaves, 0.50 g citric acid and 0.50 g carbofuran in 100 ml water placed in a coconut shell to lure *D.cucurbitae* and *D.dorsalis*.

Roomi *et al.* (1993) reported that extracts of *O.sanctum* lured *B.cucurbitae* and other fruit flies from a distance of 0.80 km in orchards in Pakistan. Based on experiments conducted in cucurbits, the use of poisoned banana fruit and ocimum traps were recommended against the fruit fly (Kerala Agricultural University, 1996a).

2.7. Chemical control of cucurbit pests and toxicity studies

2.7.1. Fruit flies

Narayanan and Batra (1960) recommended the spraying of one per cent malathion emulsion, fenthion or dimethoate with sugar at fortnightly intervals to control fruit flies in cucurbits, while spraying of carbaryl 0.10 per cent three times at fortnightly intervals from the time of flowering was effective against *D. cucurbitae* (David, 1967).

Das *et al.* (1968) observed that carbaryl cover sprays along with aldrin or heptachlor application in the soil and prompt destruction of affected fruits controlled the fruit fly.

Mote (1975) reported that tetrachlorvinphos 0.10 per cent gave the best control of the fruit fly with maximum yield followed by 0.03 per cent fenthion and 0.10 per cent carbaryl.

Nagappan *et al.* (1971) observed fruit fly damage of 15.95 per cent in snake gourd when sprayed at tri weekly intervals with 0.10 per cent dimethoate or fenthion compared to 41.39 per cent damage in control.

Malathion 0.10 per cent and dimethoate 0.10 and 0.05 per cent controlled fruit fly infestation in sponge gourd (Mann *et al.*, 1976). Pawar *et al.* (1989) reported that carbaryl 0.10 per cent and monocrotophos 0.05 per cent were most effective against *R. foveicollis* and *D. cucurbitae* respectively. Pareek and Kavadia (1988) and Srinivasan (1991) recommended sprays of carbaryl, fenthion or dimethoate against the fruit fly.

2.7.2. Other pests of cucurbits

Sevin was reported to be an effective insecticide against *A. gossypii* (Young and Ditman, 1959)

Champ (1966) observed that dimethoate 0.05 per cent controlled *Aulacophora* spp. in cucurbits.

Pareek and Noor (1980) recommended sprays of 0.03 per cent dimethoate or 0.20 per cent carbaryl to control jassid *A. biguttula biguttula* infesting ridge gourd. Borah and Saharia (1982) reported that epilachna beetle on ridge gourd was controlled by malathion and carbaryl at 1.0 kg ha^{-1}.

Tewari (1986) reported that synthetic pyrethroids viz. fenvalerate, cypermethrin, deltamethrin and permethrin were highly effective against epilachna beetle in bitter gourd.

The use of insecticides *viz.* carbaryl, malathion, dimethoate, phosphamidon or monocrotophos is recommended for the control of pests like fruit flies, epilachna beetle, red pumpkin beetle and plant lice in bitter gourd. (Kerala Agricultural University, 1993a).

Thomas and Jacob (1994b) opined that carbofuran at 1.50 kg ha^{-1} at sowing, vining and flowering controlled red pumpkin beetle on bitter gourd. Reddy (1997a) reported that application of fenvalerate at fortnightly intervals was effective against epilachna and leaf hopper.

Formothion and triazophos were effective pesticides against *B. cucurbitae* (Talpur *et al.*, 1994 and Reddy, 1997b).

2.7.3 Studies on toxicity of pesticides to pests of cucurbits (laboratory)

Chen (1960) observed that malathion 2.5 WP when used at dilutions of 1:800 for young leaves and 1:400 for old leaves effectively controlled *D.cucurbitae*.

Among nineteen insecticides tested as residual films to the adults of *D.cucurbitae* at LC50, carbaryl was more toxic than endrin and pyrethrin: malathion came eleventh in the order (Bhatia and Kaul, 1965).

Toxicity studies to the larval instars of *E. vigintioctopunctata* indicated that sevin was the most toxic followed by parathion, malathion, BHC and DDT (Jayakumari and Nair, 1968) whereas BHC, dichlorvos, phosphamidon and

malathion showed low residual toxicity and sevin and trithion showed high residual toxicity to grubs and adults of the epilachna beetle (Mathew and Nair, 1969).

Kerser *et al.* (1973) reported that dimethoate and naled were the most toxic to *D. cucurbitae*, whereas Bhatt and Bhalla (1978) indicated that fenthion followed by malathion were the most toxic. However Gupta and Verma (1979) reported that carbaryl and quinalphos were 17.8 and 9.10 times as toxic as malathion to the adults of *D. cucurbitae* respectively.

In greenhouse studies, carbaryl gave the highest mortality of epilachna beetle followed by fenvalerate and phosalone (Sreedevi *et al.*, 1993).

2.8 Effect of pesticides on natural enemies on pests of vegetables

2.8.1 Parasites

Tewari and Krishnamoorthy (1983) demonstrated the detrimental effects of pesticides against *P. foveolatus*. Endosulfan was the safest insecticide with the maximum safety index to the parasite. Similar results were obtained by Tewari (1986).

Mani and Krishnamoorthy (1984) tested the susceptibility of adults and cocoons of *Apanteles plutellae* Kurdj. to pesticides. Quinalphos was highly toxic to both whereas dichlorvos, monocrotophos and endosulfan were highly toxic to adults but relatively safe to the cocoons.

Sharaf and Bath (1985) recorded upto 90 per cent parasitism in brinjal fields in Jordan where the insecticide usage was limited and very low parasitism

where the usage was high. The adverse effect of pesticides on *A. plutellae* was observed by Mushtaque and Mohyuddin (1987) in Pakistan.

Mani and Sudha Nagarkatti (1988) evaluated the contact toxicity of thirteen pesticides at recommended field doses to the tachinid *Eucelatoria bryani* Sabrosky. Carbaryl caused the least mortality followed by dimethoate, malathion and quinalphos.

Orr *et al.* (1989) reported high levels of mortality of the adult egg parasitoid *Trissolcus bassalis* Wollaston on soybean stinkbug within six hours of exposure to methyl parathion. However, the insecticide did not affect emergence of parasitoids from their host eggs.

Srinivasa Babu *et al.* (1993) indicated that endosulfan and phosalone were highly toxic to *Trichogramma australicum* Girault, *Tetrastichus israeli* Mani and Kurian and *Bracon hebetor* Say.

Azad Thakur and Deka (1995) demonstrated that while synthetic pyrethroids were highly safe to *A. glomeratus*, malathion, chlorpyriphos, quinalphos and endosulfan were toxic within 24 hours; malathion had significantly high residual toxicity upto 21 days.

2.8.2 Predators

Jotwani *et al.* (1960) reported that malathion was extremely toxic (more than 130 fold) to the predator *Stethorus pauperculus* Weise compared to dimethoate.

Sarup *et al.* (1965) observed that the predator *C. septempunctata* was more resistant than *A. craccivora* and *A. gossypii* to carbaryl, while Satpathy *et al.* (1968) reported that methyl demeton, dimethoate and phosalone were selective to aphidophagous coccinellids.

When adult *M. sexmaculatus* beetles were fed with eight different insecticide poisoned *A. craccivora*, Satpathy *et al.* (1968) observed that dimethoate was moderately toxic whereas carbaryl and malathion were highly toxic. Lingappa *et al.* (1978) recorded 100 per cent mortality of *M. sexmaculatus* after malathion 0.10 per cent spray.

Sagar (1978) observed that a spray of binapacryl applied to sponge gourd for the control of *Tetranychus cinnabarinus* Boisduval also killed the mite predator *Stethorus* sp.

Makar and Jadhav (1981) recorded high mortality (95 to 100 per cent) of *M. sexmaculatus* adults 72 hours after exposure to carbaryl, fenitrothion and quinalphos, while methyl demeton, phosphamidon and dimethoate were moderately toxic.

Sharma and Adlakha (1986) observed that malathion, quinalphos, dimethoate and carbaryl had relative toxicities of 25.17, 14.36, 40.14 and 11.86 compared to 1.00 of DDT to the adults of *C. septempunctata*, while Chaudhary *et al.* (1983) reported that methyl demeton, quinalphos and dimethoate were comparatively less toxic and safer to *M. sexmaculatus*.

Patel *et al.* (1986) investigated the effects of four insecticides on early instars of four spider species. All the insecticides were toxic to the spiderlings.

Fenvalerate and phosphamidon were found to be the most toxic whereas monocrotophos was the least. Patel *et al.* (1987) reported that successive application of pesticides to fields resulted in qualitative as well as quantitative decline in the spider population both in relative abundance as well as in species composition.

Thayaalini and Raveendranath (1988) indicated that the use of dimethoate reduced the searching capacity and longevity of *M. sexmaculatus* compared to the botanical *Gardenia cramerii* (30 g in 100 ml water). Hussain and Fong (1989) reported that dimethoate was relatively more toxic than malathion to *M.sexmaculatus*. However Rao *et al.* (1990) demonstrated that quinalphos, dimethoate and oxydemeton methyl were safe to *M. sexmaculatus*.

Patel and Yadav (1993) observed that endosulfan was highly toxic to *M.sexmaculatus* larvae when exposed immediately after spraying.

Rai *et al.* (1996) revealed that predatory mite population diminished in okra plants treated with dicofol, monocrotophos and methyl demeton.

2.9. Effects of neem on pests of vegetables (laboratory)

2.9.1. Neem seed kernel (extracts)

As early as in 1944, Cherian and Menon reported that cold extracts of neem seed kernel (NSK) was efficient as an insecticide and their toxicity was increased by addition of soap against *A. gossypii* and *Urentius echinus* Dist.

Mane (1968) observed that gaseous NSK suspension had repellent action

against *A. foveicollis* and *Spodoptera litura* Fb. Similar observations were made by Chakravarthy *et al.* (1970).

Gill and Lewis (1971) observed that when *P. brassicae* larvae were fed on foliage treated with extract of NSK, many of the larvae died before moulting; malformation of pupae and prolongation of pupal period were also seen.

Methanol extract of NSK had antifeedant activity against *Epilachna varivestis* Muls. both in the laboratory and on potted plants (Ascher, 1980).

Singh and Srivastava (1983) observed the ethanolic extract of petroleum ether extract of NSK at five per cent completely deterred oviposition by *D.cucurbitae* on bitter gourd.

Webb *et al.* (1983) indicated that one per cent neem seed extract (NSE) disrupted the development of the American serpentine leaf miner.

Seed kernel suspension, oil emulsion and water extracts of neem leaf had significant antifeedant effect against *P. brassicae* larvae and the mean leaf area consumed was reduced by 40 to 50 per cent. (Kirpal Singh and Sharma, 1987).

Gujar and Mehrotra (1988) fed adults of *A. foveicollis* for eleven days on musk melon treated with 0.50 to 2.00 per cent NSKE and observed 50 per cent mortality within four to seven days.

Chauhan and Quadri (1989) reported that NSE at 1250 ppm was highly toxic to *Earias vitella* Fb. larvae on okra.

Jeyarajan and SundaraBabu (1990) found that azadirachtin rich neem fractions were good antifeedants against adults and fourth instar grubs of epilachna beetle on brinjal.

Jackai *et al.* (1992) reported that NSE and neem seed powder were toxic and affected the development of the pyralid *Maruca* sp and nymphs of coreid bug *Clavigrella* sp.

Sojitra and Patel (1992) found that five per cent paste suspension of NSK, repelin and neem cake had oviposition deterrent effect on bollworm of okra.

Consumption of two per cent methanolic extracts of neem seed by fourth instar larvae of *Plutella xylostella* Linn. resulted in the inhibition of growth and malformation of the larvae (Zhang *et al.*, 1992).

Ragumoorthi (1996) reported that nimbecidine, a commercial neem product had high anti-oviposition effect and reduced the fecundity, longevity of the adult and survival of the maggots of moringa fruit fly.

2.9.2. Neem seed oil (NSO) and neem products

Neem seed oil (NSO) at 0.05 per cent deterred 91 to 100 per cent oviposition by the potato tuber moth (Shelke *et al.*, 1985).

Chitra and Kandasamy (1988) evaluated eleven constituents of neem against *D. indica*, *S. litura* and *H. vigintioctopunctata*, of which Vepicidin,

Nemidin and Vemidin were found to have high antifeedant activity at concentrations ranging from 0.05 per cent to 0.50 per cent upto 48 hours.

When brinjal leaves treated with 0.025 and 0.05 per cent NSO were fed to *Epilachna sparsa* Hbst. adults by Mishra *et al.* (1990), the pre-oviposition period was 21 per cent longer than the insects fed on untreated leaves. Oviposition period was shorter than normal and eggs were smaller in size.

Bioefficacy tests of botanicals against *S. litura* by Ramachandra Rao *et al.* (1990) indicated that NSO was most effective followed by neemark, biosol and repelin in repellency, feeding deterrency, ovipositional deterrency, ovicidal action and growth inhibitory effect.

Azam (1991) observed that NSO at 1.00 and 1.25 per cent caused more than 80 per cent mortality to larvae and pupae of *L. trifolii* on cucumber leaves.

The oviposition and feeding by *L. trifolii* adults was deterred by neem products like Neem Azal-S and Margosan - O (Dimetry *et al.*, 1995).

Matter *et al.* (1993) observed that *A. gossypii* was repelled by NSO.

Lowery and Isman (1993) reported that NSO at one per cent applied to leaf discs resulted in 94 to 100 per cent mortality of aphids after nine days.

2.9.3. Neem leaf (extracts)

Steets (1975) reported that neem leaf extracts at two and five per cent

killed the larvae of *Epilachna varivestis* Muls. and *P. xylostella* fed on treated beans and cabbage foliage respectively.

Leaf extracts of neem at three and five per cent exhibited high antifeedant activity against *Selepa docilis* Btlr. on brinjal (Kerala Agricultural University, 1991).

2.10 Pest control in vegetables using neem (field)

2.10.1. Neem seed kernel (extracts)

Pradhan *et al.* (1962) observed that aqueous suspension of NSK persisted for two to three weeks on cabbage plants in the field.

Chakravarthy *et al.* (1969) indicated that NSKE sprayed on 35 day old cucumber crop offered protection against the red pumpkin beetle for six days. Asari and Nair (1972) reported that NSK suspension significantly protected brinjal against aphid and leaf hopper. NSKE at three per cent was reported to be effective for five days when sprayed on radish (Muthuraman, 1979).

Pierce (1981) reported that spraying of 0.10 per cent neem seed extract protected musk melon seedlings against *Acalymma vittatum* Fabr. (Chrysomelidae) for three days.

In Gambia, weekly application of aqueous extract of neem fruits (berries at 112.50 g per litre) contained the African melon ladybird beetle (Redknap, 1981).

Petroleum ether extract of neem at a dilution of 1:100 gave good control of *L. orbonalis* (Krishnamurthy Rao, 1983).

Field trials by Adhikary (1985) showed that crude methanol extracts of neem seed was more efficient than mevinphos and deltamethrin against *P. xylostella*. Neem seed extract applied as soil drench and foliar spray reduced the population of epilachna grubs while the shoot borer was not controlled (Kerala Agricultural University, 1985).

Fagoonee (1987) reported that NSKE was as effective as decis against the diamond backmoth and cabbage webworm. NSKE alternated with decis on weekly basis was more effective than decis alone against *H. armigera*. Siddiq (1987) observed that NSKE was effective against whitefly, leafhopper and aphid infestation on potato.

NSKE five per cent and NSO three per cent spray controlled whitefly and fruit borer in bhindi and was comparable to chemical pesticides (Kathirvel, 1988).

NSKE five per cent spray was recommended against diamond backmoth larvae in cabbage by Bandara and Kudagamage (1993) and Srinivasan and Krishnamoorthy (1993). Gomez *et al.* (1991) supported the use of NSO for management of white flies in vegetables.

2.10.2. Neem seed oil (NSO) and neem products

Mohan (1988) observed that root dipping of brinjal seedlings with NSO (three per cent) followed by NSKE five per cent spray controlled aphids and fruit borer. Mallik and Lal (1989) found that neem seed cake at five kg 200 m^{-2} reduced fruit borer infestation in bhindi.

Lowery and Isman (1993) demonstrated in field trials, the effectiveness of NSO and NSE as aphidicides.

Reghunath and Gokulapalan (1994) revealed that NSO controlled the American serpentine leaf miner and aphid in cowpea and reduced mosaic in cowpea. Similarly Samuel and Mariappan (1996) revealed that NSO and its derivatives reduced survival of aphids and transmission of mosaic in chillies. Trials conducted by KHDP (Kerala Agricultural University, 1996a) indicated that NSO 2.50 or 5.00 per cent with garlic (20 g per litre) effectively controlled epilachna beetle, jassid, aphid and mite on bitter gourd.

James Keisa and Varatharajan (1995) indicated that chilli plants sprayed with neem formulations viz. Achook and Nimin sprays alternated with monocrotophos controlled thrips better than neem products alone.

2.10.3. Neem leaf (extracts)

Singh and Sharma (1986) indicated that application of water extracts of neem leaves at five per cent at 15 days interval on cabbage and cauliflower controlled the aphid *Brevicoryne brassicae* Linn.

Saradamma (1989) found that two per cent benzene extract of neem leaves reduced populations of *H. vigintioctopunctata, A. gossypii* on brinjal and epilachna beetle on bitter gourd and was on par with carbaryl 0.20 per cent. However Venkataramireddy *et al.* (1990) opined that one per cent petroleum ether extract of neem leaves controlled epilachna beetle on brinjal.

Based on research conducted, the Kerala Agricultural University (1993a) has recommended four per cent neem leaf extract with soap water against pests of amaranthus, bhindi, brinjal and bitter gourd, neem kernel suspension at 0.10 to 0.30 per cent as an effective repellent against locusts, grasshoppers and lepidopteran chewing insects; neem leaf at 250 g per pit one week before planting against nematodes in bhindi.

2.11 Effects of other botanicals against pests of vegetables

Pajni (1965) reported that five per cent ethanolic extracts of fruits of *Melia azedarach* repelled larvae of *P. brassicae* and *A. foveicollis* whereas 10 per cent caused mortality of 78.30 and 60.00 per cent respectively within 96 hours.

Hozosawa *et al.*, 1974 reported that ether extracts of the leaves of *Clerodendron frajan, Clerodendron calamilosum* and *Clerodendron cryptophyllum* could inhibit the feeding of *S.litura*. Extracts isolated from *Clerodendron infortunatum* deterred the feeding of *S. litura* larvae (Antonius and Saito, 1981) and *P. brassicae* (Geustens *et al.*, 1993). Petroleum ether extract of *M.azedarach* and *Argemone mexicana* had good insecticidal activity against *Bagrada cruciferarum* Kirk. on turnip (Pandey *et al.*, 1981).

Sandhu and Singh (1975) observed that aqueous seed kernel of *M.azedarach* at 0.40 per cent concentration significantly reduced the feeding by *P.brassicae* larvae.

Clerodendron inerme was observed by Thripathi and Rizvi (1985) to have antifeedant activity against *Diachrisia obliqua* Walk.

Shin-Foon (1987) opined that three per cent ethanolic extract of root bark of *Tripterygium welfordii* (thunder god vine) was as effective as 0.10 per cent acephate against *A. foveicollis*. The seed extract of *Gynandropsis gynandra* was found to be most toxic to epilachna beetle followed by rhizome extract of *Acorus calamus* and shade dried stem extract of *Cyperus rotundus* (Chandel *et al.*, 1987).

Stein *et al.* (1988) reported that ethanolic and methanolic extracts of *O.sanctum* caused heavy mortality in aphids on cabbage in Thailand. Application of extracts of *Ocimum grattissimum* reduced the rate of oviposition in *Dacus* sp. (Areekul *et al.*, 1989).

Benzene extracts of *Eupatorium odoratum, C. infortunatum, Thevetia neriifolia* and *Nerium oleander* significantly reduced the population of epilachna beetle, and aphid on brinjal and epilachna beetle on bitter gourd (Saradamma, 1989).

Acetone extract of *Vitex negundo* leaves at 0.05, 0.40 and 0.50 per cent caused 100 per cent mortality in *E. vitella, D. indica* and *E. septima* while at lower concentrations,only antifeedant activity was observed (Kalavathi *et al.*, 1991).

Tobacco decoction, four per cent leaf extracts of *T. neriifolia, C.infortunatum* (with soap water), 1.50 per cent fish oil soap emulsion are being recommended against pests of vegetables like amaranthus, bhindi, brinjal, bitter gourd and cowpea (Kerala Agricultural University, 1993a).

In field experiments, Lily and Saradamma (1994) and Lily (1995) demonstrated that acetone and water extracts of *C. infortunatum* leaf was comparable to carbaryl in controlling epilachna beetle on bitter gourd.

Hebsy Bai (1996) reported that seed extracts of *T. neriifolia* was an effective antifeedant leading to larval starvation in epilachna beetle.

2.12 Effects of botanicals on natural enemies of pests

Joshi *et al.* (1982) found that application of two per cent NSK suspension to the eggs of *S. litura* parasitised by *Telenomus remus* Nixon did neither prevent emergence of parasites nor repel oviposition by female parasite. Suspension of NSK was also observed to be safe to *Chrysopa scelestes* Banks.

Schauer (1985) reported that spraying of NSKE on *M. persicae* mummies containing larvae and pupae of its parasite *Diaretiella rapae* Curtis did not prevent normal emergence of the adult parasites.

Tewari and Moorthi (1985) observed that grubs of *H. vigintioctopunctata* freshly treated with petroleum ether extracts of *M.azedarach* and rhizomes of *A.calamus* were significantly less parasitised by *P.foveolatus*.

According to Mansour *et al.* (1986), neem extracts were considerably much more toxic to the pests than to the predaceous mite *P. persimilis* and the predatory spider *Chiracanthium mildei*.

Nicotine sulphate was reported by Singh *et al.* (1988) to be harmless to the predator, *C.septempunctata*. Similarly, Rao *et al.* (1990) observed that nicotine sulphate was safe to the natural enemies of the chilli aphid.

In greenhouse trials, Hoelmer *et al.* (1990) observed that rates of parasitism of *A. gossypii* and greenhouse whitefly on plants treated upto four times

with Margosan - O were comparable to controls and significantly higher than the other pesticide treatments.

Srinath (1990) reported that plant extracts of *A.indica, T.neriifolia* and *C.infortunatum* were not as toxic as carbaryl to the predator, *M.sexmaculatus*. All the above plant extracts and tobacco decoction affected the population of predator with values ranging from 10.61 to 12.68 as against 14.80 in control.

Bandara and Kudagamage (1993) while studying the effect of neem on diamond backmoth larvae, observed that water extract of NSK (NSKW) as well as NSO did not have any harmful effect on *A. plutellae* adults. The application of NSKW on the host cocoons did not adversely affect the adult parasite emergence. Similar results were obtained with NSKE spray by Srinivasan and Krishnamoorthy (1993) who suggested the inclusion of NSKE for the management of insecticide resistant strain of diamond backmoth.

Feldhege and Schmutterer (1993) observed that parasitoids of the greenhouse whitefly *Trialeurodes vaporarioram* Westwood attacked and parasitised significantly fewer neem treated whiteflies with the deterrent effect diminishing over time. Dipping of greenhouse whitefly puparia on bean leaves in solutions of Margosan - O containing 10 ppm AZA did not harm the parasitoid, *Encarsia formosa* Gah. whereas 20 ppm AZA was slightly harmful.

Lily (1995) reported that extracts of *C.infortunatum* were safe to *C.johnsoni*. Investigations by Hebsy Bai (1996) indicated that leaf and seed extracts of *T.neriifolia* at field doses were safe to *C. johnsoni*. Parasitization of

egg masses, grubs and pupae in plots treated with extracts of *T. neriifolia* was on par with control while they were absent in the insecticide treated plots.

Osman and Bradley (1993) reported that *Cotesia glomeratus* Linn. that emerged from *P. brassicae* treated with NSE suffered high rates of mortality and often failed to spin cocoons.

Patel and Yadav (1993) indicated that the botanicals, nicotine sulphate, repelin and neemark were safe to the predator *M. sexmaculatus*.

Srinivasa Babu *et al.* (1993) reported that botanical insecticides viz. repelin and neemguard were relatively safe at lower concentrations to *T.australicum, B.hebetor* and *T.israeli* in the laboratory as well as field. However the higher concentrations of botanicals adversely affected the parasitoids.

Evaluation of botanicals against the insect pest complex of okra by Venkateshwara Rao and Rosaiah (1993) indicated that they did not adversely affect the predators like coccinellids, syrphids and spiders.

Lowery and Isman (1995) applied NSO at 0.50, 1.00 and 2.00 per cent to potted plants infested with *M. persicae* which resulted in total prevention of adult eclosion of *Coccinella undecimpunctata* L. and reduced adult eclosion of syrphid *Eupeodes fumipennis* Thompson to 11.00, 7.00 and 0.00 per cent respectively of the controls. NSO did not reduce the rate of parasitism of *M.persicae* by *D.rapae* but emergence of parasitoid adults from aphid mummies collected from treated plants was reduced to 35.00, 24.00 and 0.00 per cent respectively of the controls.

Rai *et al.* (1996) evaluated four azadirachtin-rich botanicals and six chemicals against spider mites and predatory mite complex in okra. The results showed that the botanicals did not harm the mite predators as deleteriously as the chemicals. As ovicides, plant products were comparable to the chemicals.

2.13 Combination of chemical and botanical pesticides against pests of crops

Singh and Singh (1987) reported that neem kernel suspension (NKS) had a potentiating effect on cypermethrin, carbaryl and several organophosphates against *Schistocerca gregaria* F.

Sarode and Gabhane (1988) opined that NSKE five per cent in combination with endosulfan was effective in reducing the damage by fruit borer in okra.

Rahman (1990) tested repelin, (a botanical pesticide containing neem, karanj, castor, mahua and gingelly) at 0.50 per cent concentration with conventional insecticides at the minimal suggested concentrations against the pests of tomato, brinjal, chillies, ladies finger, cabbage and coccinia. The results showed that all insecticides when used in combination with repelin gave better pest control as compared to the insecticides alone at higher doses and the quality of the produce was enhanced.

Shin-Foon (1990) applied an emulsion formulation of a botanical, toosendanin (300 ppm) in admixture with dimilin (two ppm) and fenvalerate (one ppm) for 90 per cent control of the imported cabbage worm and some noctuid larvae in the field.

Kalavathi *et al.* (1991) suggested that a combination treatment of leaf extract of *V. negundo* with endosulfan was more effective in controlling *E. vitella* larvae than the individual components.

Facknath (1993) reported that a four per cent extract of neem leaves had a synergistic effect when mixed with deltamethrin, cypermethrin and organophosphate prothioates against *P. xylostella.*

Venkateswara Rao and Rosaiah (1993) showed that nicotine sulphate and repelin alone or in combination with carbaryl was effective against jassids, aphids and *Heliothis* sp. on okra. Significant seed yields were also obtained.

The KHDP trials of the Kerala Agricultural University (1996a) revealed that malathion 0.20 per cent with garlic (20 g per litre) was effective against epilachna beetle, jassids, aphids and mites on bitter gourd.

Datta (1996) reported that NSKE (0.40 per cent) in combination with dimecron (0.05 per cent) effectively controlled thrips and aphids in cucurbits.

MATERIALS AND METHODS

MATERIALS AND METHODS

Survey of the pest complex of bitter gourd, their natural enemies, plant protection measures in bitter gourd, constraints etc. was conducted in Thiruvananthapuram district during 1995-96. The laboratory studies and field experiments were conducted in the Department of Entomology and in the Instructional Farm respectively of the College of Agriculture, Vellayani.

3.1.1. Monitoring of pests of bitter gourd, their natural enemies and survey of plant protection measures undertaken in Thiruvananthapuram district

A survey was conducted in three important vegetable growing areas of Thiruvananthapuram district, *viz.*, Kalliyoor, Venganoor and Sreekaryam. The survey covered a total of one hundred bitter gourd farmers. Fifty, thirty and twenty farmers' fields were surveyed from Kalliyoor, Venganoor and Sreekaryam respectively. Two visits *viz.*, one at flowering stage and the other at early harvest stage were conducted in each selected farmer's field. Observations were recorded in a proforma prepared for the purpose (Appendix I).

Response to a set of eighty variables were obtained from each farmer. The methodology adopted for recording observations and their natural enemies on pests of bitter gourd is given in Table 1. The criteria for assessing the level of

incidence of pest and their natural enemies are given in Tables 2 and 3 respectively. The constraints perceived by the farmers in the cultivation of bitter gourd was ranked in a continuum ranging from most important (score-5) to least important (score-1). The data were tabulated, analysed and the frequency tables were prepared.

3.1.2. Monitoring of *B. cucurbitae* using fruit fly lure trap

The Biosense stikatrap supplied by M/s Biosense Crop Protection (India) Ltd., Bombay (made in technical collaboration with Russel Fine Chemicals, U.K.) was used to monitor the male fruit fly population. The traps were installed in bitter gourd fields at fruit set (eighth week after sowing) at the following locations :-

1. Kalliyoor
2. Pappanchani
3. Venniyoor (Nellivila)
4. Block II - Instructional Farm, Vellayani
5. Block III - Instructional Farm, Vellayani
6. Block IV - Instructional Farm, Vellayani

One trap was installed in one location and one lure sufficed for one entire bitter gourd fruiting season. The traps were installed from September 1995 to March 1996. The total number of male fruit flies trapped were recorded at weekly intervals. The trend in the fruit fly population was determined statistically using a quadratic regression equation.

Table 1. Methodology adopted for recording observations of pests and their natural enemies in bitter gourd

Sl. No.	Pest	Method of observation
1.	Stem gall fly *Neolasioptera falcata*	a. Number of galls in five growing points per vine b. Number of gall fly maggots parasitised per vine
2.	Jassid *Hishimonas phycitis*	Number of adults in five leaves at random per vine
3.	Epilachna beetle *Henosepilachna septima*	a. Number of grubs on five leaves at random per vine b. Number of grubs parasitised out of five per vine c. Number of pupae parasitised out of five per vine
4.	Fruit fly *Bactrocera cucurbitae*	Number of fruits infested out of ten fruits per field (location)
5.	American serpentine leaf miner *Liriomyza trifolii*	a. Number of leaves infested out of five leaves at random per vine.
6.	Aphid *Aphis gossypii*	a. Number of adults in five leaves at random per vine b. Number of predatory insects in five leaves at random per vine c. Number of spiders per vine
7.	Yellow mite *Polyphagotarsonemus latus*	a. Number of adults in five leaves at random per vine b. Number of predatory thrips in five leaves per vine
8.	Leaf feeder *Diaphania indica*	a. Number of leaves infested out of five leaves at random per vine b. Number of larvae parasitised per vine

Table 2. Criteria for assessing level of damage of pests of bitter gourd

Sl. No.	Pest	Scale : Score :	None 0		Low 1	Medium 2	High 3
1.	*N. falcata*		Nil		≤ 10 % shoots affected	>10 to ≤ 25 % affected	>25% affected
2.	*H. phycitis*		Nil		≤ 1 adult per leaf	>1 to ≤ 5 per leaf	>5 per leaf
3.	*H. septima*		Nil		≤ 10 % leaves affected	>10.0 to ≤ 25%	>25%
4.	*B.cucurbitae*		Nil		≤ 10 % fruits damaged	>10.0 to ≤ 25%	>25%
5.	*L.trifolii*		Nil		≤ 10 % leaves affected	>10 to ≤ 25 % affected	>25% affected
6.	*A.gossypii*		Nil		≤ 10 adults per leaf	>10 to ≤ 50 per leaf	>50 per leaf
7.	*P. latus*		Nil	a)	≤ 10 mites per leaf	>10 to ≤ 50 per leaf	>50 per leaf
				b)	≤ 10 % leaves affected	>10 to < 25 % affected	>25% affected
8.	*D. indica*		Nil		≤ 10 % leaves infested	>10 to 25%	>25%

Table 3. Criteria for evaluation of incidence of natural enemies of pests of bitter gourd

Sl. No.	Natural enemy	Scale : Score :	None 0	Low 1	Medium 2	High 3
1.	Spiders		Nil	≤ 1 per vine	> 1 to ≤ 5 per vine	> 5 per vine
2.	Predatory insects		Nil	≤ 1 adult / young	> 1 to ≤ 5 per leaf	> 5 per leaf
3.	Parasites		Nil	≤ 1 parasitised larva / pupa per 10 leaves	> 1 to ≤ 5	> 5

3.1.3. Trial to compare the efficacy of Biosense stikatrap with carbofuran smeared banana fruit trap

The trial was conducted in two locations *viz.*, Block III and IV of the Instructional Farm, Vellayani during September to October, 1995. In each location, two bitter gourd plots of two cents (80 m^2) were selected. In one plot (two cents), one Biosense trap was suspended from the pandal (frame) and in the other, ten coconut shell traps (painted yellow) were hung, one in the centre of four vines. Palayankodan plantain pieces of four cm length and two cm in diameter (with the cut end smeared with one gram of carbofuran) were placed in each shell. The methodology adopted by Pillai *et al.* (1991) was followed. The poisoned bait (banana with carbofuran) was replaced once in a week. The total fruit fly catch was recorded at weekly intervals.

3.1.4. Seasonal incidence of pests of bitter gourd in relation to climate and natural enemies

The population or damage of pests of bitter gourd was assessed at fortnightly intervals in the crop cultivated in the Instructional Farm, Vellayani and farmers' fields in Kalliyoor panchayat. The observations were recorded from July 1995 to June 1996. The observations on pests, the extent of parasitization of pests and population of insect predators were recorded. The weather parameters *viz.*, maximum and minimum temperature, relative humidity, rainfall and number of rainy days were recorded from the meteorological observatory of the Department of Agronomy, College of Agriculture, Vellayani.

The pest population or intensity of infestation and natural enemies were observed as presented in Table 1. Observations on all the pests and the natural enemies were taken from five vines in each field and altogether there were five different fields.

The incidence of mosaic was also recorded at fortnightly intervals and percentage of plants infested was worked out. The data on pest population or damage incidence were tabulated and frequencies / percentage infestation worked out. These values were correlated with the natural enemy incidence and weather parameters to evaluate the degree of association of biotic and abiotic factors on population build up of pests of bitter gourd.

3.2. Assessment of the efficacy of parasites and predators of the pests of bitter gourd

Parasites and predators of the major pests of bitter gourd were collected from the Instructional Farm, College of Agriculture, Vellayani and farmers' fields. The potential parasites and predators were multiplied in the laboratory. Their efficacy was assessed in the following manner.

3.2.1. Biology and efficacy studies of the larval / pupal parasite *C. johnsoni* on *H. septima*

Rearing of *H. septima*

Egg masses of epilachna beetle were collected from the field and reared in the laboratory on bitter gourd leaves to build up the culture. The adults obtained from this culture were placed in glass jars provided with bitter gourd leaves for

feeding and egg laying. Eggs laid on each day were collected and reared out in separate glass troughs. Uniformly aged fourth instar grubs were thus obtained and used for the study.

Rearing of parasite *C. johnsoni*

Parasitised epilachna grubs and pupae were collected from the field and placed in 4.5 cm x 1.0 cm glass tubes. The emerging parasite adults were fed on 20 per cent honey solution streaked inside the tubes. The methodology followed by Mathew and Abraham (1973) was adopted for studying the life cycle of the parasite.

Ten fourth instar epilachna grubs were introduced in B19/25 glass tubes and in each tube, a pair of parasites were introduced. The oviposition efficiency by twenty female parasite adults, extent of parasitization of host grub, emergence of adult parasites per host grub and pupa were studied.

3.2.2. Studies on life cycle and feeding potential of the predator *I. scutellare*

The studies were conducted using adults of the aphid *A. gossypii* as prey. Freshly laid eggs of the hover fly were collected from the colonies of aphids infesting bitter gourd crop in the Instructional Farm. These were placed on fresh bitter gourd leaves. The stalk of the leaves were wrapped in wet cotton and placed in petridishes.

A freshly hatched maggot of the syrphid was placed among a colony of known number of aphid adults on bitter gourd leaf confined in a petriplate and aphids were replenished as and when required. The difference between number of aphids supplied and those remaining was recorded daily at 8.00 a.m. The bitter gourd leaves were replaced as and when required.

Separate experiments were conducted to assess the feeding potential of the first, second and third instars of the predator. Ten replications were maintained for each experiment. The duration of the life stages of the predator, the maggot's feeding pattern and consumption rate during the different instars were observed.

3.2.3. Life cycle, longevity studies and feeding potential of the predator *M. sexmaculatus*

Studies were conducted using adults of *A. gossypii* as prey.

Ten freshly laid eggs of *M. sexmaculatus* were kept individually in glass vials (10 x 2.5 cm) which were plugged with cotton. The incubation period was observed and on hatching, each grub was introduced into a colony of known number of *A. gossypii* adults placed on bitter gourd leaf confined on a petri plate. Aphids were replenished as and when required. The number of aphids consumed daily was recorded at 8.00 a.m. The dried bitter gourd leaves were replaced as and when required. There were ten replications and the means were worked out.

The consumption pattern of the second, third instar and adult coccinellid was also studied in this manner. The mean consumption of ten adult beetles were

also studied. The duration of different instars, pupa and longevity of adult predators were also observed.

3.2.4. Life cycle and feeding potential of predator *S. nubilis*

The life cycle and feeding potential of *S. nubilis* was determined using *A.gossypii* adults as explained in 3.2.3. The developmental period of each instar of grub and that of pupa were studied. The mean daily consumption of ten adult beetles on the first three days after emergence was recorded.

3.3. Effect of botanical and synthetic pesticides on the pests, parasites and predators of the pests of bitter gourd

3.3.1. Studies on the effect of botanicals on pests of bitter gourd

Extracts of leaf and flower of *C. infortunatum,* neem seed oil and nimbecidine (a commercial formulation of neem) were tested at different concentrations against the grubs of *H. septima* for their antifeedant effect. This was done with a view to select the best two botanicals and doses for the pest management trial in bitter gourd.

Preparation of extracts from *C. infortunatum*

C. infortunatum plants were collected from Instructional Farm, Vellayani. The leaves and freshly opened flowers were separated and used for extraction.

The fresh plant parts were sorted, divided into 20 g lots, chopped and finely ground in a mixer. They were then extracted with 50 ml water. The extract was then filtered twice using a fine muslin cloth and transferred to a volumetric

flask and volume made upto 100 ml. Thus a 20 per cent stock solution was obtained.

The extract was further diluted with water containing one per cent teepol as emulsifier for obtaining the different concentrations required for the experiments.

Twenty gram lots of fresh plant material were dried in shade. The extract from dried *C. infortunatum* was extracted with 50 ml water and prepared in the same way as explained for the fresh material.

Neem seed oil (NSO)

Neem seed oil required for the experiment was supplied by M/s. Krishna Ayurvedic Stores, Pulimoodu, Thiruvananthapuram. Neem seed oil (NSO) was thoroughly mixed with one per cent teepol. 40, 30 and 20 ml of NSO were taken in one litre of water to obtain four, three and two per cent concentrations respectively.

Nimbecidine

A commercial botanical pesticide containing azadirachtin 0.03 per cent supplied by M/s. T. Stanes and Co., Coimbatore, was used in the experiment.

In order to obtain 0.40, 0.30 and 0.20 per cent concentrations, 4.00 ml, 3.00 ml and 2.00 ml of nimbecidine respectively were dissolved in one litre of water separately.

Rearing of the test insect *H. septima*

The rearing of the test insect was done as explained in 3.2.1.

Estimation of antifeedant action of botanicals

Bitter gourd leaves of uniform age and size were weighed in an electronic balance and then dipped in solutions of the following botanical treatments.

Botanicals	Concentration of solutions (per cent)
1. *C. infortunatum* dry	8.00, 4.00 and 2.00
2. *C. infortunatum* fresh	8.00, 4.00 and 2.00
3. Neem seed oil	4.00, 3.00 and 2.00
4. Nimbecidine	0.40, 0.30 and 0.20

Ten third instar *H. septima* grubs were taken, weighed and released in each petridish which contained pre-weighed treated leaves. Three replications were maintained for each treatment.

The leaves were kept moist by providing a wet cotton plug around the leaf petiole. The grubs were pre-conditioned without food for four hours. Twenty four and 48 hours after exposure, the uneaten portions of the leaves were taken out, cleaned and weighed. The difference in weight gave the quantity of leaves consumed by the grubs. Pre-weighed leaves dipped in water and exposed to grub in petri-dishes served as control. The grubs were also taken out after 48

hours of feeding and weighed. The difference in weight gave the gain or loss in weight of the grubs. The grubs kept without food served as starved grubs.

The percentage of leaf protected by the extracts was estimated as A-B/ A x 100 where A - weight of leaf consumed in control and B - weight of leaf consumed in treatment. The difference between the weight gain of grubs in control and the mean weight loss of grubs starved for the same duration was taken as 100 per cent. Percentage of larval starvation in treatments were calculated as [(c-e)]/(c-s) x 100 where c - mean weight gain of grubs in control in 48 hours. e - mean weight gain of grubs in treatments and s - mean weight gain of grubs fully starved (the value is negative).

The data were statistically analysed to select the two most effective antifeedants.

3.3.2. Comparative efficiency of chemical pesticides to *H. septima*

The trial was conducted in the laboratory using fourth instar grubs of *H. septima*. The grubs of uniform size were collected from the culture maintained in the laboratory. The following four insecticides were tested at three doses each.

Sl.No.	Insecticide	Dose (%)
1.	Carbaryl	0.20, 0.15 and 0.10
2.	Quinalphos	0.05, 0.04 and 0.03
3.	Malathion	0.10, 0.075 and 0.05
4.	Dimethoate	0.05, 0.04 and 0.03

Water spray served as control. The procedure as suggested by Jayakumari and Nair (1968) was adopted.

The commercial formulations were diluted to get the required concentrations and sprayed on bitter gourd leaves taken in petridishes. The leaves were kept moist with a wet cotton plug wrapped around the leaf petiole. After drying for an hour, ten fourth instar grubs were released. The number of grubs dead and surviving 24 and 48 hours after release on treated leaves were observed. Percentage mortality in all the three replications for each treatment were worked out. The per cent mortality observed in control was adjusted by correcting the mortality in the treatments using Abbott's formula (Abbott, 1925). These values were transformed and subjected to statistical analysis.

The residual toxicity of the insecticides were studied in another trial. The insecticides were applied on bitter gourd vines. The leaves were collected one week after application. Each treatment had three replications. The leaves were placed in petridishes and ten fourth instar grubs were released. Observations on mortality were taken 24 and 48 hours after the release of grubs and statistical analysis done as discussed in the previous trial.

3.3.3. Assessment of the effects of extracts of botanicals and chemical pesticides on *C. johnsoni*, a parasite of the epilachna beetle

The adults of the parasite *C. johnsoni* were reared as explained in 3.2.1

A trial was conducted in the laboratory to evaluate the effect of different concentrations of botanicals as shown in 3.3.1 and the different concentrations of

pesticides (as shown in 3.3.2) on the adults of the parasite. The procedure suggested by Singh (1995) was followed. All the dilutions of the botanicals and pesticides were made with acetone. 0.10 ml of the solutions were transferred to rimless glass vials of size 5 cm and the solvent was allowed to evaporate while rotating the tubes in a horizontal position. This was done to ensure the uniform deposition of the solutes on the inner surface of the tubes. Control using acetone and three replicates of each concentration were maintained.

Ten one day old adults of *C. johnsoni* were transferred into each tube. The tubes were plugged with cotton. The cotton plug end which was inserted into the vials was previously dipped in diluted honey (20 per cent concentration). This served as food for the parasites. One, three, six and 24 hours after exposure, the mortality were recorded. Mortality in control was corrected using Abbott's formula. The data was transformed and subjected to statistical analysis.

3.3.4. Assessment of the effect of botanicals and chemicals on parasitised *H. septima* grubs and pupae

The fourth instar grubs as well as those grubs which were ready to enter the pupal phase were exposed to adults of *C. johnsoni* in the laboratory. The parasitised grubs and pupae were collected on the third day of parasitisation. These were directly sprayed with the different concentrations of botanicals and insecticide formulations. Ten parasitised grubs or pupae treated in petridishes served as one replication. There were three replications. In control, the grubs and pupae were sprayed with water. The treated host grubs were then kept in glass tubes (5 cm x 1.5 cm) in the laboratory and observed for adult emergence.

The number of adult parasites emerging in each replication was recorded. Mortality in control was observed by dissecting the parasitised grubs/pupae and counting the dead stages of the parasite. This was corrected using Abbott's formula.

3.3.5. Evaluation of toxicity of botanicals and chemical pesticides to the predator *M. sexmaculatus*

The third instar grubs of the predator *M. sexmaculatus* were obtained from the culture maintained in the laboratory. The botanicals and commercial insecticides mentioned below were included in the toxicity studies.

Sl. No.	Botanicals / Chemical pesticides	Concentrations (%)
1.	Nimbecidine	0.40 and 0.30
2.	*C. infortunatum* fresh	8.00 and 4.00
3.	Neem seed oil	4.00 and 3.00
4.	Carbaryl	0.20 and 0.15
5.	Dimethoate	0.05 and 0.04
6.	Quinalphos	0.05 and 0.04
7.	Malathion	0.10 and 0.075

The methodology of Makar and Jadhav (1981) was followed. One ml of the emulsion/suspension of the botanical/chemical pesticide in acetone was sprayed directly over clean petridishes using an atomiser and dried. Each treatment was

replicated thrice with control (acetone alone) also. Ten third instar grubs were released into the petridishes. The treated grubs were left in the dishes for an hour. After that, the grubs were transferred to fresh petridishes.

Adults of *A. gossypii* collected from untreated bitter gourd plants were provided as food to the grubs. Fresh food was given daily. Mortality counts were taken at 12, 24 and 48 hours. Moribund insects were counted as dead. Percentage mortality in all the three replications for each treatment was calculated. The per cent mortality observed in control was compensated by correcting mortalities in the treatments using Abbot's formula. Corrected per cent mortality were then transformed to angular values and subjected to analysis of variance.

3.4. Reaction of bitter gourd varieties to pests

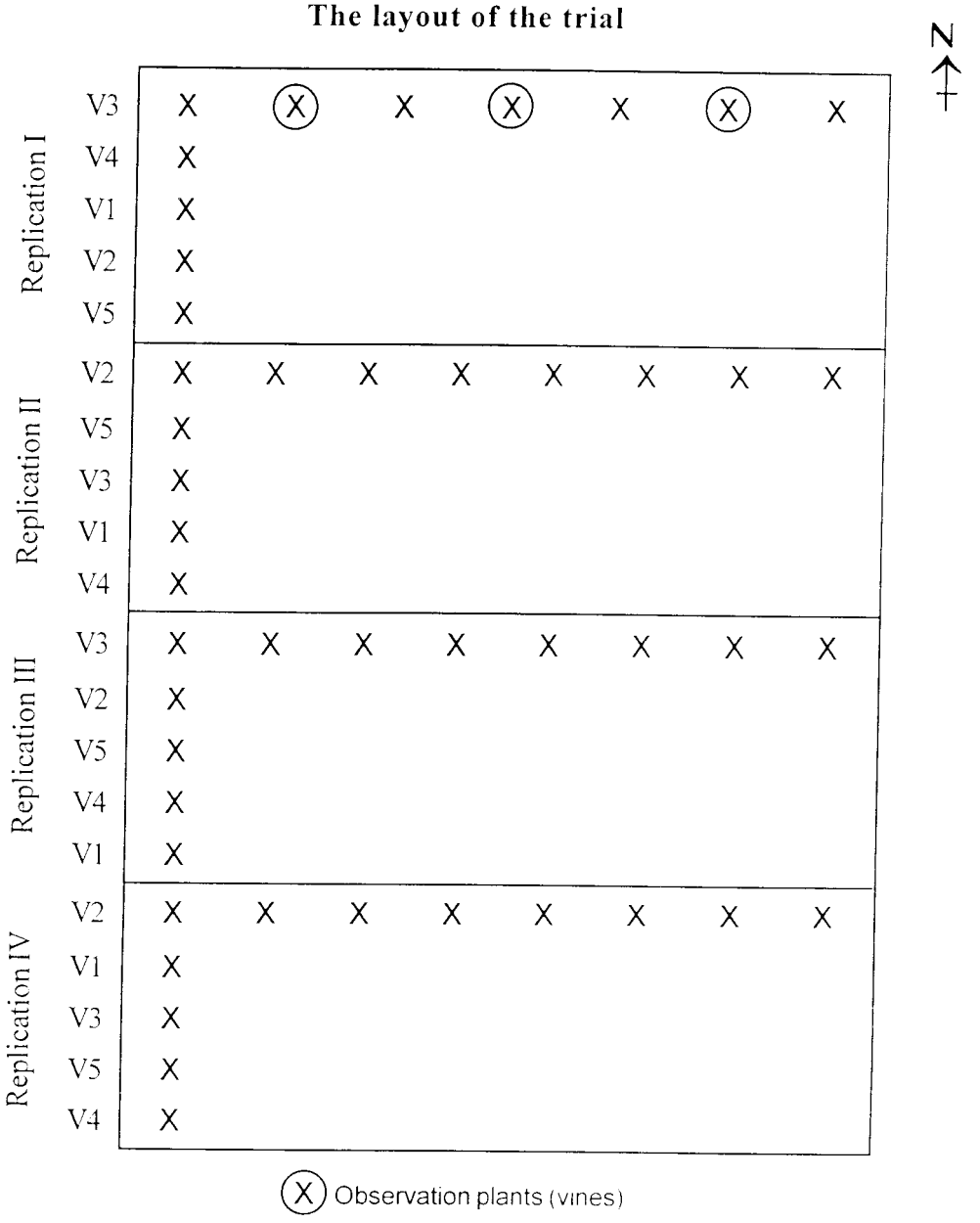
The trial was conducted from October 1995 to February 1996 in Block 'III' of the Instructional Farm, College of Agriculture, Vellayani.

The varieties selected were :

Sl. No.	Varieties	Source of seed
1.	Priya	Instructional Farm, Vellayani, Kerala
2.	Arka Harit	IIHR, Hessaraghata, Karnataka
3.	Preethi (MC-84)	College of Horticulture, Vellanikkara, Kerala
4.	Priyanka	Instructional Farm, Vellayani, Kerala
5.	Local	Farmer, Kalliyoor, Kerala.

The experiment was laid out with four replications. Each variety was sown in a line and each line was randomised in each replication. The plants were spaced at 2m x 2m. All operations except plant protection as envisaged in the Package of Practices, Kerala Agricultural University (1993a) were undertaken. In each line, there were seven plants. Observations on pests were recorded from three plants in each line.

The layout of the trial



The observations on pests and their damage were recorded in the vines from three weeks after sowing till final harvest. The pest incidence and infestation were recorded in the following manner as and when they appeared at different growth stages of the crop.

Name of pest	Method of observation
1. *H. phycitis*	Number of adults in five leaves at random per vine
2. *A. gossypii*	Number of adults in five leaves at random per vine
3. *N. falcata*	Number infested in five growing points per vine
4. *R. foveicollis*	Total number of adults per vine
5. *D. indica*	a) Number of leaves infested out of ten leaves per vine b) Number of fruits infested out of total number of fruits per vine
6. *L. trifolii*	Number of leaves infested out of ten leaves per vine
7. *H. septima*	a) Number of grubs in five leaves per vine b) Number of leaves infested in ten leaves per vine
8. *P. latus*	a) Number of leaves infested in ten leaves per vine b) Mean number in five leaves at random per vine
9. *B. cucurbitae*	Percentage of fruits infested at weekly intervals
10. Mosaic	Number of vines showing mosaic symptoms out of total number of vines of each variety.

The scale used in the basic survey to class the pest incidence as none, low, medium or high was utilised to study the pest status among the varieties at weekly intervals.

The stage susceptibility of the bitter gourd varieties to various pests was observed. The yield of markettable fruits were recorded at weekly intervals from the first to last harvest and the total yield worked out. The data were subjected to square root transformation and analysed (Snedecor and Cochran, 1980) to select the best variety for the pest management trial.

3.5. Pest Management Trial in bitter gourd

A pest management trial was conducted during two seasons from 1996 to 1997 in the Instructional Farm, Vellayani. The first trial was conducted from January to April 1996 and was repeated from January to April 1997.

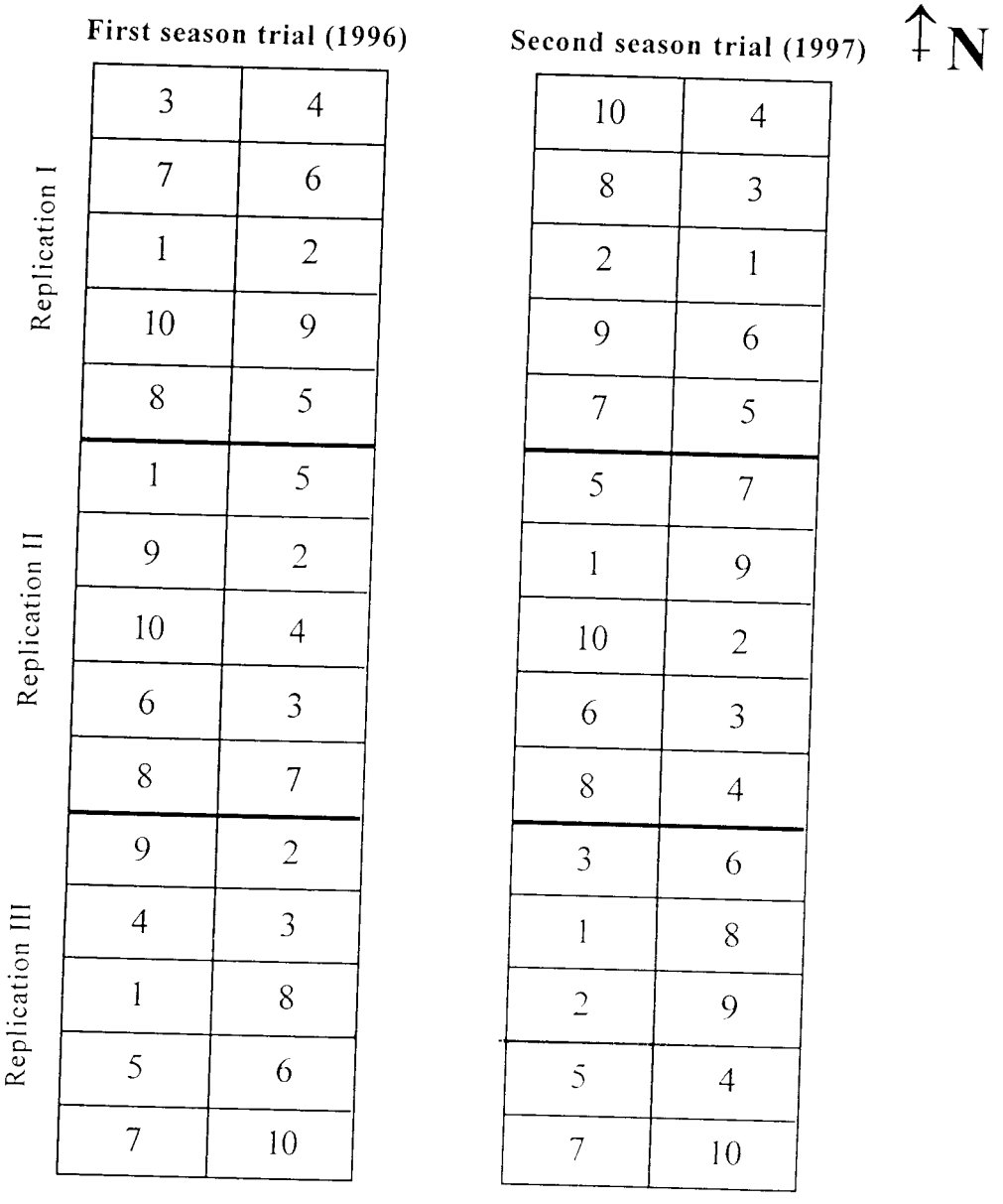
The best pest tolerant variety from the microplot trial *viz.*, Preethi (MC-84) was used in the field experiment. The experiment was laid out in a Randomised Block Design with ten treatments and three replications. A spacing of 2 x 2 m was given. In each plot of size 6 x 6m, there were nine pits and in each pit, two vines were allowed to grow.

The treatments were :

T_1	Chlorpyriphos 0.05 % soil drench	+	Dimethoate 0.05 % need based (upto fruit set)	+	Mechanical control after fruit set
T_2	Neem seed oil 3.00% soap emulsion soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_3	Nimbecidine 0.40% soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_4	Carbaryl 0.15% soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_5	Dimethoate 0.05 % soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_6	Combination of T_2 + half dose of T_4 soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_7	Combination of T_2 + half dose of T_5 soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_8	Combination of T_3 + half dose of T_4 soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_9	Combination of T_3 + half dose of T_5 soil drench	+	Need based application of same	+	Banana fruit ocimum trap
T_{10}	Control				

In treatments two to nine, two poisoned banana fruit traps and two poisoned ocimum jaggery traps (25 g *O. sanctum* leaves is crushed with 10g jaggery and mixed with 50ml water. To this, one gram of carbofuran is added) were installed in each plot at fiftieth day after sowing. A soil drench of the respective treatments was given prior to seeding and all later treatments were need based. All operations except pest management were undertaken as envisaged in the Package of Practices Recommendations of the Kerala Agricultural University (1993a).

LAYOUT



In each plot, observations were recorded from three vines three weeks after sowing onwards. The observations were taken at weekly intervals till the final harvest.

The observation on pest counts, extent of damage / infestation and count of natural enemies of pests was recorded from the vines as explained below.

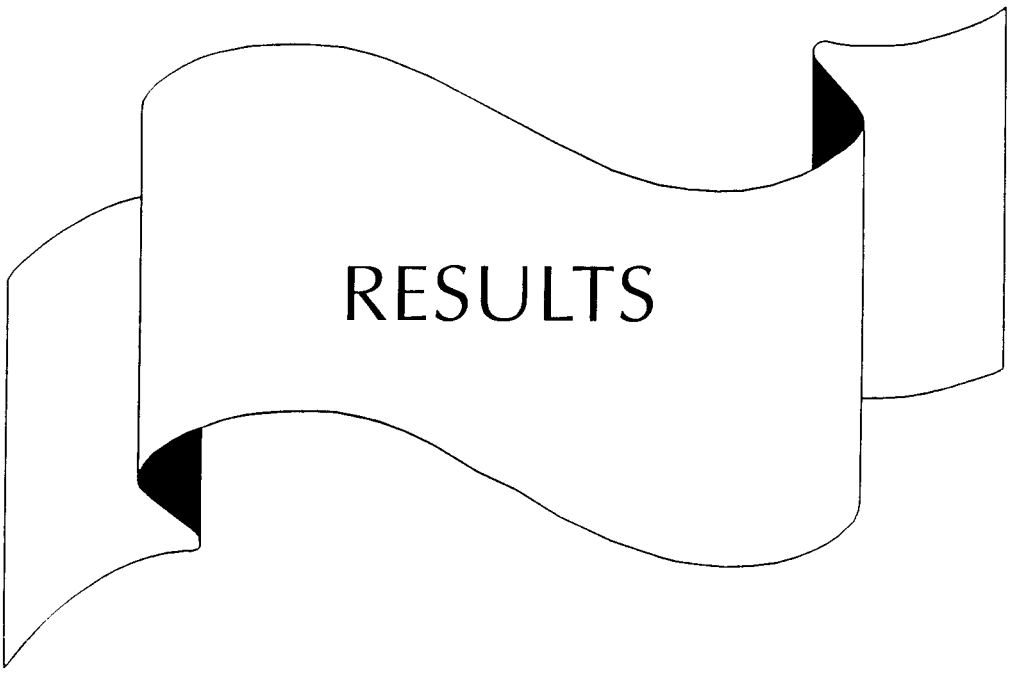
Pest	Method of observation
1. *H. phycitis*	Number of adults in five leaves at random vine^{-1}
2. *A. gossypii*	Number of adults in five leaves at random vine^{-1}
3. *N. falcata*	a) Early stage - number infested in 10 shoots b) Later stage - number of growing points infested in five points vine^{-1}
4. *R. foveicollis*	Total number of adults vine^{-1}
5. *D. indica*	a) Number of leaves infested out of ten leaves at random vine^{-1} b) Number of flowers infested out of ten numbers vine^{-1} c) Number infested out of total number of fruits vine^{-1}
6. *L. trifolii*	Number of leaves infested out of ten leaves at random vine^{-1}
7. *H. septima*	a) Number of leaves infested out of ten leaves at random vine^{-1} b) Number of grubs / adults in five leaves vine^{-1}
8. *P. latus*	a) Total number in five leaves vine^{-1}
9. *B. cucurbitae*	a) Percentage of fruits infested vine^{-1} b) Number caught in four traps plot^{-1}

The number of vines exhibiting mosaic symptoms out of total number in each plot were also recorded. The incidence of downy mildew disease on leaves was observed and index worked out.

Natural enemies	Method of observation
1. Coccinellids	Mean number of grubs / adults leaf^{-1} (10 leaves vine^{-1})
2. Syrphids	Mean number of syrphid maggots leaf^{-1} (10 leaves vine^{-1})
3. Spiders	Total number vine^{-1}
4 Parasite of *H. septima*	Number of epilachna grubs / pupae parasitised out of 25 vine^{-1}
5. Parasite of *D. indica*	Number of larvae parasitised out of larvae in ten leaves vine^{-1}
6. Parasite of *N. falcata*	Number of gall fly maggots parasitised out of total observed vine^{-1}
7. Thrips predator of *P. latus*	Mean number of thrips predators in five leaves vine^{-1}

The weight of marketable fruits and number of fruits were recorded at weekly intervals from the first to final harvest. The weekly yields were pooled to obtain the mean yield per vine in the different treatments.

The data were subjected to $\sqrt{x+1}$ transformation except the data on percentage of bitter gourd fruits infested by *B. cucurbitae* vine^{-1} which were transformed to angular values. The transformed data were then statistically analysed.


RESULTS

RESULTS

4.1 Monitoring of pests of bitter gourd, their parasites and predators and survey of plant protection measures in Thiruvananthapuram district

4.1.1 Survey

The survey covered fifty, thirty and twenty bitter gourd farmers of Kalliyoor, Venganoor and Sreekaryam panchayats of Thiruvananthapuram district.

The information on personal and socio-economic characteristics of the farmers are given in Table 4.

The results indicated that the maximum percentage of the farmers (39 per cent) were able to read and write. Most of the farmers (72 per cent) were in the age group between 31 and 50. Forty one per cent of the respondents reported annual incomes ranging from Rs. 6001 to 10000 whereas 26 per cent had an annual income of Rs. 10001 to 15000.

The survey revealed that adoption of varieties recommended by the Kerala Agricultural University was poor (seven per cent). However, the recommended spacing of 2x2 m was being followed by 77 per cent of the farmers. Ninety two per cent of the farmers cultivated the crop in wet land. The soil type was mostly

Table 4. Personal and socio-economic characteristics of bitter gourd farmers in Thiruvananthapuram district

Sl. No.	Category	Frequency	Percentage
a. Education			
1	Illiterate	9	9
2	Read only	25	25
3	Read and write	39	39
4	SSLC	25	25
5	College level	2	2
	Total	100	100
b. Age group			
1	21-30	15	15
2	31-40	35	35
3	41-50	37	37
4	> 50	13	13
	Total	100	100
c. Income per annum (Rupees)			
1	< 6000	13	13
2	6001 - 10000	41	41
3	10001 - 15000	26	26
4	15001 - 20000	5	5
5	> 20000	15	15
	Total	100	100
d. Bittergourd variety used			
1	KAU variety	7	7
2	Local variety	93	93
	Total	100	100
e. Spacing adopted			
1	Recommended (2 x 2 m)	77	77
2	Not recommended	23	23
	Total	100	100

Table 4 (Contd....)

Sl. No.	Category	Frequency	Percentage
f. Nature of land			
1	Garden land	8	8
2	Wet land	92	92
	Total	100	100
g. Soil type			
1.	Clay loam	20	20
2.	Sandy	0	0
3.	Alluvial	72	72
4.	Laterite	8	8
5.	Red loam	0	0
	Total	100	100
h. Lease rent rate of land (Rs. per cent) per annum			
1.	< 50/-	1	1.47
2.	51 to 100/-	7	10.29
3.	101 to 125/-	11	16.18
4.	126 to 150/-	29	42.65
5.	> 151/-	20	29.41
	Total	68	100.00
i. Area under bitter gourd (cents) per farmer			
1.	< 14	7	7
2.	15 to 29	43	43
3.	30 to 44	37	37
4.	45 to 59	9	9
5.	> 60	4	4
	Total	100	100
j. Organic manure use pattern			
1.	Under dose	3	3
2.	Recommended dose	18	18
3.	High dose	79	79
	Total	100	100

Table 4 (Contd....)

Sl. No.	Category	Frequency	Percentage
k. Manures used			
1.	Cowdung	17	17
2.	Poultry manure	2	2
3.	1 + 2	67	67
4.	Green leaves	0	0
5.	1 + 2 + 4	11	11
6.	Compost	0	0
7.	Cowdung + Green leaves	2	2
8.	Cowdung + compost	1	1
	Total	100	100
l. Method of application of manures			
1.	Basal only	0	0
2.	Few splits (2 to 3)	16	16
3.	Several splits (> 3)	84	84
	Total	100	100
m. Fertilizer use pattern			
1.	Under dose	3	3
2.	Recommended dose	15	15
3.	High dose	82	82
	Total	100	100
n. Fertilizers used			
1.	Straight	8	8
2.	Complex	1	1
3.	Mixtures	3	3
4.	1 and 2	47	47
5.	1 and 3	19	19
6.	1 + 2 + 3	22	22
	Total	100	100
o. Method of application of fertilizer (splits)			
1.	Less than recommended	1	1
2.	Recommended	14	14
3.	More than recommended	85	85
	Total	100	100

alluvial (72 per cent) and clay loam (20 per cent). A majority of the farmers (68 per cent) cultivated the crop on leased land. The lease rent reportedly paid by 29 per cent of the farmers ranged from Rs. 126 to 150 / cent per annum while 20 per cent gave more than Rs. 151/-. Forty three and 37 per cent of the farmers cultivated bitter gourd in an area of 15 to 29 cents and 30 to 44 cents respectively. With regard to the use of organic manure, majority of the farmers used higher than recommended quantities and among the organic manures, cowdung and poultry manure was the most preferred (67 per cent). Eighty four per cent applied the organic manure in several splits during different stages of the crop. Analysis of the fertilizer use pattern among the farmers revealed that majority (82 per cent) of the farmers used higher than recommended dose of fertilizers. Forty seven per cent of the farmers used straight fertilizers like urea, muriate of potash and complex fertilizers like ammonium phosphate (Factamphos). Majority of the farmers (85 per cent) gave more than recommended number of splits of fertilizers during the crop phase.

Pest incidence in bitter gourd in the farmers' fields

The incidence of pests in the farmers' fields were observed at flowering and early harvest stages. The relevant results are presented in Table 5 and Plates 1 and 2. The incidence of each pest or the damage due to it in each field was classified as none, low, medium, high with a score of 0, 1, 2 and 3 respectively.

1) Flowering

The incidence of *H.septima* and its damage was low in 22 per cent of the fields and damage was not recorded in 78 per cent of the fields. *D.indica* damage was recorded in all the locations. However, the infestation was low in 87

B. cucurbitae infested bitter gourd fruit

B. cucurbitae adult on fruit

H. septima adult

H. septima grubs (3rd instar)

D. indica larvae

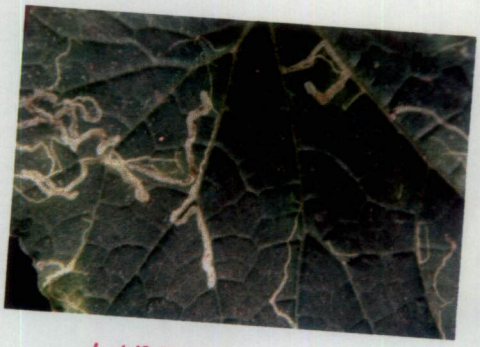
H. phycitis damage symptoms on leaf

Plate 1. Pests of bitter gourd and damage symptoms

A. gossypii on leaf

P. latus feeding symptoms on leaf

L. trifolii adult



L. trifolii damage on leaf

N. falcata damage (gall) on shoot

Aulacophora spp.

Plate 2. Pests of bitter gourd and infestation symptoms

Table 5. Percentage incidence of pests in bitter gourd in farmers' fields in Thiruvananthapuram district

Pests		Flowering stage					Early harvest stage				
	Class :	Absent	Low	Medium	High	Average Intensity Score	Absent	Low	Medium	High	Average Intensity Score
	Score :	0	1	2	3		0	1	2	3	
B. cucurbitae		0	0	0	0	0	1	96	2	1	1.03
H. septima		78	22	0	0	0.22	91	9	0	0	0.09
D. indica		0	87	13	0	1.13	92	8	0	0	0.08
H. phycitis		0	60	36	4	1.44	1	57	37	5	1.46
A. gossypii		75	18	7	0	0.32	74	19	7	0	0.33
P. latus		85	15	0	0	0.15	46	53	1	0	0.55
L. trifolii		14	84	2	0	0.88	20	78	2	0	0.82
N. falcata		65	35	0	0	0.35	0	0	0	0	0

per cent of fields while in 13 per cent, the level of damage was medium. *H.phycitis* was recorded in all the farmers' fields at flowering stage. The incidence was low in 60 per cent of the plots, medium in 36 per cent and high in four per cent. *A.gossypii* were not observed in 75 per cent of the fields. *A.gossypii* was low in 18 plots and medium in seven plots. *P.latus* was observed in low levels in 15 per cent of the fields while it was absent in rest of the fields. *L.trifolii* damage was not seen in 14 per cent of the plots while its damage was present in low levels in 84 per cent of the fields and in two per cent of the plots, the damage was of medium intensity. *N.falcata* damage was recorded in low levels in 35 per cent of the fields while damage was absent in 65 per cent of the locations.

An intensity score was worked out for the incidence of the various pests on bitter gourd at flowering. The highest score of 1.44 was attained by *H.phycitis* which was followed by *D.indica* with a score of 1.13. *L.trifolii, N.falcata, A.gossypii, H.septima* and *P.latus* obtained scores of 0.88, 0.35, 0.32, 0.22 and 0.15 respectively. The major pests observed at flowering were the jassid, *H.phycitis* and the leaf feeder, *D.indica.*

ii) Early harvest

B.cucurbitae damage was present in all the plots except one. In 96 per cent of the plots, the incidence was at a low level while in two per cent of the plots, the damage was medium. In one field, a high percentage of the fruits were damaged by *B.cucurbitae*. The presence of *H.septima* beetle and damage was observed in low intensity in nine per cent of the fields. The damage by *D.indica* was noticed in low intensity in eight per cent of the fields. *H.phycitis*

population was low in 57 per cent of the fields, medium in 37 per cent and high in five per cent of the fields. The *A.gossypii* population was low in 19 per cent of the fields and medium in seven per cent of the fields. *P.latus* was seen in 53 per cent of the plots in low intensities while medium intensity was recorded in one field. The damage by *L.trifolii* was medium in two per cent and low in 78 per cent of the fields.

At early harvest, the intensity score was the highest for *H.phycitis* (1.46). This was followed by a score of 1.03 for *B.cucurbitae*. The incidence intensity scores for *L.trifolii* , *P.latus*, *A.gossypii*, *H.septima* and *D.indica* were 0.82, 0.55, 0.33, 0.09 and 0.08 respectively. There was no stem gall fly incidence at early harvest. The incidence of *P.latus* was higher at early harvest compared to the level at flowering time. *D.indica* incidence was comparatively higher at flowering but dropped by early harvest. The survey revealed that at early harvest the jassid, *H.phycitis* and fruit fly, *B.cucurbitae* were the important pests.

Incidence of mosaic

The incidence of mosaic was observed at flowering and early harvest stages (Plate 3). The incidence was low in 29 per cent of the fields and in medium intensity in one plot at flowering (Appendix II). However at harvest, mosaic was observed in 76 per cent of the plots in varying degrees. In 58 per cent of the plots, the incidence was low whereas in six per cent of the plots, mosaic incidence was of medium intensity. In 12 per cent of the fields the crop was severely infested with mosaic. The incidence of mosaic adversely affected not only the yield but also the quality of the bitter gourd fruits.

Mosaic symptoms on vine

Downy mildew symptoms on leaves

Plate 3. Diseases of bitter gourd

Natural enemies of bitter gourd pests

The farmers' fields were observed for the natural enemies of the pests. The natural enemy distribution in each farmer's field was classed as absent, low, medium or high.

The relevant data is presented in Table 6.

Table 6. Percentage of incidence of natural enemies of pests of bitter gourd in farmers' fields in Thiruvananthapuram district

Natural enemy	Absent	Low	Medium	High
Flowering stage				
Spiders	76	23	1	0
Predatory insects	86	14	0	0
Parasites	88	12	0	0
Early harvest stage				
Spiders	80	20	0	0
Predatory insects	85	15	0	0
Parasites	94	6	0	0

At flowering, spiders were recorded in low numbers in 23 per cent of the farmers' fields and in medium levels in one plot. The predatory insects *viz.*, coccinellids and syrphids were low in number in 14 per cent of the fields and not present in 86 per cent of the fields at flowering. The incidence of parasites were low in 12 per cent of the fields. Parasitised larvae of *D.indica* and *H.septima* were observed in fields which were not indiscriminately sprayed with pesticides.

At early harvest, a low count of spiders were recorded in 20 per cent of the fields and absent in the other fields. The predatory insect larvae were observed in low numbers in 15 per cent of the fields. At early harvest, the parasitised insect larvae were observed in low levels in six per cent of the fields while they were not present in 94 per cent of the fields. The parasitised larvae of *D.indica* were recorded in two per cent of the fields while parasitised *H.septima* grubs were observed in four per cent of the fields.

The different species of the parasites and predators observed in the course of survey in the farmers' field and Instructional Farm, Vellayani are presented in Table 7 and Plates 4 & 5.

Plant protection measures adopted by bitter gourd farmers (Appendix II)

The survey revealed that 62 per cent of the farmers utilised a combination of mechanical, cultural and chemical measures against the pests of bitter gourd. Thirty per cent of the farmers adopted cultural measures along with chemical methods while eight per cent of the farmers resorted to only chemical measures. The use of pesticides was the most important pest control tactic. The most

C. johnsoni adult

Parasitised *H. septima* grubs (brown)

Parasitised *H. septima* pupae (brown)

T. ovulorum adults on *H. septima* eggs

Tetrastichus sp. egg parasite of *H. septima*

A. taragamae adult emerging from (cocoon) host *D. indica*

Plate 4. Parasites of pests of bitter gourd

M. sexmaculatus adult beetle

M. sexmaculatus grub (3rd instar)

I. scutellare maggot (3rd instar)

S. nubilis grub (4th instar)

I. scutellare adult fly

C. transversalis grub (3rd instar)

P. trinotatus adults

Plate 5. Predators of pests of bitter gourd

Wolf spider *Lycosa* sp.

Lynx spider *Oxyopes* sp.

Long jawed spider *Tetragnatha* sp.

Orb spider *Argiope* sp.

Plate 6. Spider predators of pests of bitter gourd

Table 7. Natural enemies of pests of bitter gourd recorded in Thiruvananthapuram district

Sl. No.	Pest	**Parasites**
1.	*H. septima*	a) *Chrysocharis johnsoni* S.Rao (Eulophidae) - larval - pupal parasite b) *Pediobius foveolatus* Crawford (Eulophidae) - larval - pupal parasite c) *Tetrastichus ovulorum* Ferr. (Eulophidae) - egg parasite d) *Tetrastichus* sp. (Eulophidae) - egg parasite
2.	*N. falcata*	a) *Lestodiplosis* sp. (Cecidomyiidae) - parasite of maggot b) *Tetrastichus* sp. (Eulophidae) - parasite of maggot
3.	*D. indica*	*Apanteles taragamae* Vier. (Braconidae) - larval parasite
		Predatory insects
1.	*A. gossypii*	a) *Menochilus sexmaculatus* Fabr. (Coccinellidae) b) *Scymnus nubilis* Muls. (Coccinellidae) c) *Ishiodon scutellare* Fabr. (Syrphidae) d) *Coccinella transversalis* F. (Coccinellidae) e) *Pseudaspidimerus trinotatus* (Coccinellidae)
2.	*P. latus*	*Scolothrips indicus* Priesner (Thripidae) predator of nymphs and adults
3.	*N. falcata*	*Solenopsis geminata* Fabr. (Formicidae) predator of maggots
		Spider predators
		1. Wolf spider *Lycosa* sp. (Lycosidae) - Hunting type, no webs 2. Lynx spider *Oxyopes* sp. (Oxyopidae) - Hunting type 3. Long jawed spider *Tetragnatha* sp. (Tetragnathidae) - Weak webs 4. Orb spider *Argiope* sp. (Araneidae) - Circular webs

important group of pesticides used were the organophosphates. Eighty one and 83 per cent of the farmers used only organophosphates during flowering and early harvest respectively.

The usage pattern of the different pesticides in the three panchayats of Thiruvananthapuram district at flowering and at early harvest is given in Table 8. The most commonly used pesticide was monocrotophos. Monocrotophos was used by 56 and 59 per cent of the farmers at flowering and early harvest respectively. This was followed by dimethoate, quinalphos, methyl parathion and phosphamidon. Among the carbamates, 17 per cent of the farmers used carbofuran from sowing upto four weeks after sowing. Carbaryl was used at flowering and early harvest stage by two and nine per cent of the farmers respectively. HCH (BHC) was used by four and three per cent of the farmers of Sreekaryam panchayat at flowering and early harvest respectively. One farmer applied fenvalerate, a synthetic pyrethroid at early harvest in Venganoor panchayat. The botanical pesticides like neem seed oil was not popular and it was used by only two per cent and four per cent of the farmers at flowering and early harvest respectively. Only one farmer used nimbecidine, a commercial neem pesticide at early harvest in Kalliyoor panchayat. Similarly only one farmer used neem cake as an insecticide in Venganoor panchayat. The fruit fly trap consisting of banana fruit or jaggery solution with carbofuran (contained in coconut shell) was adopted by seven per cent of the farmers.

Based on mode of action of pesticides, eight per cent of the farmers used only contact poisons while 23 per cent used only systemic pesticides. Sixty nine per cent of the farmers used both contact and systemic pesticides. Ninety seven per cent of the farmers used different pesticides belonging to various groups for

Table 8. Pesticide use against bitter gourd pests by farmers in Thiruvananthapuram district

Sl. No.	Pesticide	Panchayat							
		Kalliyoor (50)		Venganoor (30)		Sreekariyam (20)		Total (100 farmers)	
	Period :	Flowering	Early harvest	Flowering	Early harvest	Flowering	Early harvest	Flowering	Early harvest
1.	Monocrotophos	31	29	13	15	12	15	56	59
2.	Quinalphos	21	26	18	16	2	6	41	48
3.	Dimethoate	32	39	10	11	10	9	52	59
4.	Phosphamidon	10	10	6	5	3	3	19	18
5.	Methyl parathion	16	13	11	10	0	0	27	23
6.	Acephate	0	0	0	0	6	0	6	0
7.	Malathion	1	2	3	4	0	0	4	6
8.	Carbaryl	2	7	0	0	0	2	2	9
9.	HCH	0	0	0	0	4	3	4	3
10.	Pyrethroids	0	0	0	1	0	0	0	1
11.	Neem seed oil	0	0	1	4	1	1	2	5
12.	Nimbecidine	0	1	0	0	0	0	0	1
13.	Neem cake	0	0	1	0	0	0	1	0
14.	Chlorpyriphos	0	0	0	0	1	0	1	0
15.	Fruit fly trap (banana or jaggery + carbofuran)	0	5	0	1	0	1	0	7

protection against pests. A perusal of the doses of pesticides used showed that 95 per cent of the farmers used doses higher than the recommended level. Only five per cent of the farmers applied pesticides at the recommended doses. Analysis of the interval between pesticide applications revealed that upto flowering, 12 per cent of the farmers applied pesticides once in less than five days, 48 per cent once in six to ten days, 30 per cent once in more than 10 days and ten per cent applied need based. At early harvest,35, 59, two and four per cent of the farmers applied pesticides once in less than five days, six to ten days, more than 10 days and need based respectively. Ninety five per cent of the farmers did not follow the prescribed waiting periods for harvest of the bitter gourd fruits.

Information sources with regard to plant protection in bitter gourd

The information sources with regard to identification of pests, criteria for adoption of plant protection measures (based on extent of damage), preparation of spray dilution of pesticides and awareness of insecticide residues problems and contamination by bitter gourd farmers were collected during the survey. The relevant data are presented in Table 9.

Sixty nine per cent of the farmers opined that information regarding identification of the pest was obtained from mass media and interpersonal cosmopolites. Fourteen per cent of the farmers declared that their own experience, mass media, interpersonal cosmopolites and localites provided information on identification of the pests. The same trend was obtained with regard to information on criteria for adoption of plant protection measures. Only seven per cent of the farmers reported that the mass media was the only source with regard to this information.

Table 9. Sources of information on plant protection in bitter gourd

Sl. No.	Information sources	Frequency distribution of farmers			
		Identification of pests	Adoption of PP measures (extent of damage)	Preparation of spray dilution of pesticides	Awareness of insectide residue problems and contamination
1.	Own experience	0	0	0	0
*2.	Mass media	6	7	26	0
*3.	Inter personal cosmopolite	0	0	0	37
*4.	Inter personal localite	0	2	0	0
5.	Combination of 1 & 2	2	1	2	3
6.	Combination of 1 & 3	1	1	1	12
7.	Combination of 1 & 4	1	2	2	0
8.	Combination of 2 & 3	69	69	57	1
9.	Combination of 2 & 4	0	0	0	5
10.	Combination of 3 & 4	0	0	0	21
11.	Combination of 1, 2 & 3	0	0	0	2
12.	Combination of 1, 3 & 4	2	2	2	7
13.	Combination of 1, 2, 3 & 4	14	13	7	7
14.	Combination of 2 , 3 & 4	5	3	2	3
15.	Combination of 1, 2 & 4	0	0	1	2
	Total	100	100	100	100

* Mass media

a) Radio
b) TV
c) Newspaper

Inter personal cosmopolite

a) Agrl. Demonstrator
b) Agrl. Officer
c) KAU Scientist

Inter personal localite

a) Friends
b) Relatives
c) Neighbours
d) Others

Fifty seven per cent of the farmers reported that mass media and interpersonal cosmopolites influenced them with regard to information on preparation of spray dilution of pesticides. Twenty six per cent of the farmers obtained information from mass media only while seven per cent of the farmers reported that information sources included their own experience, mass media, interpersonal cosmopolites and localities.

Information on 'Awareness of insecticide residue problems and contamination' was obtained from interpersonal cosmopolites by 37 per cent of the farmers. Twenty one per cent of the farmers opined that both interpersonal cosmopolites as well as interpersonal localites were involved. However, 12 per cent of the farmers reported that their own experience and advice of interpersonal cosmopolites made them aware of pesticide related problems and contamination.

Expected income from bitter gourd cultivation

The farmers were asked about their expected income from bitter gourd cultivation. Eighteen per cent of the farmers expected a loss from the existing crop (Appendix II). Five per cent of the farmers reported expected incomes of upto Rs. 50/- per cent while forty one per cent estimated incomes ranging from Rs. 51/- to Rs. 100/- per cent. Thirty three per cent of the farmers anticipated incomes ranging from Rs. 101/- to Rs. 150/- per cent. However only three per cent of the farmers were expecting average return of above Rs. 151/- per cent of land.

Constraints in cultivation in bitter gourd

The constraints in realizing reasonable returns from bitter gourd cultivation were collected from the farmers and analysed. The relevant results are presented in Table 10.

Table 10. Constraints perceived by farmers in the cultivation of bitter gourd

Sl. No.	Constraints	Constraint Mean	Rank
1.	High rent on land	2.24	2
2.	Non availability of plant protection chemicals in time	0.11	9
3.	High cost of inputs (manures, fertilizers, chemicals etc.)	3.60	1
4.	Lack of irrigation facilities	0.12	7
5.	Lack of drainage	0.04	10
6.	High cost of labour	0.74	4
7.	Uneconomical holding size	1.27	3
8.	Lack of proper guidance	0.37	5
9.	Not aware of proper dose of chemicals and fertilizers	0.33	6
10.	Non availability of skilled labour	0.11	8

The important constraints identified were the high cost of inputs, high lease rent of land and uneconomical holding size. The results showed that the high cost of inputs with a constraint mean score of 3.60 was the greatest constraint in bitter gourd farming. This was followed by the high rent paid for leasing land with a constraint mean score of 2.24. The third important constraint was the uneconomical size of the holdings with a constraint mean of 1.27. The next constraint was the high cost of labour with a mean of 0.74. The other constraints gave lower mean values which indicated that they were not major impediments in successful cultivation of bitter gourd.

4.1.2. Monitoring of fruit fly using fruit fly lure trap

The Biosense stickatrap (lure trap) was installed in six locations during the period from October 1995 to March 1996 as shown in Table 11. The traps were set in bitter gourd fields eight weeks after sowing (WAS) coinciding with the harvest of bitter gourd fruits.

The data obtained showed that the maximum catch was during the 11 WAS and the least during nine WAS. The average catch of male flies was 49.50, 41.67, 32.50, 28.00 and 14.33 per trap 11, 12, 10, 13 and 9 WAS respectively. A comparison of the total catch over five weeks among the different locations indicated that maximum catch of 232 was obtained in Block III of the Instructional Farm, Vellayani and the least of 94 was at Pappanchani. The fruit fly catch in the other locations ranged between these counts.

The trend in the fruit fly population (y) was determined using a quadratic regression equation based on weeks after sowing (w) as follows :

$$y = 45.49 + 4.30\ x - 7.64\ x^2$$

This estimated the optimum time for maximum pest population as 11.28 weeks after sowing.

4.1.3 Comparative efficacy of the Biosense stikatrap with carbofuran smeared banana fruit traps

The relevant results are presented in Table 12. The data on the fly catch from 9 WAS to 13 WAS revealed that maximum catch was obtained during the tenth week after sowing in the Biosense trap (72.00). This was followed by catches

Table 11. Number of male fruit flies trapped at weekly intervals in Biosense stikatrap (from October 1995 to March 1996)

Sl. No.	Location	Weeks after sowing					Total catch
		9	10	11	12	13	
1.	Kalliyoor	9	24	58	35	25	151
2.	Pappanchani	8	23	32	16	15	94
3.	Venniyoor	11	30	30	34	12	117
4.	Block II Instructional Farm	12	25	72	62	39	210
5.	Block III Instructional Farm	20	43	60	68	41	232
6.	Block IV Instructional Farm	26	50	45	35	36	192
	Total catch	86	195	297	250	168	996
	Average	14.33	32.50	49.50	41.67	28.00	

Table 12. Comparative efficacy of traps against *B. cucurbitae* (mean of two locations)

Weeks after sowing	Type of trap							
	Biosense stikatrap				Carbofuran smeared banana fruit trap			
	Fruitfly distribution			% of fruits infested	Fruitfly distribution			% of fruits infested
	Males trapped	Females trapped	Total		Males trapped	Females trapped	Total	
9	59.50	—	59.50	25.00	29.00	42.00	71.00	13.33
10	72.00	—	72.00	20.00	34.50	34.00	68.50	11.67
11	57.00	—	57.00	25.00	20.00	25.50	45.50	10.00
12	34.50	—	34.50	18.33	20.50	17.50	38.00	6.67
13	34.00	—	34.00	21.67	22.00	19.50	41.50	8.33
Total	257.00	—	257.00		126.00	138.50	264.50	
Mean				22.00				10.00

in the 9th, 11th, 12th and 13th week in the descending order. Only male flies were caught in the Biosense trap (Plate 7). A total catch of 257 male flies was obtained. The percentage of fruits infested was 25.00, 20.00, 25.00, 18.33 and 21.67 during 9, 10, 11, 12 and 13 WAS respectively. The mean percentage of fruits infested in plots where Biosense trap had been installed was 22.00.

The carbofuran smeared banana fruit traps (10 numbers) caught a total of 264.50 fruit flies over the five week period. Of these, 126 were males and 138.50 females. The highest catch of 71.00 flies was obtained during the ninth week followed by 68.50 in tenth week. The catch decreased to 45.50, 38.00 and 41.50 during the 11th, 12th and 13th WAS respectively. The percentage of fruits infested during the 9th, 10th, 11th, 12th and 13th WAS was 13.33, 11.67, 10.00, 6.67 and 8.33 respectively. The overall percentage of fruits infested in the fruit trap installed plot was 10.00.

4.1.4. Seasonal incidence of pests of bitter gourd

The results of the studies on the incidence of the pests of bitter gourd in relation to natural enemies and climate conducted from July 1995 to June 1996 are presented in Table 13. The meteorological parameters are given in Fig. 1 and Appendix III.

a) Stem gall fly - *N.falcata*

The percentage of bitter gourd shoots infested was the maximum (12.80) during the second fortnight of December 1995. This was followed by damage in January 1996 second fortnight and December 1995 first fortnight (10.40 and 6.40 per cent respectively). The incidence was not seen from August to November 1995 and low from March second fortnight to June 1996.

Biosense stikatrap

Male fruit flies caught in Biosense stikatrap

Carbofuran smeared banana fruit trap

Carbofuran (poisoned) ocimum / jaggery trap

Plate 7. Fruit fly traps

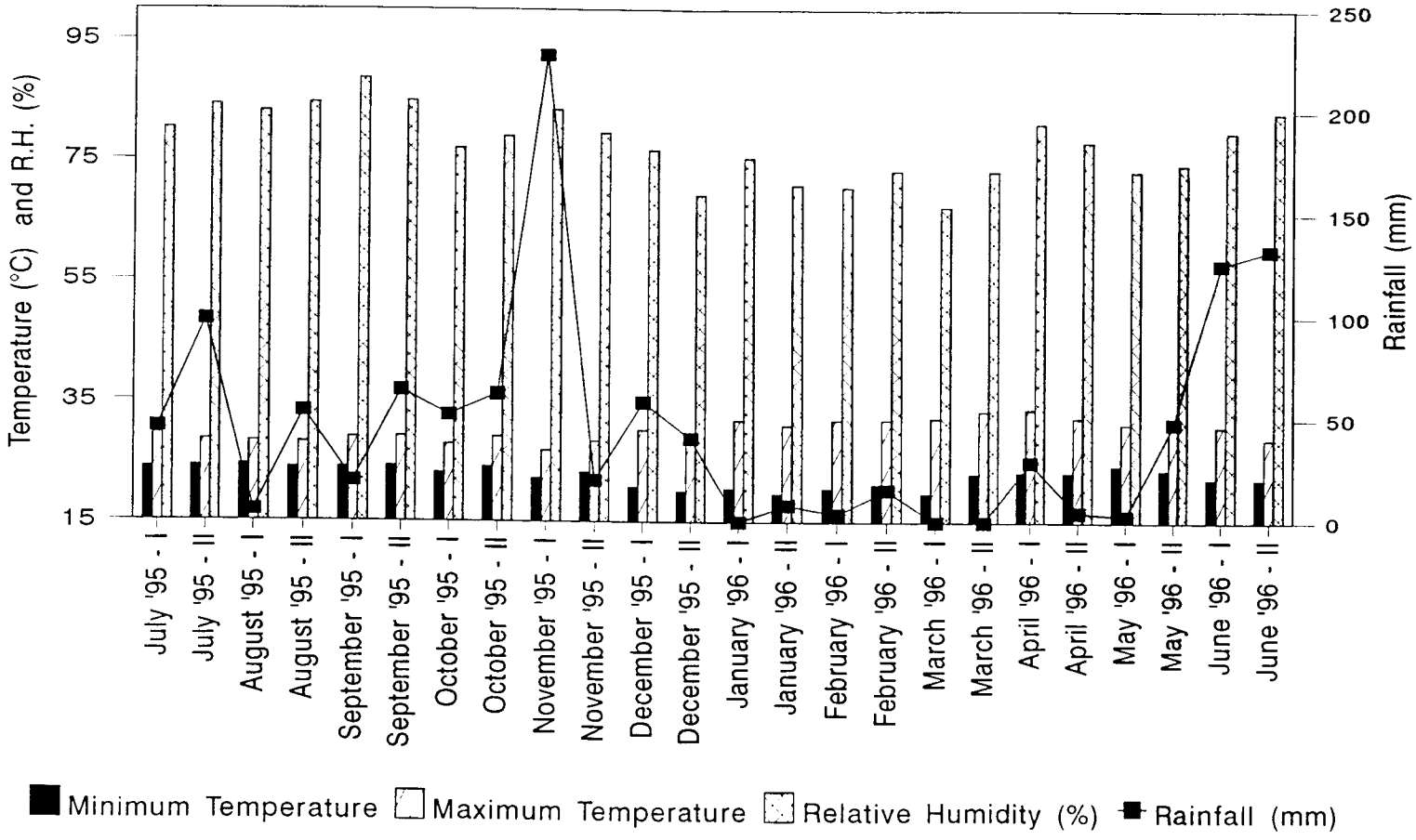


Fig. 1. Mean meteorological parameters during the cropping period (July 1995 to June 1996)

Table 13. Seasonal incidence of pests and their damage to bittergourd from July 1995 to June 1996

Period	% shoots infested by *N. falcata* vine^{-1}	Mean no. of *H. phycitis* adults leaf^{-1}	Mean no. of *H. septima* grubs leaf^{-1}	% fruits infested by *B.cucurbitae* vine^{-1}	% leaves infested by *L. trifolii* vine^{-1}	Mean no. of *A.gossypii* adults leaf^{-1}	Mean no. of *P. latus* adults leaf^{-1}	% leaves infested by *D. indica* vine^{-1}	% plants showing mosaic plot^{-1}
July 1995 - I	0.80	2.20	0.00	0.00	0.00	0.00	0.00	0.00	4.00
July 1995 - II	4.80	0.08	0.00	0.00	0.00	0.00	0.00	0.00	8.00
August 1995 - I	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00
August 1995 - II	0.00	0.00	0.54	4.00	0.00	0.00	0.00	0.00	0.00
September 1995 - I	0.00	0.00	0.94	8.80	0.00	0.00	0.00	0.00	0.00
September 1995 - II	0.00	0.00	0.93	2.40	0.00	0.00	0.00	0.00	0.00
October 1995 - I	0.00	0.00	0.22	7.20	0.00	0.00	0.00	0.00	0.00
October 1995 - II	0.00	0.00	0.22	6.40	0.00	0.00	0.00	0.00	8.00
November 1995 - I	0.00	0.87	1.18	3.20	4.00	3.50	0.00	0.00	4.00
November 1995 - II	0.00	0.66	0.66	0.00	4.00	5.93	0.00	0.00	12.00
December 1995 - I	6.40	0.40	0.26	0.00	5.60	9.24	0.58	0.00	4.00
December 1995 - II	12.80	0.44	0.05	0.00	3.20	7.24	1.19	0.00	12.00
January 1996 - I	0.10	0.98	0.00	0.00	7.20	18.13	5.48	0.00	16.00
January 1996 - II	10.40	2.10	0.00	0.00	0.00	18.68	8.60	0.00	24.00
February 1996 - I	0.00	0.70	0.00	2.40	0.00	10.24	12.12	0.00	8.00
February 1996 - II	0.00	1.55	0.00	9.60	0.00	6.55	2.40	0.00	8.00
March 1996 - I	3.20	2.25	0.00	11.20	0.00	0.00	0.06	8.80	4.00
March 1996 - II	0.00	1.96	0.00	16.80	0.00	0.00	1.06	15.20	8.00
April 1996 - I	0.00	2.56	0.00	16.80	4.80	0.00	0.00	8.80	8.00
April 1996 - II	0.00	3.45	0.00	12.00	2.40	0.00	0.00	5.60	16.00
May 1996 - I	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May 1996 - II	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June 1996 - I	3.20	0.64	0.00	0.00	0.00	0.00	0.00	0.00	33.33
June 1996 - II	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.33

I - First fortnight II - Second fortnight

b) Jassid - *H.phycitis*

H.phycitis number per leaf was the highest (3.45) in the second fortnight of April 1996 followed by population in the first fortnight of April 1996 (2.56). The population was low from the first fortnight of November 1995 to second fortnight of March 1996. *H.phycitis* were not recorded from August to October 1995, May 1996 first and second fortnight and June second fortnight.

c) Epilachna beetle - *H.septima*

The epilachna grub number per leaf ranged from 0.05 to 1.18 from the first fortnight of August to second fortnight of December 1995. The pest was not observed in July 1995 first and second fortnight and from January 1996 to June 1996.

d) Fruit fly - *B.cucurbitae*

The highest damage to bitter gourd fruits by the fruit fly was observed in the second fortnight of March (16.80 per cent) and first fortnight of April 1996 (16.80 per cent) followed by the damage in the second fortnight of April 1996 (12.00 per cent). The damage was less than 10.00 per cent during the other fortnights.

e) American serpentine leaf miner (ASLM) - *L.trifolii*

The leaf damage by ASLM was observed during November first fortnight 1995 to January first fortnight 1996 and ranged from 3.20 to 7.20 per cent. The damage was also recorded in April 1996. The damage by ASLM was not observed during the other months.

f) Aphid - *A.gossypii*

Aphids were recorded from November 1995 to February 1996. The population ranged from 3.50 to 18.68 during different fortnights. The highest incidence was in January 1996. Aphids were absent during the other months.

g) Yellow mite - *P.latus*

From December 1995 to March 1996, *P.latus* was observed. The population of *P.latus* per leaf ranged from 0.06 to 12.12 during the different fortnights. During the other months, *P.latus* was not observed.

h) Leaf feeder - *D.indica*

Leaf feeder was found only during March and April 1996. The percentage of leaves infested ranged from 5.60 to 15.20 per cent during this period. The pest was not observed during the other months.

i) Mosaic disease

The percentage of bitter gourd plants infected by mosaic ranged from 4.00 to 24.00 during October 1995 to January 1996. In July 1995, the incidence was 4.00 and 8.00 per cent for the first and second fortnights respectively. The incidence was 33.33 and 73.33 per cent in June first and second fortnights respectively.

Seasonal incidence of natural enemies of pests of bitter gourd

The results of the observations taken from July 1, 1995 to June 30, 1996 are presented in Table 14.

Table 14. Seasonal incidence of natural enemies of pests of bittergourd from July 1995 to June 1996

Period	Mean no. of parasitised *N. falcata* maggots vine^{-1}	% of parasitised *H. septima* grubs vine^{-1}	% of parasitised *H. septima* pupae vine^{-1}	Mean no. of parasitised *D. indica* larvae vine^{-1}	Mean no. of spiders vine^{-1}	Mean no. of coccinellid predator grubs leaf^{-1}	Mean no. of syrphid maggots leaf^{-1}	Mean no. of thrips predators of mite leaf^{-1}
July 1995 - I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July 1995 - II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August 1995 - I	0.00	4.00	4.80	0.00	0.08	0.00	0.00	0.00
August 1995 - II	0.00	4.80	6.40	0.00	0.28	0.00	0.00	0.00
September 1995 - I	0.00	7.20	5.60	0.00	0.28	0.00	0.00	0.00
September 1995 - II	0.00	9.60	9.60	0.00	0.20	0.00	0.00	0.00
October 1995 - I	0.00	1.60	0.80	0.00	0.08	0.00	0.00	0.00
October 1995 - II	0.00	1.60	0.80	0.00	0.08	0.00	0.00	0.00
November 1995 - I	0.00	7.20	7.20	0.00	0.16	0.09	0.06	0.00
November 1995 - II	0.00	4.80	4.00	0.00	0.28	0.16	0.07	0.00
December 1995 - I	0.00	0.80	0.00	0.00	0.32	0.49	0.20	0.00
December 1995 - II	0.00	0.00	0.00	0.00	0.28	0.24	0.16	0.14
January 1996 - I	0.08	0.00	0.00	0.00	0.08	1.00	6.28	0.25
January 1996 - II	0.04	0.00	0.00	0.00	0.28	0.74	0.40	0.32
February 1996 - I	0.00	0.00	0.00	0.00	0.20	0.93	0.59	0.56
February 1996 - II	0.00	0.00	0.00	0.00	0.12	0.15	0.88	0.02
March 1996 - I	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
March 1996 - II	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00
April 1996 - I	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00
April 1996 - II	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
May 1996 - I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May 1996 - II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June 1996 - I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June 1996 - II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

I - First fortnight II - Second fortnight

Parasite of *N.falcata* maggots

Parasitised *N.falcata* maggots were noticed in very low numbers in January 1996. The mean number of parasitised stem gall fly maggots per vine was 0.08 and 0.04 during the first and second fortnights of January 1996 respectively.

Parasite of *H.septima* grubs

H.septima grubs were found parasitised during the period from August first fortnight to December first fortnight 1995. The percentage of epilachna grubs parasitised per vine ranged from 0.80 to 9.60 during the above period. The highest incidence was in the second fortnight of September 1995.

Parasite of *H.septima* pupae

The same trend as in the case of epilachna grub parasitisation was observed. The parasitised pupae were observed from August to second fortnight of November 1995.

Parasite of *D.indica* larvae

Parasitised *D.indica* larvae were observed only in March and April 1996. The mean number of parasitised *D.indica* larvae per vine ranged from 0.04 to 0.20 during the above period.

Spiders

Spiders were observed on bitter gourd vines from August 1995 to February 1996. The population was in general low and ranged from 0.08 to 0.32 per vine during the above period.

Coccinellids

Coccinellid grub predators were noticed in bitter gourd from November 1995 to February 1996. The mean number per leaf ranged from 0.09 to 1.00 during the above months.

Syrphids

Syrphid maggots were found on bitter gourd vines from November 1995 to February 1996. The mean number per leaf ranged from 0.06 to 0.88 during the above period.

Thrips predator of *P.latus*

The thrips predator of *P.latus* was observed from December second fortnight 1995 to February second fortnight 1996. The mean number of predators ranged from 0.02 to 0.56 per leaf during the above months.

4.2. Assessment of the efficacy of parasites and predators of pests of bitter gourd

4.2.1. Biology and efficacy studies of the larval / pupal parasite *C.johnsoni* on *H.septima*

a. Biology of *C. johnsoni*

The female parasite oviposited light yellowish coloured eggs into the host *viz.*, fourth instar epilachna grubs. The incubation period ranged from one to two

days. The freshly emerged grubs were creamy yellow and consumed the internal contents of the hosts. The older grubs developed a yellowish tan. The larval period ranged from five to seven days. The full grown larvae assumed a brownish hue and had a tubular shape with tapering ends.

The fully grown parasite larvae pupated inside the host grub. The duration of the pupal period ranged from six to nine days. The life cycle (egg to adult) ranged from 13 to 17 days.

The adult parasite's head, thorax and abdomen had a greenish hue. The adult male was smaller compared to the female which had a longer abdomen.

b. Efficacy of *C. johnsoni* as a parasite of *H.septima*

The parasite adults emerged out of the host *H.septima* grub or pupa by cutting a hole in the host cuticle. Mating started immediately. Twenty four hours after mating, the mated adult female started oviposition. The eggs were thrust in groups into the host body. Each mated female was observed to parasitise four host epilachna grubs.

The mean number of parasites emerging from one host grub was 17.45 whereas, the mean number emerging from one parasitised pupa was 17.10. The ratio of progeny from a single mated female was 4.50 females per male. The longevity of mated males and fertilized females were 3.00 to 4.50 days and 4.50 to 5.50 days respectively.

The level of parasitisation of epilachna grubs and pupae by *C. johnsoni* was high in fields where epilachna population was high. The high pest population

by then caused severe damage to the bitter gourd crop. When the population of epilachna decreased, the parasites were adversely affected and their population also diminished. This was due to the fact that the adult parasites are short-lived.

4.2.2. Life cycle and feeding potential of the predator *I. scutellare* reared on *A.gossypii* on bitter gourd

a. Biology of *I. scutellaris*

The relevant results are presented in Table 15.

The mean incubation period of syrphid egg ranged from three to four days with a mean of 3.60 days. The mean duration of the first, second and third instar maggots were 2.00, 2.50 (2-3) and 3.40 (3-4) days respectively. The duration of the pupal stage was 3.80 days with a range of three to five days. The mean duration of the immature stages ranged from 13 to 18 days with a mean of 13.30 days.

The mean longevity of male and female *I. scutellare* were 9.40 (9-10) days and 11.60 (10-12) days respectively. The sex ratio of male to female was 2:1.

b. Feeding potential of *I. scutellare* (Prey - *A.gossypii* adults)

The relevant results are presented in Table 15.

The first, second and third instar maggot consumed a total of 34.61, 135.25 and 236.25 *A.gossypii* respectively. The mean total consumption during the entire larval period of 13.30 days was 406.11 *A.gossypii* adults. In the first

Table 15. Life cycle and feeding potential of syrphid *I. scutellare* reared on *A. gossypii* on bitter gourd

a) Biology of *I. scutellare*

Stage of the insect	Egg	1st instar	2nd instar	3rd instar	Pupa	Total
Mean duration (days)	3.60	2.00	2.50	3.40	3.80	13.30
Range (days)	(3-4)	—	(2-3)	(3-4)	(3-5)	(13-18)

Male longevity - 9.40 (9-10) days
Female longevity - 11.60 (10-12) days
Male : Female ratio - 2:1

b) Feeding potential of *I. scutellare*

Stage of insect	Mean number of aphids consumed during different periods after emergence (days)					Total consumption
	1	2	3	4	5	
First instar maggot	14.46 (10-23)	20.15 (22-45)	—	—	—	34.61
Second instar maggot	35.35 (19-46)	41.60 (21-54)	58.30 (26-71)	—	—	135.25
Third instar maggot	61.15 (29-92)	101.70 (70-118)	73.40 (14-105)	—	—	236.25
Total						406.11

Figures in parentheses are ranges

instar, the consumption was higher on the second day compared to the first. During the second instar, the consumption was 35.35, 41.60 and 58.30 *A.gossypii* by the first, second and third day respectively. The third instar maggot was a very active feeder and consumed 61.15, 101.70 and 73.40 *A.gossypii* on the first, second and third day respectively.

4.2.3. Life cycle, longevity studies and feeding potential of the predator *M. sexmaculatus* reared on *A.gossypii* on bitter gourd

a. Biology of *M. sexmaculatus*

The apposite results are given in Table 16.

The eggs of *M. sexmaculatus* had a mean incubation period of 2.28 days with a range of two to three days. The duration of the first, second and third instar grubs were 2.29 (2-3) days, 3.48 (3-4) days and 3.80 (3-5) days respectively. The mean pupal period ranged from three to five days with a mean of 3.50 days. The duration of the immature stages lasted for 13 to 20 days with a mean of 15.35 days.

The male and female beetle lived for 16 to 40 days (mean 28.3) and 18 to 45 days (mean 31.5 days) respectively. The sex ratio of male to female was 2:3.

b. Feeding potential of *M. sexmaculatus* (Prey - *A.gossypii* adults)

The apposite results are presented in Table 16.

The mean consumption of the first, second and third instar grubs of *M.sexmaculatus* were 11.2, 51.45 and 121.45 *A.gossypii* respectively. The daily

Table 16. Life cycle and feeding potential of coccinellid *M. sexmaculatus* reared on *A. gossypii* on bitter gourd

a) Biology of *M. sexmaculatus*

Stage of the insect	Egg	1st instar	2nd instar	3rd instar	Pupa	Total
Mean duration (days)	2.28	2.29	3.48	3.80	3.50	15.35
Range (days)	(2-3)	(2-3)	(3-4)	(3-5)	(3-5)	(13-20)

Male longevity - 28.30 (16-40) days Female longevity - 31.50 (18-45) days Male : Female ratio - 2:3

b) i. Feeding potential of *M. sexmaculatus* grub

Stage of insect	Mean number of aphids consumed during different periods after emergence (days)					Total consumption
	1	2	3	4	5	
1st instar grub	3.80 (2-7)	5.30 (3-8)	2.10 (0-6)	—	—	11.20
2nd instar grub	12.30 (7-23)	12.10 (5-16)	17.55 (4-28)	9.50 (4-14)	—	51.45
3rd instar grub	25.80 (17-45)	43.25 (38-58)	37.30 (22-40)	12.40 (2-18)	2.70 (0-12)	121.45
Total						184.10

b. ii. Feeding potential of *M. sexmaculatus* adult

	Mean number of aphids consumed during different periods after emergence (weeks)							
	1	2	3	4	5	6	7	Total
Mean number of aphids consumed	168.00	196.30	157.10	113.40	91.50	89.80	11.80	827.90
Range	(140-210)	(175-275)	(50-246)	(0-258)	(0-240)	(0-253)	(0-52)	(386-1494)

Figures in parentheses are ranges

mean consumption in the first, second and third instar ranged from 2.10 to 5.30, 9.50 to 17.55 and 2.70 to 43.25 *A.gossypii* respectively. Prior to moulting at the end of each instar, the consumption rate of the grubs declined.

The mean consumption of *A.gossypii* adults by an adult coccinellid during its life time was 827.90 and ranged from 386 to 1494.

With a mean longevity of 29.90 days, the average consumption per day was 27.69 *A.gossypii*. The feeding rate was higher during the first three weeks of adult life compared to the latter weeks. The mean number of *A.gossypii* consumed per individual predator was 168.00, 196.30 and 157.10 during the first, second and third week respectively after emergence as adult.

4.5.4. Life cycle and feeding potential of predator *S. nubilis* reared on *A.gossypii* on bitter gourd

a. Biology of *S. nubilis*

The relevant results are presented in Table 17.

The incubation period of the *S. nubilis* egg ranged from three to four days with a mean of 3.40. The grub had four instars. The first instar had a mean duration of 2.30 days (range 2 to 3 days) and whitish waxy warts developed in the first instar yellowish brown grub. The duration of the second instar ranged from one to three days with a mean of 1.20. The third instar also had the same mean duration of one to two days. The second and third instar grub was yellowish brown with warts on the body. The fourth instar was dark brown with a longer

mean duration of four to six days. The total larval period of the predator ranged from seven to 11 days with a mean of 9.30. The pupal period ranged from five to seven days with a mean of 5.50 days. The total life cycle from egg to adult ranged from 16 to 24 days with a mean of 18.20 days. The freshly emerged adult had a gold brown colour which later changed to reddish brown with a blackish hue.

b. Feeding potential of *S. nubilis*

The relevant results are presented in Table 17.

The first, second, third and fourth instar *S. nubilis* grub consumed a mean of 2.80, 10.10, 13.50 and 26.50 adult *A.gossypii* respectively.

Table 17. Development and feeding potential of coccinellid *S. nubilis* reared on *A. gossypii* adults on bitter gourd

Stage of insect	Development period in days	Mean number of aphids consumed
Egg	3.40 (3-4)	—
1st instar	2.30 (2-3)	2.80 (2-3)
2nd instar	1.20 (1-2)	10.10 (8-12)
3rd instar	1.20 (1-2)	13.50 (12-15)
4th instar	4.60 (4-6)	26.50 (19-32)
Total of grub	9.30 (7-11)	52.90 (41-62)
Pupa	5.50 (5-7)	
Adult (3 days)	—	23.50 (18-30)
Total duration of life cycle	18.20 (16-24)	—

Figures in parentheses are ranges

The average number of *A.gossypii* consumed by the grub during its four instars was 52.90. The mean number of *A.gossypii* consumed by a predator during the first three days after emergence as an adult was 23.50 (range 18-30).

4.3. Effect of botanicals and synthetic pesticides on pests, parasites and predators of the pests of bitter gourd

4.3.1. Antifeedant effect of botanicals on the feeding of third instar *H.septima* grubs on bitter gourd leaves

The relevant results are presented in Table 18. Observations of the mean weight gain of ten third instar *H.septima* grubs 24 hours after feeding on leaves receiving different treatments showed that the weight gain ranged from 1.67 to 10.29 mg among the different treatments. The least weight gain was 1.67 mg in Nimbecidine 0.40 per cent. However, it was statistically on par with neem seed oil 4.00 per cent emulsion (1.86 mg). This was followed by neem seed oil 3.00 per cent (3.57 mg) and 2.00 per cent (4.06 mg) which were on par. The latter treatment was on par with *C.infortunatum* fresh 8.00 per cent extract (4.67 mg weight gain). The weight gain in all other treatments were significantly higher. The maximum weight gain of 10.29 mg was obtained in larvae feeding on bitter gourd leaves treated with *C.infortunatum* dry 2.00 per cent extract.

Nimbecidine 0.40 per cent, neem seed oil emulsion 4.00 per cent and 3.00 per cent were the most effective in curtailing the weight gain of *H.septima* grubs.

Table 18. Antifeedant effect of botanicals on feeding of *H. septima* third instar grubs on bitter gourd leaves

Sl. No.	Treatments	Mean wt. gain of grubs 24 h after feeding (mg)	Wt. of leaves consumed by grubs 24 h after feeding (g)	% leaf protected after 24 h	Mean wt. gain/loss of grubs 48 h after release (mg)	Wt. of leaf consumed by grubs 48 h after feeding (g)	% leaf protected after 48 h	Mean larval starvation (%) after 48 h
1	*C. infortunatum* dry 8%	9.75 (3.28)	0.061 (1.030)	39.37 (6.35)	8.41	0.071 (1.034)	63.17 (8.01)	41.47 (6.52)
2	*C. infortunatum* dry 4%	9.39 (3.22)	0.057 (1.028)	41.97 (6.55)	10.78	0.095 (1.046)	49.86 (7.13)	34.82 (5.98)
3	*C. infortunatum* dry 2%	10.29 (3.36)	0.066 (1.032)	34.32 (5.94)	10.68	0.101 (1.049)	47.39 (6.96)	35.10 (6.01)
4	*C. infortunatum* fresh 8%	4.67 (2.38)	0.044 (1.022)	56.19 (7.56)	5.60	0.055 (1.027)	69.46 (8.39)	55.45 (7.51)
5	*C. infortunatum* fresh 4%	9.86 (3.29)	0.057 (1.028)	43.62 (6.68)	7.95	0.064 (1.031)	66.85 (8.24)	45.86 (6.84)
6	*C. infortunatum* fresh 2%	9.70 (3.27)	0.058 (1.028)	42.08 (6.56)	8.68	0.073 (1.036)	61.08 (7.88)	43.13 (6.64)
7	Neem seed oil 4%	1.86 (1.69)	0.022 (1.010)	81.86 (9.10)	-2.53	0.022 (1.011)	88.61 (9.47)	83.39 (9.18)
8	Neem seed oil 3%	3.57 (2.14)	0.030 (1.015)	70.51 (8.46)	-0.72	0.039 (1.019)	80.26 (9.01)	76.66 (8.81)
9	Neem seed oil 2%	4.06 (2.25)	0.032 (1.016)	68.37 (8.33)	1.04	0.047 (1.023)	75.27 (8.73)	73.19 (8.60)
10	Nimbecidine 0.4 %	1.67 (1.63)	0.021 (1.010)	79.40 (8.97)	-1.80	0.022 (1.011)	88.59 (9.46)	77.95 (8.89)
11	Nimbecidine 0.3 %	7.70 (2.95)	0.054 (1.027)	46.69 (6.91)	7.51	0.056 (1.028)	69.62 (8.40)	45.34 (6.81)
12	Nimbecidine 0.2 %	8.14 (3.02)	0.059 (1.029)	41.63 (6.53)	10.08	0.073 (1.036)	62.00 (7.94)	37.60 (6.21)
	F11,22	91.32*	10.83*	10.89*	58.25*	5.77*	7.67*	15.93*
	CD(0.05)	0.199	0.008	0.980	1.930	0.015	0.840	0.840

Transformed values given in parentheses. * Significant at 5% level

Weight of leaves consumed by *H.septima* grubs 24 hours after feeding

The weight of leaves consumed by ten third instar *H.septima* grubs 24 hours after release on treated leaves ranged from 0.021 g to 0.066 g among the different treatments (Table 18). The least consumption (0.021 g) was by grubs feeding on nimbecidine 0.40 per cent treated leaves. However, this was on par with neem seed oil 4.00 per cent, 3.00 per cent and 2.00 per cent where the quantities of leaves consumed were 0.022 g, 0.030 g and 0.032 g respectively. The leaf consumption was higher in other treatments and the highest quantity of leaves consumed was by grubs feeding on *C.infortunatum* dry two per cent extract (0.066 g).

Nimbecidine 0.40 per cent, neem seed oil at 4.00 and 3.00 per cent treatments were ranked first, second and third respectively with regard to least consumption of leaf by *H.septima* grubs.

Percentage of bitter gourd leaf protected by botanicals

The percentage of bitter gourd leaf protection ranged from 34.32 to 81.86 among the different treatments. The maximum percentage of leaf protected (81.86 per cent) was in neem seed oil 4.00 per cent treatment. This was statistically on par with nimbecidine 0.40 per cent, neem seed oil 3.00 and 2.00 per cent which protected 79.40, 70.51 and 68.37 per cent leaf area respectively. The leaf protection by the other treatments was less with *C.infortunatum* dry 2.00 per cent extract affording least protection of 34.32 per cent.

Neem seed oil 4.00 per cent emulsion and nimbecidine 0.40 per cent and neem seed oil 3.00 per cent emulsion gave best protection to leaf for 24 hours against *H.septima* grubs.

Mean weight gain / loss of grubs 48 hours after release on treated leaves

The mean weight gain or loss of ten *H.septima* grubs ranged from -2.53 mg to 10.78 mg in the different treatments (Table 18).

The loss was maximum (-2.53 mg) in neem seed oil 4.00 per cent treatment, but this was on par with nimbecidine 0.40 per cent (-1.80mg) and neem seed oil 3.00 per cent (-0.72 mg) treatments. Neem seed oil 3.00 per cent was on par with neem seed oil 2.00 per cent in which the weight gain was 1.04 mg. There was significant gain in weight by grubs feeding on leaves of all the other treatments. The maximum weight gain of 10.78 mg was observed in grubs feeding on *C.infortunatum* dry 4.00 per cent extract.

The most effective treatments were neem seed oil 4.00 per cent, nimbecidine 0.40 per cent and neem seed oil emulsion 3.00 per cent.

Weight of leaf consumed by grubs 48 hours after feeding treated leaves

The results presented in Table 18 showed that the weight of bitter gourd leaf consumed 48 hours after release on leaves ranged from 0.022 to 0.101 mg among the different treatments. The least amount of leaf (0.022 mg) was consumed by larvae feeding on neem seed oil 4.00 per cent emulsion and nimbecidine 0.40 per cent. However, these were on par with neem seed oil 3.00 per cent and 2.00 per cent treatments in which the leaf consumed were 0.039 and 0.047 mg respectively. The leaf consumed in the other treatments were comparatively higher. The maximum consumption of 0.101 mg was recorded from grubs feeding on *C.infortunatum* 2.00 per cent dry extract.

The most effective treatments based on weight of leaf consumption 48 hours after feeding on treated leaves were neem seed oil 4 per cent emulsion, nimbecidine 0.40 per cent emulsion and neem seed oil 3.00 per cent emulsion.

Percentage of bitter gourd leaf protected by botanicals after 48 hours

The results showed that the percentage of bitter gourd leaf protected (weight basis) ranged from 47.39 to 88.61 among the various treatments. The best protection of 88.61 per cent was afforded by neem seed oil 4.00 per cent and by Nimbecidine 0.40 per cent (88.59 per cent). However, these treatments were on par with neem seed oil treatments, 3.00 and 2.00 per cent. The other treatments could give a lesser percentage of protection. The least protection of 47.39 per cent was given by *C.infortunatum* 2.00 per cent dry extract.

Neem seed oil 4.00 per cent emulsion and nimbecidine 0.40 per cent and neem oil 3.00 per cent emulsions were the best treatments which afforded maximum protection of bitter gourd leaf against the *H.septima*.

Mean larval starvation percentage due to botanicals 48 hours after feeding on treated leaves

The results (Table 18) showed that the mean epilachna larval starvation percentage due to the antifeedant action of botanicals ranged from 34.82 to 83.39 among the different treatments.

The highest level of 83.39 per cent starvation was recorded in neem seed oil 4.00 per cent and was on par with nimbecidine 0.40 per cent (77.95 %)

starvation, neem seed oil 3.00 per cent (76.66 % starvation) and neem seed oil 2.00 per cent (73.19 % starvation). All the other treatments resulted in significantly lesser percentage of starvation by *H.septima* grubs. The *C.infortunatum* dry 4.00 per cent extract resulted in the least starvation percentage of 34.82. Neem seed oil 4.00 per cent, nimbecidine 0.40 per cent treatment and neem oil 3.00 per cent emulsion resulted in the highest level of starvation of *H.septima* grubs.

The results of the antifeedant trial indicated that nimbecidine 0.40 per cent and neem seed oil 4.00 and 3.00 per cent emulsion were the best treatments against *H.septima* grubs.

4.3.2. Comparative efficacy of chemical pesticides against fourth instar *H.septima* grubs

The relevant results are presented in Table 19.

A perusal of the percentage mortality of fourth instar epilachna grubs 24 hours after release on pesticide treated leaves indicated that the percentage mortality ranged from 37.61 to 72.68 per cent among the different treatments. Carbaryl 0.20 per cent recorded the highest mortality of 72.68 per cent but was on par with carbaryl 0.15 per cent, malathion 0.075 per cent, malathion 0.10 per cent, carbaryl 0.10 per cent and dimethoate 0.05 per cent. The mortality were comparatively lesser in the other treatments, while there was ten per cent mortality in the control (water spray).

The results of the analysis of percentage mortality of fourth instar *H.septima* grubs 48 hours after release on treated bitter gourd leaves indicated the following trend.

Table 19. Comparative efficacy of pesticides at different concentrations against fourth instar *H. septima* grubs at different intervals after spraying

Sl. No.	Treatments	% mortality of grubs 24 hours after release on treated leaves	% mortality of grubs 48 hours after release on treated leaves	% mortality of grubs 24 hours after release on treated leaves (7 days after spraying)	% mortality of grubs 48 hours after release on treated leaves (7 days after spraying)
1	Carbaryl 0.20 %	72.68 (58.46)	98.73 (83.50)	50.00 (44.98)	80.69 (63.90)
2	Carbaryl 0.15 %	69.24 (56.29)	89.26 (70.85)	50.00 (44.98)	67.09 (54.97)
3	Carbaryl 0.10 %	58.33 (48.89)	86.17 (68.14)	43.31 (41.14)	67.09 (54.97)
4	Quinalphos 0.05 %	48.14 (43.92)	75.02 (59.99)	0.00 (0.00)	0.00 (0.00)
5	Quinalphos 0.04 %	41.03 (39.02)	65.24 (53.25)	0.00 (0.00)	0.00 (0.00)
6	Quinalphos 0.03 %	37.61 (37.81)	46.29 (42.85)	0.00 (0.00)	0.00 (0.00)
7	Malathion 0.10 %	65.61 (54.08)	78.53 (62.37)	0.00 (0.00)	0.00 (0.00)
8	Malathion 0.075 %	66.10 (54.37)	75.02 (59.99)	0.00 (0.00)	0.00 (0.00)
9	Malathion 0.05 %	51.86 (46.05)	65.99 (54.31)	0.00 (0.00)	0.00 (0.00)
10	Dimethoate 0.05 %	55.35 (48.03)	78.53 (62.37)	6.70 (14.99)	26.23 (30.77)
11	Dimethoate 0.04 %	48.35 (44.04)	71.35 (57.61)	16.36 (23.85)	20.00 (26.55)
12	Dimethoate 0.03 %	51.86 (46.05)	67.79 (55.40)	4.53 (12.29)	23.18 (28.77)
13	Control (Water spray)	10.00 (18.43)	10.00 (18.33)	0.00 (0.00)	0.00 (0.00)
	$F_{12,24}$	2.77*	6.95*	41.89*	107.66*
	CD(0.05)	11.410	11.210	8.480	7.060

Transformed values are given in parentheses * Significant at 5% level

The percentage mortality of grubs ranged from 46.29 to 98.73 among the various treatments. The maximum mortality of 98.73 per cent was observed in larvae feeding on carbaryl 0.2 per cent and it was significantly superior to all the other treatments. Carbaryl 0.15 per cent, carbaryl 0.10 per cent, malathion 0.10 per cent, dimethoate 0.05 per cent, quinalphos 0.05 per cent and malathion 0.075 per cent caused 89.26, 86.17, 78.53, 78.53, 75.02 and 75.02 per cent mortality respectively and were on par. Among the treatments, quinalphos 0.03 per cent resulted in the least mortality of epilachna grubs (46.29 per cent).

The results of the trial on evaluating the percentage mortalities of *H.septima* grubs released on bitter gourd leaves seven days after treatment are presented in Table 19. After 24 hours, the maximum mortality of 50.00 was observed in carbaryl 0.20 and 0.15 per cent and this was on par with carbaryl 0.10 per cent. Dimethoate 0.04 per cent resulted in 16.36 per cent mortality while dimethoate 0.05 and 0.03 per cent caused 6.70 and 4.53 per cent mortality respectively. There was no mortality of grubs released on either quinalphos or malathion treated leaves. The same trend in mortality was observed 48 hours after release. Carbaryl was the most toxic followed by dimethoate.

4.3.3. Effects of extracts of botanicals and chemical pesticides on *C.johnsoni*

4.3.3.1 Toxicity of botanicals to the adults of *C. johnsoni* (Laboratory study)

The results of the trial to assess the toxic effect of botanicals against *C.johnsoni* are given in Table 20.

There was no mortality of the parasite adults one and three hours after exposure to the botanicals. After six hours, neem seed oil emulsion at 4.00 per

cent alone caused 3.33 per cent mortality of the parasite. After 24 hours, neem seed oil emulsion 4.00 per cent registered 7.04 per cent mortality of the parasite while nimbecidine 0.40 per cent resulted in 3.70 per cent mortality of the parasite.

Table 20. Percentage mortality of *C. johnsoni* adults at different intervals after exposure to botanicals

Sl. No.	Treatments	Hours after exposure			
		1	3	6	24
1	*C. infortunatum* dry 8%	0.00	0.00	0.00	0.00
2	*C. infortunatum* dry 4%	0.00	0.00	0.00	0.00
3	*C. infortunatum* dry 2%	0.00	0.00	0.00	0.00
4	*C. infortunatum* fresh 8%	0.00	0.00	0.00	0.00
5	*C. infortunatum* fresh 4%	0.00	0.00	0.00	0.00
6	*C. infortunatum* fresh 2%	0.00	0.00	0.00	0.00
7	Neem seed oil 4%	0.00	0.00	3.33	7.04
8	Neem seed oil 3%	0.00	0.00	0.00	3.33
9	Neem seed oil 2%	0.00	0.00	0.00	0.00
10	Nimbecidine 0.4%	0.00	0.00	0.00	3.70
11	Nimbecidine 0.3%	0.00	0.00	0.00	0.00
12	Nimbecidine 0.2%	0.00	0.00	0.00	0.00
13	Control	0.00	0.00	0.00	0.00

4.3.3.2 Toxicity of chemical pesticides to the parasite *C. johsoni* adults

The results presented in Table 21 revealed no significant difference among the treatments with regard to mortality of the parasite adults one hour after exposure.

Table 21. Percentage mortality of *C. johnsoni* adults at different intervals after exposure to chemical pesticides

Sl. No.	Treatments	Hours after exposure			
		1	3	6	24
1	Carbaryl 0.20 %	4.53 (12.29)	9.25 (17.70)	63.33 (52.75)	100.00 (90.00)
2	Carbaryl 0.15 %	1.14 (6.14)	2.37 (8.85)	53.33 (46.90)	100.00 (90.00)
3	Carbaryl 0.10 %	1.14 (6.14)	2.37 (8.85)	43.33 (41.14)	100.00 (90.00)
4	Quinalphos 0.05 %	1.14 (6.14)	2.37 (8.85)	70.00 (56.67)	100.00 (90.00)
5	Quinalphos 0.04 %	0.00 (0.00)	1.14 (6.14)	63.33 (52.75)	100.00 (90.00)
6	Quinalphos 0.03 %	1.14 (6.14)	1.14 (6.14)	53.33 (46.90)	89.64 (71.19)
7	Malathion 0.10 %	2.37 (8.85)	3.76 (17.21)	86.67 (68.83)	89.64 (71.19)
8	Malathion 0.075 %	1.14 (6.14)	15.72 (23.35)	86.67 (68.83)	100.00 (90.00)
9	Malathion 0.05 %	1.14 (6.14)	9.25 (17.70)	80.00 (63.41)	100.00 (90.00)
10	Dimethoate 0.05 %	4.53 (12.29)	9.25 (17.70)	80.00 (63.41)	100.00 (90.00)
11	Dimethoate 0.04 %	4.53 (12.29)	9.25 (17.70)	80.00 (63.41)	100.00 (90.00)
12	Dimethoate 0.03 %	1.14 (6.14)	2.37 (8.85)	70.00 (56.77)	100.00 (90.00)
13	Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	$F_{12,24}$	0.36	0.54	31.26*	18.35*
	CD(0.05)	—	—	4.69	4.97

Transformed values are given in parentheses * Significant at 5% level

The mortality was the highest (4.53 per cent) in carbaryl 0.20 per cent, dimethoate 0.05 and 0.04 per cent and lesser in all the other treatments. No mortality was observed in quinalphos 0.04 per cent treatment. The mortalities of the parasite ranged from 1.14 per cent to 15.72 per cent among the treatments three hours after exposure. Though all the treatments were on par, the mortality due to quinalphos treatments were comparatively lesser than the other pesticides *viz.*, carbaryl, malathion and dimethoate.

There was significant difference among treatments in causing mortality of *C. johnsoni* adults six hours after exposure. The results indicated that the mortality ranged from 43.33 to 86.67 per cent among the treatments. The highest mortality of 86.67 per cent was observed in malathion 0.10 and 0.075 per cent treatments which were statistically superior to the other treatments. Carbaryl 0.10 per cent registered the lowest mortality percentage. Twenty four hours after exposure, there was one hundred per cent mortality of *C. johnsoni* adults in all the treatments except quinalphos 0.03 per cent and malathion 0.10 per cent treatments. Thus this trial showed that all the pesticides at the three doses were toxic to the adults of *C. johsoni*.

4.3.4. Assessment of the effect of botanicals and chemical pesticides on parasitised *H.septima* grubs and pupae

4.3.4.1 Effect of botanicals on emergence of *C. johnsoni* from *H.septima* grubs and pupae

The relevant results are presented in Table 22. There was significant difference among the botanicals on emergence of the parasite adults from the

treated host grubs. The maximum emergence (81.24 per cent) was observed in control. The lowest emergence of 61.27 per cent was recorded in nimbecidine 0.40 per cent but it was on par with neem seed oil four per cent and *C.infortunatum* fresh eight per cent.

Table 22. Effect of botanicals on emergence of *C. johnsoni* adults from *H. septima* hosts

Sl. No.	Treatments	% of adult emergence	
		Host grub	Host pupa
1	*C. infortunatum* dry 8 %	72.85	75.66
2	*C. infortunatum* dry 4 %	78.16	74.96
3	*C. infortunatum* dry 2 %	80.35	77.15
4	*C. infortunatum* fresh 8 %	68.57	69.87
5	*C. infortunatum* fresh 4 %	74.20	75.40
6	*C. infortunatum* fresh 2 %	79.84	79.26
7	Neem seed oil 4 %	63.28	63.56
8	Neem seed oil 3 %	69.95	72.44
9	Neem seed oil 2 %	76.41	74.56
10	Nimbecidine 0.4 %	61.27	65.10
11	Nimbecidine 0.3 %	73.63	77.85
12	Nimbecidine 0.2 %	79.78	77.98
13	Control	81.24	81.05
	$F_{12,24}$	6.28*	7.49*
	CD(0.05)	7.46	5.50

* Significant at 5 per cent level

The same trend was observed when the different botanicals were applied on parasitised *H.septima* pupae. The maximum emergence was from the untreated control pupae. The lowest emergence of 63.56 per cent was observed in neem seed oil four per cent, but it was on par with nimbecidine 0.40 per cent.

4.3.4.2 Effect of chemical pesticides on the emergence of *C. johnsoni* from *H.septima* grubs and pupae

The relevant results of the trial are presented in Table 23. There was significant difference among the pesticides with regard to their effect on emergence of parasites from treated host epilachna grubs. Malathion and quinalphos at all the doses and carbaryl 0.20 per cent caused 100 per cent mortality and hence the emergence was nil. Dimethoate treatments were less toxic and there was 50.31, 54.19 and 63.34 per cent emergence in dimethoate 0.05, 0.04 and 0.03 per cent treatments respectively. There was 54.02 per cent emergence in carbaryl 0.10 per cent treatment. The maximum emergence of 78.30 per cent was noticed in control.

The results showed that chemical pesticide application on parasitised *H.septima* pupae adversely affected the emergence of the parasite. There was 100 per cent mortality in carbaryl 0.20 per cent, quinalphos 0.05, 0.04 per cent and all malathion doses. The emergence was the highest (74.65 per cent) in control and it was on par with dimethoate 0.03 per cent. The percentage emergence was 50.77 and 51.26 per cent in dimethoate 0.05 and 0.04 per cent treatments respectively. However, only 1.31 and 2.77 per cent of the parasite adults emerged from carbaryl 0.15 and 0.10 per cent treated pupae respectively.

Table 23. Effect of chemical pesticides on the emergence of *C. johnsoni* adults from *H. septima* hosts

Sl. No.	Treatments	% of adult emergence	
		Host grub	Host pupa
1	Carbaryl 0.20 %	0.00 (1.00)	0.00 (1.00)
2	Carbaryl 0.15 %	5.10 (2.47)	1.31 (1.52)
3	Carbaryl 0.10 %	54.02 (7.42)	2.77 (1.94)
4	Quinalphos 0.05 %	0.00 (1.00)	0.00 (1.00)
5	Quinalphos 0.04 %	0.00 (1.00)	0.00 (1.00)
6	Quinalphos 0.03 %	0.00 (1.00)	1.20 (1.48)
7	Malathion 0.10 %	0.00 (1.00)	0.00 (1.00)
8	Malathion 0.075 %	0.00 (1.00)	0.00 (1.00)
9	Malathion 0.05 %	0.00 (1.00)	0.00 (1.00)
10	Dimethoate 0.05 %	50.31 (7.16)	50.77 (7.20)
11	Dimethoate 0.04 %	54.19 (7.43)	51.26 (7.23)
12	Dimethoate 0.03 %	63.34 (8.02)	62.25 (7.95)
13	Control	78.38 (9.85)	74.65 (9.64)
	$F_{12,24}$	656.66*	14.37*
	CD(0.05)	0.357	2.182

Transformed values are given in parentheses * Significant at 5 % level

Thus dimethoate was observed to be the safest to *C.johnsoni* among the pesticides tested on parasitised grubs and pupae of *H.septima*.

4.3.5. Toxicity of botanicals and chemical pesticides to the third instar grubs of *M.sexmaculatus*

The results (Table 24) showed that 12 hours after exposure to the botanicals *viz.*, nimbecidine *C.infortunatum* fresh and neem seed oil, there was no mortality of the predator grubs. However the chemical pesticides were toxic to the grubs of the predator. The mortality ranged from 58.53 to 75.81 per cent among the pesticide treatments. Compared to the other pesticides, dimethoate and carbaryl at the two doses caused lesser mortalities to grubs ranging from 58.53 to 62.25 per cent.

Twenty four hours after exposure, the same trend was observed. Botanicals were safe to the predator. Carbaryl 0.15 per cent and dimethoate 0.04 per cent were comparatively safer pesticides.

The botanicals except neem seed oil 4.00 per cent were observed to be safe at all doses to grubs of *M.sexmaculatus* 48 hours after exposure (mortality 1.28 %). With regard to the effect of chemical pesticides on predator grubs at 48 hours after exposure, the mortality trend was on similar lines as in 12 and 24 hours.

The botanicals were safe to the third instar grubs of *M.sexmaculatus*. The chemical pesticides were toxic and caused mortality. Among the pesticides, dimethoate and carbaryl were the least harmful to grubs of *M.sexmaculatus*.

Table 24. Percentage mortality of third instar grubs of *M. sexmaculatus* at different intervals after exposure to botanicals and chemical pesticides

Sl. No.	Treatments	Hours after exposure		
		12	24	48
1	*C. infortunatum* fresh 8 %	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2	*C. infortunatum* fresh 4 %	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
3	Neem seed oil 4 %	0.00 (0.00)	0.00 (0.00)	1.28 (6.49)
4	Neem seed oil 3 %	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
5	Nimbecidine 0.4 %	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
6	Nimbecidine 0.3 %	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
7	Carbaryl 0.20 %	58.53 (49.89)	76.05 (60.68)	83.20 (65.77)
8	Carbaryl 0.15 %	58.53 (49.89)	68.90 (56.08)	76.05 (60.66)
9	Quinalphos 0.05 %	72.67 (58.46)	83.20 (65.77)	86.58 (68.48)
10	Quinalphos 0.04 %	68.90 (56.08)	79.27 (62.89)	90.23 (71.75)
11	Malathion 0.10 %	75.81 (60.51)	82.97 (65.60)	95.22 (77.35)
12	Malathion 0.075 %	72.42 (58.30)	79.27 (62.89)	86.58 (68.48)
13	Dimethoate 0.05 %	62.25 (52.07)	72.68 (58.46)	79.27 (62.89)
14	Dimethoate 0.04 %	58.53 (49.89)	65.61 (54.08)	72.66 (58.46)
	$F_{13,26}$	40.23*	538.17*	84.81*
	CD (0.05)	3.688	3.928	10.710

Transformed values are given in parentheses.

* Significant at 5% level

4.4. Reaction of bitter gourd varieties to pests

4.4.1 Pest incidence in bitter gourd varieties

The relevant results are presented in Tables 25 and 26.

Mean number of leaves infested by *L.trifolii* was the least in the variety 'Priya' (0.75) and the highest in 'Arka Harit' at three weeks after sowing. The mean number of *H.septima* grubs out of five leaves per vine was the least (0.08) in Preethi and it was on par with Arka Harit (0.025). The number was higher in the other varieties.

The mean number of leaves infested by *H.septima* per vine ranged from 0.08 to 0.92 among the varieties. The least infestation of 0.08 was recorded in Preethi followed by Arka Harit (0.25). The *H.phycitis* count per leaf was 1.44 in the local variety and they were not observed in Arka Harit.

Low incidence of *H.septima* and *H.phycitis* was observed at four weeks after sowing. The mean number of *H.septima* grubs in five leaves per vine ranged from 0.00 to 1.92, the highest being in Priyanka and Preethi. Similarly the mean number of leaves infested per vine by *H.septima* ranged from 0.00 to 1.25 among the varieties. No *H.septima* infestation was seen in Arka Harit. *H.phycitis* numbers per leaf was maximum in the local variety and was absent Arka Harit.

The incidence of *H.septima, H.phycitis* and *N.falcata* were observed at five weeks after sowing. The mean number of *H.septima* grubs ranged from 0.08 (in Arka Harit) to 2.34 (in Priya) among the varieties. The mean number of

Table 25. Pest incidence in bitter gourd varieties upto fruitset (3 to 7 weeks after sowing)

Pest/damage	Varieties	Weeks after sowing				
		3	4	5	6	7
Mean number of leaves infested by *L. trifolii* vine^{-1}	Priya	0.75	0.00	0.00	1.92	0.00
	Arka Harit	1.25	0.00	0.00	0.84	0.00
	Preethi	0.84	0.00	0.00	1.75	0.00
	Priyanka	1.00	0.00	0.00	1.75	0.00
	Local	0.84	0.00	0.00	2.08	0.00
$F_{4,12}$		3.35*			7.46*	
CD(0.05)		0.331			0.547	
Mean number of *H. septima* grubs vine^{-1}	Priya	0.74	1.92	2.34	0.00	0.00
	Arka Harit	0.25	0.00	0.08	0.00	0.00
	Preethi	0.08	0.83	1.00	0.00	0.00
	Priyanka	0.67	1.92	2.17	0.00	0.00
	Local	1.09	1.67	1.84	0.00	0.00
$F_{4,12}$		6.10*	8.24*	17.57*		
CD(0.05)		0.501	0.898	0.689		
Mean number of leaves infested by *H. septima* vine^{-1}	Priya	0.67	1.08	1.34	0.00	0.00
	Arka Harit	0.25	0.00	0.08	0.00	0.00
	Preethi	0.08	0.57	0.67	0.00	0.00
	Priyanka	0.67	1.25	1.42	0.00	0.00
	Local	0.92	1.17	1.33	0.00	0.00
$F_{4,12}$		8.91*	20.19*	27.25*		
CD(0.05)		0.352	0.361	0.342		
Mean number of *H. phycitis* adults leaf^{-1}	Priya	0.80	1.17	3.67	3.09	2.51
	Arka Harit	0.00	0.00	0.00	1.67	0.70
	Preethi	0.57	0.75	2.25	2.58	2.82
	Priyanka	0.19	1.67	2.00	3.25	3.38
	Local	1.44	1.75	4.58	4.42	3.76
$F_{4,12}$		19.56*	24.02*	14.72*	10.93*	2.10
CD(0.05)		0.394	0.453	1.406	0.936	—
% of shoots infested by *N. falcata* vine^{-1}	Priya	0.00	0.00	3.57 (2.14)	8.33	0.00
	Arka Harit	0.00	0.00	0.00 (1.00)	0.00	0.00
	Preethi	0.00	0.00	1.88 (1.70)	11.67	0.00
	Priyanka	0.00	0.00	2.55 (1.88)	10.00	0.00
	Local	0.00	0.00	1.08 (1.40)	10.00	0.00
$F_{4,12}$				0.643	1.06	
CD(0.05)				—	—	
% of leaves infested by *P. latus* vine^{-1}	Priya	0.00	0.00	0.00	24.18	43.09 (6.56)
	Arka Harit	0.00	0.00	0.00	11.67	10.78 (3.43)
	Preethi	0.00	0.00	0.00	24.17	31.20 (5.67)
	Priyanka	0.00	0.00	0.00	20.83	33.77 (5.90)
	Local	0.00	0.00	0.00	28.33	28.96 (5.47)
$F_{4,12}$					4.66*	10.90*
CD(0.05)					8.959	1.10
Mean number of *P. latus* adults leaf^{-1}	Priya	0.00	0.00	0.00	0.00	16.00
	Arka Harit	0.00	0.00	0.00	0.00	3.38
	Preethi	0.00	0.00	0.00	0.00	8.08
	Priyanka	0.00	0.00	0.00	0.00	8.18
	Local	0.00	0.00	0.00	0.00	9.93
$F_{4,12}$						12.59*
CD(0.05)						3.956

Transformed values are given in parentheses. * Significant at 5% level

Table 26. Pest incidence in bitter gourd varieties after fruitset (8 to 13 weeks after sowing)

Pest / damage	Varieties	Weeks after sowing					
		8	9	10	11	12	13
Mean no. of *H. phycitis* adults leaf^{-1}	Priya	5.75	0.00	0.00	0.00	0.00	0.00
	Arka Harit	1.31	0.00	0.00	0.00	0.00	0.00
	Preethi	4.12	0.00	0.00	0.00	0.00	0.00
	Priyanka	5.79	0.00	0.00	0.00	0.00	0.00
	Local	4.71	0.00	0.00	0.00	0.00	0.00
	$F_{4,12}$	4.85*					
	CD (0.05)	2.565					
% of leaves infested by *P. latus* vine^{-1}	Priya	34.28 (5.94)	0.00	0.00	0.00	0.00	0.00
	Arka Harit	13.95 (3.87)	0.00	0.00	0.00	0.00	0.00
	Preethi	31.21 (5.68)	0.00	0.00	0.00	0.00	0.00
	Priyanka	30.80 (5.64)	0.00	0.00	0.00	0.00	0.00
	Local	30.44 (5.61)					
	$F_{4,12}$	2.68					
	CD (0.05)	—					
Mean no. of *P. latus* adults leaf^{-1}	Priya	16.42	0.00	0.00	0.00	0.00	0.00
	Arka Harit	4.60	0.00	0.00	0.00	0.00	0.00
	Preethi	7.05	0.00	0.00	0.00	0.00	0.00
	Priyanka	7.60	0.00	0.00	0.00	0.00	0.00
	Local	12.75	0.00	0.00	0.00	0.00	0.00
	$F_{4,12}$	5.38*					
	CD (0.05)	6.371					
% of fruits infested by *B. cucurbitae*	Priya	40.96 (6.48)	54.27 (7.43)	52.34 (7.30)	51.05 (7.21)	59.68 (7.79)	59.63 (7.79)
	Arka Harit	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
	Preethi	11.63 (3.55)	27.34 (5.33)	40.48 (6.44)	41.84 (6.54)	52.78 (7.33)	43.92 (6.70)
	Priyanka	29.71 (5.54)	43.09 (6.64)	38.66 (6.30)	52.41 (7.31)	56.45 (7.58)	36.00 (6.08)
	Local	38.19 (6.26)	45.24 (6.80)	52.38 (7.31)	48.23 (7.02)	61.76 (7.92)	69.81 (8.41)
	$F_{4,12}$	18.38*	34.78*	57.13*	28.44*	66.77*	18.66*
	CD (0.05)	1.655	1.357	1.081	1.565	1.126	2.1
% of leaves infested by *D. indica*	Priya	0.00	17.50	18.87 (4.46)	0.00	0.00	0.00
	Arka Harit	0.00	0.00	0.00 (1.00)	0.00	0.00	0.00
	Preethi	0.00	24.17	19.65 (4.54)	0.00	0.00	0.00
	Priyanka	0.00	18.33	18.02 (4.36)	0.00	0.00	0.00
	Local	0.00	21.67	21.44 (4.74)	0.00	0.00	0.00
	$F_{4,12}$		4.46*	9.21*			
	CD (0.05)		13.884	1.607			
% of fruits infested by *D. indica*	Priya	0.00	0.00	9.45	0.00	0.00	0.00
	Arka Harit	0.00	0.00	0.00	0.00	0.00	0.00
	Preethi	0.00	0.00	7.78	0.00	0.00	0.00
	Priyanka	0.00	0.00	10.42	0.00	0.00	0.00
	Local	0.00	0.00	11.03	0.00	0.00	0.00
	$F_{4,12}$			1.49			
	CD (0.05)			—			
% of vines showing mosaic	Priya	7.15	0.00	10.71	0.00	0.00	11.70 (3.56)
	Arka Harit	0.00	0.00	0.00	0.00	0.00	0.00 (1.00)
	Preethi	7.15	0.00	7.15	0.00	0.00	5.02 (2.45)
	Priyanka	0.00	0.00	7.15	0.00	0.00	9.12 (3.18)
	Local	7.15	0.00	10.71	0.00	0.00	11.75 (3.57)
	$F_{4,12}$	1.13		1.36			2.46
	CD (0.05)	—		—			—

Transformed values are given in parentheses. * Significant at 5% level

leaves infested by *H.septima* ranged from 0.08 in Arka Harit to 1.42 in Priyanka. The number of *H.phycitis* per leaf varied significantly among the varieties. The count was significantly higher in Priya and the local variety. There was no significant variation among varieties with regard to *N.falcata* attack and it ranged from 0.00 to 3.57 per cent.

The pests observed were *P.latus*, *H.phycitis*, *L.trifolii* and *N.falcata* at six weeks after sowing. The percentage of bitter gourd leaves infested by *P.latus* ranged from 11.67 in Arka Harit to 28.33 in the local variety. Among the different varieties, *H.phycitis* number per leaf ranged from 1.67 to 4.42. The population was the least in Arka Harit which was on par with Preethi. *L.trifolii* damage on leaf varied significantly among the varieties. The least damage (0.84) was in Arka Harit and the maximum (2.08) in the local variety. The percentage of growing points infested by *N.falcata* did not differ significantly and ranged from 0.00 to 11.67 per cent.

Seven weeks after sowing, *P.latus* and *H.phycitis* were observed. The mean number of *P.latus* per leaf varied from 3.38 in Arka Harit to 16.00 in Priya. The percentage of leaves infested by *P.latus* ranged from 10.78 to 43.09 per cent. The least *P.latus* attack was observed in Arka Harit and the highest in Priya. The mean number of *H.phycitis* per leaf (0.70 to 3.76) did not vary significantly.

Eight weeks after sowing, *P.latus*, *H.phycitis*, *B.cucurbitae* and mosaic incidence were observed in the vines. The mean *P.latus* count per leaf ranged from 4.60 (in Arka Harit) to 16.42 (in Priya). The percentage of vines infested by *P.latus* ranged from 13.95 to 34.28, maximum damage being in Priya. Fruit set in Arka Harit was nil while all the other varieties bore fruits. The percentage

of fruits damaged by fruit fly ranged from 11.63 to 40.96 in the other varieties. The least damage was observed in Preethi while Priya registered the maximum. *H.phycitis* number per leaf varied significantly and the least was in Arka Harit (1.31). The percentage of bitter gourd vines showing mosaic ranged from 0.00 to 7.15 among the vines. Mosaic was not observed in Arka Harit and Priyanka whereas, 7.15 per cent of the plants were affected in all the other varieties.

B.cucurbitae and *D.indica* attack were observed on bitter gourd vines at nine weeks after sowing. The variety Arka Harit had become stunted and incapable of fruit set. The percentage of fruits damaged by fruit fly varied from 27.34 (Preethi) to 54.27 (Priya). The percentage of leaves infested by the *D.indica* was the maximum in Preethi (24.17 per vine) and was on par with Priya, Priyanka and Local.

B.cucurbitae, *D.indica* damage and mosaic were observed in the vines at ten weeks after sowing. The variety Arka Harit had withered by the tenth week. The percentage of fruits infested ranged from 38.66 (Priyanka) to 52.38 (Local). The percentage of fruits infested by *D.indica* and mosaic infestation did not differ significantly among the varieties.

At eleven weeks after sowing, *B.cucurbitae* infestation was high. It ranged from 41.84 to 52.41 among the varieties though the variation was not significant. High infestation by fruit fly (52.78 to 61.76 per cent) was also noticed at twelve weeks after sowing.

During the thirteenth week also, the percentage of fruits infested by *B.cucurbitae* was high and ranged from 36.00 to 69.81 among the varieties. The percentage of vines exhibiting mosaic symptoms differed from 5.02 (Preethi) to 11.75 (local variety).

The mean *B.cucurbitae* infestation over the season (six weeks) ranged from 38.62 to 55.16 per cent. The least infestation of 38.62 per cent was observed in Preethi. The infestation was significantly higher in Priyanka, Priya and the local variety (47.96, 53.90 and 55.16 per cent respectively).

Yield of bitter gourd fruits among the varieties

The results on yield data are presented in Table 27.

At nine weeks after sowing, the yield of markettable fruits ranged from 256.25 in Priyanka to 356.25 g $vine^{-1}$ in Priya. At ten weeks after sowing, Preethi registered an yield of 575 g $vine^{-1}$ which was significantly higher than the other varieties. The fruit yield ranged from 256.25 to 487.50 g $vine^{-1}$ at eleven weeks after sowing. Preethi registered the highest yield (487.50 g $vine^{-1}$) which was on par with Priya. The same trend in yield was observed at twelve weeks after sowing. The yield was the highest (468.75 g) in Preethi and it was superior to the other varieties. During the thirteenth week the fruit yield ranged from 250 g in local variety to 418.75 g $vine^{-1}$ in Preethi.

There was significant difference among the varieties with regard to the total yield of fruits. The highest yield of 2275 g $vine^{-1}$ (5687.5 kg ha^{-1}) was recorded in Preethi and it was significantly superior to all the other varieties.

A perusal of the results of pest incidence, especially fruit fly damage and yield of fruits indicated that Preethi was the best variety. Hence the variety Preethi was selected for the ensuing Pest Management Trial (PMT).

Table 27. Yield of fruits among the bitter gourd varieties

Varieties	Wt. of fruits g vine^{-1} 9 WAS	Wt. of fruits g vine^{-1} 10 WAS	Wt. of fruits g vine^{-1} 11 WAS	Wt. of fruits g vine^{-1} 12 WAS	Wt. of fruits g vine^{-1} 13 WAS	Total yield	
						g vine^{-1}	kg ha^{-1}
Priya	356.25	431.25	356.25	275.00	300.00	1693.75	4099.38
Arka Harit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Preethi	350.00	575.00	487.50	468.75	418.75	2275.00	5687.50
Priyanka	256.25	412.50	275.00	300.00	275.00	1518.75	3796.88
Local	212.50	343.75	256.25	218.75	250.00	1287.50	3218.75
$F_{4,12}$	11.36*	33.68*	14.25*	13.69*	14.75*	125.10*	125.10*
CD (0.05)	132.55	113.78	145.88	140.87	123.12	231.68	579.20

WAS - Weeks after sowing * Significant at 5% level

4.5. Pest Management Trial in bitter gourd

4.5.1. First season (1996)

The Pest Management Trial (PMT) in bitter gourd was conducted from January 1996 to April 1996 (Plate 8) and the results of pest and damage incidence at third week after sowing are presented in Table 28.

Three weeks after sowing

The mean number of *H.phycitis* varied significantly among the treatments. The lowest population of 1.76 *H.phycitis* per leaf was observed in T_4 which was on par with T_8, T_7, T_5 and T_6. The maximum population of 6.49 was observed in control. The percentage of shoots infested by *N.falcata* ranged from 2.14 to 19.15 and did not vary significantly.

Four weeks after sowing

The results of pest incidence are presented in Table 29. The pest observed were *H.phycitis*, *N.falcata* and *L.trifolii*. There was no significant difference among treatments with regard to the distribution of the above pests.

An application (spray) of all the treatments were given one day after taking the above observations. Pest incidence was recorded one week later coinciding with the fifth week after sowing.

Five weeks after sowing

The results of pest status are presented in Table 30. The pests observed were *H.phycitis*, *L.trifolii*, *N.falcata*, *H.septima* and *A.gossypii*.

Pest Management Trial at Vellayani

View of Pest Management Trial

Pest management trial 8 weeks after sowing

Pest management trial 11 weeks after sowing

Plate 8. Pest management trial

Table 28. Pest / damage incidence in bitter gourd three weeks after sowing - Season I

	Treatments	Mean number of *H. phycitis* adults leaf^{-1}	% of shoots infested by *N. falcata* 10 shoots^{-1}
T_1	Chlorpyriphos 0.05 % soil drench + Dimethoate 0.05 % need based + Mechanical control after fruit set	4.14 (2.27)	2.14 (1.77)
T_2	Neem seed oil 3% soap emulsion soil drench + need based application of same + banana fruit / ocimum trap	4.44 (2.33)	5.47 (2.54)
T_3	Nimbecidine 0.4% soil drench + need based application of same + banana fruit / ocimum trap	5.95 (2.64)	3.81 (2.19)
T_4	Carbaryl 0.15% soil drench + need based application of same + banana fruit / ocimum trap	1.76 (1.66)	7.80 (2.97)
T_5	Dimethoate 0.05 % soil drench + need based application of same + banana fruit / ocimum trap	2.70 (1.92)	2.14 (1.77)
T_6	Combination of T_2 + half dose of T_4 soil drench + need based application of same + banana fruit / ocimum trap	2.70 (1.92)	2.14 (1.77)
T_7	Combination of T_2 + half dose of T_5 soil drench + need based application of same + banana fruit / ocimum trap	2.39 (1.84)	3.81 (2.19)
T_8	Combination of T_3 + half dose of T_4 soil drench + need based application of same + banana fruit / ocimum trap	2.00 (1.73)	7.80 (2.97)
T_9	Combination of T_3 + half dose of T_5 soil drench + need based application of same + banana fruit / ocimum trap	3.87 (2.21)	2.14 (1.77)
T_{10}	Control	6.49 (2.74)	19.15 (4.49)
	$F_{9,18}$	4.10*	0.92
	CD (0.05)	0.54	—

Transformed values are given in parentheses.

* Significant at 5% level

NB : Soil drench given prior to seeding.

Table 29. Pest / damage incidence in bitter gourd four weeks after sowing - Season I

Treatments	Mean number of *H. phycitis* leaf^{-1}	% of shoots infested by *N. falcata* vine^{-1}	% of leaves infested by *L. trifolii* vine^{-1}
T_1	6.43 (2.73)	7.80 (2.97)	8.37 (3.06)
T_2	7.72 (2.95)	19.15 (4.49)	6.67 (2.77)
T_3	8.65 (3.11)	9.86 (3.29)	7.98 (3.00)
T_4	6.83 (2.80)	7.80 (2.97)	6.41 (2.72)
T_5	5.54 (2.56)	15.54 (4.07)	3.55 (2.13)
T_6	5.70 (2.59)	5.47 (2.54)	6.41 (2.72)
T_7	5.08 (2.47)	7.80 (2.97)	5.45 (2.54)
T_8	6.65 (2.77)	10.48 (3.39)	2.72 (1.93)
T_9	7.10 (2.85)	9.86 (3.29)	0.85 (1.36)
T_{10}	8.11 (3.02)	22.21 (4.82)	10.88 (3.45)
$F_{9,18}$	1.14	0.51	1.18
CD (0.05)	—	—	—

Transformed values are given in parentheses.

Table 30. Pest / damage incidence in bitter gourd at five weeks after sowing - Season I

Treatments	Mean no. of *H. phycitis* leaf^{-1}	% of leaves infested by *L. trifolii* vine^{-1}	% shoots infested by *N. falcata* vine^{-1}	Mean no. of *H. septima* grubs leaf^{-1}	Mean no. of *A. gossypii* leaf^{-1}
T_1	5.25 (2.50)	6.67 (2.77)	10.39 (3.37)	0.00 (1.00)	20.39 (4.63)
T_2	3.61 (2.15)	3.33 (2.08)	10.88 (3.45)	0.69 (1.30)	36.05 (6.09)
T_3	9.89 (3.30)	5.21 (2.49)	24.09 (5.01)	0.30 (1.14)	40.89 (6.47)
T_4	3.17 (2.04)	9.54 (3.25)	17.29 (4.28)	0.00 (1.00)	12.83 (3.72)
T_5	4.60 (2.37)	1.96 (1.72)	8.66 (3.11)	0.00 (1.00)	19.83 (4.56)
T_6	3.33 (2.08)	0.85 (1.36)	2.72 (1.93)	1.63 (1.62)	9.95 (3.31)
T_7	2.86 (1.96)	2.80 (1.95)	3.82 (2.19)	0.00 (1.00)	13.38 (3.79)
T_8	4.16 (2.27)	4.90 (2.43)	5.53 (2.55)	0.38 (1.18)	11.64 (3.56)
T_9	3.95 (2.23)	2.80 (1.95)	7.16 (2.86)	0.00 (1.00)	21.01 (4.69)
T_{10}	9.03 (3.17)	7.71 (2.95)	23.68 (4.97)	1.38 (1.58)	38.06 (6.25)
$F_{9,18}$	6.35*	1.54	2.39	2.17	10.90*
CD(0.05)	0.547	—	—	—	1.060

Transformed values are given in parentheses

* Significant at 5% level

The mean number of *H.phycitis* per leaf ranged from 2.86 in T_7 to 9.89 in T_3 among the treatments. The percentage of leaves infested by *L.trifolii* ranged from 0.85 (T_6) to 9.54 (T_4) where as the shoot infestation by gall fly ranged from 2.72 (T_6) to 24.09 (T_3) among the treatments. The mean number of *H.septima* grubs per leaf did not show any significant variation among the treatments. The *A.gossypii* population per bitter gourd leaf ranged from 9.95 (T_6) to 40.89 (T_3).

The relevant results on the incidence of natural enemies of the different pests of bitter gourd are given in Table 31. In general, there was no significant difference in natural enemy incidence among treatments. However, treatments receiving botanicals and control registered higher level of parasitisation. The percentage of stem gall fly maggots parasitised ranged from 0.00 to 1.33.

The mean number of coccinellid predator adults per leaf ranged from 0.00 to 0.54 (control) which were on par among themselves. Similarly the mean number of coccinellid predator grubs per leaf showed no significant variation among treatments and the count varied for 0.00 to 0.88 (T_9). Syrphid maggots were observed in T_3, T_7 and T_8 treatments only and did not vary significantly among the varieties. The distribution of the spider fauna varied among the treatments, though not significantly. The highest number was observed in control (0.44).

As the population of the *A.gossypii* was significantly higher in the neem seed oil (T_2) and nimbecidine (T_3) treatments, treatments T_2 and T_3 were applied as need based after the fifth week of sowing.

Table 31. Incidence of natural enemies of pests of bitter gourd five weeks after sowing - Season I

Treatments	Mean no. of parasitised *N. falcata* maggots vine^{-1}	Mean no. of coccinellid predator adults leaf^{-1}	Mean no. of coccinellid predator grubs leaf^{-1}	Mean no. of of syrphid maggots leaf^{-1}	Mean no. of spiders vine^{-1}
T_1	0.00	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.10 (1.05)
T_2	0.00	0.10 (1.05)	0.43 (1.19)	0.00 (1.00)	0.20 (1.10)
T_3	1.33	0.00 (1.00)	0.30 (1.14)	0.20 (1.10)	0.00 (1.00)
T_4	0.00	0.10 (1.05)	0.10 (1.05)	0.00 (1.00)	0.00 (1.00)
T_5	0.00	0.32 (1.15)	0.32 (1.15)	0.00 (1.00)	0.00 (1.00)
T_6	0.33	0.10 (1.05)	0.20 (1.10)	0.00 (1.00)	0.00 (1.00)
T_7	0.67	0.44 (1.20)	0.55 (1.25)	0.10 (1.05)	0.10 (1.05)
T_8	0.00	0.21 (1.10)	0.20 (1.10)	0.10 (1.05)	0.10 (1.05)
T_9	1.00	0.41 (1.19)	0.88 (1.37)	0.00 (1.00)	0.21 (1.10)
T_{10}	0.67	0.54 (1.24)	0.73 (1.31)	0.00 (1.00)	0.44 (1.20)
$F_{9,18}$		1.87	1.50	0.83	1.83
CD(0.05)	—	—	—	—	—

Transformed values are given in parentheses

* Significant at 5% level

Six weeks after sowing

The relevant results are presented in Table 32. The pests observed were *H.phycitis*, *A.gossypii*, *D.indica* and *P.latus*. There was no significant difference among the treatments with regard to the mean number of *H.phycitis* per leaf. The *A.gossypii* population per leaf ranged from 11.98 in T_7 to 27.90 in control vines. There was no significant difference among the treatments with regard to the population of *D.indica* larvae and the percentage of leaves damaged by this pest. The mean number of *P.latus*s was the lowest (12.75 per leaf) in T_6 which was on par with T_1 and T_5. The highest *P.latus* population was registered in T_9 (22.63) followed by T_{10} (21.08).

The incidence of mosaic and downy mildew were observed in the vines at six weeks after sowing. The percentage of vines exhibiting mosaic symptoms ranged from 2.34 (T_6) to 18.12 (T_{10}) though the variation was not significant. The incidence of mosaic was in general less than six per cent in vines receiving botanical pesticide application while the incidence was higher in the other treatments. The downy mildew disease index varied significantly among the treatments. The lowest value of 24.35 was in neem seed oil 3.00 per cent treatment, but was on par with the other treatments except T_4, T_8, T_9 and T_{10}.

The results of observation on natural enemies at six weeks after sowing are given in Table 33. The mean number of parasitised *D.indica* larvae per vine ranged from 0.00 (T_5) to 0.66 (T_3) among the treatments. Eventhough there was no significant difference among the treatments, the incidence of parasitised larvae was in general more in botanical based treatments and control compared to those receiving only chemical pesticides.

Table 32. Pest / damage incidence in bitter gourd six weeks after sowing - Season I

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *A. gossypii* leaf^{-1}	Mean no. of *D. indica* larvae leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	Mean no. of *P. latus* leaf^{-1}	% of vines showing mosaic plot^{-1}	Downy mildew disease index
T_1	6.76 (2.79)	20.31 (4.62)	1.47 (1.57)	13.94 (3.86)	14.10 (3.89)	11.11 (3.48)	31.03 (5.66)
T_2	5.88 (2.62)	13.70 (3.83)	0.67 (1.29)	9.82 (3.29)	19.39 (4.52)	6.04 (2.65)	24.35 (5.04)
T_3	6.47 (2.73)	13.32 (3.78)	1.19 (1.48)	10.57 (3.40)	17.64 (4.32)	6.04 (2.65)	26.40 (5.23)
T_4	5.96 (2.64)	13.54 (3.81)	0.78 (1.33)	12.04 (3.61)	18.88 (4.46)	8.61 (3.10)	35.49 (6.04)
T_5	7.57 (2.93)	16.62 (4.20)	0.50 (1.23)	8.37 (3.06)	15.44 (4.05)	11.57 (3.55)	33.13 (5.84)
T_6	5.79 (2.61)	13.65 (3.83)	0.63 (1.28)	8.66 (3.11)	12.75 (3.71)	2.34 (1.83)	31.03 (5.66)
T_7	3.96 (2.23)	11.98 (3.60)	0.30 (1.14)	5.21 (2.49)	16.22 (4.15)	6.04 (2.65)	33.13 (5.84)
T_8	9.08 (3.17)	17.39 (4.29)	0.86 (1.36)	6.41 (2.72)	19.38 (4.51)	6.04 (2.65)	39.83 (6.39)
T_9	8.27 (3.05)	13.40 (3.80)	1.00 (1.41)	8.82 (3.13)	22.63 (4.86)	6.04 (2.65)	42.19 (6.57)
T_{10}	11.39 (3.52)	27.90 (5.38)	1.87 (1.69)	13.20 (3.77)	21.08 (4.70)	18.12 (4.37)	44.06 (6.71)
$F_{9,18}$	1.92	4.82*	2.26	1.11	9.41*	0.63	4.13
CD(0.05)	—	0.738	—	—	0.353	—	0.798

Transformed values are given in parentheses * Significant at 5% level

Table 33. Incidence of natural enemies of pests of bitter gourd six weeks after sowing - Season I

Treatments	Mean no. of parasitised *D. indica* larvae vine^{-1}	Mean no. of coccinellid predator adults leaf^{-1}	Mean no. of coccinellid predator grubs leaf^{-1}	Mean no. of syrphid maggots leaf^{-1}	Mean no. of thrip predators of mite leaf^{-1}	Mean no. of spiders vine^{-1}
T_1	0.20 (1.10)	0.32 (1.15)	0.89 (1.37)	0.33 (1.15)	0.00 (1.00)	0.44 (1.20)
T_2	0.32 (1.15)	0.10 (1.05)	0.32 (1.15)	0.21 (1.10)	0.43 (1.19)	0.21 (1.10)
T_3	0.66 (1.29)	0.50 (1.23)	0.59 (1.26)	0.00 (1.00)	0.55 (1.25)	0.10 (1.05)
T_4	0.10 (1.05)	0.20 (1.10)	0.43 (1.19)	0.10 (1.05)	0.21 (1.10)	0.10 (1.05)
T_5	0.00 (1.00)	0.20 (1.10)	0.38 (1.18)	0.21 (1.10)	0.10 (1.05)	0.30 (1.14)
T_6	0.32 (1.15)	0.41 (1.19)	0.53 (1.24)	0.20 (1.10)	0.00 (1.00)	0.21 (1.10)
T_7	0.10 (1.05)	0.20 (1.10)	0.20 (1.10)	0.32 (1.15)	0.43 (1.19)	0.20 (1.10)
T_8	0.33 (1.15)	0.55 (1.25)	0.67 (1.29)	0.21 (1.10)	0.53 (1.24)	0.00 (1.00)
T_9	0.33 (1.15)	0.21 (1.10)	0.44 (1.20)	0.32 (1.15)	0.75 (1.32)	0.10 (1.05)
T_{10}	0.53 (1.24)	0.32 (1.15)	0.53 (1.24)	0.30 (1.14)	0.75 (1.32)	0.32 (1.15)
$F_{9,18}$	2.27	1.63	0.49	0.59	0.40	0.61
CD(0.05)	—	—	—	—	—	—

Transformed values are given in parentheses

The mean number of coccinellid predator adults per leaf ranged from 0.10 to 0.55 and did not differ significantly among the treatments. The mean number of coccinellid predator grubs per leaf ranged from 0.20 to 0.89 but there was no statistical variation.

In general, the mean number of syrphid maggots per leaf was low and ranged from 0.00 to 0.33 among the treatments. The count of thrip predator *S. indicus* of the *P.latus* varied from 0.00 to 0.75 (in T_9 and control). The incidence of the predator was generally higher in treatments receiving botanicals. The spider number per vine was low and varied among the treatments though not significantly.

After recording the pest and disease incidence at six weeks after sowing, it was evident that the population of pests were on the increase. Need based application of all the treatments were given. As downy mildew was present, a spray of Mancozeb (Indofil M-45) at 4.00 g litre^{-1} was applied on all the vines including control.

Seven weeks after sowing

Observations on pest incidence was recorded in the next week i.e., seven weeks after sowing. The data are presented in Table 34.

The pests observed included the *H.phycitis, D.indica* and *P.latus*.

The mean number of *H.phycitis* did not vary significantly among the treatments and ranged from 2.46 to 4.28 per leaf. The percentage of leaves infestated by *D. indica* was statistically on par among the treatments (range

Table 34. Pest / damage incidence in bitter gourd seven weeks after sowing - Season I

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *D. indica* larvae vine^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	Mean no. of *P. latus* leaf^{-1}
T_1	3.34 (2.08)	0.19 (1.09)	17.53 (4.30)	59.69 (7.79)
T_2	3.53 (2.13)	0.18 (1.09)	16.65 (4.20)	57.67 (7.66)
T_3	3.92 (2.22)	0.22 (1.10)	15.97 (4.12)	67.00 (8.25)
T_4	3.20 (2.05)	0.16 (1.08)	14.16 (3.89)	42.32 (6.58)
T_5	3.75 (2.18)	0.19 (1.09)	17.28 (4.28)	54.31 (7.44)
T_6	3.15 (2.04)	0.20 (1.10)	14.39 (3.92)	47.43 (6.96)
T_7	2.46 (1.86)	0.21 (1.10)	16.65 (4.20)	41.53 (6.52)
T_8	3.69 (2.16)	0.26 (1.12)	22.01 (4.80)	63.88 (8.05)
T_9	3.50 (2.12)	0.32 (1.15)	23.23 (4.92)	75.01 (8.72)
T_{10}	4.28 (2.30)	0.38 (1.17)	24.25 (5.03)	82.98 (9.16)
$F_{9,18}$	1.58	1.80	1.00	3.53*
CD(0.05)	—	—	—	1.381

Transformed values are given in parentheses * Significant at 5% level

14.16 to 24.25). The mean number of *D.indica* larvae per leaf was less inspite of the higher percentage of leaf infestation. The *P.latus* population per leaf varied significantly among treatments. The lowest population of 41.53 was recorded in T_7 but it was on par with T_4, T_6, T_5, T_2 and T_1 treatments. The maximum of 82.98 was recorded in the control vines.

The results of the observations on natural enemies of pests at seven weeks after sowing are presented in Table 35. The mean number of *D.indica* larvae parasitised per vine (ranged from 0.04 to 0.22) did not vary significantly among the treatments. The mean number of predatory thrips per leaf ranged from 0.33 to 1.64 among the treatments. The spider population also did not vary significantly among the treatments.

A need based spray of all the treatments was given after recording the observations at seven weeks after sowing.

Eight weeks after sowing

The results are given in Table 36. The banana / ocimum traps were installed by the fiftieth day after sowing.

The pests infesting bitter gourd were *H.phycitis*, *D.indica* and *B.cucurbitae*. The *H.phycitis* count per leaf differed significantly among the treatments. The lowest count of 2.33 *H.phycitis* per leaf was observed in T_7 while the highest count of 4.75 was recorded in control vines.

The mean number of *D.indica* larvae per leaf was in general low and the highest number of 0.12 per leaf was noticed in control vines. The percentage of

Table 35. Incidence of natural enemies of pests of bitter gourd seven weeks after sowing - Season I

Treatments	Mean no. of parasitised *D. indica* larvae vine^{-1}	Mean no. of thrips predators of mites leaf^{-1}	Mean no. of spiders vine^{-1}
T_1	0.11 (1.05)	1.33 (1.52)	0.10 (1.05)
T_2	0.22 (1.11)	1.64 (1.62)	0.21 (1.10)
T_3	0.11 (1.05)	1.33 (1.52)	0.32 (1.15)
T_4	0.11 (1.05)	0.33 (1.15)	0.10 (1.05)
T_5	0.04 (1.02)	0.73 (1.31)	0.10 (1.05)
T_6	0.21 (1.10)	1.11 (1.45)	0.32 (1.15)
T_7	0.13 (1.06)	0.88 (1.37)	0.20 (1.10)
T_8	0.20 (1.10)	1.16 (1.47)	0.32 (1.15)
T_9	0.14 (1.07)	1.41 (1.55)	0.41 (1.19)
T_{10}	0.16 (1.08)	1.31 (1.52)	0.89 (1.37)
$F_{9,18}$	0.60	1.52	1.97
CD(0.05)	—	—	—

Transformed values are given in parentheses.

Table 36. Pest / damage incidence in bitter gourd and population of spiders eight weeks after sowing - Season I

Treatment	Mean no. of *D. indica* larvae leaf^{-1}	Mean no. of *H. phycitis* leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of spiders vine^{-1}
T_1	0.02 (1.01)	3.25 (2.06)	4.35 (2.31)	4.34 (2.31)	35.52 (36.57)	0.38 (1.18)
T_2	0.01 (1.00)	2.91 (1.98)	0.85 (1.36)	9.83 (3.29)	43.31 (41.14)	0.78 (1.33)
T_3	0.02 (1.01)	3.56 (2.14)	0.85 (1.36)	8.82 (3.13)	44.35 (41.74)	0.75 (1.32)
T_4	0.00 (1.00)	2.92 (1.98)	1.96 (1.72)	4.34 (2.31)	44.27 (41.69)	0.21 (1.10)
T_5	0.01 (1.00)	3.39 (2.10)	1.96 (1.72)	4.34 (2.31)	35.52 (36.57)	0.44 (1.20)
T_6	0.00 (1.00)	2.66 (1.91)	0.85 (1.36)	5.45 (2.54)	31.32 (34.02)	0.32 (1.15)
T_7	0.00 (1.00)	2.33 (1.83)	0.00 (1.00)	6.41 (2.72)	41.32 (39.98)	0.21 (1.10)
T_8	0.01 (1.00)	3.33 (2.08)	0.85 (1.36)	6.02 (2.65)	43.31 (41.14)	0.10 (1.05)
T_9	0.03 (1.02)	3.26 (2.06)	1.96 (1.72)	7.71 (2.95)	38.69 (38.45)	0.33 (1.15)
T_{10}	0.12 (1.06)	4.73 (2.39)	9.01 (3.16)	23.25 (4.92)	55.36 (48.06)	1.11 (1.45)
$F_{9,18}$	5.66*	3.53*	4.18*	11.70*	1.60	2.29
CD(0.05)	0.022	0.240	0.903	0.684	—	—

Transformed values are given in parentheses * Significant at 5% level

leaves infested by the *D.indica* ranged from 0.00 in T_7 to 9.01 in control. The percentage of flowers infested by *D.indica* larvae ranged from 4.34 (T_4, T_5 and T_1) to 23.25 (T_{10}). The percentage of tender fruits attacked by *B.cucurbitae* ranged from 31.32 to 55.36 and was on par among the treatments.

The spider population per vine did not show any significant variation. The spiders were more in treatments receiving botanicals and in control vines.

Nine weeks after sowing

The pests encountered were the *H.phycitis*, *D.indica* and *B.cucurbitae* (Table 37).

There was significant difference among the treatments with regard to *H.phycitis* number per leaf. The lowest number of 2.11 was observed in T_7 and the maximum in control - T_{10} (5.51). *D.indica* was observed to infest not only the leaves but also damage flowers and fruits. The percentage of leaf infestation showed significant variation and ranged from 12.04 (T_3) to 25.51 (control). The mean number of *D.indica* larvae per leaf differed among treatments. The lowest number of 0.30 was seen in T_4. The highest number of 0.96 was observed in control and it was significantly higher than all the other treatments. The mean number of parasitised *D.indica* larvae per vine ranged from 0.00 to 0.74 (T_{10}). The percentage infestation of leaves by *D.indica* was the highest in control vines. The percentage of flowers infested by *D.indica* larvae ranged from 13.19 in T_2, T_3, T_4 and T_7 to 26.38 in T_{10} (control) and all the treatments were on par and superior to control. The percentage of fruits infested by *D.indica* larvae ranged from 7.71 in T_7 and T_5 to 17.73 in control.

Table 37. Pest / damage incidence and natural enemy distribution in bitter gourd nine weeks after sowing - Season I

Treatments	Mean no. of *H. phycitis* leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	Mean no. of *D. indica* larvae leaf^{-1}	Mean no. of parasitised *D. indica* larvae vine^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *D. indica* larvae vine^{-1}	Mean no. of *B. cucurbitae* trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of spiders vine^{-1}	% of vines showing mosaic plot^{-1}
T_1	3.84 (2.20)	22.17 (4.81)	0.63 (1.28)	0.36 (1.16)	16.54 (4.19)	9.80 (3.29)	0.00 (1.00)	19.05 (25.87)	0.55 (1.25)	22.22 (4.82)
T_2	3.22 (2.05)	14.39 (3.92)	0.47 (1.21)	0.13 (1.07)	13.19 (3.77)	8.82 (3.13)	7.75 (2.96)	29.15 (32.66)	0.66 (1.29)	14.42 (3.93)
T_3	4.18 (2.28)	12.04 (3.61)	0.47 (1.21)	0.16 (1.08)	13.19 (3.77)	8.66 (3.11)	7.49 (2.91)	28.85 (32.47)	0.88 (1.37)	18.12 (4.37)
T_4	3.01 (2.00)	12.16 (3.63)	0.30 (1.14)	0.00 (1.00)	13.19 (3.77)	11.06 (3.47)	6.57 (2.75)	19.23 (26.00)	0.33 (1.15)	18.12 (4.37)
T_5	3.02 (2.01)	16.54 (4.19)	0.43 (1.20)	0.00 (1.00)	14.16 (3.89)	7.71 (2.95)	6.78 (2.79)	20.37 (26.82)	0.32 (1.15)	11.57 (3.55)
T_6	2.72 (1.93)	18.84 (4.45)	0.37 (1.17)	0.05 (1.02)	15.50 (4.06)	11.06 (3.47)	5.80 (2.61)	11.89 (20.16)	0.32 (1.15)	6.04 (2.65)
T_7	2.11 (1.76)	13.19 (3.77)	0.50 (1.22)	0.21 (1.10)	13.19 (3.77)	7.71 (2.95)	6.51 (2.74)	13.78 (21.78)	0.43 (1.19)	8.61 (3.10)
T_8	3.41 (2.10)	13.19 (3.77)	0.53 (1.24)	0.17 (1.08)	14.16 (3.89)	10.00 (3.32)	6.46 (2.73)	19.36 (26.10)	0.32 (1.15)	18.12 (4.37)
T_9	2.76 (1.94)	16.36 (4.17)	0.56 (1.25)	0.27 (1.13)	13.51 (3.81)	13.32 (3.78)	7.18 (2.86)	17.82 (24.96)	0.55 (1.25)	18.12 (4.37)
T_{10}	5.51 (2.55)	25.51 (5.15)	0.96 (1.40)	0.74 (1.32)	26.38 (5.23)	17.73 (4.33)	0.00 (1.00)	42.51 (40.67)	0.86 (1.36)	29.39 (5.51)
$F_{9,18}$	3.25*	4.96*	6.01*	3.62*	2.50*	4.76*	31.46*	3.04*	1.253	1.340
CD(0.05)	0.361	0.690	0.087	0.148	0.847	0.573	0.404	10.236	—	—

Transformed values are given in parentheses

* Significant at 5% level

The mean number of *B.cucurbitae* caught per trap in treatments T_2 to T_9 ranged from 5.80 to 7.75. The catch did not vary significantly. However, the damage to fruits was reduced considerably in the trap installed plots.

The percentage of fruits damaged by *B.cucurbitae* differed among treatments and ranged from 11.89 to 42.51 per cent. The least damage of 11.89 per cent was in T_6 which was on par with T_7, T_9, T_1, T_4, T_8 and T_5. Control registered highest damage of 42.51 per cent which was significantly higher than all the other treatments.

The spider count per vine was in general low (0.32 to 0.88 per vine) and did not vary significantly among treatments.

The percentage of vines showing mosaic symptoms ranged from 6.04 (T_6) to 29.39 (T_{10}) though the variation was not statistically significant among the treatments.

An application of treatments T_2 to T_9 was given at nine weeks after sowing after recording the observations.

Ten weeks after sowing

The pests observed were *B. cucurbitae*, *H. phycitis* and *D. indica* (Table 38).

The percentage of fruits infested by *B.cucurbitae* ranged from 2.33 in T_7 to 57.50 in T_{10} (control) and there was significantly higher damage in control compared to the other treatments.

Table 38. Pest / damage incidence and population of spider in bitter gourd ten weeks after sowing - Season I

Treatments	Mean no. of *H. phycitis* leaf^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *D. indica*	Mean no. of *B. cucurbitae* caught trap^{-1} vine^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of spiders vine^{-1}
T_1	1.61 (1.62)	16.55 (4.19)	7.71 (2.95)	0.00 (1.00)	15.33 (23.04)	0.21 (1.10)
T_2	2.13 (1.77)	6.67 (2.777)	5.45 (2.54)	5.25 (2.50)	12.89 (21.03)	0.55 (1.25)
T_3	2.24 (1.80)	7.71 (2.95)	5.45 (2.54)	4.90 (2.43)	16.78 (24.17)	0.66 (1.29)
T_4	0.89 (1.37)	4.34 (2.31)	4.34 (2.31)	3.99 (2.23)	9.17 (17.62)	0.00 (1.00)
T_5	0.83 (1.35)	4.34 (2.31)	4.34 (2.31)	4.51 (2.35)	15.43 (23.12)	0.10 (1.05)
T_6	1.05 (1.43)	4.34 (2.31)	2.80 (1.95)	4.27 (2.30)	5.09 (13.03)	0.00 (1.00)
T_7	1.27 (1.51)	3.75 (2.18)	4.34 (2.31)	3.04 (2.01)	2.33 (8.78)	0.00 (1.00)
T_8	1.31 (1.52)	5.45 (2.54)	4.34 (2.31)	4.54 (2.35)	10.59 (18.99)	0.20 (1.10)
T_9	0.94 (1.39)	5.45 (2.54)	5.45 (2.54)	4.65 (2.38)	10.33 (18.64)	0.10 (1.05)
T_{10}	4.59 (2.36)	25.37 (5.14)	29.73 (5.54)	0.00 (1.00)	57.50 (49.30)	0.53 (1.24)
$F_{9,18}$	12.58*	11.03*	12.23*	17.04*	14.51*	3.53*
CD (0.05)	0.267	0.869	0.868	0.411	8.410	0.174

Transformed values are given in parentheses

* Significant at 5% level

The *H.phycitis* number varied significantly among treatments and the lowest number was observed in T_5 (0.83) and it was on par with T_4, T_9, T_6, T_7 and T_8. Control registered the highest count of 4.59.

The percentage of flowers infested by the *D. indica* differed significantly and ranged from 3.75 to 25.37 among the treatments. The lowest damage was observed in T_7 and it was on par with all other treatments except T_1. The highest damage was seen in the control vines. The percentage of bitter gourd fruits infested by *D.indica* larvae differed significantly among treatments. The lowest damage was noticed in T_6 (2.80) which was on par with all other treatments except T_1. Control (T_{10}) registered the highest damage of 29.73 per cent.

The mean number of *B.cucurbitae* caught per trap did not show any significant variation. The numbers caught ranged from 3.04 to 5.25 in the treatments plots where the traps were installed.

The treatments showed significant variation among themselves as far as the mean number of spiders per vine was concerned. The highest count was in T_3 (0.66) which was on par with T_2 and control.

Eleven weeks after sowing

The relevant results are presented in Table 39. The pests observed were *H.phycitis* and *B.cucurbitae*.

The mean number of *H.phycitis* per leaf varied significantly between all treatments and control. All treatments were on par and *H.phycitis* count was the lowest in T_6 (0.06) control vines had the highest number of 2.74.

Table 39. Pest / damage incidence and population of spiders in bitter gourd eleven weeks after sowing - Season I

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *B. cucurbitae* caught trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of spiders vine^{-1}
T_1	0.72 (1.31)	0.00 (1.00)	15.74 (23.37)	0.21 (1.10)
T_2	0.27 (1.13)	2.75 (1.94)	20.99 (27.26)	0.10 (1.05)
T_3	0.55 (1.24)	2.31 (1.82)	19.27 (26.03)	0.10 (1.05)
T_4	0.34 (1.16)	2.58 (1.89)	15.19 (22.93)	0.10 (1.05)
T_5	0.33 (1.15)	2.30 (1.82)	19.83 (26.43)	0.10 (1.05)
T_6	0.06 (1.03)	1.73 (1.65)	12.16 (20.40)	0.21 (1.10)
T_7	0.55 (1.24)	1.48 (1.58)	11.80 (20.08)	0.21 (1.10)
T_8	0.50 (1.22)	2.05 (1.75)	19.49 (26.19)	0.00 (1.00)
T_9	0.44 (1.20)	2.65 (1.91)	20.45 (26.88)	0.00 (1.00)
T_{10}	2.74 (1.93)	0.00 (1.00)	76.71 (61.12)	0.10 (1.05)
$F_{9,18}$	9.17*	21.90*	7.69*	0.48
CD (0.05)	0.244	7.560	0.378	—

Transformed values are given in parentheses

* Significant at 5% level

The same trend was observed with regard to *B.cucurbitae* infestation. The mean number of *B.cucurbitae* caught per trap varied from 1.48 to 2.75 among the treatments where the traps were installed. The fruit damage in control (76.71 per cent) was significantly higher compared to treatments.

The distribution of spiders was very meagre and ranged from 0.00 to 0.21 per cent among the treatments.

Twelve weeks after sowing

B.cucurbitae and *H.phycitis* were observed and the results are presented in Table 40.

The mean *H.phycitis* count per leaf varied significantly among treatments. Control recorded the highest count of 0.67 per leaf. There were no *H.phycitis* in T_6 but it was on par with six other treatments T_7, T_5, T_2, T_9, T_3 and T_8.

The mean number of *B.cucurbitae* caught per trap ranged from 1.00 to 1.58 in treatments T_2 to T_9. The percentage of fruits infested by *B.cucurbitae* differed significantly among the treatments. In the control vines, there were no fruits. In the treatment plots, the fruit damage ranged from 9.58 (T_3) to 38.97 (T_5).

Yield of bitter gourd fruits

The number of fruits and yield were recorded at weekly intervals commencing from eighth week till the twelfth week. The relevant results are presented in Table 41.

The mean number of bitter gourd fruits at eight weeks ranged from 1.00 (in control) to 2.33 (T_6 and T_7) per vine and had significant difference. The mean yield

per vine was the highest in T_6 (550 g) which was on par with T_7 and T_4. The lowest yield was in control (158.33 g).

At nine weeks after sowing, the fruit number and fruit yield showed significant variation among the treatments. The highest count (5.00) was observed in T_6 which was on par with T_5 and T_7. A fruit yield of 1380 g vine^{-1} was registered in T_6 which was on par with T_7 and T_8. Fruit yield in control was the lowest (411.67 g vine^{-1}).

Table 40. Pest / damage incidence in bitter gourd twelve weeks after sowing - Season I

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *B. cucurbitae* caught trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}
T_1	0.65 (1.29)	0.00 (1.00)	10.44 (18.85)
T_2	0.10 (1.05)	0.83 (1.35)	21.33 (27.49)
T_3	0.16 (1.07)	1.06 (1.44)	9.58 (18.03)
T_4	0.28 (1.13)	1.14 (1.46)	24.95 (29.95)
T_5	0.10 (1.05)	0.99 (1.41)	38.97 (38.61)
T_6	0.00 (1.00)	1.58 (1.61)	21.98 (27.95)
T_7	0.10 (1.05)	0.74 (1.32)	16.61 (24.04)
T_8	0.21 (1.10)	1.00 (1.41)	30.03 (33.22)
T_9	0.11 (1.05)	1.45 (1.56)	24.54 (29.68)
T_{10}	0.67 (1.29)	0.00 (1.00)	0.00 (1.00)
$F_{9,18}$	5.42*	3.80*	3.45*
CD(0.05)	0.129	0.315	17.090

Transformed values are given in parentheses. * Significant at 5% level

Table 41 . Yield of bitter gourd fruits and cost : benefit ratio - Season I

Treatments	No. of fruits vine^{-1} 8 WAS	Wt. of fruits g vine^{-1} 8 WAS	No. of fruits vine^{-1} 9 WAS	Wt. of fruits g vine^{-1} 9 WAS	No. of fruits vine^{-1} 10 WAS	Wt. of fruits g vine^{-1} 10 WAS	No. of fruits vine^{-1} 11 WAS	Wt. of fruits g vine^{-1} 11 WAS	No. of fruits vine^{-1} 12 WAS	Wt. of fruits g vine^{-1} 12 WAS	Total fruit yield		Cost : benefit ratio
											g vine^{-1}	kg ha^{-1}	
T_1	2.00	383.33	3.33	983.33	3.33	1025.00	2.33	641.67	1.67	300.00	3333.33	8333.33	1 : 5.18
T_2	1.67	291.67	2.67	800.00	2.67	950.00	2.33	591.67	2.00	328.33	2961.67	7404.18	1 : 3.08
T_3	1.33	308.33	2.33	830.00	2.67	891.67	2.67	643.33	1.67	325.00	2998.33	7495.83	1 : 3.69
T_4	2.00	466.67	4.00	1093.33	3.67	1216.67	3.00	716.67	1.67	391.67	3885.00	9712.50	1 : 5.43
T_5	2.00	416.67	4.67	1105.00	3.67	1150.00	3.00	733.33	1.67	391.67	3796.67	9491.68	1 : 6.34
T_6	2.33	550.00	5.00	1380.00	5.00	1550.00	3.67	883.33	2.00	575.00	4938.33	12345.83	1 : 5.33
T_7	2.33	491.67	4.33	1320.00	6.00	1816.67	4.00	983.33	2.33	583.33	5195.00	12987.50	1 : 6.07
T_8	1.33	350.00	3.67	1175.00	4.33	1333.33	3.33	916.67	1.67	383.33	4158.33	10395.83	1 : 5.01
T_9	1.67	366.67	3.33	1066.67	4.00	1316.67	3.00	850.00	2.00	375.00	3975.00	9937.50	1 : 4.50
T_{10}	1.00	158.33	1.67	411.67	1.33	350.00	1.00	133.33	0.00	0.00	1053.00	2632.50	
$F_{9,18}$	2.86*	7.35*	10.17*	13.16*	18.40*	43.01*	13.14*	32.43*	5.42*	12.70*	6.51*		
CD(0.05)	0.781	123.002	0.985	230.730	0.904	180.697	0.685	125.827	0.801	134.470	433.290		

* Significant at 5% level

At ten weeks after sowing, T_7 registered the highest fruit number and fruit yield (6.00 and 1816.67 g vine^{-1} respectively) which was superior to all the other treatments. Control recorded the lowest value for fruit number and yield. The same trend was observed at the eleven week stage where T_7 was on par with T_6 and T_8 with regard to the fruit number. Regarding fruit yield, the highest yielder T_7 (983.33 g) was on par with T_8.

At twelve weeks after sowing, all the treatment plots were found superior to control. The mean fruit number ranged from 0.00 (control) to 2.33 (T_7) and the yield of fruits varied from 0.00 to 583.33 g T_7 registered the highest yield and was on par with T_6 (575 g vine^{-1}). All other treatments were on par.

During the first season experiment, the yield of bitter gourd fruits over five weeks (Table 41) ranged from 1053.00 g to 5195.00 g vine^{-1} (2632.50 to 12987.50 kg ha^{-1}). The treatments varied significantly and the maximum yield was obtained in T_7 (Treatment - Combination of neem seed oil 3.00 per cent soap emulsion and dimethoate 0.025 per cent soil drench prior to seeding plus need based application of the same plus poisoned banana fruit / ocimum trap) which was statistically on par with T_6 (Treatment - Combination of neem seed oil 3.00 per cent soap emulsion and carbaryl 0.075 per cent soil drench prior to seeding plus need based application of the same plus poisoned banana fruit / ocimum trap). The yield in other treatments was lesser. All the treatments were significantly superior to the control where an yield of 1053.00 g vine^{-1} could only be realized.

The cost : benefit ratio (Table 41) was the highest in T_5 (1:6.34) followed by T_7 (1:6.07). The lowest ratio of 1:3.08 was obtained in T_2.

4.5.2. Second season (1997)

The second season Pest Management Trial was conducted from January 1997 to April 1997.

Three weeks after sowing

The pests observed in bitter gourd were *H.phycitis*, *L.trifolii* and *N.falcata*. The results are presented in Table 42.

The mean number of *H.phycitis* per leaf ranged from 1.56 to 2.72 among the treatments. The lowest count of 1.56 was observed in T_8 and it was statistically on par with the other treatments.

Table 42. Pest damage incidence in bitter gourd three weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	% of leaves infested by *L. trifolii* vine^{-1}	% of shoots infested by *N. falcata* 10 shoots^{-1}
T_1	1.65 (1.63)	1.96 (1.72)	2.14 (1.77)
T_2	2.17 (1.78)	5.45 (2.54)	2.14 (1.77)
T_3	2.72 (1.93)	3.33 (2.08)	5.47 (2.54)
T_4	1.83 (1.68)	0.85 (1.36)	2.14 (1.77)
T_5	1.72 (1.65)	1.96 (1.72)	5.47 (2.54)
T_6	1.71 (1.65)	2.80 (1.95)	2.14 (1.77)
T_7	1.60 (1.61)	0.85 (1.36)	2.14 (1.77)
T_8	1.56 (1.60)	1.96 (1.72)	5.47 (2.54)
T_9	1.61 (1.61)	2.80 (1.95)	2.14 (1.77)
T_{10}	2.32 (1.82)	5.45 (2.54)	5.47 (2.54)
$F_{9,18}$	2.10	1.32	0.26
CD(0.05)	—	—	—

Transformed values are given in parentheses.

The percentage of leaves infested by *L.trifolii* ranged from 0.85 to 5.45 among the treatments. The least damage was observed in T_7 and T_4, though no statistical variation was observed among the treatments. The percentage of growing points infested by *N.falcata* did not vary significantly but the infestation ranged from 2.14 to 5.47 per cent.

After recording the observations, the treatments T_2 and T_3 (Neem seed oil 3.00 per cent emulsion and nimbecidine 0.4 per cent) were applied to the respective plots.

Four weeks after sowing

The pests observed were *H.phycitis* , *N.falcata*, *L.trifolii* and *A.gossypii* (Table 43).

There was significant differences among treatments on *H.phycitis* count. The count ranged from 1.78 in T_8 to 2.89 in T_3. T_8 was on par with T_6, T_9, T_7 and T_5. The percentage of shoots affected by *N.falcata* ranged from 5.47 to 20.00 and there was no significant difference among the treatments. The percentage of leaves infested by *L.trifolii* ranged from 9.82 in T_7 to 19.98 in T_{10} (control). All the treatments recorded significantly lower damage than control. The number of *A.gossypii* per leaf did not vary significantly though the population ranged from 22.44 to 32.54 among the treatments.

The natural enemies of pests were also observed at four weeks after sowing. The mean number of gall fly maggots parasitised per vine ranged from 0.00 to 0.63 among the treatments which were on par among themselves. There was significant variation among treatments on the number of coccinellid predator grubs per leaf. T_8 registered the maximum number of 0.67 which was on par with

Table 43. Pest / damage incidence and natural enemy distribution in bitter gourd four weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	% of shoots infested by *N. falcata* vine^{-1}	% of leaves infested by *L. trifolii* vine^{-1}	Mean no. of *A. gossipii* leaf^{-1}	Mean no. of *N. falcata* maggots parasitised vine^{-1}	Mean no. of coccinellid predator grubs leaf^{-1}	Mean no. of spiders vine^{-1}
T_1	2.33 (1.82)	10.00 (3.32)	10.75 (3.43)	24.04 (5.00)	0.00 (1.00)	0.00 (1.00)	0.32 (1.15)
T_2	2.44 (1.86)	5.47 (2.54)	12.16 (3.63)	28.54 (5.44)	0.30 (1.14)	0.44 (1.20)	0.44 (1.20)
T_3	2.89 (1.97)	12.98 (3.74)	13.32 (3.78)	23.90 (4.99)	0.63 (1.28)	0.44 (1.20)	0.32 (1.15)
T_4	2.33 (1.83)	12.98 (3.74)	14.27 (3.91)	25.27 (5.13)	0.00 (1.00)	0.00 (1.00)	0.10 (1.05)
T_5	2.19 (1.79)	10.00 (3.32)	14.27 (3.91)	22.44 (4.84)	0.00 (1.00)	0.20 (1.10)	0.00 (1.00)
T_6	1.88 (1.70)	5.47 (2.54)	13.20 (3.77)	24.37 (5.04)	0.00 (1.00)	0.10 (1.05)	0.21 (1.10)
T_7	2.22 (1.79)	12.98 (3.74)	9.82 (3.29)	28.93 (5.47)	0.00 (1.00)	0.32 (1.15)	0.10 (1.05)
T_8	1.78 (1.67)	10.00 (3.32)	10.76 (3.43)	26.00 (5.20)	0.30 (1.14)	0.67 (1.29)	0.55 (1.25)
T_9	2.00 (1.73)	12.98 (3.74)	14.16 (3.89)	32.54 (5.79)	0.30 (1.14)	0.66 (1.29)	0.66 (1.29)
T_{10}	2.72 (1.93)	20.00 (4.58)	19.98 (4.58)	31.13 (5.67)	0.63 (1.28)	0.67 (1.29)	0.55 (1.25)
$F_{9,18}$	5.10*	2.12	2.81*	0.71	1.25	5.21*	2.70*
CD (0.05)	0.126	—	0.646	—	—	0.151	0.175

Transformed values are given in parentheses

* Significant at 5% level

control (T_{10}), T_9, T_2, T_3 and T_7. The mean spider number varied from 0.00 to 0.66. The highest number of 0.66 per vine was observed in T_9 which was on par with T_8, T_{10}, T_2, T_3 and T_1, spiders were not observed in T_5.

All the need based treatments were applied at four weeks after sowing. The observations on pest incidence and natural enemies were taken seven days after spraying viz., at five weeks after sowing.

Five weeks after sowing

The results are presented in Table 44. The mean number of *H.phycitis* per leaf ranged from 1.39 in T_4 to 3.10 in T_{10}. Control recorded significantly higher count than the other treatments. There was significant difference among treatments as far as the mean number of *A.gossypii* per leaf was concerned. The number ranged from 12.77 (T_7) to 30.92 (control). T_7 was on par with T_1, T_6, T_4. The counts in all the treatments were significantly lower than the control. The percentage of shoots infested by *N.falcata* was the least (3.81 per cent) in T_4 which was on par with the other treatments. The infestation ranged from 3.81 to 26.45 per cent. The percentage of leaf infestation by *L.trifolii* varied from 4.34 in T_6 to 16.54 in T_{10}. T_6 was on par with T_7, T_5, T_8, T_9, T_2 and T_1.

The natural enemies of pests observed at five weeks after sowing included coccinellids, syrphids, spiders and parasite of *N.falcata*. The highest count of coccinellid predator grub per leaf was observed in control (0.91) which was significantly higher than the other treatments. T_5 and T_9 recorded the least count (0.06). Coccinellid predator adult number was maximum in control and it was on par with

Table 44. Pest / damage incidence and natural enemy distribution in bitter gourd five weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *A. gossipii* leaf^{-1}	% of shoots infested by *N. falcata* vine^{-1}	% of leaves infested by *L. trifolii* vine^{-1}	Mean no. of coccinellid predator adults leaf^{-1}	Mean no. of coccinellid predator grubs leaf^{-1}	Mean no. of syrphid maggots leaf^{-1}	Mean no. of *N. falcata* maggots parasitised vine^{-1}	Mean no. of spiders vine^{-1}
T_1	1.44(1.56)	14.21(3.90)	16.31(4.16)	7.71(2.95)	0.06(1.03)	0.19(1.09)	0.13(1.06)	0.30(1.14)	0.00(1.00)
T_2	1.89(1.70)	19.21(4.50)	10.48(3.39)	5.45(2.54)	0.26(1.12)	0.47(1.21)	0.33(1.15)	0.63(1.28)	0.44(1.20)
T_3	1.77(1.67)	22.89(4.89)	12.81(3.72)	8.82(3.13)	0.13(1.06)	0.47(1.21)	0.06(1.03)	0.30(1.14)	0.32(1.15)
T_4	1.39(1.54)	16.32(4.16)	3.81(2.19)	10.87(3.45)	0.06(1.03)	0.26(1.12)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_5	1.60(1.61)	18.56(4.42)	10.48(3.39)	6.41(2.72)	0.06(1.03)	0.06(1.03)	0.13(1.06)	0.00(1.00)	0.00(1.00)
T_6	1.49(1.58)	15.99(4.12)	10.00(3.32)	4.34(2.31)	0.26(1.12)	0.33(1.15)	0.18(1.09)	0.00(1.00)	0.10(1.05)
T_7	1.66(1.63)	12.77(3.71)	7.80(2.97)	6.41(2.72)	0.13(1.06)	0.20(1.10)	0.26(1.12)	0.30(1.14)	0.21(1.10)
T_8	1.78(1.67)	17.59(4.31)	12.98(3.74)	6.67(2.77)	0.19(1.09)	0.40(1.18)	0.19(1.09)	0.30(1.14)	0.10(1.05)
T_9	1.72(1.65)	17.19(4.27)	16.31(4.16)	7.28(2.88)	0.00(1.00)	0.06(1.03)	0.13(1.06)	0.63(1.28)	0.00(1.00)
T_{10}	3.10(2.02)	30.92(5.65)	26.45(5.24)	16.54(4.19)	0.46(1.21)	0.91(1.38)	0.60(1.26)	0.63(1.28)	0.65(1.29)
$F_{9,18}$	12.83*	8.56*	0.74	3.83*	2.25	4.30*	3.42*	0.91	4.97*
CD(0.05)	0.113	0.556	—	0.805	—	0.148	0.118	—	0.132

Transformed values are given in parentheses

* Significant at 5% level

other treatments (range 0.00 to 0.46). The mean number of syrphid maggots per leaf ranged from 0.00 to 0.60 among the treatments. The highest number of 0.60 was recorded in control which was on par with T_2 (0.33). The mean number of *N.falcata* maggots parasitised per vine was in general low and not significant among the treatments. The spider number was the highest in control (0.65) and it was on par with T_2 (0.44) and significantly superior to other treatments.

Six weeks after sowing

The pests recorded were *H.phycitis* and *A.gossypii*. The results are presented in Table 45.

The mean *H.phycitis* number per leaf did not show any significant variation among treatments and the number varied from 2.55 to 4.49. The mean number of *A.gossypii* per leaf varied significantly among the treatments and ranged from 19.22 in T_7 to 35.69 in control (T_{10}).

The natural enemies of pests were recorded at six weeks after sowing were coccinellids, syrphids and spiders. The mean number of coccinellid predator adults per leaf ranged from 0.13 in T_2 and T_6 to 0.86 in T_{10}. Control registered the highest count and was on par with T_3 and T_9. Mean number of coccinellid predatory grubs per leaf ranged from 0.19 (T_1 and T_5) to 1.46 (T_{10}). The highest count was observed in control which was on par with T_7, T_9 and T_3.

The mean number of syrphid maggots per leaf (range 0.00 to 0.91) and the mean number of spiders per vine (range 0.00 to 0.44) did not differ significantly among the treatments.

Table 45. Pest / damage incidence and natural enemy distribution in bitter gourd six weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *A. gossypii* leaf^{-1}	Mean no. of coccinellid predator adults leaf^{-1}	Mean no. of coccinellid predator grubs leaf^{-1}	Mean no. of syrphid maggots leaf^{-1}	Mean no. of spiders vine^{-1}	% of vines showing mosaic plot^{-1}
T_1	2.99 (2.00)	21.08 (4.70)	0.20 (1.10)	0.19 (1.09)	0.30 (1.14)	0.10 (1.05)	11.11 (3.48)
T_2	2.69 (1.92)	23.52 (4.95)	0.13 (1.06)	0.49 (1.22)	0.76 (1.33)	0.44 (1.20)	11.11 (3.48)
T_3	2.94 (1.99)	30.63 (5.62)	0.52 (1.23)	0.86 (1.36)	0.91 (1.38)	0.33 (1.15)	14.42 (3.93)
T_4	2.98 (2.00)	21.85 (4.78)	0.26 (1.12)	0.26 (1.12)	0.00 (1.00)	0.20 (1.10)	6.04 (2.65)
T_5	2.88 (1.97)	23.65 (4.96)	0.19 (1.09)	0.19 (1.09)	0.13 (1.06)	0.00 (1.00)	11.11 (3.48)
T_6	2.55 (1.88)	23.14 (4.91)	0.13 (1.06)	0.53 (1.24)	0.32 (1.15)	0.10 (1.05)	6.04 (2.65)
T_7	2.93 (1.98)	19.22 (4.50)	0.40 (1.18)	1.33 (1.53)	0.26 (1.12)	0.21 (1.10)	11.11 (3.48)
T_8	3.42 (2.10)	24.92 (5.09)	0.26 (1.12)	0.25 (1.12)	0.73 (1.32)	0.21 (1.10)	14.42 (3.93)
T_9	2.73 (1.93)	30.93 (5.65)	0.47 (1.21)	0.98 (1.41)	0.63 (1.27)	0.10 (1.05)	18.12 (4.37)
T_{10}	4.49 (2.34)	35.69 (6.06)	0.86 (1.36)	1.46 (1.57)	0.66 (1.29)	0.21 (1.10)	29.39 (5.51)
$F_{9,18}$	1.64	5.67*	3.25*	5.80*	1.80	1.16	3.54*
CD(0.05)	—	0.616	0.155	0.222	—	—	1.314

Transformed values are given in parentheses

* Significant at 5% level

Mosaic incidence was the highest (29.39 per cent) in control which was on par with T_9 (18.12 per cent) but significantly higher than the other treatments. The lowest incidence (6.04 per cent) was observed in T_4 and T_6 treatments.

An application of all need based treatments were given on the sixth week after sowing. The poisoned banana fruit / ocimum traps were set at the fiftieth day after sowing.

Seven weeks after sowing

The results are presented in Table 46.

The pests observed were *H.phycitis*, *D.indica* and *B.cucurbitae*.

The mean number of *H.phycitis* per leaf ranged from 1.33 (T_7) to 3.82 (T_{10}) among the treatments. Although the least number was observed in T_7, it was on par with all the other treatments except control. The number of *D.indica* larvae per leaf varied significantly among the treatments. The lowest number of (0.22) was observed in T_8 which was on par with T_7, T_9, T_1 and T_6. The highest number of 1.76 per leaf was noticed in the control and this was significantly higher than all other treatments. The percentage of leaves infested by *D.indica* varied from 4.34 in T_6 to 21.06 in T_{10}. All the treatments except T_3 showed significantly lesser damage compared to control (T_{10}). The percentage of flowers infested by *D.indica* differed significantly among the treatments and ranged from 3.75 to 15.50 (T_{10}). The least damage was observed in T_7 which was on par with T_6, T_9, T_4 and T_8 and significantly lesser than the other treatments. The *B.cucurbitae* damage on tender fruits ranged from 0.00 to 93.92 per cent. However, the difference among the treatments was not significant.

Table 46. Pest / damage and natural enemy incidence in bitter gourd seven weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *D. indica* larvae leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *B.cucurbitae* vine^{-1}	Mean no. of parasitised *D. indica* larvae vine^{-1}	Mean no. of spiders vine^{-1}	Downy mildew disease index
T_1	1.66 (1.63)	0.45 (1.21)	7.71 (2.95)	12.17 (3.63)	20.26 (26.74)	0.10 (1.05)	0.00 (1.00)	37.16 (6.18)
T_2	1.61 (1.61)	1.00 (1.41)	11.86 (3.59)	9.83 (3.29)	3.02 (10.00)	0.53 (1.24)	0.44 (1.20)	28.77 (5.46)
T_3	1.54 (1.59)	0.83 (1.35)	13.20 (3.77)	13.20 (3.71)	13.74 (21.75)	0.44 (1.20)	0.33 (1.15)	26.16 (5.21)
T_4	1.55 (1.60)	0.67 (1.29)	8.82 (3.13)	5.45 (2.54)	0.00 (0.00)	0.00 (1.00)	0.33 (1.15)	37.55 (6.21)
T_5	1.75 (1.66)	0.97 (1.40)	9.83 (3.29)	10.00 (3.32)	25.02 (30.00)	0.00 (1.00)	0.21 (1.10)	37.55 (6.21)
T_6	1.72 (1.65)	0.46 (1.21)	4.34 (2.31)	4.34 (2.31)	41.34 (40.00)	0.21 (1.10)	0.21 (1.10)	22.06 (4.80)
T_7	1.33 (1.53)	0.23 (1.11)	5.45 (2.54)	3.75 (2.18)	4.15 (11.75)	0.00 (1.00)	0.21 (1.10)	15.41 (4.05)
T_8	1.72 (1.65)	0.22 (1.10)	5.34 (2.52)	8.82 (3.13)	6.70 (14.99)	0.10 (1.05)	0.20 (1.10)	24.28 (5.03)
T_9	1.77 (1.67)	0.40 (1.18)	7.71 (2.95)	4.58 (2.36)	25.02 (30.00)	0.10 (1.05)	0.20 (1.10)	22.06 (4.80)
T_{10}	3.82 (2.20)	1.76 (1.66)	21.06 (4.70)	15.50 (4.06)	93.92 (74.99)	0.89 (1.37)	0.33 (1.15)	44.36 (6.73)
$F_{9,18}$	14.68*	9.48*	4.63*	3.61*	1.27	5.31*	0.77	9.36*
CD(0.05)	0.145	0.165	0.980	1.049	—	0.161	—	0.816

Transformed values are given in parentheses * Significant at 5% level

The mean number of parasitised *D.indica* larvae observed ranged from 0.00 to 0.89 per vine. The highest number of 0.89 was observed in control and it was on par with T_2. The number of parasitised larvae were lesser in the other treatments and not recorded in T_4, T_5 and T_7. The mean number of spiders per vine was in general low and the difference among treatments was not significant. No spiders were observed in T_1 whereas T_2 had the highest population of 0.44.

The incidence of downy mildew varied significantly and the highest index of 44.36 was recorded in control which was on par with T_5, T_4 and T_1. The lowest was in T_7 (15.41). The incidence of downy mildew was lesser in vines receiving botanical treatments.

The need based treatments T_1, T_5, T_6 and T_9 were applied at the seventh week after sowing. A spray of the fungicide, mancozeb (Indofil M-45) was also applied in all the plots.

Eight weeks after sowing

The pests observed were *H.phycitis*, *D.indica*, *R.foveicollis*, and *B.cucurbitae*. The natural enemies recorded were parasite of *D.indica* and spiders. The relevant results are furnished in Table 47.

The mean number of *H.phycitis* per leaf ranged from 1.47 to 3.49. The lowest count was observed in T_7 but it was on par with all other treatments and superior to control. The mean number of *D.indica* larvae was the lowest (0.12) in T_7 which was on par with T_5, T_6, T_4, T_9, T_1, T_8 and T_2 and the highest in T_{10} (control). The percentage of leaves infested by *D.indica* ranged from 7.71 in T_3

Table 47. Pest / damage incidence and natural enemy distribution in bitter gourd eight weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *D. indica* larvae leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *D. indica* larvae vine^{-1}	Mean no. of *R. foveicollis* beetles vine^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of parasitised *D. indica* larvae vine^{-1}	Mean no. of spiders vine^{-1}
T_1	1.66 (1.63)	0.18 (1.09)	16.54 (4.19)	16.54 (4.19)	11.05 (3.47)	5.75 (2.60)	20.26 (26.74)	0.00 (1.00)	0.21 (1.10)
T_2	2.00 (1.73)	0.25 (1.12)	8.82 (3.13)	15.76 (4.09)	12.04 (3.61)	6.08 (2.66)	41.32 (39.98)	0.33 (1.15)	0.10 (1.05)
T_3	1.77 (1.67)	0.39 (1.18)	7.71 (2.95)	13.83 (3.85)	15.41 (4.05)	4.41 (2.33)	37.75 (37.89)	0.00 (1.00)	0.32 (1.15)
T_4	1.72 (1.65)	0.18 (1.08)	12.17 (3.63)	15.26 (4.03)	13.34 (3.79)	2.77 (1.94)	13.74 (21.75)	0.10 (1.05)	0.10 (1.05)
T_5	1.83 (1.68)	0.13 (1.06)	13.20 (3.77)	13.32 (3.78)	8.66 (3.11)	3.78 (2.19)	13.74 (21.75)	0.10 (1.05)	0.10 (1.05)
T_6	1.81 (1.68)	0.15 (1.07)	11.05 (3.47)	8.82 (3.13)	4.58 (2.36)	3.91 (2.22)	15.91 (23.50)	0.33 (1.15)	0.21 (1.10)
T_7	1.47 (1.57)	0.12 (1.06)	8.82 (3.13)	9.83 (3.29)	3.55 (2.13)	4.33 (2.31)	3.02 (10.00)	0.20 (1.10)	0.21 (1.10)
T_8	1.72 (1.65)	0.18 (1.09)	15.50 (4.06)	11.85 (3.58)	11.05 (3.47)	7.50 (2.91)	2.37 (8.85)	0.33 (1.15)	0.33 (1.15)
T_9	1.99 (1.73)	0.17 (1.08)	23.06 (4.91)	12.96 (3.74)	6.75 (2.78)	6.42 (2.72)	6.70 (14.99)	0.21 (1.10)	0.43 (1.19)
T_{10}	3.49 (2.12)	0.39 (1.18)	28.84 (5.46)	24.32 (5.03)	19.63 (4.54)	7.42 (2.90)	35.81 (36.74)	0.67 (1.29)	0.55 (1.25)
$F_{9,18}$	6.90*	3.53*	14.53*	2.23	2.16	4.15*	1.26	3.59*	1.15
CD(0.05)	0.171	0.071	0.631	—	—	0.480	—	0.138	—

Transformed values are given in parentheses * Significant at 5% level

to 28.84 in T_{10}. The infestation was the least in T_3 and it was on par with T_2, T_7 and T_6. The percentage of flowers infested by *D.indica* did not show any significant variation among treatments. The infestation varied from 8.82 to 24.32 per cent. There was no significant variation on the percentage of fruits infested by *D.indica* larvae though the damage varied from 3.55 (T_7) to 19.63 (control). The number of *R.foveicollis* per vine varied significantly among treatments. The least number of 2.77 was observed in T_4 which was on par with T_5, T_6, T_7 and T_3. The percentage of fruits infested by *B.cucurbitae* did not vary significantly among the treatments. However, *B.cucurbitae* damage was high in T_2 and T_3 treatments.

The mean number of parasitised *D.indica* larvae varied significantly among the treatments. The highest count of 0.67 was noticed in control. In T_1 and T_3, parasitised larvae were not recorded. The mean number of spiders per vine was low and did not differ significantly among the treatments.

The treatments T_2, T_3 and T_9 were applied eight weeks after sowing.

Nine weeks after sowing

The pests observed were *H.phycitis*, *D.indica* and *B.cucurbitae* (Table 48).

There was significant difference among treatments on the mean number of *H.phycitis* per leaf. The lowest count of 1.47 was recorded in T_7 and it was on par with all the other treatments and superior to T_6 and control. Though the mean number of *D.indica* larvae per leaf was the least in T_2 it was on par with all the other treatments except control. The percentage of leaves infested by *D.indica* ranged significantly from 7.71 (T_3) to 28.79 (T_{10}) among the treatments. The

Table 48. Pest / damage and natural enemy incidence in bitter gourd nine weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *D. indica* larvae leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *D. indica* larvae vine^{-1}	Mean no. of *B. cucurbitae* caught trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of parasitised *D. indica* larvae vine^{-1}	Mean no. of spiders vine^{-1}	% of vines showing mosaic plot^{-1}
T_1	1.78 (1.67)	0.14 (1.07)	19.89 (4.57)	22.10 (4.81)	22.04 (4.80)	0.00 (1.00)	3.02 (10.00)	0.10 (1.05)	0.10 (1.05)	22.22 (4.82)
T_2	1.70 (1.64)	0.08 (1.04)	8.82 (3.13)	8.82 (3.13)	8.82 (3.13)	3.99 (2.33)	3.02 (10.00)	0.10 (1.05)	0.21 (1.10)	11.11 (3.48)
T_3	1.49 (1.58)	0.09 (1.04)	7.71 (2.95)	6.67 (2.77)	6.67 (2.77)	3.33 (2.08)	10.44 (18.85)	0.00 (1.00)	0.10 (1.05)	18.12 (4.37)
T_4	1.83 (1.68)	0.16 (1.07)	11.06 (3.47)	14.16 (3.89)	14.16 (3.89)	7.08 (2.84)	21.62 (27.70)	0.21 (1.10)	0.10 (1.05)	18.12 (4.37)
T_5	1.94 (1.71)	0.12 (1.06)	13.20 (3.77)	16.54 (4.19)	13.19 (3.77)	7.67 (2.94)	23.40 (28.92)	0.21 (1.10)	0.10 (1.05)	14.42 (3.93)
T_6	2.22 (1.79)	0.09 (1.04)	11.05 (3.47)	14.26 (3.91)	14.26 (3.91)	6.33 (2.71)	28.65 (32.35)	0.10 (1.05)	0.21 (1.10)	6.04 (2.65)
T_7	1.47 (1.57)	0.13 (1.06)	8.82 (3.13)	9.99 (3.32)	9.99 (3.32)	4.88 (2.42)	28.84 (32.47)	0.21 (1.10)	0.32 (1.15)	14.42 (3.93)
T_8	1.87 (1.70)	0.27 (1.13)	15.50 (4.06)	15.76 (4.09)	15.76 (4.09)	5.96 (2.64)	30.67 (33.61)	0.66 (1.29)	0.44 (1.20)	18.12 (4.37)
T_9	2.09 (1.76)	0.23 (1.11)	23.06 (4.91)	15.97 (4.12)	15.97 (4.12)	5.40 (2.53)	28.65 (32.35)	0.33 (1.15)	0.10 (1.05)	18.12 (4.37)
T_{10}	3.76 (2.18)	0.55 (1.24)	28.79 (5.46)	26.20 (5.22)	26.20 (5.22)	0.00 (1.00)	20.26 (26.75)	0.66 (1.29)	0.33 (1.15)	36.86 (6.15)
$F_{9,18}$	5.77*	3.31*	15.03*	4.49*	4.64*	43.93*	1.53	3.90*	1.35	4.02*
CD(0.05)	0.215	0.102	0.645	1.035	1.013	0.315	—	0.147	—	1.340

Transformed values are given in parentheses

* Significant at 5% level

percentage of flowers damaged by the larvae ranged from 6.67 to 26.20 (T_{10}) and the least damage was recorded in T_3 which was on par with T_2 and T_7. The percentage of fruits infested by the larvae varied significantly from 6.67 in T_3 to 26.20 in T_{10}.

The number of *B.cucurbitae* caught per trap ranged from 3.33 to 7.67 in the treatments T_2 to T_9 where the banana fruit / ocimum traps had been installed. The mean catch in T_5 was the highest (7.67) but it was on par with T_4, T_6 and T_8. The least catch was observed in T_3. The percentage of fruits infested by *B.cucurbitae* did not vary significantly among the treatments.

The incidence of parasitised *D.indica* larvae varied among treatments. The highest count was observed in T_{10} and T_8 (0.66 per vine). In T_3, no parasitised larvae was recorded. The spider count per vine (range 0.10 to 0.44) did not vary significantly among the treatments.

The percentage of vines showing mosaic symptoms differed significantly and ranged from 6.04 in T_6 to 36.86 in T_{10} (control). T_{10} was on par with T_1.

An application of the treatments T_2 to T_9 were given after recording the above observations.

Ten weeks after sowing

The pests observed were *H.phycitis*, *D.indica* and *B.cucurbitae*. The relevant results are presented in Table 49.

Table 49. Pest / damage incidence and natural enemy distribution in bitter gourd ten weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *D. indica* larvae leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *D. indica* larvae vine^{-1}	Mean no. of *B. cucurbitae* caught trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	% of parasitised *D. indica* larvae vine^{-1}	Mean no. of spiders vine^{-1}
T_1	2.33 (1.82)	0.13 (1.06)	11.05 (3.47)	15.41 (4.05)	8.82 (3.13)	0.00 (1.00)	8.44 (16.88)	0.21 (1.10)	0.10 (1.05)
T_2	1.22 (1.49)	0.01 (1.00)	2.80 (1.95)	1.94 (1.72)	0.85 (1.36)	6.54 (2.75)	7.84 (16.25)	0.00 (1.00)	0.10 (1.05)
T_3	1.43 (1.56)	0.01 (1.00)	5.45 (2.54)	4.34 (2.31)	2.80 (1.95)	5.74 (2.60)	7.66 (16.06)	0.00 (1.00)	0.10 (1.05)
T_4	1.66 (1.63)	0.03 (1.02)	0.85 (1.36)	0.85 (1.36)	0.85 (1.36)	9.00 (3.16)	28.72 (32.39)	0.10 (1.05)	0.10 (1.05)
T_5	1.82 (1.68)	0.02 (1.01)	2.80 (1.95)	1.96 (1.72)	1.69 (1.64)	9.73 (3.28)	17.34 (24.60)	0.00 (1.00)	0.10 (1.05)
T_6	1.55 (1.60)	0.01 (1.00)	2.14 (1.77)	1.96 (1.72)	0.00 (1.00)	8.17 (3.03)	11.56 (19.87)	0.00 (1.00)	0.21 (1.10)
T_7	1.72 (1.65)	0.01 (1.00)	0.85 (1.36)	0.85 (1.36)	0.00 (1.00)	7.39 (2.90)	12.50 (20.69)	0.00 (1.00)	0.10 (1.05)
T_8	1.44 (1.56)	0.03 (1.02)	1.53 (1.59)	1.53 (1.59)	2.14 (1.77)	7.72 (2.95)	17.75 (24.91)	0.10 (1.05)	0.10 (1.05)
T_9	2.00 (1.73)	0.02 (1.01)	3.75 (2.18)	4.34 (2.31)	0.00 (1.00)	7.14 (2.85)	22.82 (28.52)	0.00 (1.00)	0.10 (1.05)
T_{10}	4.54 (2.35)	0.40 (1.18)	24.25 (5.03)	28.60 (5.44)	14.40 (3.92)	0.00 (1.00)	50.00 (44.98)	0.44 (1.20)	0.21 (1.10)
$F_{9,18}$	14.29*	6.58*	7.06*	16.88*	6.85*	64.23*	2.86*	4.02*	0.20
CD(0.05)	0.194	0.065	1.273	0.970	1.112	0.311	21.970	0.098	—

Transformed values are given in parentheses * Significant at 5% level

The mean number of *H.phycitis* per leaf ranged from 1.22 in T_2 to 4.54 in T_{10}. The highest count was recorded in control which was significantly higher than the counts in all the other treatments. The highest number (0.40) *D.indica* larvae per vine was observed in control which was significantly higher than the count in the other treatments. The percentage of leaves infested by *D.indica*, was the highest in control, but the lowest damage was observed in T_4 and T_7 (0.85 per cent). The mean percentage of flowers infested by *D.indica* was the highest in control which was significantly higher compared to all the treatments. The percentage of fruits infested by the larvae ranged from 0.00 to 14.40 among the treatments. Fruit infestation was not observed in T_6, T_7 and T_9 treatments. In T_2, T_4, T_5, T_8 and T_3, the damage was low and significantly lesser than T_1 and T_{10}.

The mean number of *B.cucurbitae* caught per trap showed significant variation among treatments where traps were installed. The highest catch (9.73) was observed in T_5 but it was on par with T_4 and T_6. The percentage of fruits infested by *B.cucurbitae* was the least (7.66 per cent) in T_3 which was on par with all other treatments except control where the damage was 50.00 per cent.

The mean number of parasitised *D.indica* larvae per vine varied from 0.00 to 0.44 among the treatments. The incidence was the maximum in control (T_{10}) which was significantly higher than the others. The spider number per vine was in general low and did not vary significantly among the treatments

Eleven weeks after sowing

The results are presented in Table 50. The pests observed were *H.phycitis*, *D.indica* and *B.cucurbitae*.

Table 50. Pest / damage incidence and natural enemy distribution in bitter gourd eleven weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *D. indica* larvae leaf^{-1}	% of leaves infested by *D. indica* larvae vine^{-1}	% of flowers infested by *D. indica* larvae vine^{-1}	% of fruits infested by *D. indica* larvae vine^{-1}	Mean no. of *B. cucurbitae* caught trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	% no. of parasitised *D. indica* larvae vine^{-1}	Mean no. of spiders vine^{-1}
T_1	2.99 (2.00)	0.18 (1.08)	14.40 (3.92)	12.17 (3.63)	8.82 (3.13)	0.00 (1.00)	9.25 (17.70)	0.21 (1.10)	0.33 (1.15)
T_2	1.94 (1.72)	0.05 (1.02)	3.75 (2.18)	5.45 (2.54)	0.85 (1.36)	6.31 (2.70)	8.44 (16.88)	0.00 (1.00)	0.55 (1.24)
T_3	2.22 (1.79)	0.08 (1.04)	3.75 (2.18)	5.45 (2.54)	3.55 (2.13)	6.07 (2.66)	9.25 (17.70)	0.10 (1.05)	0.21 (1.10)
T_4	1.66 (1.63)	0.10 (1.05)	3.75 (2.18)	4.34 (2.31)	1.96 (1.72)	6.58 (2.75)	17.52 (24.74)	0.00 (1.00)	0.21 (1.10)
T_5	1.77 (1.67)	0.06 (1.03)	1.96 (1.72)	5.45 (2.54)	1.53 (1.59)	7.30 (2.88)	22.06 (28.00)	0.00 (1.00)	0.21 (1.10)
T_6	1.49 (1.58)	0.02 (1.01)	0.00 (1.00)	1.96 (1.72)	2.80 (1.95)	6.91 (2.81)	16.13 (23.67)	0.10 (1.05)	0.10 (1.05)
T_7	1.77 (1.67)	0.02 (1.01)	0.85 (1.36)	3.33 (2.08)	0.85 (1.36)	5.15 (2.48)	17.15 (24.45)	0.00 (1.00)	0.00 (1.00)
T_8	1.72 (1.65)	0.04 (1.02)	2.80 (1.95)	1.96 (1.72)	4.34 (2.31)	5.33 (2.52)	17.41 (24.65)	0.10 (1.05)	0.10 (1.05)
T_9	2.05 (1.75)	0.07 (1.03)	5.45 (2.54)	1.53 (1.59)	2.14 (1.77)	4.54 (2.35)	10.44 (18.85)	0.10 (1.05)	0.10 (1.05)
T_{10}	3.65 (2.16)	0.43 (1.20)	17.63 (4.32)	17.54 (4.31)	16.55 (4.19)	0.00 (1.00)	20.26 (26.74)	0.32 (1.15)	0.33 (1.15)
$F_{9,18}$	11.13*	17.09*	5.98*	7.29*	4.19*	5.43*	0.28	1.24	1.86
CD(0.05)	0.162	0.040	1.269	0.956	1.287	0.042	—	—	—

Transformed values are given in parentheses

* Significant at 5% level

The mean number of *H.phycitis* per leaf ranged from 1.49 (T_6) to 3.65 (T_{10}) among the treatments. The mean number of *D.indica* larvae per leaf ranged from 0.02 to 0.43 and the highest number was observed T_{10} which was significantly higher compared to the other treatments. The percentage of leaves and flowers infested by *D.indica* larvae was significantly higher in T_1 and T_{10} compared to the others. The same trend was observed in the level of infestation of fruits by this pests where all the treatments except T_1 and T_{10} were on par. The mean number of *B.cucurbitae* caught per trap ranged from 4.54 to 7.30 among the treatments T_2 to T_9. The count was the highest in T_5 which was significantly higher than the others. The percentage of fruits damaged by *B.cucurbitae* did not show any significant variation among the treatments.

The control (T_{10}) vines registered the maximum number of parasitised *D.indica* larvae though the variation was not statistically significant. Spider number ranged from 0.00 to 0.55 per vine and the treatments did not vary significantly among themselves.

At the eleventh week, application of all the need based treatments (T_2 to T_9) was conducted.

Twelve weeks after sowing

The pests observed were *H.phycitis* and *B.cucurbitae* and the natural enemy noticed was spider (Table 51).

There was significant variation on the mean number of *H.phycitis* per leaf. The lowest count (1.44) was in T_4 which was on par with T_6, T_8, T_5, T_2 and T_7. The mean number of *B.cucurbitae* caught per trap was on par among

Table 51. Pest / damage incidence and population of spiders in bitter gourd twelve weeks after sowing - Season II

Treatments	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *B. cucurbitae* caught trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of spiders vine^{-1}
T_1	3.16 (2.04)	0.00 (1.00)	2.37 (8.85)	0.31 (1.15)
T_2	1.83 (1.68)	3.58 (2.14)	10.44 (18.85)	0.14 (1.19)
T_3	1.94 (1.72)	3.50 (2.12)	11.70 (19.99)	0.44 (1.20)
T_4	1.44 (1.56)	3.71 (2.17)	13.73 (21.74)	0.20 (1.10)
T_5	1.61 (1.61)	3.93 (2.22)	10.44 (18.85)	0.21 (1.10)
T_6	1.55 (1.60)	3.65 (2.16)	11.70 (19.99)	0.10 (1.05)
T_7	1.83 (1.68)	3.93 (2.22)	10.44 (18.85)	0.20 (1.10)
T_8	1.55 (1.60)	3.48 (2.12)	11.70 (19.99)	0.20 (1.10)
T_9	1.89 (1.70)	2.94 (1.99)	2.37 (8.85)	0.21 (1.10)
T_{10}	3.65 (2.16)	0.00 (1.00)	4.15 (11.75)	0.66 (1.29)
$F_{9,18}$	20.59*	10.75*	0.23	0.73
CD (0.05)	0.131	0.440	—	—

Transformed values are given in parentheses

* Significant at 5% level

the treatments T_2 to T_9. The percentage of fruits infested by *B.cucurbitae* (range 2.37 to 13.73) did not vary significantly among the treatments. The mean number of spiders per vine (range from 0.10 to 0.66) did not vary significantly among the treatments.

Thirteen weeks after sowing

The results are presented in Table 52. The pests recorded were *H.phycitis* and *B.cucurbitae*.

The *H.phycitis* count varied among treatments and the lowest count of 0.99 was observed in T_7 and T_4 which was on par with T_6, T_5, T_9, T_2 and T_3. The highest catch of *B.cucurbitae* per trap (1.83) was observed in T_7 and it was on par with T_6, T_3 and T_8. In general, the catch was reduced. Though the percentage of fruits damaged by *B.cucurbitae* ranged from 2.37 to 30.76, there was no significant difference.

The spider count per vine was low and T_1 and T_{10} recorded the highest count (0.21 per vine). No spiders were observed in T_5, T_7 and T_8 treatments.

Fourteen weeks after sowing

The percentage of fruits infested by *B.cucurbitae* did not show any significant difference among treatments (Table 52).

Yield of bitter gourd fruits

The mean number and weight of fruits were recorded at weekly intervals from the seventh week to the fourteenth week after sowing and presented in Tables 53 and 54.

Table 52. Pest / damage incidence and population of spiders in bitter gourd at thirteen and fourteen weeks after sowing - Season II

Treatments	13 WAS				14 WAS
	Mean no. of *H. phycitis* leaf^{-1}	Mean no. of *B. cucurbitae* caught trap^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}	Mean no. of spiders vine^{-1}	% of fruits infested by *B. cucurbitae* vine^{-1}
T_1	2.33 (1.83)	0.00 (1.00)	2.37 (8.85)	0.21 (1.10)	0.00 (0.00)
T_2	1.33 (1.52)	0.74 (1.32)	3.02 (10.00)	0.10 (1.05)	0.00 (0.00)
T_3	1.39 (1.54)	1.33 (1.53)	30.76 (33.67)	0.10 (1.05)	0.00 (0.00)
T_4	0.99 (1.41)	1.17 (1.47)	24.68 (29.77)	0.10 (1.05)	4.15 (11.75)
T_5	1.10 (1.45)	1.14 (1.46)	20.45 (26.88)	0.00 (1.00)	0.00 (0.00)
T_6	1.03 (1.43)	1.64 (1.63)	13.74 (21.75)	0.10 (1.05)	6.70 (14.99)
T_7	0.99 (1.41)	1.83 (1.68)	23.66 (29.09)	0.00 (1.00)	4.15 (11.75)
T_8	1.49 (1.58)	1.33 (1.53)	27.98 (31.92)	0.00 (1.00)	0.00 (0.00)
T_9	1.15 (1.47)	0.66 (1.29)	2.37 (8.85)	0.10 (1.05)	4.15 (11.75)
T_{10}	2.80 (1.95)	0.00 (1.00)	6.70 (14.99)	0.21 (1.10)	0.00 (0.00)
$F_{9,18}$	12.27*	15.00*	1.90	0.73	0.74
CD (0.05)	0.157	0.182	—	—	—

Transformed values are given in parentheses

* Significant at 5% level

Table 53. Mean number and yield of bitter gourd fruits upto eleven weeks after sowing - Season II

Treatments	No. of fruits vine^{-1} 7 WAS	Wt. of fruits g vine^{-1} 7 WAS	No. of fruits vine^{-1} 8 WAS	Wt. of fruits g vine^{-1} 8 WAS	No. of fruits vine^{-1} 9 WAS	Wt. of fruits g vine^{-1} 9 WAS	No. of fruits vine^{-1} 10 WAS	Wt. of fruits g vine^{-1} 10 WAS	No. of fruits vine^{-1} 11 WAS	Wt. of fruits g vine^{-1} 11 WAS
T_1	1.00	100.00	1.67	200.00	3.33	400.00	4.33	923.33	3.33	691.67
T_2	1.00	100.00	2.00	266.67	3.67	558.33	4.33	983.33	3.67	900.00
T_3	1.67	175.00	2.67	275.00	3.67	566.67	4.33	1008.33	3.67	933.33
T_4	3.00	275.00	2.67	358.33	3.67	683.33	4.67	1316.67	5.33	1233.33
T_5	1.67	143.33	2.00	275.00	4.67	616.67	5.00	1166.67	4.67	1066.67
T_6	1.33	166.67	3.67	448.33	4.00	783.33	7.67	1600.00	6.67	1516.67
T_7	2.33	240.00	3.67	458.33	6.00	866.67	9.00	1783.00	7.67	1666.67
T_8	1.67	191.67	2.33	300.00	3.67	650.00	6.33	1350.00	6.33	1316.67
T_9	1.00	111.67	2.00	250.00	2.00	516.67	5.67	1100.00	4.33	1066.67
T_{10}	0.33	33.33	0.67	66.67	1.33	175.00	1.67	325.00	1.33	233.33
$F_{9,18}$	1.22	0.98	2.93*	2.92*	6.92*	4.78*	4.22*	7.01*	7.41*	8.47*
CD(0.05)	—	—	1.566	199.577	1.450	264.833	2.930	460.973	2.032	421.341

* Significant at 5% level

Table 54. Mean number and yield of bitter gourd fruits from twelve weeks after sowing and the cost : benefit ratio - Season II

Treatments	No. of fruits vine^{-1} 12 WAS	Wt. of fruits g vine^{-1} 12 WAS	No. of fruits vine^{-1} 13 WAS	Wt. of fruits g vine^{-1} 13 WAS	No. of fruits vine^{-1} 14 WAS	Wt. of fruits g vine^{-1} 14 WAS	Total fruit yield		Cost : benefit ratio
							g vine^{-1}	kg ha^{-1}	
T_1	2.67	370.00	3.00	450.00	0.67	100.00	3235.00	8087.50	1 : 4.84
T_2	3.00	483.33	3.67	633.33	0.67	100.00	4025.00	10062.50	1 : 4.03
T_3	2.67	516.67	3.00	550.00	0.33	66.67	4091.67	10229.18	1 : 3.52
T_4	3.00	616.67	4.00	716.67	1.33	216.67	5416.67	13541.68	1 : 7.82
T_5	3.00	300.00	4.00	633.33	1.00	133.33	4335.00	10837.50	1 : 7.16
T_6	3.33	716.67	3.33	666.67	1.33	208.33	6106.67	15266.68	1 : 6.27
T_7	3.67	783.33	4.00	766.67	2.00	250.00	6815.00	17037.50	1 : 8.57
T_8	3.33	583.33	3.33	700.00	1.00	166.67	5258.33	13145.83	1 : 6.57
T_9	3.00	533.33	3.33	600.00	1.00	133.33	4311.67	10779.18	1 : 4.89
T_{10}	1.00	116.67	0.33	33.33	0.00	0.00	983.33	2458.33	
$F_{9,18}$	2.18	4.58*	4.94*	7.28*	3.37*	2.15	6.51*		
CD(0.05)	—	275.126	1.443	231.525	0.910	—	1893.050		

* Significant at 5% level

The number of fruits per vine and the weight of fruits per vine did not differ significantly among the treatments at seven weeks after sowing. However, during the eighth week, maximum fruit number was obtained in T_6 and T_7 which was on par with T_3, T_4 and T_8. The fruit weight was highest in T_7 (458.33 g). All the treatments were superior to control in fruit number and fruit weight.

At nine weeks after sowing, T_7 registered the highest fruit number (6.00) and fruit weight (866.67 g) but it was on par with T_5 in fruit number and T_6, T_4, T_8 and T_5 in fruit yield.

During the tenth week after sowing, the fruit number and fruit yield was the highest in T_7 which was on par with T_6 and T_8. The same trend was observed during the eleventh week also.

During the twelfth of week the fruit number per vine did not show any significant difference but, the fruit weight was maximum in T_7 (783.33 g) which was on par with T_6, T_4, T_8, T_9 and T_3 treatments.

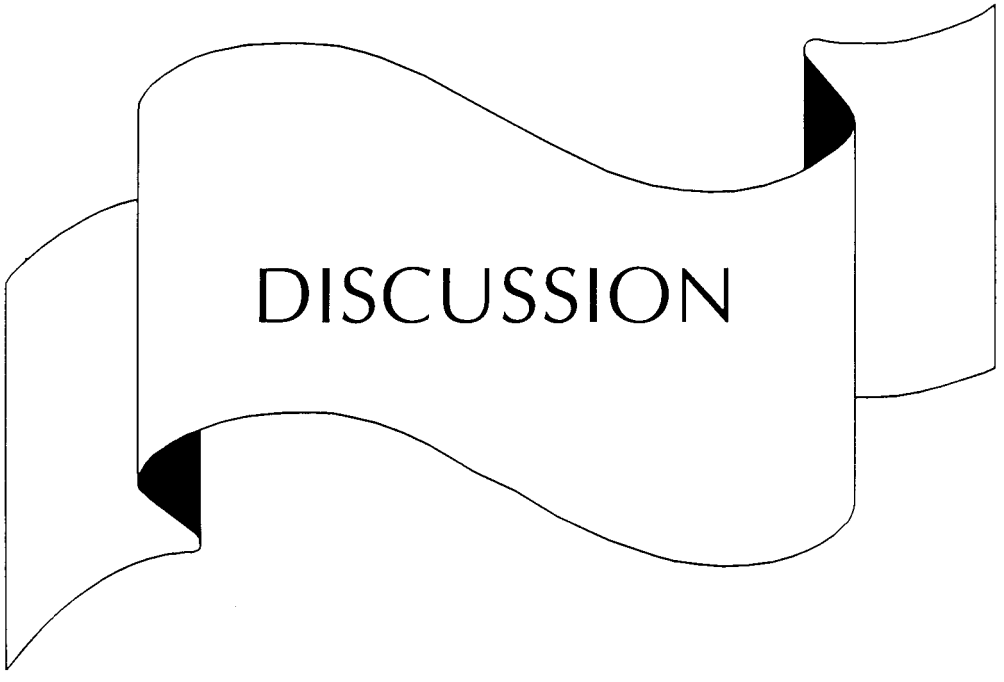
During the thirteenth week, all the treatments were on par and superior to control with regard to the mean number of fruits per vine. Fruit yield was maximum in T_7 which was on par with all the other except T_1 and control.

At fourteen weeks after sowing, T_7 recorded the highest fruit number per vine which was on par with T_6 and T_4. There were no fruits in the control vines (T_{10}). The fruit yield did not vary significantly among the treatments.

The total yield of bitter gourd fruits over seven weeks ranged from 983.33 g vine^{-1} (2458.33 kg ha^{-1}) to 6815.00 g vine^{-1} (17037.50 kg ha^{-1}) among the

treatments and varied significantly. T_7 (Treatment - Combination of neem seed oil 3.00 per cent soap emulsion and dimethoate 0.025 per cent soil drench prior to seeding plus need based application of the same plus poisoned banana fruit / ocimum trap) produced the highest yield which was on par with T_6, T_4 and T_8. The yield in control (983.33 g vine^{-1}) was significantly lower than all the other treatments.

The cost : benefit ratio (Table 54) was the highest in T_7 (1:8.57) followed by T_4 (1:7.82). The lowest ratio of 1:3.52 was obtained in treatment T_3.


DISCUSSION

DISCUSSION

The results of the present investigation on pest management of bitter gourd are discussed.

5.1. Monitoring of pests of bitter gourd, their parasites and predators and survey of plant protection measures undertaken in Thiruvananthapuram district

The results of the study conducted in Kalliyoor, Venganoor and Sreekaryam panchayats of Thiruvananthapuram district are given in 4.1.1.

The educational status of the various subjects under the study varied widely. The maximum percentage of farmers (37 per cent) was in the 31 to 40 age group. Forty one per cent of the farmers declared annual incomes ranging from rupees 6001 to 10,001 whereas, 26 per cent obtained income between rupees 10,001 to 15,000.

Most of the bitter gourd farmers had taken land on lease and the lease rent ranged from less than rupees 50 to more than rupees 150 per cent (40 m^2). Similar findings were reported in the KHDP survey report (Kerala Agricultural University, 1996a). The higher rent in some locations was attributed to assured irrigation, competition for prime productive land and access for marketing the produce.

The demand for wetland especially by the lease farmers was evident from the fact that 93 per cent of them raised the crop in wetlands. As lease rents were high and suitable wetland limited, the area under bitter gourd per farmer was also limited. About 80 per cent of the farmers had a field area ranging from 15 to 44 cents (600 to 1760 m^2). Majority of the farmers used local varieties which were either their own or purchased from other farmers. This was due to the lack of awareness about varieties released by Kerala Agricultural University and non-availability of quality seeds in time. The spacing between vines varied among the different farmers.

About 80 per cent of the farmers applied organic matter at a rate higher than the recommended dose of 25 tonnes ha^{-1} and that too in several splits even after fruiting of the vines. The same trend was noticed with regard to the use of fertilizers. More than 80 per cent of the farmers applied fertilizers at doses higher than the recommended dose of 70:25:25 kg NPK ha^{-1}. The fertilizers were also applied as several splits often at weekly intervals even after fruiting and harvest of early fruits. Binoo Bonny (1991) opined that experience in vegetable cultivation had significant positive association with extent of adoption of improved vegetable cultivation practices. This wide variation in cultural and manurial practices was also observed in the KHDP survey 1994-95 (Kerala Agricultural University, 1996a).

The pests recorded on bitter gourd included the fruit fly, epilachna beetle, leaf feeder, jassid, aphid, yellow mite, American serpentine leaf miner (ASLM) and stem gall fly. (Table 5). These pests were also observed during the KHDP survey in 1994-95 (Kerala Agricultural University, 1996a). Among the pests, the

jassid *H.phycitis* recorded the highest intensity of 1.44. This pest has been mentioned as a pest of bitter gourd leaves by Nair (1995). This was followed by the leaf feeder *D.indica* with a score of 1.13. It was earlier recorded and studied as *M. indica* (Patel and Kulkarny, 1956) and as *E. indica* (Nayar *et al.*, 1976). The other pests were in lesser magnitude.

At early harvest, the highest intensity score of 1.46 was obtained by the jassid followed by fruit fly (score 1.03). The incidence of other pests was less. A comparatively higher score of 1.46 was obtained as the population of jassids was medium in 37 per cent of the plots. Inspite of fruit fly having a score of 1.03, a perusal of the data showed that this pest was present in 99 per cent of the plots. The incidence was however low in 96 per cent of the plots. This could be attributed to the sustained use of insecticides on the crop. The other pests except of ASLM (score 0.82) were in lesser intensities.

Thus the major pests observed in bitter gourd at flowering were the jassid and leaf feeder and at early harvest, the jassid and fruit fly.

The natural enemies of pests of bitter gourd *viz.*, spiders, predatory insects and parasites were in general low due to the indiscriminate use of pesticide spraying by farmers (Table 6). The natural enemies were observed in fields which were not sprayed at short intervals and in those neglected due to heavy incidence of mosaic (Table 7). Spider fauna was observed in low levels in about 20 per cent of the fields at flowering and early harvest and not seen in 76 per cent of the fields. Patel *et al.* (1987) observed that spider abundance and species composition declined due to pesticide application in groundnut. Similar observations were made by Pfrimmer (1964) in cotton ecosystem.

The predatory insects observed belonged to Coccinellidae and Syrphidae whereas, parasites included those infesting larvae of epilachna beetle and the leaf feeder *D.indica*. Sharaf and Bath (1985) also observed very low parasitism in brinjal fields where insecticide use was high. Similar results were reported by Mushtaque and Mohyuddin (1987) in Pakistan.

The survey revealed that 62 per cent of the farmers adopted a combination of plant protection measures which included collection and destruction of damaged plant parts, pests, raking of soil at the base and use of chemical pesticides. Similar observations were made by Marimuthu (1982) among chilli farmers of Tamil Nadu. The use of insecticides was the most important pest control tactic. The organophosphorus pesticides were the most widely used.

The most commonly used insecticides were monocrotophos, dimethoate, quinalphos, methyl parathion and phosphamidon (Table 8). The use of these pesticides in vegetables was also reported by Mathew *et al.* (1995), Kerala Agricultural University (1996b) and Santhoshkumar (1997). The carbamates were not very popular. Carbofuran was reportedly used by 10 per cent of the farmers at seeding till vining of the crop. HCH which is phytotoxic to cucurbits was used by a few farmers. Fenvalerate, a synthetic pyrethroid was also used. The botanicals viz., neem oil, commercial neem products found few takers. Fruitfly trap was installed by seven per cent of the farmers which indicated that it was gaining acceptance as a useful measure among the farmers. The KHDP survey (Kerala Agricultural University, 1996a) in vegetable areas revealed that 95 to 98 per cent of the farmers relied on chemicals alone against pests of vegetables. Most of the farmers used different pesticides during a single crop season. However, 95 per

cent of the farmers used pesticides at doses higher than recommended. This has resulted in the increased incidence of sucking pests like jassid resulting in mosaic like symptoms of crinkling and yellowing of leaves.

Irrespective of the pesticide used, farmers take three to five ml. of the insecticide per litre of water to make the spray solution. This was also observed in the KHDP survey (Kerala Agricultural University, 1996a).

Another finding was that only nine per cent and four per cent of the farmers respectively resorted to need based application of pesticides at flowering and early harvest respectively. Fifty to sixty per cent of the farmers applied pesticides once at intervals between six and ten days. A majority of farmers (95 per cent) did not observe the waiting periods for harvest of the bitter gourd fruits. The application of high dose of pesticides at short intervals coupled with non-compliance of waiting periods was a testimony of the unwarranted use of pesticides. Similar observations were made by Rahiman *et al.* (1986). The obvious fall out was the possibility of insecticide residues above the MRL in bitter gourd fruits. Mathew *et al.* (1995) reported that monocrotophos and phosphamidon were the major contaminants of vegetables exported from Thiruvananthapuram. Santhoshkumar (1997) reported that market samples of bitter gourd fruit samples tested in Thiruvananthapuram district had organophosphorus pesticide residues above MRL.

The incidence of mosaic was a major problem in bitter gourd. Eventhough the mosaic incidence in general was low at flowering, it was present in 76 per cent of the fields. In 12 per cent of the fields, the infection was severe and the farmers had practically abandoned the crop. The KHDP survey (Kerala Agricultural

University, 1996a) also reported that mosaic was a major menace in bitter gourd cultivation.

Most of the bitter gourd farmers (69 per cent) relied mostly on mass media and interpersonal cosmopolites with regard to identification of pests, criteria for adoption of plant protection measures and preparation of spray dilution of pesticides (Table 9). The awareness regarding insecticide residue problems and contamination was created mainly by interpersonal cosmopolites and interpersonal localites. The interaction with interpersonal cosmopolites like Agricultural demonstrator, Agricultural officer and Kerala Agricultural University scientist was more in Kalliyoor and Venganoor panchayats. The advent of the KHDP in these areas has had an impetus in this context.

Inspite of the knowledge gained by farmers on judicious plant protection through different information sources, it was obvious that this was not being put to practice. The indiscriminate use of pesticides on the bitter gourd crop has been explained earlier. Meera (1995) opined that irrational use of pesticides was due to lack of adequate knowledge and unfavourable attitude towards scientific plant protection. However, Binoo Bonny (1991) observed that majority of the vegetable cultivators (67 per cent) had a medium level of knowledge of improved vegetable cultivation practices. A shift to IPM with chemical insecticides as a need based tool will take time.

Queries to the farmers at early harvest on the expected returns from their bitter gourd crop evoked varied responses. The farmers whose fields were ravaged by mosaic did not expect profits. About 70 per cent of the farmers

expected returns ranging from Rs 51/- to Rs 150/- per cent (40 m^{-2}) and this was based on the variation in lease rent rates. The high rent rate on land, high pest incidence and fear of the farmers on assured yields influenced them to apply pesticides at high levels at short intervals. The general consensus among the farmers was that bitter gourd cultivation entailed a high degree of risk compared to other vegetables like snake gourd, cowpea etc.

The survey (Table 10) revealed that the high cost of inputs with a constraint mean of 3.60 was the most important impediment in bitter gourd cultivation. The inputs included manures, fertilizers, pesticides and 'pandal' materials. Binoo Bonny and Prasad (1996) reported that high cost of plant protection chemicals as the most important constraint in vegetable production. The high rent for leased land especially wetland with assured irrigation was the next important constraint (mean 2.24).

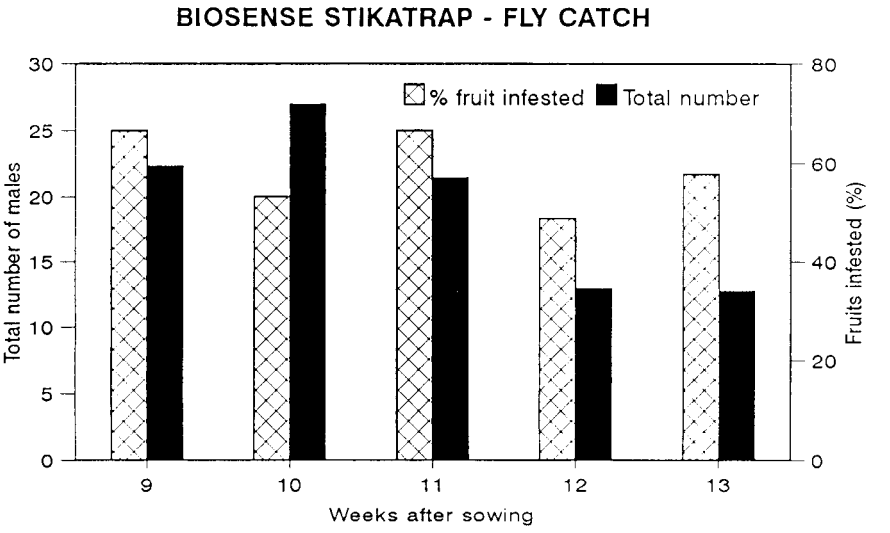
The landless bitter gourd farmers were thus under duress as they had to pay rent even if the crop failed. The other tangible constraints were the uneconomical holding size and high cost of labour. This study showed that untimely supply of inputs was not an important constraint.

A perusal of the male fruit fly catch using Biosense stikatrap in six locations (Table 11) from 9 WAS to 13 WAS indicated that the maximum catch was during the eleventh week. The trend in fruit fly population was determined statistically and the population was optimum at 11.28 weeks after sowing. The tephritid adult population peaked at the maximum fruiting stage of the crop.

A comparison of the catch among the different locations indicated that the numbers caught per week were more (38.40 to 46.40) in the Instructional Farm, Vellayani compared to that in farmers' fields (18.80 to 30.20). The reason could be due to the shorter interval of spraying which was in general prophylatic in the farmers' fields compared to the need based application of insecticides in the Instructional Farm, Vellayani.

The efficacy of the Biosense stikatrap was compared to the carbofuran smeared banana fruit traps. The results given in Table 12 and Fig. 2 revealed that ten carbofuran smeared banana traps were more efficient than one Biosense trap in trapping the fruit flies in an area of two cents (80 m^2). The Biosense trap caught male flies only (average 51.10 per week) whereas, both male and female flies (average 25.20 and 27.70 per week respectively) were trapped in the carbofuran banana fruit traps. This difference was manifested in the percentage of fruits damaged by the fly in the respective plots. The percentage of fruits infested was 22.00 in the Biosense trap plot whereas, only 10.00 per cent of the fruits were infested in the banana fruit trap plot, where the male:female ratio of flies caught was 1:1.1. The Biosense trap cost Rs 150/- whereas the fruit traps incurred an expense of Rs 40/-. Hence the banana fruit trap could be recommended to be installed at the start of the fruiting season till harvest in bitter gourd. The lure trap like Biosense stikatrap can be used to monitor the fruit fly incidence in bitter gourd growing locations. Pillai *et al.* (1991) recommended the use of banana fruit with carbofuran against bitter gourd fruit fly as it was effective and low cost.

The association of the pests of bitter gourd and their natural enemies as well as their relationship with biotic factors viz., maximum temperature and minimum



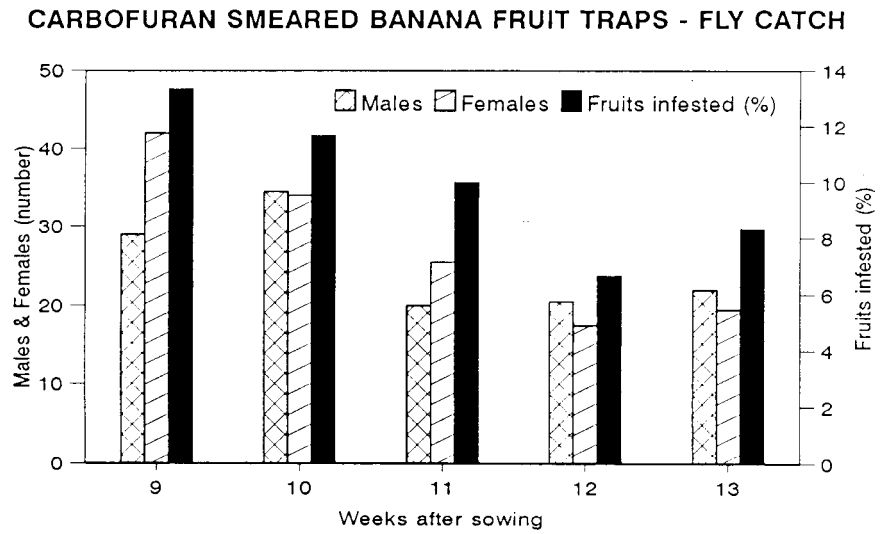


Fig. 2. Comparative efficacy of one Biosense trap with ten carbofuran smeared banana fruit traps

temperature, relative humidity, total rainfall and number of rainy days was studied for one year (1st July 1995 to 30th June 1996) and correlations worked out (Table 55).

The percentage of bitter gourd shoots infested by stem gall fly were significantly and negatively correlated to the minimum temperature and relative humidity. There was significant positive correlation (r = 0.6178) between jassid count and maximum temperature.

The maximum temperature had a significant negative correlation (r = -0.6646) with epilachna grub count. However, the epilachna grub count had a significant positive correlation with relative humidity and number of rainy days. There was significant negative correlation between parasitised epilachna grubs and maximum temperature while relative humidity and number of rainy days had significant positive correlation. The same trend was observed with regard to the correlation of weather parameters with parasitised epilachna pupae.

There was negative correlation between spider count and maximum temperature, minimum temperature and total rainfall and positive correlation with relative humidity and number of rainy days. This agreed with the findings of Faleiro *et al.* (1990).

The percentage of fruits infested by fruit fly was significantly and positively correlated with maximum temperature, but was negatively correlated to relative humidity, total rainfall and number of rainy days. However, Nath (1966) and Gupta and Verma (1992) observed that fruit fly populations were positively correlated with temperature and relative humidity. Fang and Chang (1984) opined that temperature and rainfall regulated population of melon fly.

Table 55. Correlation between pests of bittergourd, natural enemies and weather parameters

Parameters	Max. Temp. (°C)	Min. Temp. (°C)	R.H. (%)	Rain fall (mm)	No. of rainy days
Y_1	0.0248	-0.5680*	-0.4287*	0.0276	-0.0480
Y_2	0.6178*	-0.0343	-0.3400	-0.3038	-0.3928
Y_3	-0.6646*	0.3317	0.6240	0.3865	0.5398*
Y_4	-0.6154*	0.3987	0.6435*	0.2939	0.4841*
Y_5	-0.6027*	0.4037	0.6347*	0.2977	0.4679*
Y_6	-0.3765	-0.2908	0.0543	-0.0467	0.1806
Y_7	0.4981*	0.0692	-0.0675	-0.2802	-0.2786
Y_8	0.1089	-0.3221	-0.0324	0.0523	-0.0479
Y_9	0.1782	-0.7235*	-0.4491*	-0.2340	-0.3633
Y_{10}	0.2409	-0.6753*	-0.4373*	-0.2695	-0.4009
Y_{11}	0.2860	-0.5853	-0.4567	-0.2535	-0.3697
Y_{12}	0.3134	-0.5914*	-0.4826*	-0.3204	-0.4520*
Y_{13}	0.2561	-0.5833*	-0.4733*	-0.2896	-0.4107*
Y_{14}	0.2044	-0.4118*	-0.2104	-0.2351	-0.3611
Y_{15}	0.6257*	-0.0506	-0.2637	-0.3060	-0.4509*
Y_{16}	0.5693*	-0.2037	-0.3431	-0.2903	-0.4368*
Y_{17}	-0.0182	-0.2893	-0.2347	0.3180	-0.0752

* Significant at 5% level

Parameters

Y_1 - % of shoots infested by stem gall fly
Y_2 - Jassid count leaf^{-1}
Y_3 - Epilachna grub count leaf^{-1}
Y_4 - Parasitised % of epilachna grubs vine^{-1}
Y_5 - Parasitised % of epilachna pupae vine^{-1}
Y_6 - Mean no. of spiders vine^{-1}
Y_7 - % of fruits infested by fruit fly
Y_8 - % of leaves infested by ASLM
Y_9 - Aphid count leaf^{-1}
Y_{10} - No. of coccinellid predator grubs leaf^{-1}
Y_{11} - No. of syrphid maggots leaf^{-1}
Y_{12} - No. of mites leaf^{-1}
Y_{13} - No. of thrip predator of mite leaf^{-1}
Y_{14} - No. of parasitised gall fly maggots vine^{-1}
Y_{15} - % leaves infested by leaf feeder larvae vine^{-1}
Y_{16} - No. of parasitised leaf feeder larvae vine^{-1}
Y_{17} - % of vines affected by mosaic.

The aphid count on leaves was significantly and negatively correlated with minimum temperature and relative humidity. Similar correlations were obtained by Mathew *et al.* (1971) on pea aphids in relation to climatic factors in Kerala. The number of coccinellid predator grubs per leaf was significantly and negatively correlated with minimum temperature (r = -0.6753) and relative humidity (r = -0.4373) and negatively correlated with rainfall. The grub count had a positive correlation with maximum temperature. This agreed with the observation of Upadhyay *et al.* (1980) on insect predators of the safflower aphid. The same trend in correlation was observed between syrphid larvae per leaf and the weather parameters.

The correlation between mite *P.latus* count per leaf and minimum temperature, relative humidity and number of rainy days was significant and negative. However, Sudharma (1996) observed that *P.latus* incidence on pumpkin was negatively correlated with maximum temperature and positively correlated with rainfall and humidity. The number of parasitised stem gall fly maggots per vine were negatively correlated to minimum temperature. The parasite incidence of stem gall fly was also negatively correlated to relative humidity, total rainfall and number of rainy days. There was significant positive correlation between the leaf feeder infestation and maximum temperature (r = 0.6257). However, the correlation with number of rainy days was significantly negative.

Correlations were worked out between the pest incidence and their natural enemies (Appendix IV). There was a positive correlation between stem gall fly incidence and number of parasitised gall fly maggots per vine. Significant positive correlations were also observed between the epilachna grub count per leaf and

percentage and parasitised epilachna grubs and pupae. There was a significant positive correlation between aphid population and the coccinellid grub and syrphid maggot predators. Similar results were obtained by Mathew *et al.* (1971) in cowpea. The incidence of spiders was negatively correlated with jassid population. However, there was a significant positive correlation with the population of epilachna grubs as well as aphids. The mite population was positively correlated with that of their thrip predator.

The positive correlation between pests and their natural enemies thus indicated that peaks of pest abundance matched peaks of their natural enemy numbers. Once the prey numbers reduced, the population of natural enemies also declined. Such observations were made by Baskaran and Veeravel (1989) also. The conservation of existing natural enemies is thus important. Predators can be collected wherever abundant and released in crop fields. Similarly, parasitised stages of pests can be gathered and adult parasites be allowed to emerge in the vicinity of the crop.

The climatic factors affected the pests and natural enemies in different ways. There are several factors interacting among the components of the biotic system and their relationship with abiotic elements. These interactions are dynamic and are bound to change from season to season and one component may conceal the effect of the other element. Mathew *et al.* (1971), Hijam and Singh (1991) and Reji Rani (1995) have reported on these aspects. Thus the effects of temperature or rainfall on pest abundance could be masked by the effect of predators. Correlation studies may have to be conducted over several seasons to obtain congruous conclusions.

5.2. Assessment of the efficacy of parasites and predators of pests of bitter gourd

The natural enemies of bitter gourd pests observed are listed in 4.2 of results. Among the parasites of the pests of bitter gourd *C.johnsoni* on epilachna beetle, *H.septima* alone was significant. Hence the biology of this parasite and its efficacy against *H.septima* were investigated in detail. As observed in para 4.2.1, the life cycle from egg to adult ranged from 13 to 17 days under laboratory conditions. Mathew and Abraham (1973) reported that the life cycle of *C.johnsoni* ranged from 12 to 16 days on the epilachna grubs.

The mean number of parasites emerging from one host grub and host pupa were 17.45 and 17.10 respectively. The ratio of progeny from a single mated female was 4.50 females per male. The males were shorter lived compared to the females. Mathew and Abraham (1973) and Lily (1995) reported a mean number of 20.00 and 17.75 parasites respectively emerging from a single grub. The level of parasitisation of epilachna grubs and pupae was high in fields, where the pest population was high. The high pest population would by then have caused severe damage to the bitter gourd leaves. However, Puttarudriah and Krishnamurthi (1954) opined that insecticidal control was not advisable when natural incidence of parasites was high. When the population of epilachna decreased, the parasites were adversely affected and their populations also diminished. This was due to the fact that the adult parasites are short lived. In management of *H.septima*, the role of natural enemy conservation is considerable. The parasitised grubs and pupae can be collected and kept in perforated containers in the field for the adults to emerge. This along with mechanical collection and destruction of eggs, grubs, pupae and adults of the beetle would keep the pest under check.

Among the predators detected in Thiruvananthapuram district, *I.scutellare, M.sexmaculatus* and *S. nubilis* were prominent. The biology of these predators and their feeding potential were investigated.

With regard to *I.scutellare* (para 4.2.3 of results), the incubation period of egg and the duration of the three larval instars and pupae were 3.60, 2.00, 2.50, 3.40 and 3.80 respectively with a total of 13.30 days. The female longevity (11.60 days) was different from the male (9.40 days) by about two days. The data on the life cycle of this predator agreed with the observations made by Sitaraman (1966) and Reji Rani (1995).

With regard to *C. sexmaculatus* (para 4.2.3 of results), the duration of the incubation period, first, second and third instars of grub and pupa were 2.28, 2.29, 3.48, 3.80 and 3.50 days respectively. The mean total duration was 15.35 days. Bagal and Trehan (1949) reported that the number of larval instars varied with season. Jacob (1963) observed four larval instars whereas, Reji Rani (1995) recorded three instars with a mean duration of 15.90 days. The longevity of the male and female did not vary much and ranged from 16 to 45 days. Reji Rani (1995) reported a longevity range of 18 to 44 days whereas, Bagan and Trehan (1949) observed a mean longevity of 60 days.

The duration of the incubation period of the egg, first, second, third and fourth larval instars and pupa of *S. nubilis* (para 4.2.4 of results) were 3.40, 2.30, 1.20, 1.20, 4.60, 9.30 and 5.50 days respectively with a total mean duration of 18.20 days. This agreed broadly with the observations made by Johnson (1972) and Patro and Behera (1992).

The maggot of *I.scutellare* consumed about 400 aphids (*A.gossypii*) adults during the different larval stages. Sitaraman (1966), Sarala Devi (1967) and Reji Rani (1995) observed consumption of aphids to the tune of 450, 383 and 450 *A. craccivora* aphids respectively. The consumption by the three larval instars were 9, 33 and 58 per cent of the total number. These findings broadly concurred with the earlier reports of Sitaraman (1966) and Reji Rani (1995).

The larvae of *M.sexmaculatus* consumed about 184 aphids during its life time (para 4.2.3) and the percentage consumption of first, second and third larval instars were 6, 29 and 65 per cent respectively. Lokhande and Mohan (1990) and Reji Rani (1995) reported consumption per larva of 73.52 and 84 aphids respectively whereas, Bagal and Trehan (1949) observed a higher rate (303 per larva). The mean consumption per adult coccinellid as 827.90 adult aphids with a mean longevity of 29.90 days, the average per day was 27.69 nymphs. The consumption reported by Jacob (1963), Sarala Devi (1967), Lokhande and Mohan (1990) and Reji Rani (1995) were 29.00, 27.00, 27.00 and 23.77 aphids per day respectively. However, Haque and Islam (1978) reported a high rate of 57.00 aphids per day.

Compared to *I.scutellare* and *M.sexmaculatus*, the feeding potential of *S. nubilis* was much less. However, higher population of *S. nubilis* consumed high number of aphids. The present investigations showed that the larval instars consumed a mean total of 52.90 aphids whereas, the adults consumed an average 23.50 aphids during the first three days after emergence. Johnson (1972) reported that a grub of *S. nubilis* consumed 50 to 63 *Pentalonia* sp. whereas, the adult fed on 6 to 11 aphids a day. Patro and Behera (1992) reported that the grub of *Scymnus* sp. consumed 139.8 $\pm$ 11.25 *A. craccivora* during its development.

Of the two predators viz., *I.scutellare* and *M.sexmaculatus*, the former had a shorter life cycle and higher longevity. However, the latter was more among aphid colonies. Though the feeding potential of the immature stages of *I.scutellare* was higher, the adult *M.sexmaculatus* was an efficient predator of aphids. Thus the contribution of *M.sexmaculatus* as a natural enemy could be rated higher than *I.scutellare*. The observations in the field revealed that the egg laying of the fast moving predator was in general low among the aphid colonies resulting in low predator build up. It has been observed that predator population has a positive association with that of aphids. However, Srikanth and Lakkundi (1990) and Reji Rani (1995) observed that predators alone did not play an important role in pest suppression and that abiotic factors were also involved. The role of natural enemies in pest suppression is important and IPM strategies that cause least damage to them will be required. This would go a long way in keeping pest population levels low.

5.3. Effect of botanicals and synthetic pesticides on pests, parasites and predators of pests of bitter gourd

Antifeedant effect of botanicals on the feeding of third instar *H.septima* grubs

The present investigations (para 4.3.1. of results) revealed that among the botanicals, nimbecidine 0.40 per cent, neem seed oil emulsion (NSO) four and three per cent were the most effective in curtailing the weight gain of epilachna grubs 24 hours after feeding on leaves receiving the different treatments. The least consumption of treated bitter gourd leaves 24 hours after exposure was in

nimbecidine 0.40, NSO four and three per cent (0.021, 0.022 and 0.030 mg respectively). The percentage of leaves protected was the maximum (88.61 per cent) in NSO four per cent (T_7) and it was followed by nimbecidine 0.40 per cent (T_{10}) NSO three per cent (T_8) (Fig. 3). Clerodendron extract exhibited lower levels of phagodeterrency. However, Saradamma (1989) reported that benzene extracts of *C. infortunatum* exhibited high antifeedant activity and leaf protection of bitter gourd against *H.septima*.

The antifeedant effect of the botanicals was more pronounced 48 hours after release of larvae on treated leaves. Based on the mean weight gained or lost by ten epilachna grubs 48 hours after exposure, the most effective treatments were NSO four per cent, nimbecidine 0.40 per cent and NSO three per cent. Consequently, these were the most effective treatments based on weight of leaves consumed 48 hours after feeding on treated leaves. Thus NSO four per cent emulsion, nimbecidine 0.40 per cent and NSO three per cent emulsion afforded the maximum protection (in descending order) of bitter gourd leaves against the epilachna grubs. The larval starvation was the highest in NSO four per cent emulsion followed by nimbecidine 0.40 per cent and NSO three per cent. The antifeedant activity of neem against pests of vegetables was revealed by Reed *et al.* (1982), Reed and Reed (1984), Chitra and Kandasamy (1988) and Jeyarajan and Sundara Babu (1990). Eventhough the antifeedant effect of *C. infortunatum* extract was lesser compared to neem, nevertheless, the findings agreed broadly with those of Lily (1995).

Based on the antifeedant trial results, neem seed oil (NSO) three per cent and nimbecidine 0.40 per cent were selected for the ensuing experiments and pest management trial.

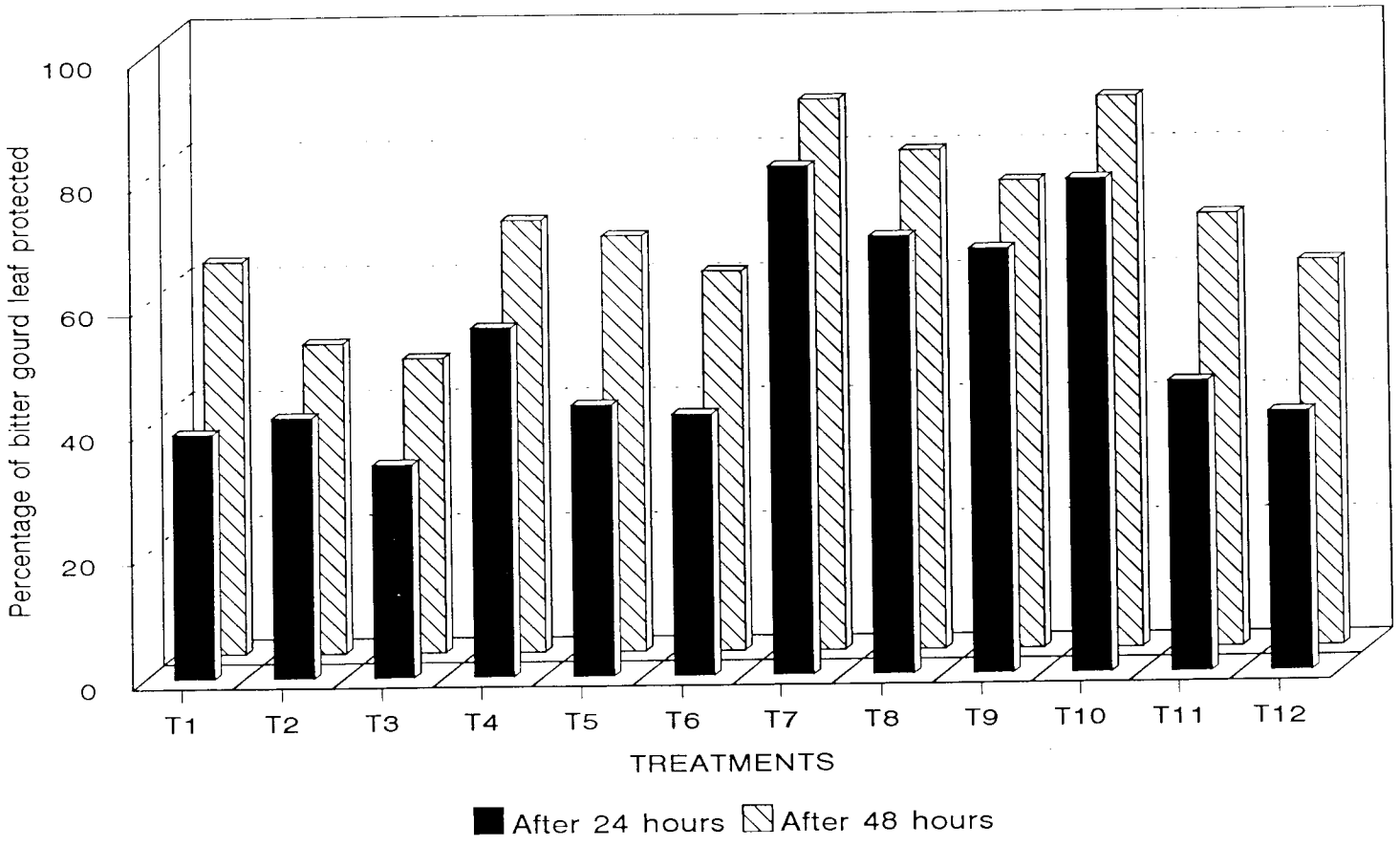


Fig. 3. Percentage of bitter gourd leaf protected by botanicals (against *H.septima*)

The investigations (4.3.2 of results) showed that 24 hours after release of fourth instar epilachna grubs on pesticide spray treated leaves, carbaryl 0.20 per cent recorded the highest mortality. This was followed by carbaryl 0.15 per cent and malathion 0.05 per cent. Observations taken 48 hours after release indicated maximum mortality in carbaryl 0.20 per cent and it was significantly superior to all other treatments, among which carbaryl 0.15 and 0.10 per cent were the best. Jayakumari and Nair (1968) reported that among different pesticides, carbaryl was the most toxic to epilachna grubs. Mathew and Nair (1969) also reported on the low and high residual toxicity of malathion and sevin respectively to grubs and adults of the epilachna beetle.

The percentage mortality of epilachna grubs 24 hours after release on bitter gourd leaves (collected from vines seven days after spraying) was the highest (50.00 per cent) in carbaryl 0.20 per cent followed by carbaryl 0.15 per cent and 0.10 per cent. Dimethoate treatments also caused mortalities ranging from 12.29 to 16.36 per cent. This indicated that carbaryl and dimethoate persisted in the plant whereas, there was no mortality on either quinalphos or malathion (contact poisons) treated leaves. Carbaryl and dimethoate were more effective against *H.septima* compared to quinalphos and malathion. Naseema Beevi *et al.* (1990) opined that the bioefficacy of malathion was lesser than dimethoate and quinalphos in bitter gourd.

The results presented in para 4.3.3 revealed that botanicals in general were not harmful to the parasite *C.johnsoni*. Neem seed oil four per cent emulsion and nimbecidine 0.40 per cent caused 7.04 and 3.01 per cent mortality of the parasite adults 24 hours after exposure. Srinivasa Babu *et al.* (1993) opined that

botanical insecticides at lower doses were relatively safe to parasites whereas, higher concentrations adversely affected them. NSK (25 g lit^{-1}) application did not affect *A.plutellae* adults (Bandara and Kudagamage, 1993). This suggested the compatibility of parasites with botanicals.

The chemical pesticides did not differ in their toxicity to *C.johnsoni* one hour after exposure. Three hours after exposure, the mortalities ranged from 1.14 to 15.72 per cent. However, twelve hours after exposure, the mortality was highest (86.67 per cent) in malathion 0.10 and 0.075 per cent and least in carbaryl 0.10 per cent. The observations taken 24 hours after exposure revealed that all the pesticides at the three selected doses were toxic to *C.johnsoni*. Screening of pesticides for their selectivity to natural enemies has been carried out by several workers. The findings were in broad agreement to the studies of pesticides on *E.bryani* by Mani and Sudha Nagarkatti (1988). Azad Thakur and Deka (1995) also reported that malathion 0.05 per cent and quinalphos 0.05 per cent were toxic within 24 hours to *A.glomeratus*.

The findings reflected the difficulty in integrating natural enemies with conventional pesticide application in IPM programmes. Surveillance of the field for pests is required and in situations which warrant chemical pesticide use, spot application in the loci of infestation could be recommended.

The investigations (para 4.3.4 of results) indicated that the higher doses of botanicals slightly affected the emergence of adult *C.johnsoni* from both larvae and pupae (Fig. 4). The lower doses were not harmful. Similar results on the nontoxic nature of botanicals related to emergence of hymenopteran parasites were

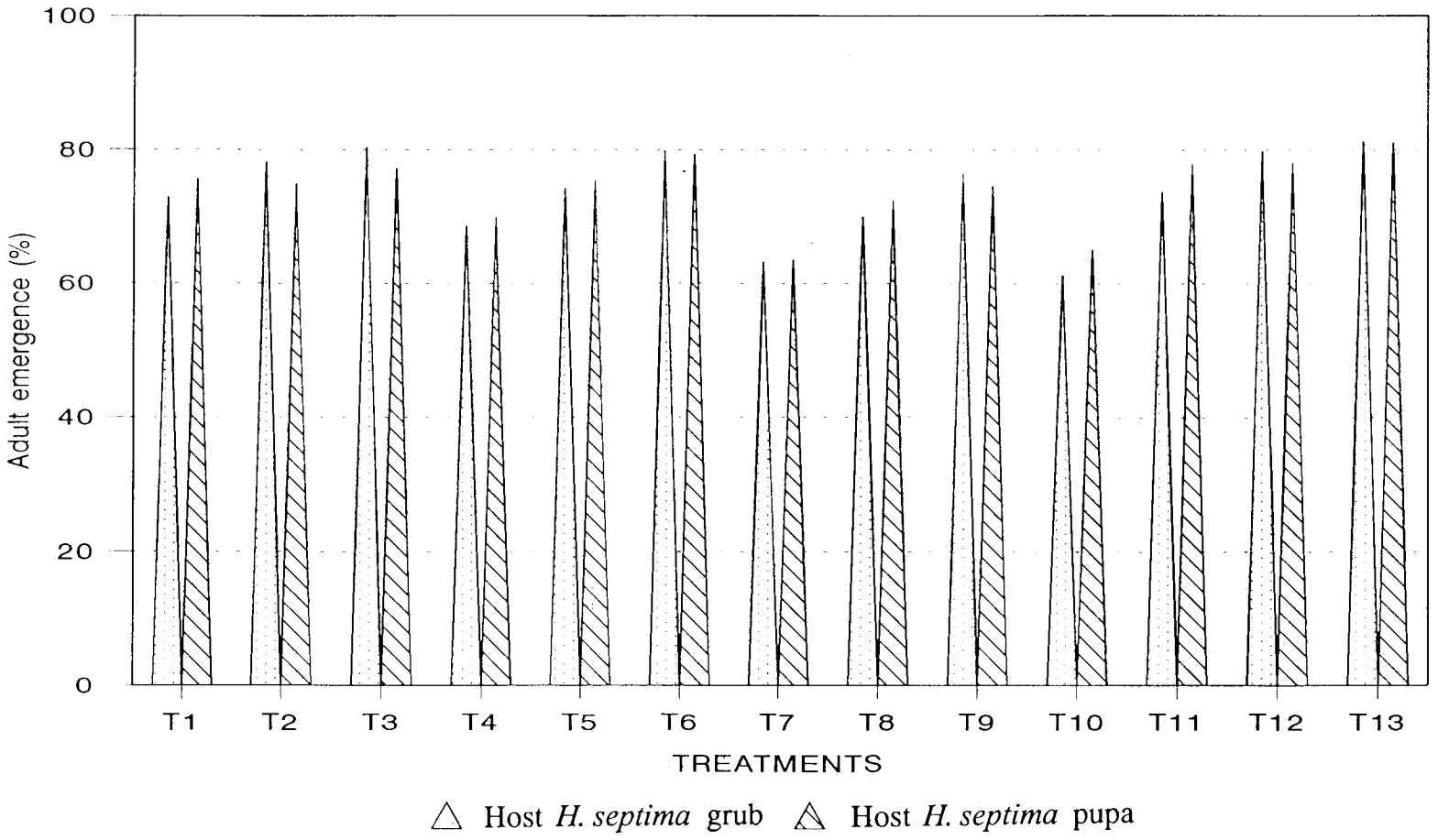


Fig. 4. Percentage emergence of adult *C.johnsoni* after exposure of parasitised hosts to botanicals

obtained by Stark *et al.* (1990), Bandara and Kudagamage (1993), Feldhege and Schmutterer (1993), Lily (1995) and Hebsy Bai (1996). Neem with its selectivity towards phytophagous insects like aphids and compatibility with biotic agents can be included in IPM programmes.

The studies showed that chemical pesticides adversely affected the emergence of *C.johnsoni* adults from treated parasitised epilachna grubs and pupae (Fig. 5). The contact pesticides viz., malathion and quinalphos were more toxic than carbaryl and dimethoate. The high level toxicity to parasites when pesticides were applied to parasitised eggs have been reported by Mani and Krishnamoorthi (1984) and Santharam and Kumaraswami (1985). Among the pesticides tested, dimethoate at different doses recorded the lowest mortality of the parasites. The results highlighted the need for collection of parasitised stages before insecticidal application. The emerging parasites are to be released after observing the waiting periods.

The results (para 5.3.5.) indicated that the botanicals were safe to *M.sexmaculatus* grubs 12 and 24 hours after exposure (Fig. 6). Only NSO caused a low mortality (1.28 per cent) 48 hours after exposure. This agreed with the findings reported by Srinath (1990) and Patel and Yadav (1993). The chemical pesticides were toxic (range of mortality 58 to 75 per cent) 12 hours after exposure. Dimethoate and carbaryl were comparatively less toxic. The same trend was observed 24 and 48 hours after exposure. Satpathy *et al.* (1968) and Makar and Jadhav (1981) opined that dimethoate exhibited low to moderate toxicity to adult *M.sexmaculatus* whereas, carbaryl was more toxic. On the contrary, Hussain and Fong (1989) and Thayaalini and Raveedranath (1988) reported that dimethoate had an adverse effect on the coccinellid.

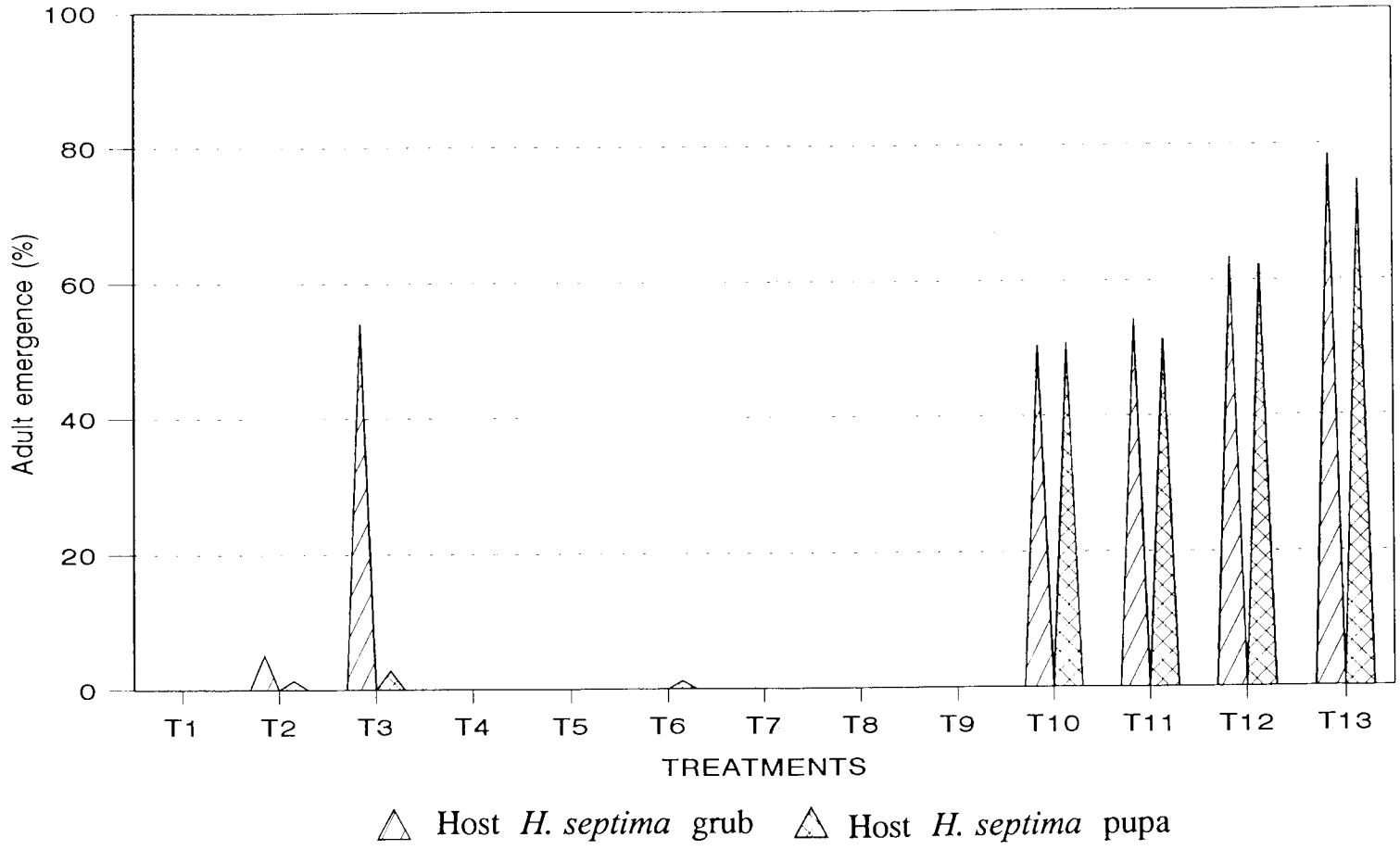


Fig. 5. Percentage emergence of adult *C.johnsoni* after exposure of parasitised hosts to chemical pesticides

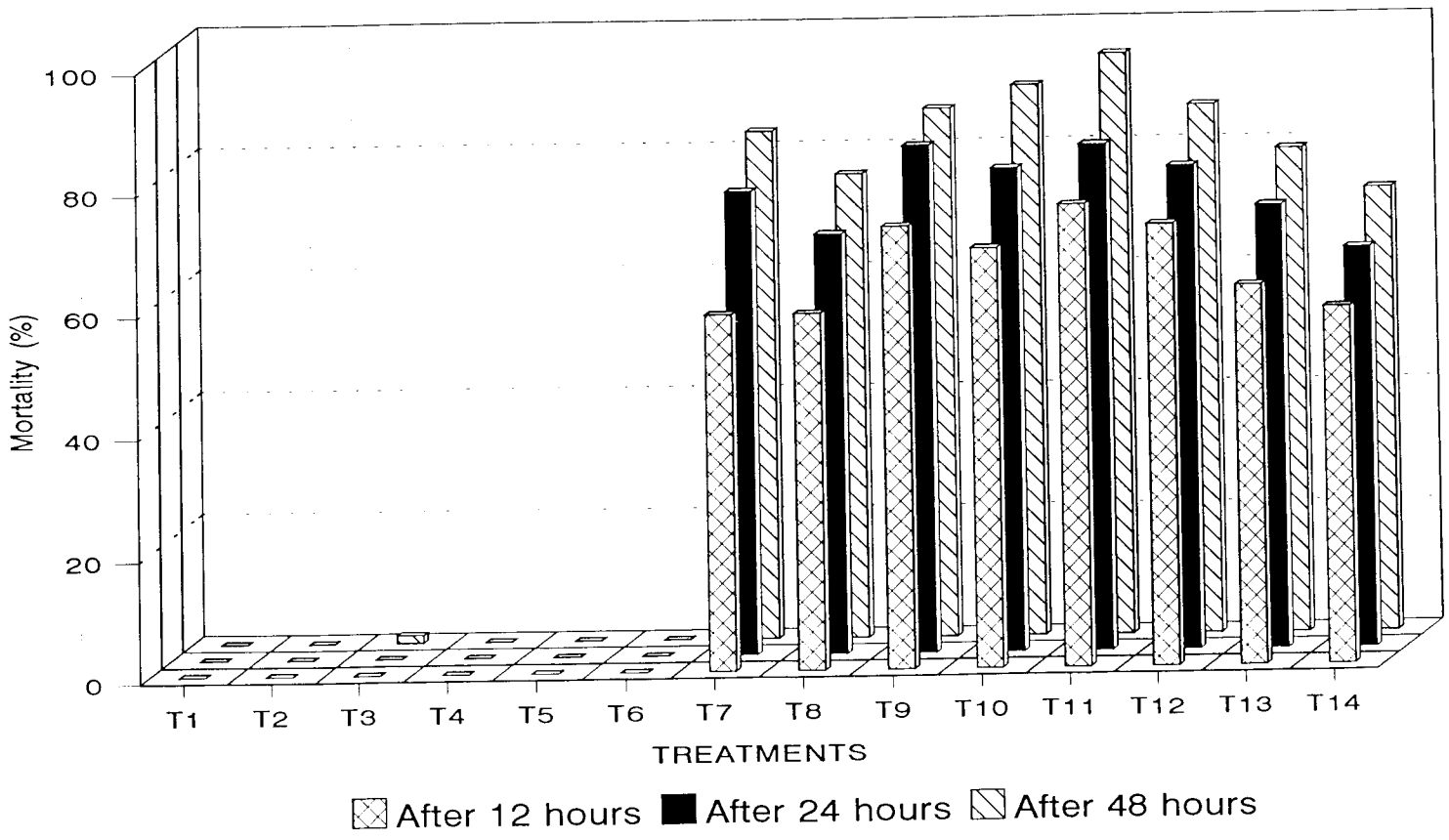


Fig. 6. Percentage mortality of *M.sexmaculatus* grubs after exposure to botanicals / chemicals

The present studies indicated that contact pesticides like quinalphos and malathion were not as selectively toxic as dimethoate and carbaryl. Hence, they were comparatively unsafe to the natural enemies. This was in agreement with the reports of Satpathy *et al.* (1968) and Thomas and Phadke (1991).

Based on the investigations on the effect of synthetic and botanical pesticides on the natural enemies of the pests of bitter gourd and their efficacy against pests, the following botanicals and insecticides were selected for the ensuing pest management trials. 1) Neem seed oil (NSO) three per cent soap emulsion, 2) nimbecidine 0.40 per cent, 3) dimethoate 0.05 per cent and 4) carbaryl 0.15 per cent.

5.4. Reaction of bitter gourd varieties to pests

The results (4.4) of the trial revealed the presence of pests at different intensities among the varieties. The intensity of pests among the varieties at different weeks after sowing are presented in Table 56.

At three weeks after sowing, *L.trifolii* had the highest intensity score (2.00) and all the varieties were infested. *L.trifolii* has been reported on cucurbits by Spencer (1973) and Srinivasan *et al.* (1995). Krishnakumar *et al.*, (1997) opined that bitter gourd was not a preferred host but this was disputed by Jeyakumar and Uthamaswamy (1998). *H.septima* incidence was low among the varieties. Arka Harit exhibited the least infestation by *H.phycitis*.

Table 56. Pest intensity among bitter gourd varieties at different weeks after sowing

Pest / damage	Variety	Weeks after sowing											Grand total of score for variety
		3	4	5	6	7	8	9	10	11	12	13	
	V_1	2	-	-	2	-	-	-	-	-	-	-	
L. trifolii	V_2	2	-	-	1	-	-	-	-	-	-	-	
damage	V_3	2	-	-	2	-	-	-	-	-	-	-	
(leaves)	V_4	2	-	-	2	-	-	-	-	-	-	-	
	V_5	2	-	-	2	-	-	-	-	-	-	-	
	IS	2.0	-	-	1.8	-	-	-	-	-	-	-	
	V_1	1	2	2	-	-	-	-	-	-	-	-	
H. septima	V_2	1	0	1	-	-	-	-	-	-	-	-	
grub	V_3	1	1	1	-	-	-	-	-	-	-	-	
population	V_4	1	2	2	-	-	-	-	-	-	-	-	
	V_5	1	2	2	-	-	-	-	-	-	-	-	
	IS	1.0	1.4	1.6	-	-	-	-	-	-	-	-	
	V_1	1	1	2	2	2	3	-	-	-	-	-	
H. phycitis	V_2	0	0	0	1	1	2	-	-	-	-	-	
adult	V_3	1	1	2	2	2	2	-	-	-	-	-	
population	V_4	1	1	2	2	2	3	-	-	-	-	-	
	V_5	1	1	2	2	2	2	-	-	-	-	-	
	IS	0.8	0.8	1.6	1.8	1.8	2.4	-	-	-	-	-	
	V_1	-	-	1	1	-	-	-	-	-	-	-	
N. falcata	V_2	-	-	0	0	-	-	-	-	-	-	-	
damage	V_3	-	-	1	2	-	-	-	-	-	-	-	
(shoots)	V_4	-	-	1	1	-	-	-	-	-	-	-	
	V_5	-	-	1	1	-	-	-	-	-	-	-	
	IS	-	-	0.8	1.2	-	-	-	-	-	-	-	
	V_1	-	-	-	2	3	2	-	-	-	-	-	
P. latus	V_2	-	-	-	2	2	2	-	-	-	-	-	
infestation	V_3	-	-	-	2	3	2	-	-	-	-	-	
(leaves)	V_4	-	-	-	2	3	2	-	-	-	-	-	
	V_5	-	-	-	3	3	2	-	-	-	-	-	
	IS	-	-	-	2.2	2.8	2.0	-	-	-	-	-	
	V_1	-	-	-	-	-	3	3	3	3	3	3	
B. cucurbitae	V_2	-	-	-	-	-	0	0	0	0	0	0	
infestation	V_3	-	-	-	-	-	2	3	3	3	3	3	
(fruits)	V_4	-	-	-	-	-	3	3	3	3	3	3	
	V_5	-	-	-	-	-	3	3	3	3	3	3	
	IS	-	-	-	-	-	2.2	2.4	2.4	2.4	2.4	2.4	
	V_1	-	-	-	-	-	-	2	2	-	-	-	50
D indica	V_2	-	-	-	-	-	-	0	0	-	-	-	16
infestation	V_3	-	-	-	-	-	-	2	2	-	-	-	46
(leaves)	V_4	-	-	-	-	-	-	2	2	-	-	-	49
	V_5	-	-	-	-	-	-	2	2	-	-	-	50
	IS	-	-	-	-	-	-	1.6	1.6	-	-	-	

IS - Intensity score V_1 - Priya V_2 - Arka Harit V_3 - Preethi V_4 - Priyanka V_5 - Local

Class of pest (score) 0 - Absent 1 - Low 2 - Medium 3 - High

At four weeks after sowing, *H.septima* incidence (1.40) was higher compared to *H.phycitis* (0.80). Arka Harit was the most tolerant variety against *H.septima* followed by Preethi. The incidence of epilachna beetle has been reported on bitter gourd by Kapur (1966), Abbas and Nakamura (1995), Lily (1995), Hebsy Bai (1996) and Sreekala (1997). The damage by the jassid *H.phycitis* was reported by Nair (1975).

At five weeks after sowing, the intensity scores were identical (1.60) for both *H.septima* and *H.phycitis*. Arka Harit and Preethi exhibited maximum tolerance to *H.septima*. *H.phycitis* was not observed in Arka Harit whereas, it was present in medium intensity in all the other varieties. *N.falcata* damage was not observed in Arka Harit and was low in all the other varieties.

At six weeks after sowing, the yellow mite *P.latus* was the most serious among the varieties with a mean score of 2.20. All the varieties except the local showed medium level of infestation. Arka Harit was the most tolerant against *L.trifolii*, *H.phycitis* and *N.falcata*. All the other varieties exhibited a medium level of infestation against *L.trifolii* and *H.phycitis*. Sudharma (1996) reported on the damage by *P.latus* on bitter gourd.

At seven weeks after sowing, *P.latus* was the major pest. All the varieties except Arka Harit showed high level of infestation. Arka Harit showed the maximum tolerance to the jassid whereas, the other varieties exhibited medium intensity of infestation.

At eight weeks after sowing, the varieties were infested by *H.phycitis*, *P.latus* and *B.cucurbitae*. The varieties exhibited medium to high levels of

infestation by *H.phycitis* whereas, *P.latus* incidence was medium in all the varieties. Arka Harit did not bear any fruits. Priya, Priyanka and local variety were highly susceptible to *B.cucurbitae* whereas, Preethi was less susceptible.

At nine weeks after sowing, all the varieties that fruited were highly susceptible to *B.cucurbitae*. All the varieties were infested at medium intensity by *D.indica* larvae except Arka Harit. The damage by *D.indica* has been reported by Patel and Kulkarny (1956), Nair (1995) and Ravi *et al.* (1997). The same trend was observed at ten weeks after sowing.

During the eleventh, twelfth and thirteenth week after sowing, the fruit fly damage was high and an intensity score of 2.40 was observed during the three weeks. All the varieties which fruited were susceptible to *B.cucurbitae* attack. Darshan Singh *et al.* (1976), Jalaja (1989) and Padmanabhan (1989) reported that all cultivars of bitter gourd tested against fruit fly were susceptible. Among 69 bitter gourd cultivars tested, Pal *et al.* (1984) observed that two cultivars possessing resistance to fruit fly had thick and tough fruit rind. Thus it could be seen that Arka Harit exhibited the maximum tolerance against pests and the other varieties were more susceptible. However, the range of resistance was inadequate for recommending a variety without the risk of high damage levels in the absence of chemical application.

The grand total of the intensity score of each variety indicated that Arka Harit was the best pest tolerant variety with a total score of 16. However, this variety did not bear fruit and had to be rejected. The intensity scores registered by Preethi, Priyanka, Priya and the local variety were 46, 49, 50 and 50

respectively. Eventhough *B.cucurbitae* attack was high, more number of fruits were produced in the variety Preethi compared to the other varieties. Preethi recorded the highest yield of 5688 kg ha^{-1} of bitter gourd fruits which was superior to the other varieties.

Thus a perusal of the pest incidence especially that of *B.cucurbitae* and yield of fruits (Fig. 7) among the varieties indicated that Preethi (MC-84) was the best. Hence this variety was selected for the ensuing Pest Management Trial.

5.5. Pest Management Trial in bitter gourd

The results of the pest management trial conducted in two seasons *viz.*, in 1996 and 1997 are given under 4.5. As the treatments involved need based applications, pooled analysis of the two seasons' data were not undertaken. Hence the results are explained separately. However, the pest and natural enemy scenario of the two seasons are being discussed weekwise.

Three weeks after sowing

During the first and second season, the mean number of *H.phycitis* ranged from 1.76 to 6.41 and 1.56 to 2.72 per leaf respectively among the treatments and differed significantly. The count in control was the highest during both the seasons.

The percentage of shoots infested by *N.falcata* did not differ significantly among the treatments and control during both the seasons. *L.trifolii* damage was observed in the second season but did not differ significantly among the treatments.

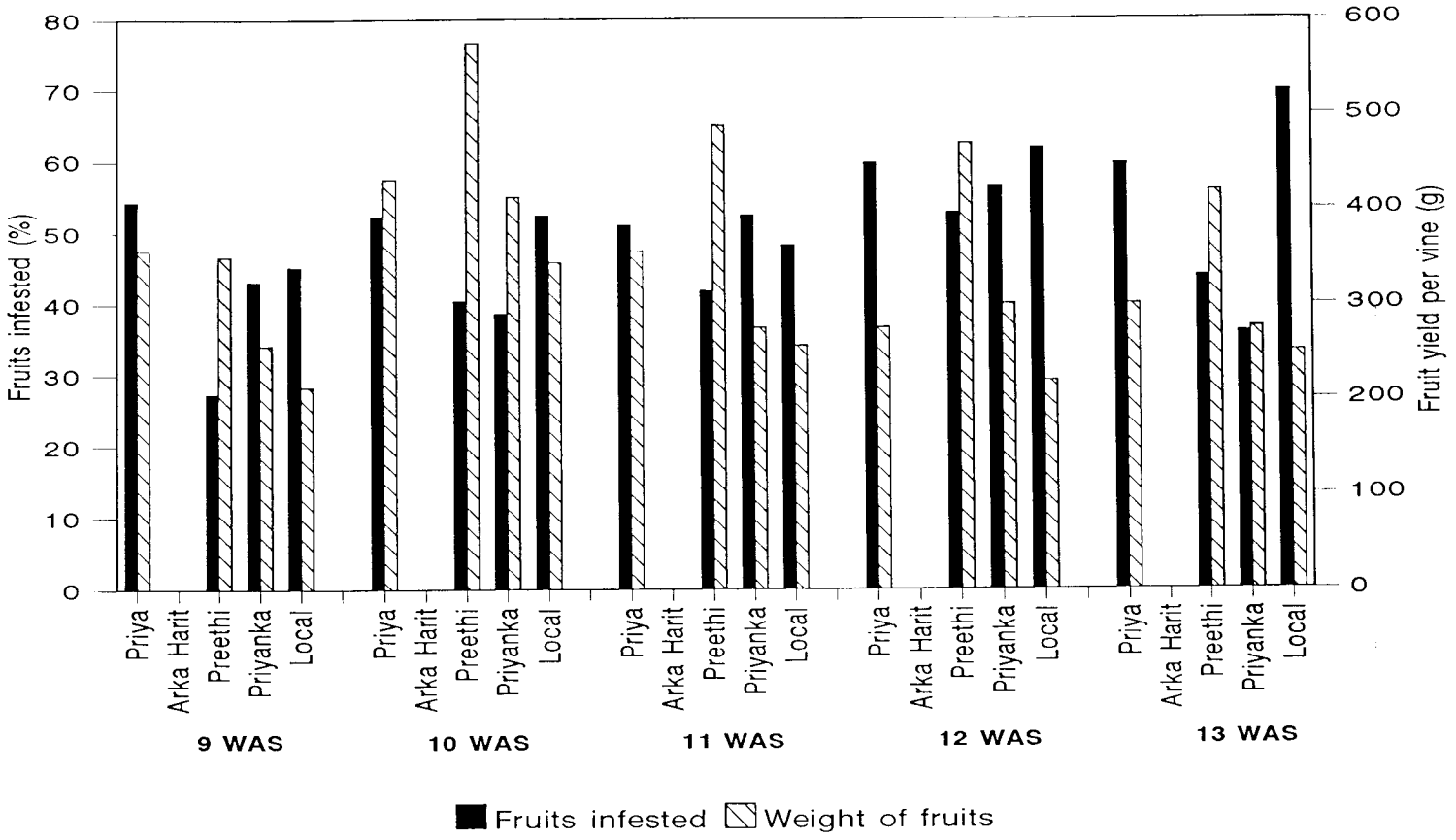


Fig. 7. Fruit fly incidence and yield in bitter gourd varieties

During the second season, NSO three per cent (T_2) and nimbecidine 0.40 per cent (T_3) treatments were applied.

Four weeks after sowing

During season one, the infestation by *L.trifolii, N.falcata* and *H.phycitis* was on par among treatments. An application of all the need based treatments was given as the jassid population was on the increase. However, during the second season, the pests observed were *L.trifolii, N.falcata, H.phycitis* and *A.gossypii*. The percentage of leaves infested by *L.trifolii* as well as *H.phycitis* count varied significantly among the treatments. *N.falcata* and *L.trifolii* damage was lower compared to control indicating their effectiveness. The parasite incidence on *N.falcata* maggots was low. However, the mean number of spiders / vine and mean number of coccinellid predators / leaf varied among the treatments. The population of natural enemies were comparatively lower in those receiving chemical pesticides which showed their incompatibility with natural enemies. A need based spray of the treatments was given at four week after sowing during both the seasons.

Five weeks after sowing

During the first season, the pests encountered were *H.phycitis, L.trifolii, N.falcata* and *A.gossypii*. Among these, the jassid and aphid count per leaf varied among the treatments. The pest incidence was high in spite of the previous need based applications. During the second season, the pests observed were *H.phycitis, N.falcata, A.gossypii* and *L.trifolii*. Among these, the incidence of the first three differed significantly among the treatments. However, aphid and jassid count per leaf was lesser whereas, ASLM damage was higher than the first season.

The incidence of natural enemies of the pests was in general low. Though their incidence was higher in botanical treatments, it was on par with the other treatments.

Among the natural enemies of pests, coccinellid grubs, syrphid maggots and spider count varied significantly among the treatments. The highest incidence was in control indicating that treatments were detrimental to natural enemies. The difficulty in augmenting natural control with conventional pesticides in pest management was obvious. Eventhough predators were associated with aphids, they were not able to control aphid population which peaked at times. Similar observations were made by Reji Rani (1995).

An application of treatments T_2 and T_3 were given at five weeks after sowing during the first season.

Six weeks after sowing

In the first season *H.phycitis, A.gossypii, D.indica* and *P.latus* were observed. However, the jassid and yellow mite count varied significantly among the treatments. Observations on the incidence of mosaic and powdery mildew showed that the level of incidence was comparatively lower in vines receiving botanicals. Thus neem was observed to have mosaic suppressive as well as fungicidal properties. This agreed with the findings of Reghunath and Gokulapalan (1994) of the effect of neem seed oil on cowpea mosaic.

Though natural enemies of the pests were observed, their number incidence was low. However, the incidence of natural enemies viz., *S. indicus*,

the predator of mite and *A. taragamae* was higher in vines receiving botanicals. This indicated the compatibility of natural enemies with botanical insecticides. This broadly agreed with the findings of Srinath (1990), Katok *et al.* (1993) and Lowery and Isman (1993).

During the second season, the incidence of *H.phycitis* was low and not significant, but *A.gossypii* numbers differed significantly among treatments and were higher compared to first season.

The incidence of mosaic and downy mildew was maximum in control. The disease index of downy mildew was comparatively lower in botanical treatments.

The natural enemy distribution was low and their population was comparatively higher in control and botanical applied vines.

At six weeks after sowing, an application of the need based treatments along with fungicide, Mancozeb (Indofil M-45) at 4 g litre^{-1} was given during the first season.

Seven weeks after sowing

H.phycitis and *D.indica* were observed in both the seasons. The level of infestation and population of *D.indica* larvae did not differ significantly among treatments during the first season. In the second season, the jassid number per leaf though low, differed significantly between treatments and control.

D.indica damage on leaves as well as flowers was low and varied among

treatments. *P.latus* was observed during the first season and population level was on the higher side. *B.cucurbitae* damage was also observed in all treatments except T_4.

A perusal of the natural enemies indicated the presence of thrip predator of mite, though not significant during the first season. The percentage of *D.indica* larvae parasitised per vine did not vary significantly in the first season, but differed significantly among treatments during the second. The spider number per vine in general was low during both the seasons.

During the first season a need based spray of all treatments were given while in season two, T_1, T_5, T_6, T_9 treatments were applied. The banana / ocimum traps were installed by the fiftieth day after sowing in line with the results of the KHDP experiments (Kerala Agricultural University, 1996a). An application of the fungicide Mancozeb (Indofil M-45) at 4 g litre^{-1} was given during the second season.

Eight weeks after sowing

The pests observed during both the seasons were *H.phycitis* and *D.indica*. The pumpkin beetle *R. foveicollis* was observed during the second season and varied significantly among the treatments. The jassid count per leaf was in general higher in the first season compared to the second. The mean number of *D.indica* larvae varied significantly among treatments during both the seasons. The percentage of leaves and flowers infested by *D.indica* was higher during the second season compared to season one and varied among treatments. The fruit infestation by *D.indica* larvae was recorded during the second season. The damage by *D.indica* has been explained by Nair (1989). The botanicals alone or botanical with insecticide combinations were effective in curtailing *D.indica*.

The fruit set was low and *B.cucurbitae* damage was observed. However, the infestation was on par among the treatments during both the seasons.

The mean number of spiders per vine was low and not significant among treatments during both the seasons. The populations was higher in control and botanical treatments. This concurred with the findings of Venkateswara Rao and Rosaiah (1993). However, the percentage of parasitised *D.indica* larva varied significantly and the maximum was in control indicating that treatments especially chemical pesticides reduced parasite incidence.

During the second season, the need based treatments T_2 and T_3 were applied.

Nine weeks after sowing

The pests observed during both the seasons were *H.phycitis*, *D.indica* and *B.cucurbitae*. NSO (3 per cent) plus dimethoate 0.025 per cent treatment (T_7) recorded the lowest count of jassid during both the seasons and in general, the population per leaf was higher in the second season. The leaf, flower and fruit damage by *D.indica* was lower in vines receiving neem indicating its antifeedant effect. The percentage of fruits infested by fruit fly varied significantly during first season though not significant the second season. The fruit fly catch during the week considerably reduced the damage in fruits in the respective plots. There was variation in the total fruitset in the different plots. The percentage of vines infested by mosaic was less in the plots receiving botanical (neem) application alone or in combination with chemical pesticides. This revealed the ability of neem to suppress mosaic.

Regarding the natural enemy incidence, the number of spiders per vine was low in both seasons. However, the number of parasitised *D.indica* larvae vine^{-1} was higher in season one compared to season two.

As the incidence of *D.indica* and *B.cucurbitae* was observed, a need based application of all treatments, T_2 to T_9 was applied nine weeks after sowing during both the seasons.

Ten weeks after sowing

H.phycitis, D.indica, and *B.cucurbitae* were encountered during both the seasons. The jassid population differed significantly among treatments and the treatments in general controlled the jassids. Similarly the application of treatments controlled *D.indica* attack on leaves (season one) as well as on flowers and fruits (season one and two). The fruit fly damage was also checked by the need based treatments (T_2 to T_9) in combination with bait traps.

The percentage of parasitised *D.indica* larvae was lower in treatment applied (T_2 to T_9) plots. Similarly the spider count was higher in control and botanical (neem) alone plots indicating the compatibility of neem with predators.

Eleven weeks after sowing

The counts indicated that treatments applied kept under check *H.phycitis* as well as *B.cucurbitae* during both the seasons. The damage on flowers and fruits were seen during the second season. The fruit fly damage to fruit could not be completely prevented by bagging. Nine to 15 per cent damage were observed in bagged fruits (T_1).

Spider fauna per vine was in general low in both seasons. Similarly the incidence of parasite *A. taragamae* on *D.indica* was also low during the second season.

Twelve weeks after sowing

H.phycitis count was low though significant among treatments during both seasons. The damage by *B.cucurbitae* and catches of fruit fly adults in the traps had also decreased as the total fruit set had reduced. In the first season, the crop had ceased to bear fruits. The spiders were observed in very low numbers during the second season.

Thirteen weeks after sowing

B.cucurbitae damage and catch of adult tephritids was reduced as the fruit production had declined. *H.phycitis* was also observed. Spider count per vine was also low. The last observation on fruit fly incidence taken at fourteen weeks after sowing indicated a very low incidence of the pest.

Highlights of the pest management trial

The occurrence of the different pests in bitter gourd and the time of application of the need based treatments during first season and second season are given in Tables 57 and 58 respectively. The pest encountered were the jassid, American serpentine leaf miner, yellow mite, aphid, epilachna beetle, leaf, flower and fruit feeder and the fruit fly. Among these, the most important were the leaf, flower and fruit feeder *D.indica* and the fruit fly *B.cucurbitae*.

Table 57. Pest incidence and need based treatments in Pest Management Trial (Season I - 1996)

WAS	Pests	Treatments given (need based)
3	Jassid, stem gall fly	
4	Jassid, stem gall fly, ASLM	T_1 to T_9
5	Jassid, stem gall fly, ASLM, epilachna, aphid	T_2 & T_3
6	Jassid, aphid, leaf feeder, mite	T_1 to T_9, Indofil - M-45 (all plots)
7	Jassid, leaf feeder, mite	T_1 to T_9, Banana / ocimum trap
8	Jassid, leaf feeder, fruit fly	
9	Jassid, leaf feeder, fruit fly	T_2 to T_9
10	Jassid, leaf feeder, fruit fly	
11	Jassid, fruit fly	
12	Jassid, fruit fly	

Table 58. Pest incidence and need based treatments in Pest Management Trial (Season II - 1997)

WAS	Pests	Treatments given (need based)
3	Jassid, stem gall fly, ASLM	T_2 & T_3
4	Jassid, aphid, stem gall fly, ASLM	T_1 to T_9
5	Jassid, aphid, stem gall fly, ASLM	
6	Jassid, aphid	T_1 to T_9
7	Jassid, leaf feeder, fruit fly	T_1, T_5, T_6 and T_9 Indofil M-45 (all plots) Banana / ocimum trap
8	Jassid, leaf feeder, fruit fly, pumpkin beetle	T_2 & T_3
9	Jassid, leaf feeder, fruit fly	T_2 to T_9
10	Jassid, leaf feeder, fruit fly	
11	Jassid, leaf feeder, fruit fly	T_2 to T_9
12	Jassid, fruit fly	
13	Jassid, fruit fly	
14	Fruit fly	

Among the treatments, the botanical with chemical pesticide combinations were the most effective in combating the pests of bitter gourd. The antifeedant and other effects of neem coupled with the toxic effect of chemical pesticides were more lethal to the pest than their individual effects. The botanicals also exhibited mosaic suppressive and fungicidal properties.

Bagging of fruits *viz.*, T_1 treatment did not offer much protection against *D.indica* larvae. The fruit fly damage was also observed in the bagged fruits during the fruiting season. Jalaja (1989) opined that polythene bagging of bitter gourd fruits offered cent per cent protection against fruit fly and was economical. The present studies indicated that bagging was an uneconomic proposition especially in commercial cultivation and this agreed with the findings of Batra (1954).

Apart from the effect of banana / ocimum traps, the reduction of damage by fruit fly in plots receiving NSO or nimbecidine was also observed. This was due to their ovipositional deterrent effect. This agreed with the findings of Singh and Srivastava (1983) and Sojitra and Patel (1992).

The incidence of natural enemies of pests was in general low. The natural enemies of pests were in higher numbers in plots receiving botanicals alone and control. The treatments having chemical pesticide alone or chemical pesticides with botanical combination were in general unfavourable to the natural enemies. Among the spider predators, more of hunting type than web spinners were observed especially in the insecticide treated vines. This could be due to the possibility of webs collecting the pesticide spray resulting in death of web spinners. Similar observations were made by Samu *et al.* (1992).

Yield of bitter gourd fruits

The yield among the different treatments during both the seasons is presented in Fig. 8. During the first season (Table 41), the number and yield of fruits recorded from the eighth to twelfth week after sowing indicated the highest yield during the tenth week. The highest yield of 12987.50 kg ha^{-1} was realised from T_7. This was on par with T_5. The highest cost : benefit ratio was realised in T_5 (1 : 6.34) followed by T_7 (1 : 6.07).

During the second season (Table 53 and 54) more number and higher yield of fruits were recorded from the seventh to fourteenth weeks after sowing compared to season one. The yield was the highest (17037.50 kg ha^{-1}) in T_7 and it was on par with T_6, T_4 and T_8. Jalaja (1989) obtained an yield of 10762 kg ha^{-1} of bitter gourd fruits by mechanical protection and trapping of adult fruit fly. Yield of 20 t ha^{-1} of bitter gourd fruits was obtained from the variety Punjab 14 (Thakur *et al.*, 1994). The cost : benefit ratio was highest in T_7 (1 : 8.57) followed by T_4 (1 : 7.82). T_6 (NSO and carbaryl combination) gave lower cost benefit ratio inspite of good yield. This was because of the high cost of carbaryl.

The results of the two seasons thus showed that combination of NSO three per cent soap emulsion and dimethoate 0.025 per cent drench at seeding (T_7) plus need based application and banana / ocimum trap at fruit set till final harvest was the best treatment. The effectiveness of combinations of botanicals and chemical insecticides against vegetable pest has been discussed by Sarode and Gabhane (1988), Rahman (1990), Venkateswara Rao and Rosaiah (1993) and Datta (1996). The second best was NSO three per cent soap emulsion and carbaryl 0.075 per cent combination. Mote (1975) reported that carbaryl 0.10

TREATMENTS (Fig. 8)

T_1	Chlorpyriphos 0.05 % soil drench	+	Dimethoate 0.05 % need based (upto fruit set)	+	Mechanical control after fruit set
T_2	Neem seed oil 3.00% soap emulsion soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_3	Nimbecidine 0.40% soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_4	Carbaryl 0.15% soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_5	Dimethoate 0.05 % soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_6	Combination of T_2 + half dose of T_4 soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_7	Combination of T_2 + half dose of T_5 soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_8	Combination of T_3 + half dose of T_4 soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_9	Combination of T_3 + half dose of T_5 soil drench	+	Need based application of same	+	Banana fruit / ocimum trap
T_{10}	Control				

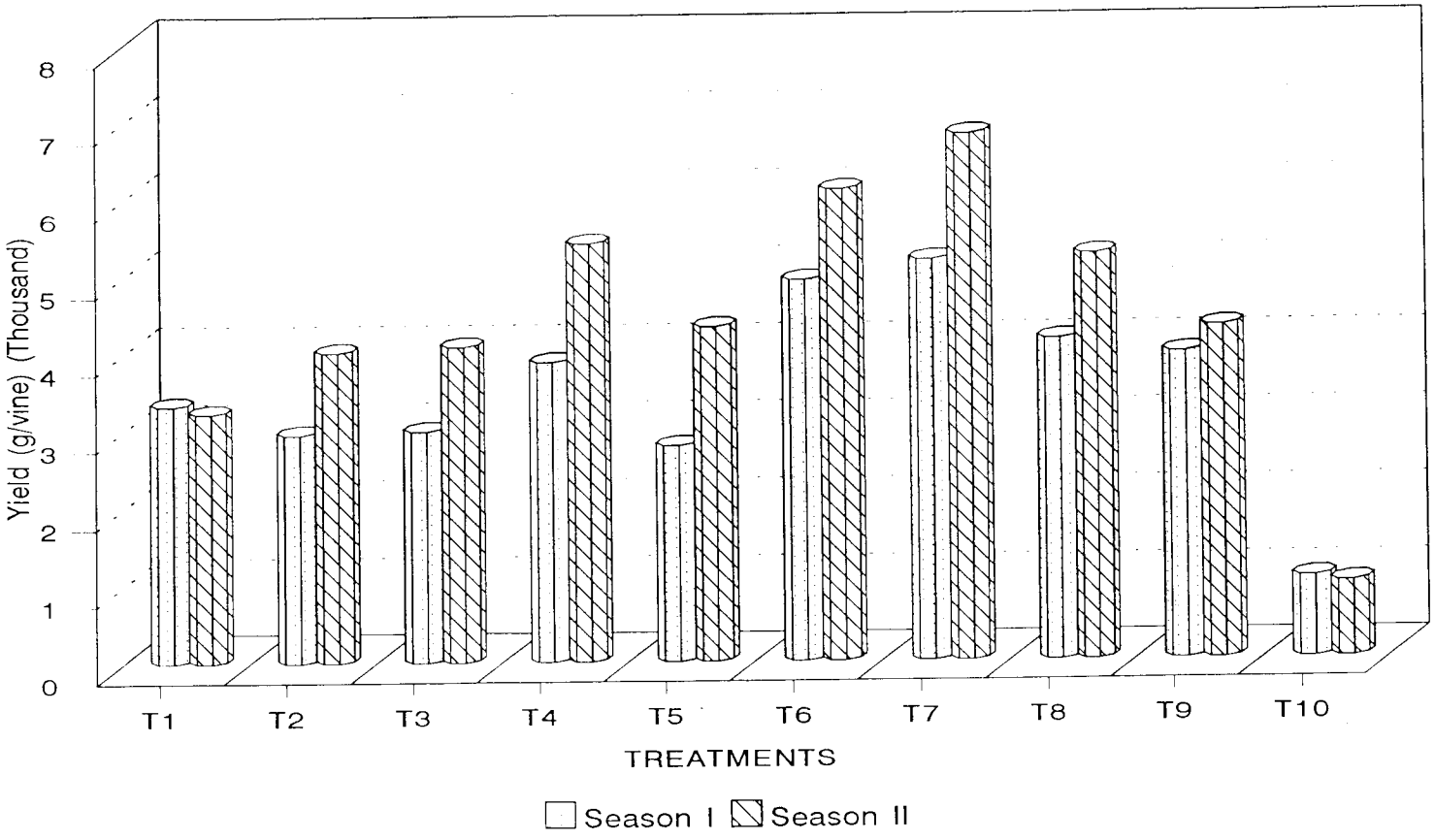


Fig. 8. Yield of bitter gourd in pest management trial during two seasons (1996 and 1997)

per cent gave the highest yield of bitter gourd. However, it could be recommended only till the first fruit set as use of carbaryl after flowering has been restricted. However situations like the outbreak of *D.indica* warrant the use of pesticides like carbaryl.

The advantage of applying neem along with chemical pesticide against a target pest is that the antifeedant action of neem is likely to inhibit the feeding of the pest which would make it more susceptible to the toxic action of the chemical pesticide. The potentiating effect of neem on pesticides was reported by Singh and Singh (1987).

The results obtained from the present investigation established the propriety of using a combination of botanical and chemical pesticide in managing the pests of bitter gourd. The desirability of using botanicals in vegetables has by now gained acceptance. Based on the findings of the investigation, the following information could be recommended in IPM strategies in bitter gourd.

1. Use healthy seeds of bitter gourd variety 'Preethi' (MC-84) for planting

2. Basal drenching of combination of neem seed oil soap emulsion (NSO) three per cent plus dimethoate 0.025 per cent or NSO three per cent plus carbaryl 0.075 per cent prior to seeding. This can be recommended in areas where pumpkin beetles are endemic.

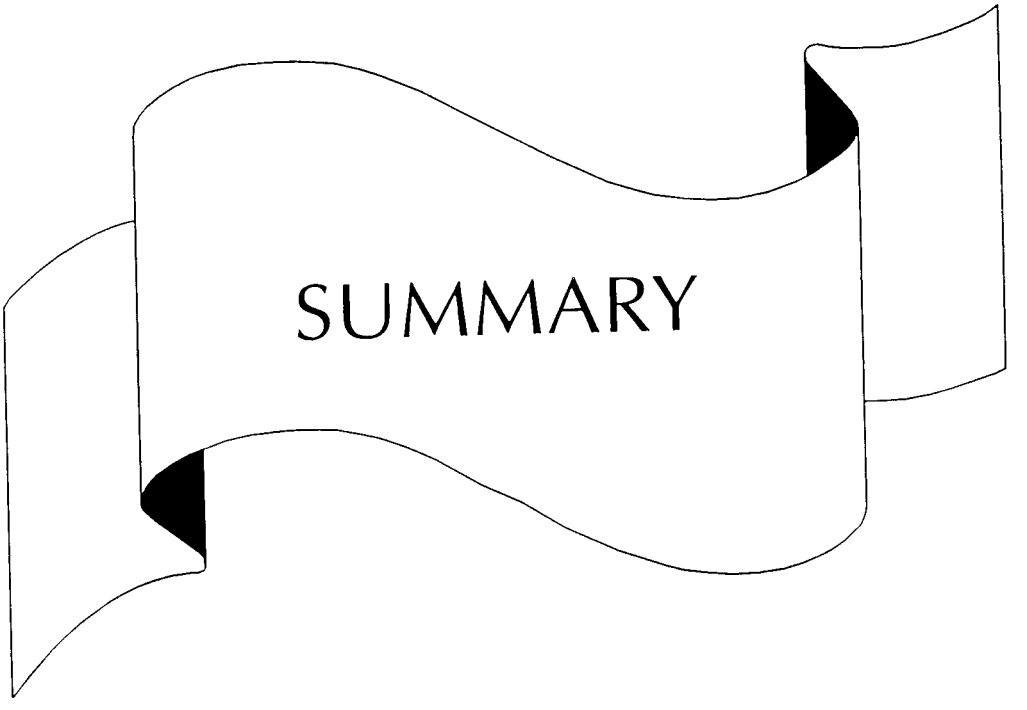
3. Inspect for incidence for pests and their natural enemies. Remove pest stages wherever possible. Need based application of above combination of botanical and chemical pesticides till fruitset to control pests like *H.septima*, *D.indica* *L.trifolii* and *N.falcata*. Spray the lower surface of leaves to control sucking pests like *A.gossypii*, *H.phycitis* and *P.latus*.

4. Plants exhibiting mosaic should be removed and destroyed. Collect and destroy diseased parts like leaves. Apply fungicide - Mancozeb to control foliar disease like downy mildew.

5. Monitor incidence of *B.cucurbitae* by using lure trap (eg. Biosense stikatrap). Set traps at 50 days after sowing of seed. One coconut shell trap (painted yellow) with ripe banana (Palayankodan) smeared with carbofuran granules is to be placed alternately with a shell trap containing crushed *O.sanctum* leaves plus jaggery and carbofuran, each in the centre of four vines. Traps are spaced at two metres and replenished once in seven days till final harvest. Remove and destroy infested fruits.

6. After fruitset, it is advisable to avoid the use of chemical pesticides. Harvest mature fruits before application of pesticides. Apply (need based) a combination of neem seed oil three per cent soap emulsion and dimethoate 0.025 per cent. Follow the waiting period for harvest of fruits.

The future line of work could include the screening of pesticides of botanical origin and their combination with chemicals for their efficacy against pests. Various types of traps and poison baits to capture pests of bitter gourd like *D.indica* have to be designed. Another aspect is to develop techniques for the mass multiplication and release of effective natural enemies like *M.sexmaculatus*.


SUMMARY

SUMMARY

Studies were conducted in 1995-1996 to monitor the incidence of pests, their parasites and predators in bitter gourd, evaluate the methods of plant protection, find out the sources of information on plant protection and identify the constraints in cultivation of bitter gourd among one hundred farmers in Kalliyoor, Venganoor and Sreekaryam panchayats of Thiruvananthapuram district. Laboratory experiments were conducted to assess the efficacy of parasites and predators on the pests of bitter gourd, study the effect of chemical pesticides and botanicals on the pests of bitter gourd and their parasites and predators. The reaction of five bitter gourd varieties to pests was studied in a field experiment in the Instructional Farm, Vellayani. Based on the results of the above experiments, a pest management trial was conducted during two seasons (from January to April of 1996 and 1997).

The results are summarised

The highlights of the socio-economic characteristics of the farmers were

1. Thirty nine per cent of the farmers were able to read and write

2. Seventy two per cent of the farmers were between 31 and 50 age group

3. Forty one per cent declared incomes between Rs. 6001 to Rs. 10,000 while twenty six per cent had an annual income between Rs. 10,001 to Rs, 15,000 per annum

4. KAU varieties were adopted only by seven per cent of the farmers

5. Recommended spacing (2m x 2m) was followed by 92 per cent of the farmers

6. Ninety three per cent of the farmers cultivated the crop in wetland

7. Sixty eight per cent of farmers took land on lease paying different rates of rent

8. Eighty per cent of farmers applied organic manures and fertilizers higher than the recommended rate.

The major pests in bitter gourd at flowering were the jassid (*H. phycitis*) and the leaf feeder (*D. indica*) whereas,at early harvest the jassid and fruit fly (*B.cucurbitae*) incidence was the highest. The other pests recorded were stem gall fly (*N. falcata*), epilachna beetle (*H. septima*), aphid (*A. gossypii*), yellow mite (*P. latus*) and American serpentine leaf miner (*L. trifolii*). Mosaic incidence was severe in twelve per cent of the fields. The distribution of natural enemies of the pests was in general, low and included spiders, predatory insects and parasites. The important natural enemies in Thiruvananthapuram district were

a) *C. johnsoni* - larval/pupal parasite on *H. septima*

b) *I. scutellare* - syrphid predator on *A. gossypii*

c) *M. sexmaculatus* - coccinellid predator on *A. gossypii*

d) *S. nubilis* - coccinellid predator on *A. gossypii*

With regard to the plant protection measures, 62 per cent adopted a combination of mechanical, cultural and chemical measures. Use of insecticides was the most important control tactic. The most commonly used insecticides were monocrotophos, dimethoate, quinalphos and methyl parathion. Ninety five per cent of farmers used pesticides at higher than recommended doses. Fifty to sixty per cent applied pesticides at regular intervals between 6 to 10 days whereas, less than 10 per cent used pesticides need based. Waiting period was followed by only five per cent of the farmers.

Seventy per cent of farmers relied mostly on mass media and interpersonal cosmopolites for information on plant protection. The most important constraint perceived by the farmers in bitter gourd cultivation was the high cost of inputs, followed by the high rate of lease rent.

Monitoring of the male fruit fly using the Biosense stikatrap (Lure) in six locations revealed that maximum catch was during the eleventh week after sowing coinciding with the peak harvest of fruits. Ten carbofuran smeared banana fruit traps (in yellow coloured coconut shells) were more efficient and low cost compared to one Biosense trap in trapping fruitflies in 80 m^2 area.

Studies on the seasonal incidence of pests and their natural enemies in relation to climate from July 1995 to June 1996 indicated that the increase of pests and enemies were more from November 1995 to April 1996.

Correlation studies indicated that the pest and natural enemy incidence in general were positively correlated to maximum temperature and negatively

correlated to minimum temperature, relative humidity, rainfall and number of rainy days; the exception being the incidence of epilachna beetle and its natural enemies. The correlation coefficients might change from season to season due to the variations in the effects of different biotic and abiotic factors on the pests.

Studies on the biology of the parasite *C.johnsoni* on *H.septima* indicated that the life cycle from egg to adult ranged from 13 to 17 days. The mean number of parasites emerging from one host grub and host pupa was 17.45 and 17.10 respectively. The ratio of the progeny emerging from a single mated female was 4.50 females per male. Studies on the life cycle of the insect predators showed that *I.scutellare*, *M.sexmaculatus* and *S.nubilis* had a life cycle of 13.30, 15.35 and 18.20 days respectively. The syrphid maggot of *I.scutellare* consumed an average of 406 aphids whereas the grub and the adult *M.sexmaculatus* consumed an average of 184 and 824 aphids respectively. Thus *M.sexmaculatus* was observed to be more promising than *I.scutellare*. *S.nubilis* had a lesser feeding potential.

Experiments conducted to determine the antifeedant effect of botanicals against the third instar *H.septima* grubs showed that neem seed oil four per cent, nimbecidine 0.40 per cent and neem seed oil three per cent afforded bitter gourd leaf protection of 88.61, 88.59 and 80.26 per cent respectively after 48 hours. The corresponding larval starvation percentages were 83.39, 77.95 and 76.66 respectively. Neem seed oil three per cent and nimbecidine 0.40 per cent were selected for further experiments.

Studies to test the efficacy of chemical pesticides against fourth instar *H.septima* grubs indicated that carbaryl and dimethoate were more persistent and effective than quinalphos and malathion.

In another experiment, botanicals were observed to be safe to *C.johnsoni* except the doses of neem seed oil 4.00 per cent, 3.00 per cent and nimbecidine 0.40 per cent (mortality 7.04, 3.33 and 3.70 per cent respectively 24 hours after exposure). The percentage of parasite adult emergence from treated parasitised *H.septima* grub and pupa ranged from 63.28 to 80.35 and 63.56 to 79.26 respectively whereas in control (untreated) host grub and pupa, the mean percentage emergence was 81.26 and 81.05 respectively. In general, the application of botanicals on parasitised host *H.septima* grubs and pupae did not seriously affect the emergence of *C.johnsoni*. Chemical pesticide application affected the emergence of *C.johnsoni* from *H.septima* grub and pupa. Among the pesticides tested, emergence of *C.johnsoni* in dimethoate treatments was the highest and ranged from 50.31 to 63.64 per cent and 50.77 to 62.25 per cent in host grub and pupa respectively.

When selected botanicals were tested against third instar grubs of *M.sexmaculatus*, they were safe except neem seed oil 4.00 per cent (1.28 per cent mortality 48 hours after exposure). Selected chemical pesticides were found to be toxic to the third instar grubs of *M.sexmaculatus* (mortality range 58.83 to 75.30 per cent 12 hours after exposure). The same trend was observed 24 and 48 hours after exposure. Dimethoate was observed to be the least toxic to the grubs of the predator.

Neem seed oil 3.00 per cent, nimbecidine 0.40 per cent, carbaryl 0.15 per cent and dimethoate 0.05 per cent were selected for the pest management trial.

The reaction of five bitter gourd *viz.*, Priya, Arka Harit, Preethi, Priyanka and Local to pests were studied in a field experiment. The intensity score obtained by the varieties to the pests *viz.*, American serpentine leaf miner, epilachna beetle, jassid, stem gall fly, yellow mite, leaf and flower feeder and fruit fly were 50, 16, 46, 49 and 50 for Priya, Arka Harit, Preethi, Priyanka and Local respectively. As Arka Harit did not fruit, Preethi which gave the maximum yield of fruits was selected for the pest management trial.

A pest management trial was conducted for two seasons (1996 and 1997). The results indicated that the combination of neem seed oil 3.00 per cent soap emulsion (NSO) with dimethoate 0.025 per cent drench at seeding with need based application of same and poisoned banana / ocimum trap (from fruit set till final harvest) was effective against bitter gourd and gave maximum yield. The yield was 12987 kg ha^{-1} and 17037.50 kg ha^{-1} during the first and second season respectively. The corresponding cost : benefit ratios were 1 : 6.07 and 1 : 8.57 respectively. NSO 3.00 per cent and carbaryl 0.075 per cent combination was effective and could be recommended till fruit set.

Bagging of fruits did not offer much protection against *D. indica*. Installation of banana / ocimum traps 50 days after sowing till final harvest was effective in trapping fruit fly adults.

The incidence of natural enemies of pests was in general low in the treatments involving chemical pesticides.

Based on the results of the investigations, the following findings could be recommended as part of IPM strategies in bitter gourd.

1. Use bitter gourd variety 'Preethi'.

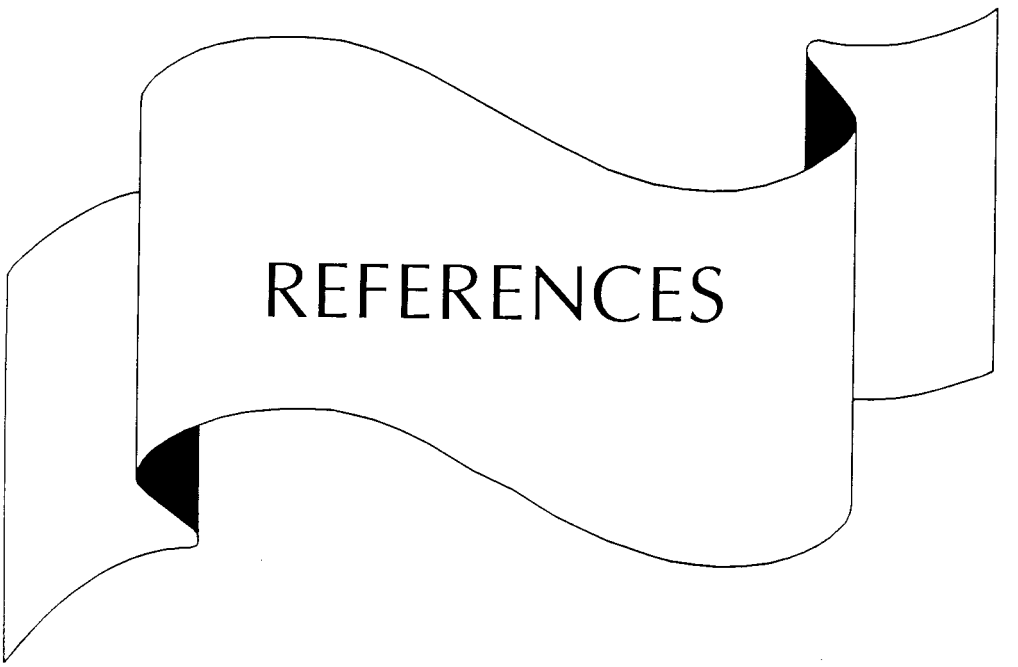
2. Basal drenching of combination of NSO 3.00 per cent with either dimethoate 0.025 per cent or carbaryl 0.075 per cent prior to seeding. This is recommended in areas where pests like pumpkin beetles are endemic.

3. Need based application of the above treatments till fruit set to control stem gall fly, leaf feeder and leaf miner. Spray the lower surface of leaves to control aphids, jassids and mites.

4. Use fungicide (Mancozeb) against foliar diseases (downy mildew)

5. Monitor fruit fly incidence by using lure trap. At 50 days after sowing, set yellow coloured coconut shell trap containing carbofuran smeared banana fruit (Palayankodan) alternated with carbofuran poisoned ocimum - jaggery trap at 2.00 m spacing. Continue trapping till final harvest and replenish traps once in seven days.

6. After fruit set, need based application of a combination of NSO 3.00 per cent and dimethoate 0.025 per cent is recommended.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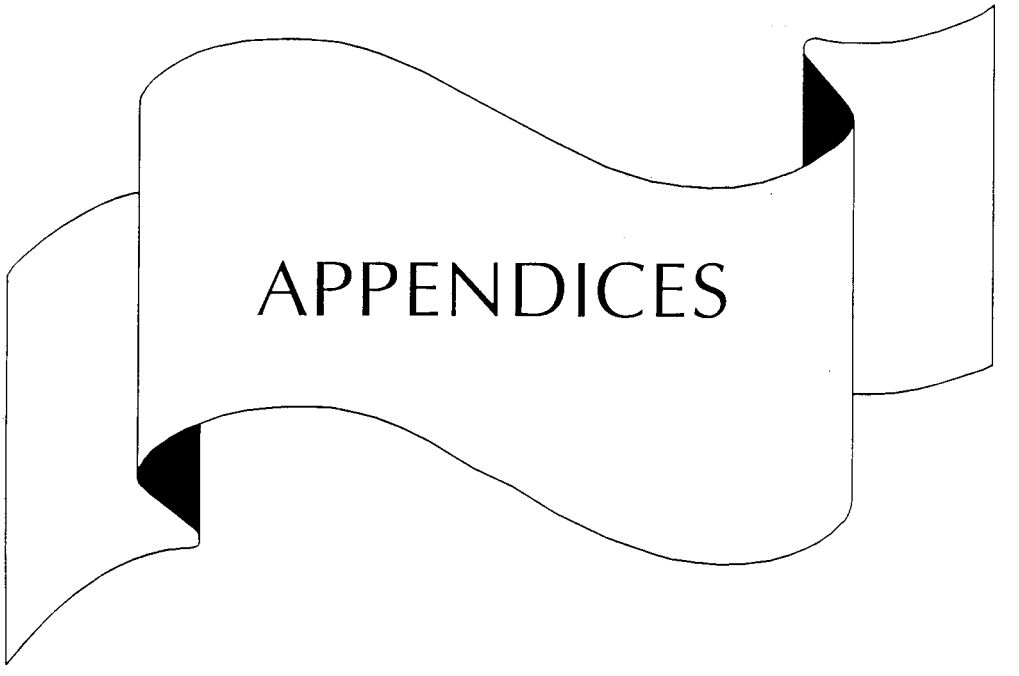
APPENDICES

APPENDIX - I

SURVEY OF BITTER GOURD CULTIVATION IN THIRUVANANTHAPURAM DISTRICT (FARMERS' FIELDS)

1. Location (Panchayat) :
2. Stage of the crop (weeks after planting) :
3. Name of the Farmer :
4. Address :
5. Age (in completed years) :
6. Education :
7. Size of holding (ha are)

Income

8. a. Main occupation :
   b. Subsidiary occupation :
9. Whether
   a. Own land :
   b. On lease and rate :
   c. Soil type :
10. Whether wetland or garden land :
    a. Variety used :
    b. Source of seed :
11. Method of cultivation (spacing) :
12. Details of organic manures used :

Name	Dose	Time of application (stage of crop)
a) Cowdung		
b) Green leaves		
c) Compost		
d) Others		

13. Details of chemical fertilizers used : Yes / No

Name	Dose	Time of application (stage of crop)
a) Urea		
b) Superphosphate		
c) M. Rock phosphate		
d) MOP		
e) Others		
f) Mixtures		
g) Complex - 17:17:17		

14. Incidence of pests, their predators and parasites

a) Pests of bitter gourd

Name	Intensity			
	Absent	Low	Medium	High

b) Details of disease of bitter gourd :

c) Details of parasites if any :

d) Details of predators in any :

15. Details of plant protection measures adopted

Do you adopt plant protection measures : Yes / No

If Yes, give details

a. Collection and destruction of pests / damaged parts : Yes / No

b. Mechanical protection of fruits, trapping etc. : Yes / No

c. Raking the soil at the base : Yes / No

d. Use of chemical pesticides : Yes / No

Name of pest	Chemical	Dose	Interval of application

e. Any other method

f. Waiting period followed : Yes / No

16. How do you get the information for the following

Particulars	Information source								
	Own experience	*Mass media		**Interpersonal cosmopolite			***Interpersonal localite		
		a	b	c	a	b	c	a	b	c
1. Identification of pest									
2. Criteria for adoption of plant protection measures (extent of damage)									
3. Preparation of spray dilution of pesticides									
4. Awareness of insecticide residue problems and contamination									
5. Others (if any)									

*a) Radio
b) TV
c) News Paper

**a) Agrl. Demonstrator
b) Agrl. Officer
c) KAU Scientist

***a) Friends
b) Relatives
c) Neighbours
d) Others

17. Expected income from area cultivated

18. Constraints in obtaining reasonable returns from crop cultivation (Give grade based on importance) **Grade**

1. High rent on leased land
2. Non-availability of pp chemicals in time
3. High cost of plant protection chemicals / fertilizers
4. Lack of irrigation facilities
5. Lack of drainage
6. High cost of labour
7. Uneconomical holding size
8. Lack of proper guidance
9. Not aware of correct dose of chemicals and fertilizers
10. Non-availability of skilled labour
11. Others if any

19. Any other information on pesticide / fertilizer use

APPENDIX II

I. Level of mosaic infestation in bitter gourd fields

Sl. No.	Category	Flowering		Pre harvest	
		Frequency	Percentage	Frequency	Percentage
1	None	70	70	24	24
2	Low	29	29	58	58
3	Medium	1	1	6	6
4	High	0	0	12	12
	Total	100	100	100	100

II. Plant protection measures adopted by bitter gourd farmers

Sl. No.	Category	Frequency	Percentage
a. Plant protection measures adopted			
1	Chemical only	8	8
2	Cultural and chemical	30	30
3	Mechanical, cultural and chemical	62	62
	Total	100	100
b. Usage of carbofuran by bitter gourd farmers			
1	Use carbofuran	17	17
2	Do not use carbofuran	83	83
	Total	100	100
c. Class of pesticides used (based on mode of action)			
1	Contact	8	8
2	Systemic	23	23
3	Contact and systemic	69	69
	Total	100	100

Sl. No.	Category	Frequency	Percentage
d. Dose of pesticides used			
1	Recommended dose	5	5
2	Higher than recommended dose	95	95
	Total	100	100

e. Interval between application of pesticides

Sl. No.	Category	Upto flowering		After flowering	
		Frequency	Percentage	Frequency	Percentage
1	< 5 days	12	12	35	35
2	6 - 10 days	48	48	59	59
3	> 10 days	30	30	2	2
4	Need based	10	10	4	4
	Total	100	100	100	100

Sl. No.	Category	Frequency	Percentage
f. Observation of waiting period			
1	Waiting period followed	5	5
2	Waiting period not followed	95	95
	Total	100	100

III. Expected income from bitter gourd cultivation (per cent of land)

1	Loss	18	18
2	Upto Rs. 50/-	5	5
3	Rs. 51/- to Rs. 100/-	41	41
4	Rs. 101/- to Rs. 150/-	33	33
5	Above Rs. 151/-	3	3
	Total	100	100

APPENDIX - III

Weather parameters

Period	Temperature (°C)		Relative Humidity (%)	Total rainfall (mm)	Number of rainy days
	Maximum	Minimum			
July 1995 - I	24.33	23.79	80.13	45.60	7
July 1995 - II	28.45	24.02	84.09	98.10	5
August 1995 - I	28.15	24.27	82.96	5.25	3
August 1995 - II	28.02	23.88	84.34	53.44	8
September 1995 - I	28.86	23.94	88.43	19.65	7
September 1995 - II	29.03	24.15	84.67	63.75	6
October 1995 - I	27.79	22.99	76.83	51.75	6
October 1995 - II	29.00	24.02	78.82	51.75	6
November 1995 - I	26.73	22.13	83.23	227.40	11
November 1995 - II	28.24	23.13	79.40	19.95	14
December 1995 - I	30.15	20.65	76.57	58.05	6
December 1995 - II	29.62	19.94	69.16	40.48	4
January 1996 - I	31.77	20.52	75.27	0.00	0
January 1996 - II	30.90	19.63	70.84	8.00	2
February 1996 - I	31.79	20.47	70.47	3.75	1
February 1996 - II	31.83	21.19	73.26	15.54	2
March 1996 - I	32.15	19.75	67.27	0.00	0
March 1996 - II	33.26	22.93	73.20	0.00	0
April 1996 - I	33.65	23.23	81.10	29.25	4
April 1996 - II	32.23	23.19	78.08	4.80	2
May 1996 - I	31.24	24.32	73.20	3.00	2
May 1996 - II	31.84	23.58	74.31	48.00	4
June 1996 - I	30.75	22.13	79.63	125.55	10
June 1996 - II	28.73	22.01	82.83	132.60	6

APPENDIX IV

Correlation between pests of bitter gourd and their natural enemies

Parameters			'r' value
1. Percentage of shoots infested by stem gall fly	x	No. of parasitised gall fly maggots per vine	0.2879
2. Epilachna grub count per leaf	x	Percentage of parasitised epilachna grubs	0.9693
3. Epilachna grub count per leaf	x	Percentage of parasitised epilachna pupae	0.9360
4. No. of aphids per leaf	x	Coccinellid predator grubs per leaf	0.9299
5. No. of aphids per leaf	x	Syrphid predator maggots per leaf	0.9570
6. No. of jassids per leaf	x	No. of spiders per vine	-0.2817
7. No. of epilachna grubs per leaf	x	No. of spiders per vine	0.5189
8. No. of aphids per leaf	x	No. of spiders per vine	0.4897
9. No. of mites per leaf	x	No. of spiders per vine	0.2948
10. No. of mites per leaf	x	No. of thrips predators per leaf	0.9746

MONITORING AND MANAGEMENT OF THE PEST COMPLEX OF BITTER GOURD

(Momordica charantia L.*)*

BY

NANDAKUMAR C.

ABSTRACT OF THE THESIS

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COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

Surveys were conducted in 1995-96 among one hundred bitter gourd farmers in Thiruvananthapuram district. Information on the personal and socio-economic characteristics of the farmers was gathered. Field visits indicated that among the pests at flowering, the jassid, *H.phycitis* and leaf feeder, *D.indica* were important. At early harvest, the jassid and fruitfly *B.cucurbitae* were the major pests. Among the natural enemies observed, the potential ones were *C.johnsoni* (parasite on *H.septima*), *I.scutellare*, *M.sexmaculatus* and *S.nubilis* (predators on *A.gossypii*).

Mosaic was severe in 12 per cent of the plots. Sixty two per cent of the farmers used a combination of mechanical, cultural and chemical measures against pests. Most common pesticides used belonged to the organophosphate group. Farmers in general adopted injudicious methods of chemical control. Seventy per cent farmers relied on mass media and interpersonal cosmopolites for information on plant protection. The most important constraint perceived by farmers was the high cost of inputs *viz.*, plant protection chemicals, manures and fertilizers.

Monitoring of fruit fly incidence using Biosense stikatrap (lure) indicated the maximum catch at eleven weeks after sowing. Ten carbofuran smeared banana fruit traps (in yellow coloured coconut shell) were found to be more efficient than one Biosense trap in trapping the fruit fly.

Studies on seasonal incidence of the pests and their natural enemies from 1995 to 1996 indicated that they were more from November '95 to April '96.

In studies on the assessment of potential natural enemies of pests, the biology and efficacy of *C.johnsoni* against epilachna beetle was observed. Among the predators *viz.*, *I.scutellare*, *M.sexmaculatus* and *S.nubilis* whose biology and feeding potential was studied, *M.sexmaculatus* was observed as the most efficient predator of aphids.

In another set of experiments, the effects of botanicals and chemical pesticides on pests and their natural enemies were studied. The antifeedant effect of botanicals on third instar *H.septima* grubs indicated that neem seed oil (three per cent) and nimbecidine (0.40 per cent) were effective. Estimation of the comparative effect of chemical pesticides against the fourth instar *H.septima* grubs showed that carbaryl and dimethoate were more effective than quinalphos and malathion. Toxicity studies of botanicals and chemical pesticides to *M.sexmaculatus* grubs and *C.johnsoni* adults as well as parasite emergence from treated larval / pupal *H.septima* hosts indicated that botanicals were safe whereas, the chemicals were toxic to the natural enemies. Based on the above experiments, the botanicals *viz.*, neem seed oil three per cent, nimbecidine 0.40 per cent and the chemical pesticides,carbaryl 0.15 per cent and dimethoate 0.05 per cent were selected for the pest management trial in bitter gourd.

The reaction of five bitter gourd varieties *viz.*, Priya, Arka Harit, Preethi, Priyanka and local to pests was tested in a field trial. Based on pest infestation and yield, Preethi was selected for the pest management trial.

The pest management trial was conducted for two seasons (January to April, 1996 and 1997). The results indicated that combination of botanical with chemical pesticide was the best in pest control. Based on the results the following recommendations were suggested as part of IPM strategies in bitter gourd.

1. Use variety 'Preethi' (MC-84) for planting

2. Basal drenching of combination of neem seed oil three per cent soap emulsion with either dimethoate (0.025 per cent) or carbaryl (0.075 per cent) prior to seeding. This is recommended in areas where pests like pumpkin beetles are endemic.

3. Need based application of above till fruit set to control pests.

4. Apply fungicide (Mancozeb) to control foliar disease (downy mildew).

5. Monitor fruit fly incidence using lure trap. Set yellow painted coconut shell traps containing carbofuran smeared banana (palayankodan) alternated with carbofuran poisoned ocimum / jaggery (2m spacing) at flowering till final harvest.

6. After fruit set, use (need based) a combination of neem seed oil three per cent soap emulsion and dimethoate 0.025 per cent.