BIOCONTROL OF PESTS OF VEGETABLE COWPEA

(<u>Vigna</u> <u>unguiculata</u> sub sp. <u>sesquipedalis</u> (L.) Verdcourt)

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THESIS

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1997

To the ones I owe my life.......

......Achan & Amma

DECLARATION

I hereby declare that this thesis entitled "Biocontrol of pests of vegetable cowpea Vigna unguiculata sub sp. sesquipedalis (L.) Verdcourt" 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "Biocontrol of pests of vegetable cowpea Vigna unguiculata sub sp. sesquipedalis (L.) Verdcourt" is a record of research work done independently by Miss. BINDU.S.S under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Tim Allen

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INTRODUCTION

1. INTRODUCTION

Vegetable cowpea (*Vigna unguiculata* sub sp. *sesquipedalis* (L.) Verdcourt) has great demand in Kerala due to its high dietary value and is cultivated throughout the year as pure crop in rice fallows and in garden lands. Insect pests viz. pea aphids and pod borers are the major constraints in the productivity of this crop. To tackle these pests, farmers often resort to frequent and massive applications of insecticides even in the pod bearing stage which often culminates in high pesticide residues in the harvested pods which are immediately consumed in domestic markets or exported to gulf countries (Mathew *et al.*, 1995) Unless a sound alternative to the ecologically disruptive pesticides is made available to the growers, a way out of the present situations can never be thought of.

It is now universally recognized that the most effective and acceptable pest management strategies from the point of preservation of environment has biological control as the pivotal concern. Success in applied biological control is often dependent on a thorough understanding of the organisms involved, both injurious and beneficial and their intricate interactions. Basic studies on systematics, biology and ecology of pests and their natural enemies are therefore an integral part of the field of biological control (De Bach, 1964). The control that can be exerted over pests by their natural enemies need to be harnessed and used to its maximum potential in any insect pest management programme. Inevitably the first step in any investigation on the role of natural enemy in pest control involves a field survey to determine the species present and how their numbers vary in relation to those of the insect pests.

Augmentative releases can offer practical alternatives to pesticides in situations where crops are of high value, natural enemies are readily available at competitive prices and guidelines on relative methods, rates and timings are available.

The versatile and voraceous green lace wing, *Chrysoperla carnea* Stephens is being used in pest management programmes in cotton, sunflower, ground nut and fruit crops through augmentative releases. The effectiveness of *C. carnea* in controlling aphids, whiteflies, thrips and mites have been demonstrated (Krishnamoorthy and Mani, 1989; Kalyanasundaram, et al. 1994). The additive advantage of *C. carnea* is that they are tolerant to pesticides (Pree *et al.*, 1989). Commercial insectaries of *C. carnea* are also now available in different parts of Tamil Nadu and Karnataka.

Biocontrol often must be combined with several tactics if economical and effective control is to be achieved While doing so priority is to be given to biocontrol and other tactics considered in terms of their impact on bioagents and their efficiency.

Though parasitoids and predators have been identified from the cowpea ecosystems in Kerala and ecological studies of some of them have been carried out (Sitaraman, 1966; Reji Rani, 1995) their significance in the dynamics of cowpea pest population have not been fully established. The status of biological control of cowpea pests yet remains low.

Keeping the above facts in mind, the present project entitled 'Biocontrol of pests of vegetable cowpea *Vigna unguiculata* sub sp. *sesquipedalis* (L.) Verdcourt was taken up with the following objectives.

(1) To determine the population of insect pests and their natural enemies in the insecticide sprayed and unsprayed ecosystems in vegetable cowpea

(2) To assess the suitability of utilizing *C. carnea* in pest management programmes in vegetable cowpea and

(3) To study the role of botanicals, neem oil emulsion and tobacco decoction and the insecticide malathion individually and in combination with *C. carnea* in the management of pests of vegetable cowpea.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The vegetable cowpea *Vigna unguiculata* sub sp. *sesquipedalis* is prone to attack by an array of insect pests. The literature on pests of cowpea, their natural enemies and control measures and the role of the bioagent *Chrysoperla carnea* Stephens in the management of pests is briefly reviewed below.

2.1 Pests of cowpea and the damage caused by them

2.1.1 Pea aphid

Mathew *et al*. (1971) reported that the pea aphid *Aphis craccivora* Koch. is a serious pest of cowpea in Kerala during dry periods. Gupta and Singh (1981) stated that *A. craccivora* is a widespread pest of cowpea in India and it caused significant damage by feeding on stems, terminal shoots, petioles of seedlings, pods and flowers. They further emphasised that the aphids in the tropical regions are more important as agents in the transmission of viral diseases of cowpea than as direct feeders. Dhuri and Singh (1983) and Attia *et al*. (1986) observed *A. craccivora* as the most damaging species in cowpea from mid May to end of September in India. This aphid was reported as one of the most important pests of cowpea by many other scientists also (Chhabra *et al*., 1983; Ngugi *et al*. 1986; Suh, 1985; Sudharma *et al*., 1987 and Garhwal *et al*., 1994).

Koshy *et al*. (1987) reported an yield loss of 13.34 to 33.89 percentage by the aphids in cowpea. Srikanth and Lakkundi (1988) found that the rate of reproduction of cowpea aphid *A. craccivora* was more in cowpea than in any other pulse crop.

2.1.2 Pod borers

The spotted pod borer *Maruca testulalis* (Geyer) was reported as one of the serious pests of cowpea. (Taylor, 1978; Singh and Van Emden, 1979; Dabrowski *et al*., 1983; Dhuri and Singh, 1983; Ezeuch and Taylor, 1984; Jackai and Daoust, 1986; Ngugi *et al*., 1985; Samalo and Pathaik, 1986 and Suh 1986). Karel (1985) reported that *M. testulalis* larvae were more abundant and injurious to cowpea crop than any other borers and the pod damage caused by them averaged between 13 and 31 per cent; the seed damage averaged to 16 per cent and a total yield loss of 33 to 53 per cent. According to Singh and Allen (1980) and Jackai and Daoust (1986), the yield loss due to *M. testulalis* ranged from 30 to 50 per cent. Koshy *et al*. (1987) reported a loss of 33 to 42 per cent in pods due to the attack of *M. testulalis*. According to Singh and Jackai (1988) this pest is a major limitation to the successful cultivation of cowpea in many countries. Wijayagunasekara and Ranasinghe (1992) and Jaiswal and Patil (1993) reported *M. testulalis* as the most abundant species in cowpea crop. Dreyer *et al*. (1994) observed that 80 per cent of the cowpea plants were attacked by this pest.

Helicoverpa armigera (Hubner) was reported as an established, serious pest of cowpea throughout India (Reed *et al*., 1979; Chhabra *et al*., 1983; Ngugi *et al*., 1985; Mensah, 1988; Kashyap *et al*., 1990).

2.1.3 Pod bugs

The pod sucking bugs pose serious problem in cowpea and the coreids, *Clavigralla tomentosicollis* and *Riptortus dentipes* are the most important species (Mensah, 1988; Ofuya, 1989). Khamala (1978) found that the nymphs and adults of pod bugs attacked young tender pods and shrivelled them. According to Jackai and Daoust (1986), two or more pairs of *C. tomentosicollis* adults per ten plants caused economic yield reduction. Chiang and Jackai (1988) observed that several species of pod sucking bugs in the families of Coreidae, Alydidae and Pentatomidae infested cowpea and caused great economic loss. Among them the most widespread and damaging species were the coreids, *C. tomentosicollis* and *Riptortus* spp. Ngugi *et al*. (1985) found *C. gibbosa* as one of the major pests of cowpea. Suh *et al*. (1986) reported that *C. tomentosicollis* formed about 99 per cent of the pod sucking bugs found on cowpea. Mensah, 1988 identified a number of coreid and pentatomid bugs as the destructive post flowering pests of cowpea. According to Ofuya (1989), a hemipterous bug complex consisting of *C. gibbosa*, *C. tomentosicollis* and *Riptortus* spp. caused 30 per cent yield reduction in cowpea crop.

2.1.4 Leaf miner

Singh and Merrett (1980) reported that the leaf miner *Liriomyza trifolii* (Burgess) caused almost near collapse of cowpea crops. *L. trifolii* was identified as a devastating pest of cowpea (Parrella, 1987; Jones *et al.* 1987; Salamero *et al.*, 1987 and Heinz *et al.*, 1988). Price and Dunstar (1983) found that 50 per cent of the cowpea leaves were mined by a *L. trifolii*..

2.1.5 Thrips

The flower thrips *Megalurothrips sjostedti* - caused an yield loss upto cent per cent in tropical countries (Gupta and Singh, 1981). They also reported another foliage thrips *M. distalis* in India. This pest has been reported as one of the important flowering stage pests of cowpea (Ngugi *et al.*, 1985; Suh, 1986; Mensah, 1988; Ofuya, 1989).

2.2 Natural enemies

2.2.1 Predators

2.2.1.1 Coccinellids

The coccinellid, *Cheilomenes sexmaculatus* (Fabr.) was recorded as a predator of the aphid *A. craccivora*. (Lefroy, 1909; Bagas and Trahan, 1949). Other coccinellid predators reported in the aphid colony were *Scymnus xerampelinus* Muls.

(Lefroy, 1909), *S. quadrillum* (F.), *Brumus scutularis* F., *Adonia variegata* Goze., *S. nubilus* Muls. and *S. gracilis* Motsch. (Kapur, 1942). The presence of *Chilocorus nigritus*, Fabr. in the aphid colony was reported by Khan and Hussain (1965). *Micraspis discolour* F. (Agarwala *et al.*, 1988) and *Brumus* and *Coccinella* sp. (Falerio *et al.*, 1990) were the other aphid predators reported.

Saharia (1980) reported that *Menochilus sexmaculatus* was the most abundant and persistant predator of *A. craccivora* because of its short life cycle, larger population and fairly high feeding potential. The occurrence of *C. rependa*, *Harmonia dinudata* and *S. bisellata* in aphid colonies was also reported by him.

Agarwala and Gosh (1988) reported the occurrence of 30 species of aphidophagous coccinellids in India and this includes *Brumoides scuturalis*, *C. nigritus*, *C. septumpunctata*, *C. transversalis*, *H. octomaculata*, *M. sexmaculatus*, *Pseudoaspidimerus circumflexus*, *S. pyrocheilus*, *S. quadrillum* and *Spitocaria bisellata*.

Parasuraman (1989) found eight species of coccinellids feeding on *A. craccivora* in pulses of which *M. sexmaculatus* and *Scymnus* sp. were dominant constituting 43 per cent and 25 per cent of the total predatory population respectively. Masum and Sardar (1994) conducted field studies on the effect of aphidophagous predator *M. sexmaculatus*. They observed that ten predator larvae consumed on an average 38-40 bean aphids per week. Among a total of 450 to 500 aphids per plant, 96 to 100 per cent control was effected in three weeks. The feeding rate of the adult predatory coccinellid was higher than that of the larvae.

Ofuya (1995a) observed that the population of *A. craccivora* can be considerably reduced by the action of the coccinellid predator *Cheilomenes lunata* (F.).

2.2.1.2 Syrphids

Xanthogramma scutellare Fb. was the most important syrphid predator in Kerala (Sita Raman, 1966). He also observed peak population of these flies during November and March-April.

2.2.1.3 Other predators

Patel and Yadav (1992) from their experiment reported that *H. armigera* was attacked by a predatory mirid *Nesidiocoris tenuis*.

Dicyphus tamaninii preyed on the larvae of the agromyzid *L. trifolii* (Salamero *et al.*, 1987).

2.2.2 Parasitoids

Pandey and Rajendrasingh (1984) and Srivastava and Singh (1988) reported that the braconid *Trioxys indicus* was an important parasitoid of *A. craccivora*. Attia *et al.* (1986) recorded the parasitism by this species of braconid on aphids and reported that the peak parasitism of 10 per cent occurred in June and July. Marullo (1985) reported parasitisation of aphids by *Lysiphlebus fabarum* and *L. testaceipes* (Stray *et al.*, 1987). The braconid *T. indicus* was introduced into Australia from India to control *A. craccivora* (Sandow, 1986).

Singh *et al.* (1987) observed that the parasitoids preferred the third instar nymphs of the aphids. According to Li and Wen (1988), the braconid *Aphidius avenae* parasitized more than eighty individual aphids. Selim *et al.* (1987) reported *A. colemani* and *L. fabarum* as important parasitoids in the aphid colonies. Yumruktepe and Uygun (1994) reported eight species of braconids and two species of Lygaeids from aphid colony. Kamel *et al.* (1994) observed that the aphids were parasitized by *L. confusus*, *A. metricariae*, *Praon volucre* and *T. angelicae*.

Level of parasitisation of *M. testulalis* larvae in cowpea was studied by Don and Pedro (1983). They found that the most commonest parasitoides were *Phanerotoma* sp. and *Braunisia* sp. and their mean level of parasitism was 5.7 to 6.8 per cent.

Lateef and Reddy (1984) in their studies on the parasitoids of *M. testulalis* in ICRISAT observed a maximum of 13.8 per cent parasitism of *M. testulalis* by the braconid

P. hendecasiella. Barrion *et al*. (1987) in their study on the natural enemies of the bean podborer *M. testulalis* in the Philippines recorded the parasitisation of *M. testulalis* by a braconid *Cremnops* sp.

Okeyo *et al*. (1991) revealed the presence of atleast seven parasitoids attacking *M. testualis* on cowpea crop. A pupal endoparasitoid *Antrocephalus* sp. was the most predominant. Parasitoids contributed to 40.65 per cent of the general mortality. Observed parasitism only contributed 3.25 to 3.8 per cent during their experimentation.

Divakar and Pawar (1982) reported ichneumonids, *Campoletis chloridae*, *Eriborus* sp., *Xanthopimpla punctata*; braconids *Bracon hebetor*, *B. greeni*, *Apanteles* sp; bethylid, *Parasierola* sp.; a trichogrammatid, *Trichogramma chilonis* and the tachinids *Eucarcelia illota*, *Palexorista laxa* and *Goniophthalmus halli* as parasitoids of *H. armigera*. Fang *et al*. (1984) observed parasitism of *H. armigera* by the ichneumonid *C. chloridae* and braconid *Microplitis* sp. About 16 to 47.9 per cent mortality of the first instar larvae of *H. armigera* was effected by these parasitoids. Hanumanna *et al*. (1984) observed that the parasitism by *Trichogramma* on *H. armigera* ranged from 88.48 to 98.49 per cent. Ragadhamaiah *et al*. (1984) found out that one day old larvae of *H. armigera* were parasitized by the egg-larval parasite *Chelonus blackburni* (Cameron). In USA and Australia, Nordlund and Lewis (1985) achieved control against *H. armigera* through imported solitary larval parasitoids, *H. demolitor*.

Pawar *et al*. (1985) observed hymenopterous parasites *C. chloridae*, *Enicospilus* sp., *Eriborus argenteopilosus* and *Microchelonus curvimaculatus* and tachinids *Carcelia illota*, *G. halli*, *Sturmiopsis inferans* and *Palexorista solennis* parasitising on *H. armigera*. The extent of parasitization of *H. armigera* was 25-30 per cent by the ichneumonids *C. chloridae* and 15-20 per cent by the tachinid *Peribaea* sp. (Tripathi and Sharma, 1985). Meierrose and Araiyo (1986) noted that the average parasitism by *T. rhenana* and *Telenomus* sp was 80.4 per cent. Sivaprakasam *et al*. (1986) identified the larval parasites, *C. illota* (Curren), *C. chloridae* (Uchida) and *G. halli* (Mensil) as parasites of *H. armigera*. The mean percentage of parasitisation range was 3.3 by *C. illota*, 3.7 per cent by *C. chloridae* and 2.4 per cent by *G. halli*. The natural enemy complex of *H. armigera* consists of *Brachymeria wittei* (Setmitz), *Voria ruralis* (Fallen), *Charops bicolor* (Szepligets), *C. chloridae* (Uchida) (Joginder *et al*., 1990). Eggs of *H. armigera* were parasitized by *Trichogramma*. Yazlovestkii *et al*. (1992) reported *B. hebetor* as an important ectoparasitoid of *H. armigera*. Goven and Efil (1994) identified 25 species of parasitoids from *H. armigera*. They reported a larval mortality of 25 to 48 per cent and a pupal mortality of 27 per cent by the parasitoids. Noori (1994) recorded a parasitism of 24 per cent in mid June and 95 per cent in early June by *B. hebetor* on *H. armigera*. Richter and Zhumanov (1994) observed a tachinid parasite *Goniophthalmus* attacking *H. armigera*. According to Dover *et al.* (1995), *Microplitis demolitor* was a braconid wasp which parasitized the larval stages of *H. armigera*.

Neuenschwander *et al.* (1987) observed the presence of five indigenous eulophids, larval parasitoids and five other rare parasitoids, frequently parasitizing over 90 per cent or the leaf miner *L. trifolii*. They were *Hemiptarsensus semialbielava* (Girault), two *Chrysonotomyia* spp., *Opius dissitus* and *Dialuropsis callichrona*. *Diglyphus intermedius* was a good control agent against *L. trifolii* (Jones *et al.*, 1986). *L. trifolii* was frequently attacked by the parasitoids *D. begini* and the population was kept well below the economic damage (Nucifora and Calabretta, 1986; Heinz *et al.*, 1988).

2.3 Control of cowpea pests

2.3.1 Insecticides

Rajasekaran and Sundara Babu (1984) revealed that endosulfan 0.07 per cent and monocrotophos 0.04 per cent applied at the rate of 500 litres spray fluid per hectare gave the maximum protection against pod borers and pod fly. He also assessed the efficacy of certain insecticides against *A. craccivora* on cowpea. He observed that methyl demeton 0.025

per cent spray was the most effective treatment followed by 0.04 per cent monocrotophos. Endosulfan at 0.07 per cent was the safest insecticide for the coccinellid predator *M. sexmaculatus* followed by 0.04 per cent monocrotophos.

In 1984, Saxena *et al.* reported that when plots were treated with malathion and endosulfan against *M. testulalis*, the insecticide treated plots yielded 30 to 50 per cent higher than that of the untreated plot.

Ke *et al.* (1985) studied the efficacy of organo-chlorine insecticides against the legume pod borer. They found that two or three weekly sprays of Dichlorvos gave effective control of the pest.

Mote and Kadam (1985) reported that malathion 0.05 per cent endosulfan 0.05 per cent and diazinon 0.05 per cent were effective in controlling *H. armigera*. Larval counts of *M. testulalis* on flowers and pods were also lower in plots treated with insecticides.

Jackai and Singh (1986) tested 20 insecticides against pests of cowpea. The effect of almost all the insecticides were on par in controlling the pest; yields were increased 5 to 8 fold in the insecticide treated plots.

Sudharma *et al.* (1987) reported that malathion 0.05 per cent applied on need basis was the best treatment among the various insecticides for the control of cowpea aphids.

Bhat *et al.* (1988) recorded that the pest incidence was lowest and the grain yield highest in cowpea plots treated with monocrotophos at 250 ml per hectare. Chauhan *et al.* (1988) observed that monocrotophos 0.04 per cent and malathion 0.05 per cent were effective against *A. craccivora* attacking cowpea crop. They recommended that malathion 0.05 per cent application should be repeated at 7 days intervals.

Dino (1988) conducted experiments to study the application timings for the control of insect pests of cowpea. Deltamethrin at 12.5 g ai per hectare and cypermethrin at 50 g ai per hectare were the insecticides used. For both the insecticides, the yield loss increased as the interval between the last sprays increased.

According to Kashyap *et al.* (1990), malathion and monocrotophos were the least toxic compounds, when sprayed against the neonate larvae of *H. armigera*.

According to El-Ghar *et al.* (1994) three days after the application of malathion, the population of *A. craccivora* reduced considerably.

Garhwal *et al.* (1994) reported that methyl demeton 0.02 per cent was found to be the most effective insecticide in controlling the cowpea aphid, *A. craccivora*.

2.3.2 Botanicals

2.3.2.1 Neem

Saxena *et al.* (1980) revealed that neem oil deterred the egg-laying by homopterans.

Ho and Kibuka (1983) reported that neem oil at 10 per cent concentrations gave better protection at early vegetative growth stages than neem cake or urea 5 per cent Neem oil was found to be less toxic to the predatory mirid *Cyrtorrhinus lividipennis*.

Krishnaiah and Kalode (1984) reported that 5 per cent neem oil spray had low acute and persistant toxicity against hoppers, and relatively higher population of a predacious mirid was observed in plots treated with neem oil as compared to other pesticides. One per cent pure kernel suspension was very effective in reducing the weight gain by *Spodoptera litura* (Rao and Srivastava, 1984).

Babu and Rajasekharan (1984) reported that neem oil 3 or 5 per cent permitted the lowest damage rate against the pod borer *H. armigera*.

Systemic effect of neem seed extract by seed drenching was demonstrated by Larew *et al.* (1985) against the leaf miner *L. trifolii*.

Kumar and Sangappa (1984) reported that 5 per cent spray of neem oil reduced the mean percentage of the pods damaged by *H. armigera* to 3.10 per cent as compared to 7.45 per cent in control plot.

One per cent emulsion of neem oil spray killed all the aphids (*A. craccivora*, *A. gossypii* and *M. persicae*) in 1-2 h but showed phytotoxicity. 0.1 per cent and 0.2 per cent took 24 h and 48 h respectively to achieve the same results. 0.2 per cent emulsion showed no build up of aphids on the plants for three weeks. The larvae and adults of predacious coccinellids and the larvae of syrphids were unaffected by any of the treatments (Srivastava and Parmar, 1985).

Verma and Singh (1985) suggested that neem seed oil 0.1 per cent was an effective antifeedant. According to Koul (1987) neem oil emulsion exhibited feeding deterrency and growth inhibition in early third instar larvae of *S. litura*. Fifty per cent spray of neem oil effectively controlled the vector and disease by green leaf hopper (Saxena, 1986).

Bhat *et al*. (1988) reported that neem seed extract at 25 kg per hectare increased the yield and reduced the pod borer incidence in cowpea to 42.34 per cent Cobbinah and Osei-Owusu (1988) suggested that the defatted neem cake applied as a dust not only decreased the incidence of the pyralid *M. testulalis* but also significantly increased the pod yield.

Thakur *et al.*, 1988 reported that 5 per cent neem seed kernel extract spray can be used as an effective insecticide since it is cheaper and safer to beneficial insects in comparison to highly toxic synthetic insecticides. Kareem *et al.* (1988) studied the efficacy of 3 per cent neem seed kernel extract on *Etiella zinckinella*, *M. testulalis* and *H. armigera*. Cost benefit ratio was greater for neem seed kernel extract.

Schmutterer (1990) reported that oviposition by several species of lepidopterous insects and egg hatchability decreased on neem treated plants or substrates.

Singh and Singh (1993) found that application of 0.5 per cent neem oil resulted in 85 per cent mortality of cowpea pod bug, 0.02 per cent emulsified concentrate resulted in 100 per cent mortality 48 hours after exposure and 0.5 per cent as the most effective repellent. Neem seed extracts and neem oils were reported to be oviposition deterrents to noctuid moths, *H. armigera* and *S. litura* (Naumann and Isman, 1995).

2.3.2.2 Tobacco decoction

Koshy *et al.* (1987) reported that the predominant alkaloid found in tobacco decoction is effective against sucking pests like aphids, white flies, scales, thrips etc.

According to Chari *et al*., 1990, tobacco decoction reduced the incidence of *H. armigera*, *S. litura*, *M. persicae* and *B. tabaci*.

2.3.3 Role of the green lace wing *C. carnea*, in the management of pests

Patel *et al*. (1976) reported *C. carnea* as a predator of aphids. Manjunath *et al*. (1976) observed the feeding of eggs and larvae of *H. armigera* by *C. carnea*. The sugarcane whitefly *Aleurlobus barodensis* (Maskell) and *Pectinophora gossipiella* (Saund) were preyed upon by *C. carnea* (Inayatullah, 1984; Henneberry and Claytor, 1985).

According to Adashkerich (1987) the aphid lion (*C. carnea*) was potentially the most promising natural enemy for release against the sucking pests of cotton and other crops. Krishnamoorthy and Mani (1989) recorded the predatory potential of *C. carnea* and suggested that they can be effectively used against mealy bugs. Ushchecov (1989) studied the effectiveness of *C. carnea* for control of aphid in cotton. According to him the eggs and larvae are used for initial colonization and the predator can be released at anytime of the year or any stage of growth of the plants and is active in a wide range of temperatures.

Heinz *et al*. (1988) demonstrated that aphids of green house marigold were kept controlled by regular release of the predator *C. carnea*. Stark and Hopper (1988) explained that the field releases of *C. carnea* to control *H. armigera* w not affected by the parasitism by *H. croceipes*.

Hagley (1989) released *C. carnea* @ 335000 eggs/ha to control the apple aphid, and greatly reduced the number of apterous adults and nymphs of *A. pomi*.

The effectiveness of *C. carnea* as a predator on cotton aphid *A. gossypii* was studied by Yuksel and Gocmen (1992). According to them prey consumption by the first instar larvae was 53.6, second instar larvae 174.4 and 424.4 by the third instar larvae. Balasubramani and Swamiappan (1994) found that during the course of development each *C. carnea* larvae consumed an average of 662.53 eggs of *H. armigera* 419.8. *A. gossypii*, 329.10 pupae of *B. tabaci* and 288.45 nymphs of *A. biguttula*. In all cases, the third instar larvae consumed the major portion of the total number and it ranged from 60-80 per cent.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Assessment of the incidence of major pests and natural enemies associated with pests of vegetable cowpea.

3.1.1 Monitoring of pests and natural enemies in insecticide sprayed vegetable cowpea in farmers' fields.

A detailed monitoring on the incidence of major pests and natural enemies associated with vegetable cowpea in Thiruvananthapuram district was done during kharif (June to August) and rabi (October to December) 1996. Two locations viz. Palappur and Kalliyoor were selected for the study as the farmers in these locales were reported to use pesticides heavily for controlling the pests (Mathew *et al*., 1995). From these two locations, eight progressive farmers were selected whose plots were more or less maintained under uniform management practices. Each plot size was approximately 400 sq.m.

Observations on the incidence of pests and natural enemies were recorded from all the eight plots selected, at weekly intervals. Ten observational plants were selected at random from each plot leaving two border rows. Observations were taken during early hours of the day.

3.1.1.1 Pea aphid

The number of pea aphids (*Aphis craccivora* (Koch.) present in five centimeter shoot length from the tender growing points of each observational plant were recorded.

3.1.1.2 American serpentine leaf miner

Ten plants were randomly selected from each plot. From each plant, five leaves were collected and the number of larvae and pupae if any within the tunnels were counted.

3.1.1.3 Pod borers

To assess the incidence of pod borer complex in toto the number of pods showing damage holes in the basal region or on the pods were counted. The total number of pods present at that time were also recorded.

3.1.1.4 Pod bugs

To assess the population of the pod bugs viz., *Riptortus pedestris* and *Clavigralla gibbosa* five sweeps were taken across the plot and the number of pod bugs collected were recorded.

3.1.1.5 Spider mites

Three leaves were randomly selected from top, middle and bottom portions of each observational plants and the counts of spider mites were taken.

3.1.1.6 Natural enemies

3.1.1.6.1 Natural enemies in sweep nets

Counts of each species of parasitoid and predator collected in five sweep nets were recorded.

3.1.1.6.2 Predators in aphid colonies

The immature stages of aphid predators viz., the *coccinellids* and syrphids present in 5 cm aphid colony were counted.

3.1.1.6.3 Predatory mites

Counts of predatory mites were taken from the leaves collected from the top, middle and bottom portions of the plants for observing the phytophagous mites (3.1.1.5).

3.1.1.6.4 Natural enemies from infested plant parts

Infested leaves and pods were collected from the field and observed in the laboratory for the emergence of parasitoids and predators.

3.1.1.7 Preservation and identification of natural enemies

The natural enemies collected from the field were preserved in 90 per cent ethyl alcohol and identified.

3.1.2 Monitoring of pests and natural enemies in unsprayed vegetable cowpea

Vegetable cowpea was raised without any insecticides during Kharif and Rabi 1996 in the Instructional Farm, attached to College of Agriculture, Vellayani in order to monitor the status of pests and natural enemies in the unsprayed crop.

Vegetable cowpea, variety Sharika (Selection 107) was raised in an area of 60 sq.cm. After land preparation, ridges and furrows were taken 45 cm apart and seeds were dibbled at a spacing of 15 cm along the furrows with two seeds per hole. The crop was maintained as per package of practices recommendations (KAU, 1993) excepting the plant protection measures.

Observations on the pests and natural enemies were taken as given under 3.1.1.1 to 3.1.1.7.

3.1.2.1 Meteorological observations

Data on rainfall, relative humidity, maximum and minimum temperature were collected from the records maintained at the Department of Agronomy, College of Agriculture, Vellayani.

3.1.3 Comparison of incidence of pests and natural enemies from insecticide sprayed plots with that of unsprayed plots

The data on the population of pests and natural enemies in the insecticide sprayed crops were compared with that of the unsprayed plots using students 't' test.

3.2 Management of cowpea pests using the predator *C. carnea* and botanical insecticides

A field experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani during February to May 1997 to test the efficacy of *C. carnea* at different densities (3.2.3) in controlling the pests of cowpea. The effect of botanicals and synthetic insecticide, malathion in the management of cowpea pests and their impact on natural enemies were also studied.

3.2.1 Mass culturing of *C. carnea* and its host *Corcyra cephalonica* Stainton

Mass culturing of *C. carnea* was done on the eggs of *C. cephalonica* according to the procedure given by Patel *et al.*, 1988. The nucleus culture of *C. carnea* and its prey host *C. cephalonica* were obtained from the Biocontrol laboratory of the Agricultural College and Research Institute, Madurai. Mass culturing of *C. carnea* was done in the insectary of Department of Entomology, College of Agriculture, Vellayani.

3.2.1.1 Mass culturing of *C. cephalonica*

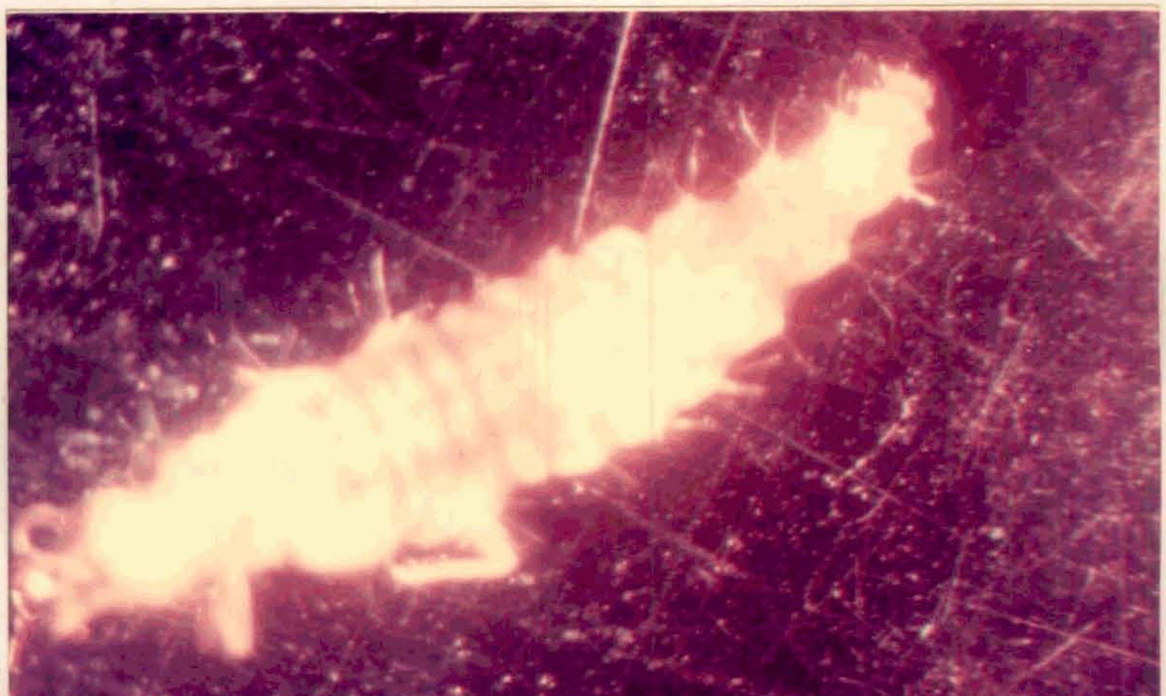
The cleaned eggs of *C. cephalonica* were sprinkled over half-grained bajra grains at the rate of one cc per 2.5 kg of grains fortified with 10 g of yeast. The substratum was taken in plastic basins of 11 x 37.5 cm size and covered with muslin cloth. Care was taken to maintain the culture free from storage pests by mixing 5g wettable sulphur (80%). This was kept undisturbed for a period of one month. The adults that emerged from 35th day onwards were collected in small vials and transferred to oviposition cages for egg laying. The oviposition cages constituted wide mouthed plastic containers of one litre capacity. The bottom portion of the container was removed and covered with wire mesh to facilitate the easy collection of eggs. Five such oviposition cages were maintained. They were placed on a stand with basins underneath to collect the eggs. Each day the emerging adults were introduced into a new cage and the eggs were collected daily and cleaned. The adult Corcyra were fed with 10 per cent honey in small vials tied to the neck of the oviposition cage. The culture was maintained at room temperature (26±4°C).

3.2.1.2 Mass culturing of *C. carnea*

Paper strips containing eggs of *C. carnea* (Plate I) were placed in small plastic containers and covered with muslin cloth were maintained for the hatching of the larvae (Plate I).

Plate 1

A



B

Paper bits were provided in between the larvae, to avoid cannibalism. Three days old eggs of *C. carnea* (approximately 500 nos.) were mixed with 0.5 cc Corcyra eggs. The larvae on hatching started feeding the eggs and they were transferred to separate containers and 0.2 cc of corcyra eggs were provided per hundred larvae. The pupal cocoons (Plate 3) formed were collected 24 h after formation. The adults (Plate 4) that emerged after one week were colle-cted using small glass vials and transferred to larger containers. The containers were wrapped with brown paper sheets with their rough surface facing the inner side of the bottle to provide a favourable substratum for the adults to lay eggs and secured tightly with muslin cloth. The adults were fed with a diet provided on the inner side of the bottle on cotton swabs. The diet constituted of drinking water, 50 per cent honey, protinex and fructose in the ratio 1:1:1:1. These were ground well to a thick paste. Cotton swabs dipped in the diet were glued to the inner side of the container. After a pre-oviposition period of four days, eggs were collected by removing the brown paper. The adults were transferred to fresh containers. The eggs were used for further culture maintenance and for the experimental purpose. Mass culturing of *C. carnea* was carried out at room temperature (26±4°C).

Plate II *Chrysoperla carnea*

A. pupa

B. adult

Plate II

3.2.2 Raising the crop

Vegetable cowpea seeds of the variety Sharika (Selection - 107) obtained from the Instructional Farm, College of Agriculture, Vellayani was used for the experiment. The size of each plot was 2m x 2m. A spacing of 45 cm between rows and 1m between plots was given. Four rows of vegetable cowpea maintained between two plots served as buffer. The crop was maintained as per the package of practices recommendations (KAU, 1993).

3.2.3 Treatments

The experiment was laid out in randomized block design with 11 treatments each replicated thrice. The treatments were as detailed below.

T_1 - *Chrysoperla carnea* larvae @ 50/plot at fortnightly intervals

T_2 - *C. carnea* larvae @ 50/plot at monthly intervals

T_3 - *C. carnea* larvae @ 100/plot at fortnightly intervals

T_4 - *C. carnea* larvae @ 100/plot at monthly intervals

T_5 - Neem oil emulsion, 10 per cent spray at fortnightly intervals.

T_6 - Tobacco decoction, 2 per cent spray at fortnightly intervals,

T_7 - Malathion, 0.05 per cent need based application.

T_8 - Neem oil emulsion, 10 per cent at fortnightly intervals + *C. carnea* @ 50 per plot at fortnightly intervals.

T_9 - Tobacco decoction, 2 per cent + *C. carnea* @ 50 per plot at fortnightly intervals.

T_{10} - Malathion 0.05% need based application and *C. carnea* @ 50 /plot at fortnightly intervals.

T_{11} - Untreated control.

3.2.3.1 Release of *Chrysoperla carnea*

The second instar larvae of *C. carnea* were selected for the release. The release as per requirement was done between 6.00 and 7.30 a.m

3.2.3.2 Preparation of neem oil emulsion

100 ml of neem oil was mixed with 10 ml of teepol. To this little water was added and thoroughly mixed. The emulsion was further diluted with 1 litre of water by constant stirring to get 10 per cent neem oil emulsion.

3.2.3.3 Preparation of tobacco decoction

Two per cent tobacco decoction used for the experiment purpose was prepared by steeping 100 g of tobacco wastes in one litre of water. Then 25 g of ordinary bar soap was sliced and dissolved separately in another vessel. The soap solution was added to the tobacco decoction under violent agitation. This stock solution was diluted six times before spraying.

3.2.3.4 Preparation of malathion emulsion 0.05 per cent

One ml of malathion 50 per cent EC was added to a little water and further made up to one litre with constant stirring to get 0.05 per cent emulsion. This was applied on need basis on 35th day after sowing.

3.2.4 Assessment of the incidence of pests and natural enemies

Observations on the incidence of aphids, american serpentine leaf miner, pod borers and pod bugs were taken at weekly intervals as mentioned under 3.1.1.

The occurrence of natural enemies was also recorded at weekly intervals. The counts of each species of parasitoid and predator collected in five sweep nets were recorded. The crop was also monitored for the presence of different stages of *C. carnea* released.

3.2.5 Yield per plot

The weight and number of pods were recorded individually from each plot when harvested once in two days leaving the buffer plants.

RESULTS

4. RESULTS

4.1 Monitoring of pests and natural enemies associated with pests of vegetable cowpea

4.1.1 Monitoring of pests and natural enemies in insecticide sprayed vegetable cowpea in farmers' fields

4.1.1.1 Pests

Details on the pests associated with vegetable cowpea collected from two locations viz., Palappur and Kalliyoor in Thiruvananthapuram district are presented in Table 1. The pests encountered were the pea aphid, *Aphis craccivora*, the american serpentine leaf miner, *Liriomyza trifolii*, the pod bugs, *Riptortus pedestris* and *Clavigralla gibbosa* and the pod borers, *Helicoverpa armigera*, *Lampides boeticus* and *Maruca testulalis*,

Data relating to the mean population of the pests in insecticide sprayed vegetable cowpea, collected from eight farmers' fields during kharif and rabi seasons are presented in Table 2.

4.1.1.1.1 Pea aphid

During first two weeks after sowing in kharif, 1996 (last week of June and first week of July) there was no aphid

Table 1 Important pests associated with vegetable cowpea in Thiruvananthapuram District

Scientific name	Family	Order
Aphis craccivora	Aphididae	Hemiptera
Clavigralla gibbosa	Coreidae	Hemiptera
Helicoverpa armigera	Noctuidae	Lepidoptera
Lampides boeticus	Lycaenidae	Lepidoptera
Liriomyza trifolii	Agromyzidae	Diptera
Maruca testulalis	Pyralidae	Lepidoptera
Riptortus pedestris	Coreidae	Hemiptera

Table 2 Mean number of pests in the insecticide sprayed vegetable cowpea in farmers' fields during kharif and rabi, 1996

Pests		Weeks after sowing 1	2	3	4	5	6	7	8	Pooled mean
Pea aphid (mean number per 5 cm shoot length)	A	0	0	4.25	9.88	3.00	0.38	1.88	1.00	20.39
	B	0.63	0	1.50	5.38	8.25	4.75	1.75	0.38	22.64
American serpentine leaf miner (Mean number of damaged leaves per plant)	A	2.88	2.75	4.00	0.50	0	0	0.38	1.13	11.64
	B	3.25	3.63	4.25	3.38	0.75	0	0.25	0	15.51
Pod bugs (i) <u>Riptortus pedestris</u>	A	0	0	2.25	3.75	2.25	0.38	2.25	1.25	12.13
	B	0	0.50	1.13	1.25	2.50	1.13	1.88	1.38	9.77
(ii) <u>Clavigralla gibbosa</u>	A	0	0	0.50	1.25	0.38	0.25	0.25	0.63	3.26
	B	0	0.25	0.38	0.75	0.25	0.25	0.50	0.50	2.88
(mean number per 5 sweep nets)										
Pod borers (mean number of damaged pods per plant)	A	0	0	0	0.50	2.13	1.50	0.75	0.38	5.26
	B	0	0	0	0.13	0.25	1.88	1.75	1.50	5.51

Data not analysed statistically
Data presented are mean of sample plots

A - kharif, 1996
B - rabi, 1996

infestation in all the plots observed. During the third week, the infestation of aphids commenced in the fields and the mean number of aphids observed was 4.25 per 5 cm shoot length. The population of aphids reached its peak period during the next week (9.88) and reduced gradually during the succeeding weeks upto harvest. The pooled mean of aphid population during the cropping season was 20.39.

During the rabi season the aphid incidence was observed from the first week after sowing till eighth week after sowing (8.25). In the preceding and succeeding weeks, the mean values were 5.38 and 4.75 respectively. The pooled mean during the rabi season was 22.64.

4.1.1.1.2 American serpentine leaf miner

The american serpentine leaf miner was present from the very beginning of the crop in kharif as well as in rabi. The mean number of damaged leaves per plant were 2.88 and 2.75 respectively, during first and second weeks after sowing and it reached its peak during the third week after sowing, the mean number of damaged leaves was four per plant. The infestation reduced drastically during the later periods of the crop. The mean number of damaged leaves during the cropping season was 11.64 per plant.

The mean infestation of the leaf miner ranged from 0.25 to 4.25 during rabi season. As in the kharif crop, there was a decline in the infestation during the later part of the cropping period and the mean population for the rabi season was 15.51 .

4.1.1.1.3 Pod bugs

R. pedestris and *C. gibbosa* were the pod bugs observed in the insecticide sprayed plots in the farmers' fields and they were noticed only during three weeks after sowing in the kharif crop. The population of *R. pedestris* present during the fourth week after sowing was 3.75 in the kharif crop while that of *C. gibbosa* was only 1.25. The population of the pod bug complex then got reduced. The mean population recorded during the cropping period for *R. pedestris* was 12.13 and that for *C. gibbosa* was 3.26.

The pod bugs were found in the rabi crop from the second week after sowing onwards to the end of the eighth week after sowing, with slight fluctuations. The mean population for *R. pedestris* was found to be 9.77 and that for *C. gibbosa* was 2.88, less than that during the kharif season.

4.1.1.1.4 Pod borers

The pod borer complex in the insecticide sprayed plots was *M. testulalis*, *H. armigera* and *L. boeticus*. The pod borer infestation commenced from the fourth week after planting. The maximum infestation of 2.13 damaged pods per plant was noticed during the fifth week after sowing and reduced considerably thereafter.

In the rabi season also the pod borer attack was observed during the later half of the cropping season and the pooled mean recorded for the cropping period was 5.88.

4.1.1.1.5 Spider mites

There was no infestation of mites during the entire cropping period in all the leaf samples collected from the insecticide sprayed plots in the farmers' fields during both the seasons.

4.1.1.2 Natural enemies

Details on the natural enemies associated with pests of vegetable cowpea are presented in Table 3. *Argyrophylax nigrotibialis* and *Tomosvaryella subvirescens* (Plate III) were observed to parasitize *H. armigera* and *Sundapteryx biguttula biguttula* respectively. *Charops* sp. and *Goniozus triangulifer* (Plate IV) were observed frequently in the aphid colony. Another unidentified hymenopteran (Plate V) was found to parasitize *H. armigera*.

The predators of *A. craccivora* observed were *Menochilus sexmaculatus* (Plate VI), *Micraspis crocea* and *Scymnus* sp (Plate VII) *Xanthogramma scutellarae* (Plate VIII).

Plate III Parasites of *H. armigera* and *S. bigutula bigutula*

A. *Argyrophylax nigrotibialis*, parasite of *H. armigera*

B. *Tomosvaryella subvirescens*, parasite of *S. bigutula bigutula*

Plate III

A

B

Plate IV Parasites associated with *A. craccivora*

A. *Charops* ***sp***

B. *Goniozus triangulifer*

Plate IV

B

Plate V Unidentified hymenopteran parasite of *H. armigera*

Plate V

Plate VI Predator of *A. craccivora, Menochilus sexmaculatus*

Plate VI

Plate VII *Scymnus* sp (larvae) in aphid colonies

Plate VII

Plate VIII

A

Plate IX *Salius* sp

Plate IX

Table 3 Natural enemies associated with pests of vegetable cowpea in Thiruvananthapuram district

Scientific name	Family	Order	Host
Parasites			
Argyrophylax nigrotibialis (Baranov)	Tachinidae	Diptera	*Helicoverpa armigera* (Hubner)
Charops sp.	Ichneumonidae	Hymenoptera	*
Goniozus triangulifer (Kieffer)	Bethylidae	Hymenoptera	*
Tomosvaryella subvirescens (Loew)	Pipunculidae	Diptera	*Sundapteryx biguttula biguttula*
Unidentified	Ichneumonidae	Hymenoptera	*H. armigera*
Predators			
Euborellia stali	Carcinophoridae	Dermaptera	**
Menochilus sexmaculatus (Fb.)	Coccinellidae	Coleoptera	*Aphis craccivora* (Koch.)
Micraspis crocea (Fb.)	Coccinellidae	Coleoptera	*A. craccivora*
Salius sp	Scoliidae	Hymenoptera	*
Solenopsis geminata (Fb.)	Formicidae	Hymenoptera	*
Xanthogramma scutellarae (Fb.)	Syrphidae	Diptera	*A. craccivora*

* Frequently collected in sweep nets
** Only in farmers' fields

The predaters such as *Salius* sp (Plate IX) and *E. stali* were also found in the crop.

The data relating to the population of natural enemies in the insecticide treated plots in the farmers' fields during kharif and rabi seasons are presented in Table 4.

4.1.1.2.1 Parasitoids

4.1.1.2.1.1 *A. nigrotibialis*

The population of *A. nigrotibialis* collected in the sweep nets ranged between 0.38 and 2.75. The maximum population was observed during the third week after sowing (2.75) and the pooled mean for the kharif season was 8.26.

During the rabi season also, *A. nigrotibialis* was found throughout the cropping season and the pooled mean was 6.77.

4.1.1.2.1.2 *T. subvirescens*

Though the population of *T. subvirescens* was lower, they were found throughout the cropping seasons and the pooled mean during the kharif season was 2.77 while that during the rabi season was 2.51.

4.1.1.2.1.3 *Charops* sp.

Among the hymenopterans, *Charops* sp was dominant in the farmers' fields. They were found in the field from the

Table 4 Mean number of natural enemies in the insecticide sprayed plots in farmers's fields at differnt intervals after planting

Natural enemies		Weeks after planting								Pooled mean
		1	2	3	4	5	6	7	8	
1. *Argyrophylax nigrotibialis*	A	0.38	0.75	2.75	1.25	0.88	0.75	0.75	0.75	8.26
	B	0.63	0.75	1.25	0.50	0.63	0.88	1.00	1.13	6.77
2. *Charops* sp.	A	0	0.50	0.75	0.25	0.25	0.13	0	0	1.88
	B	0.25	0	0	0	0.13	0.13	0	0.25	0.76
3. *Goniozus triangulifer*	A	0	0	0.50	0.13	0	0	0	0	0.63
	B	0.13	0	0	0	0	0.13	0	0.25	0.51
4. *Tomosvaryella subvirescens*	A	0.13	0.13	0.13	1.25	0.25	0.50	0	0.38	2.77
	B	0.25	0.50	0.50	0.13	0.25	0.50	0.13	0.25	2.51
5. *Menochilus sexmaculatus*	A	0.75	0.13	1.38	1.63	0.63	0.38	0.63	0.25	5.78
	B	3.88	2.25	5.00	2.75	4.63	3.00	3.63	2.75	27.89
6. *Salius* sp.	A	0	0	0.13	0.13	0	0	0	0	0.26
	B	0.13	0	0	0	0	0	0.13	0	0.26
7. *Xanthogramma scutillarae*	A	0	0	0	0	0	0	0	0.63	0.63
	B	0	0	0	0	0.25	0.50	0	0	0.75
Predatory larvae										
8. *X. scutellarae*	A	0	0	0.25	0.88	0.50	0	0.13	0	1.76
	B	0	0	0.13	0.25	0.25	0.25	0.25	0	1.11
9. *M. sexmaculatus*	A	0	0	0	0.25	0	0	0	0	0.25
	B	0	0	0.13	0.38	0.25	0.13	0.13	0	1.02

Data not analysed statistically
Data presented are mean of sample plots

A - kharif, 1996
B - rabi, 1996

second week after sowing upto sixth week after sowing during the kharif season whereas in the rabi season, they were noticed upto the eighth week after sowing. The pooled mean during the kharif was 1.88 while that during rabi was 0.76.

4.1.1.2.1.4 *G. triangulifer*

G. triangulifer was found only during the third and fourth week after sowing in the kharif crop whereas in the rabi crop they were seen intermittently during the first, sixth and eighth week after sowing. The pooled mean during the kharif crop was 0.63 while that of rabi was 0.51.

4.1.1.2.2 Predators

4.1.1.2.2.1 *M. sexmaculatus*

M. sexmaculatus were present throughout the kharif season and the mean population ranged from 0.25 to 1.63 per five sweep nets. The pooled mean of *M. sexmaculatus* for the entire kharif season was 5.78.

Throughout the rabi season also *M. sexmaculatus* was present and the mean population ranged from 2.25 to 5.00. The pooled mean for the rabi season was 27.89.

4.1.1.2.2.2 *X. scutellarae*

The adults of *X. scutellarae* were collected in the sweepnets only during the eighth week after sowing and the pooled mean population was 0.63 per five sweep nets. A similar trend was seen in the adult *X. scutellarae* population in the rabi crop also and the pooled mean was 0.75.

4.1.1.2.2.3 *Salius* sp.

Only very few adults of these sp. were found both in kharif and rabi season and both the seasons accounted for a pooled mean of 0.26 during the entire period.

4.1.1.2.2.4 Predatory larvae in aphid colonies

The larvae of *M. sexmaculatus* and *X. scutellarae* (Plate VIII) were observed along with the aphids from the third week after sowing. The population of larval *X. scutellarae* ranged from 0.13 to 0.88 with a pooled mean of 1.76 but larvae of *M. sexmaculatus* appeared in the field only during the fourth week after sowing in the kharif season, with a pooled mean of 0.25.

In the rabi season the predatory larval counts of *X. scutellarae* were more or less the same as that of kharif. The pooled mean during rabi was 1.11 and that of *M. sexmaculatus* was 1.02 and was more than that during the kharif crop.

4.1.1.2.2.5 Predatory mites

The predatory mites also were not found in the leaves collected for observation, during both the seasons.

4.1.1.2.2.6 Natural enemies from infested plant parts

There was no emergence of parasitoids from pest infested leaves and pods kept in the laboratory for observation.

4.1.2 Monitoring of major pests and natural enemies in unsprayed vegetable cowpea

4.1.2.1 Pests

All the pests listed in Table 1 expect American serpentine leaf miner were observed in the unsprayed vegetable cowpea. The data relating to the mean number of pests in the unsprayed vegetable cowpea in the Instructional Farm, Vellayani are presented in Table 5.

4.1.2.1.1 Pea aphid

There was no infestation of pea aphids upto the fourth week after sowing but during the fifth week after sowing, there was a spurt in the population and the mean number of aphids were 44. The population reduced considerably thereafter for two weeks and sho t up during the eighth week after sowing.

During the rabi season, there was no aphid infestation upto the fifth week after sowing. The population was maximum (74) during the sixth week after sowing and then it reduced to 40 during the next week.

Table 5 Mean number of pests in the unsprayed vegetable cowpea raised in Instructional Farm, Vellayani during kharif and rabi, 1996

Pests		Weeks after sowing								Pooled mean
		1	2	3	4	5	6	7	8	
Pea aphid (mean number per 5 cm shoot length)	A	0	0	0	0	44	6	3	50	103
	B	0	0	0	0	0	74	40	13	127
American serpentine leaf miner (Mean number of damaged leaves per plant)	A	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-
Pod bugs (i) *Riptortus pedestris*	A	0	0	0	4	1	0	10	19	34
	B	0	0	0	1	4	0	5	10	20
(ii) *Clavigralla gibbosa* (mean number per 5 sweep nets)	A	0	0	0	0	0	0	15	5	20
	B	0	0	0	0	0	0	4	1	5
Pod borers (mean number of damaged pods per plant)	A	0	0	0	0	2	0	2	5	9
	B	0	0	0	0	0	0	7	4	11

Data not analysed statistically
Data presented are mean of sample plots

A - kharif, 1996
B - rabi, 1996

4.1.2.1.2 American serpentine leaf miner

Both the kharif and rabi seasons were totally free from the attack of american serpentine leaf miner.

4.1.2.1.3 Pod bugs

R. pedestris and *C. gibbosa* were the pod bugs present. The pod bug population appeared from the fourth week after sowing in the kharif season and there was heavy incidence of the pest during the seventh and eighth weeks after sowing. The mean number of *R. pedestris* observed were 10 and 19 and that of *C. gibbosa* were 5 and 10 respectively during the seventh and eighth weeks.

In the rabi crop, though there was no infestation of pod bugs in the early stage of the crop, there was a high incidence during seventh and eighth week respectively, and the mean values for *R. pedestris* was 15 and 5 and that for *C. gibbosa* was 4 and 1 during the period respectively.

4.1.2.1.4 Pod borer

The pod borer attack was lower during the kharif season, the maximum number of damaged pods were observed during the eighth week after sowing with a mean of five borer infested pods per plant. In the rabi crop, the pod borer incidence was comparatively higher, but observed only during the seventh and eighth week after sowing with mean values of 7 and 4 respectively.

4.1.2.2 Natural enemies

The data relating to the population of the natural enemies in the unsprayed vegetable cowpea in the Instructional Farm, Vellayani are given in Table 6.

4.1.2.2.1 Parasitoids

4.1.2.2.1.1 *A. nigrotibialis*

The population of *A. nigrotibialis* collected in the sweep nets ranged from 2 to 4, and the pooled mean during the kharif season was 7. The population slightly decreased during the rabi season and the pooled mean was 4.

4.1.2.2.1.2 *T. subvirescens*

During the rabi crop, *T. subvirescens* was found only during the fifth to seventh week after sowing, whereas in the rabi season, it was noticed from the fourth week onwards. But the pooled mean during the kharif and rabi seasons accounted to 8 and 4 numbers respectively.

4.1.2.2.1.3 *Charops* sp.

Charops sp. was found only during the third week after sowing in the kharif crop where as in the rabi crop, it

Table 6 Mean number of natural enemies in the unsprayed plots in Instructional Farm, Vellayani at different intervals after planting

Natural enemies		Weeks after planting								Pooled mean
		1	2	3	4	5	6	7	8	
1. *Argyrophylax nigrotibialis*	A	0	0	0	2	0	4	1	0	7
	B	1	0	0	0	1	0	0	2	4
2. *Charops* sp.	A	0	0	2	0	0	0	0	0	2
	B	0	1	2	3	1	0	0	0	7
3. *Goniozus triangulifer*	A	0	0	1	0	0	0	0	0	1
	B	0	1	0	2	0	0	0	0	3
4. *Tomosvaryella subvirescens*	A	0	0	0	2	2	3	1	0	8
	B	0	0	0	0	1	1	2	0	4
5. *Menochilus sexmaculatus*	A	2	2	4	3	3	3	3	2	22
	B	2	3	7	7	8	3	5	6	41
6. *Salius* sp.	A	0	0	0	0	0	0	0	0	0
	B	0	0	0	2	0	0	0	0	2
7. *Xanthogramma scutillarae*	A	0	0	2	3	4	2	2	1	14
	B	2	0	0	0	0	4	0	0	6
Predatory larvae										
8. *X. scutellarae*	A	0	0	1	1	1	1	0	0	4
	B	0	0	0	0	0	2	2	0	4
9. *M. sexmaculatus*	A	0	0	0	1	0	1	0	0	2
	B	0	0	0	0	0	2	0	0	2

Data not analysed statistically
Data presented are mean of sample plots

A - kharif, 1996
B - rabi, 1996

existed from the second week upto fifth week after sowing; the pooled mean during the rabi season was 7.

4.1.2.2.1.4 *G. triangulifer*

This parasitoid was the least noticed in both the seasons and the pooled mean for kharif season was one whereas in the rabi season, it increased to 3.

4.1.2.2.2 Predators

4.1.2.2.2.1 *M. sexmaculatus*

During the kharif season, the population of *M. sexmaculatus* ranged from 2 to 4 whereas in the rabi season, it ranged from 2 to 8. The pooled mean for the kharif season was 22 and that for rabi season was 41.

4.1.2.2.2.2 *X. scutellarae*

X. scutellarae was the syrphid present in the unsprayed cowpea in kharif and rabi seasons. A higher population of *X. scutellarae* were present in the kharif crop and the pooled mean was 14 whereas in the rabi season, the corresponding value was only 6.

4.1.2.2.2.3 *Salius* sp.

This predator was found only during the fourth week after sowing in the rabi season in the unsprayed crop.

4.1.2.2.2.4 Predatory larvae in aphid colony

The larvae of the predator *X. scutellarae* and coccinellid *M. sexmaculatus* were found along with the aphids in their colonies and the population of *X. scutellarae* ranged from 1 to 2 during both kharif and rabi season and the pooled mean was 4 during the kharif as well as rabi season. The population of *M. sexmaculatus* was fewer than that of *X. scutellarae* but the pooled mean during both the kharif and rabi seasons were 2.

4.1.3 Comparison between the population of pests and natural enemeies in the insecticide sprayed vegetable cowpea in farmers' fields and unsprayed plots in the Instructional Farm, Vellayani, during kharif and rabi, 1996

The results of statistical analysis of the data relating to the pooled mean are presented in Table 7.

4.1.3.1 Pests

The pest population during the kharif and rabi season was generally more in the unsprayed plots than in the sprayed plots. During the kharif season, the pooled mean of the aphids and pod bugs were significantly higher (103 and 54) in the unsprayed plots whereas the pod borer population was on par and there was no incidence of leaf miner in unsprayed plots. During the rabi season, there was an increase in the aphid population than in the kharif season. The leaf miner infestation was absent during this season also in the untreated plots.

Table 7 Comparison between the population of pests and natural enemies in insecticide sprayed vegetable cowpea in farmers' fields and unsprayed plots in the Instructional Farm, Vellayani, during kharif and rabi, 1996

Pests/Natural enemies	Mean population of pests/ Natural enemies (pooled) - Kharif season		Computed t_7	Mean population of pests/ natural enemies (pooled) - Rabi season		Computed t_7
	Insecticide Treated plot	Untreated plot		Insecticide Treated plot	Untreated plot	
Pests						
Aphids/5 cm shoot length	20.39	103	15.78^{**}	22.64	127	7.52^{**}
American serpentine leaf miner (Infested leaves per plant)		0	-	16	0	-
Pod bugs - *R. pedestris*	12.13	34		9.77	20	-
C. gibbosa	3.26	20		2.88	5	-
Pod bug (total)	15.39	54	7.51^{**}	12.65	25	2.80^{*}
Pod borers	5.26	9	1.96	5.51	11	3.30^{*}
Natural enemies						
Parasitoids						
Argyrophylax nigrotibialis	8.26	7		6.77	4	
Charops sp.	1.88	2		0.75	7	
Goniozus triangulifer	0.63	1		0.51	3	
Tomosvaryella subvirescens	2.75	8		2.50	4	
Predators						
Menochilus sexmaculatus	5.78	22		27.89	41	
Xanthogramma scutellarae	0.63	14		0.75	6	
Salius sp	0.26	0		0.26	2	
Natural enemies (total)	20.21	54	9.93^{**}	35.45	67	4.40^{*}
Predatory larvae						
M. sexmaculatus	0.25	2		1.02	2	
X. scutellarae	1.75	4		1.11	4	
Predatory larvae (total)	2.00	6	3.74^{*}	2.13	6	2.06^{*}

* - Significant at 5% level
** - Significant at 1% level

4.1.3.2 Natural enemies

The population fluctuation of the natural enemies in the sprayed and unsprayed plots during both kharif and rabi seasons is shown in the Fig. 1 to 4; Fig. 1 and 3 show the fluctuations of parasitoids while Fig. 2 and 4 show the fluctuations of predators during kharif and rabi seasons respectively.

The population of the natural enemies was higher in the unsprayed plots than in the insecticide sprayed fields during both kharif and rabi seasons. The data on the pooled mean of the various parasitoids and predators were subjected to statistical analysis which showed that the population of natural enemies both in kharif and rabi was significantly higher in untreated plots than in the treated fields. As far as the predatory larval population were concerned, there was significant difference between sprayed and unsprayed fields and the unsprayed fields harboured significantly more populaton of predatory larvae of *M. sexmaculatus* and *X. scutellarae*.

4.2 Management of cowpea pests using *C. carnea*, botanicals and insecticides

4.2.1 Effect of *C. carnea*, neem oil, tobacco decoction and malathion on aphids

The data relating to the population of aphids at different intervals after the release of *C. carnea*, application

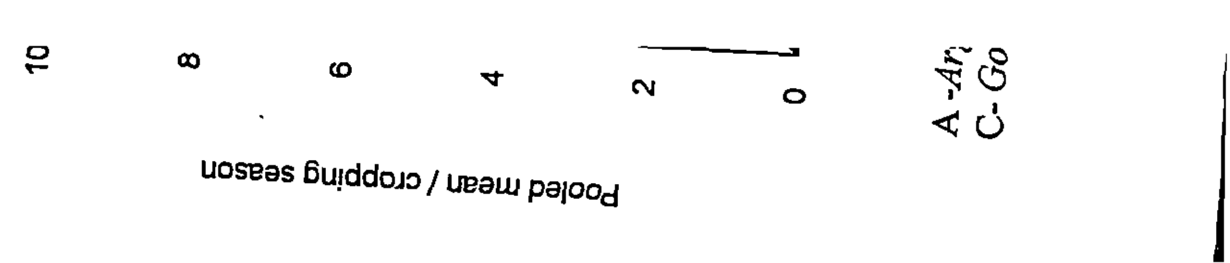
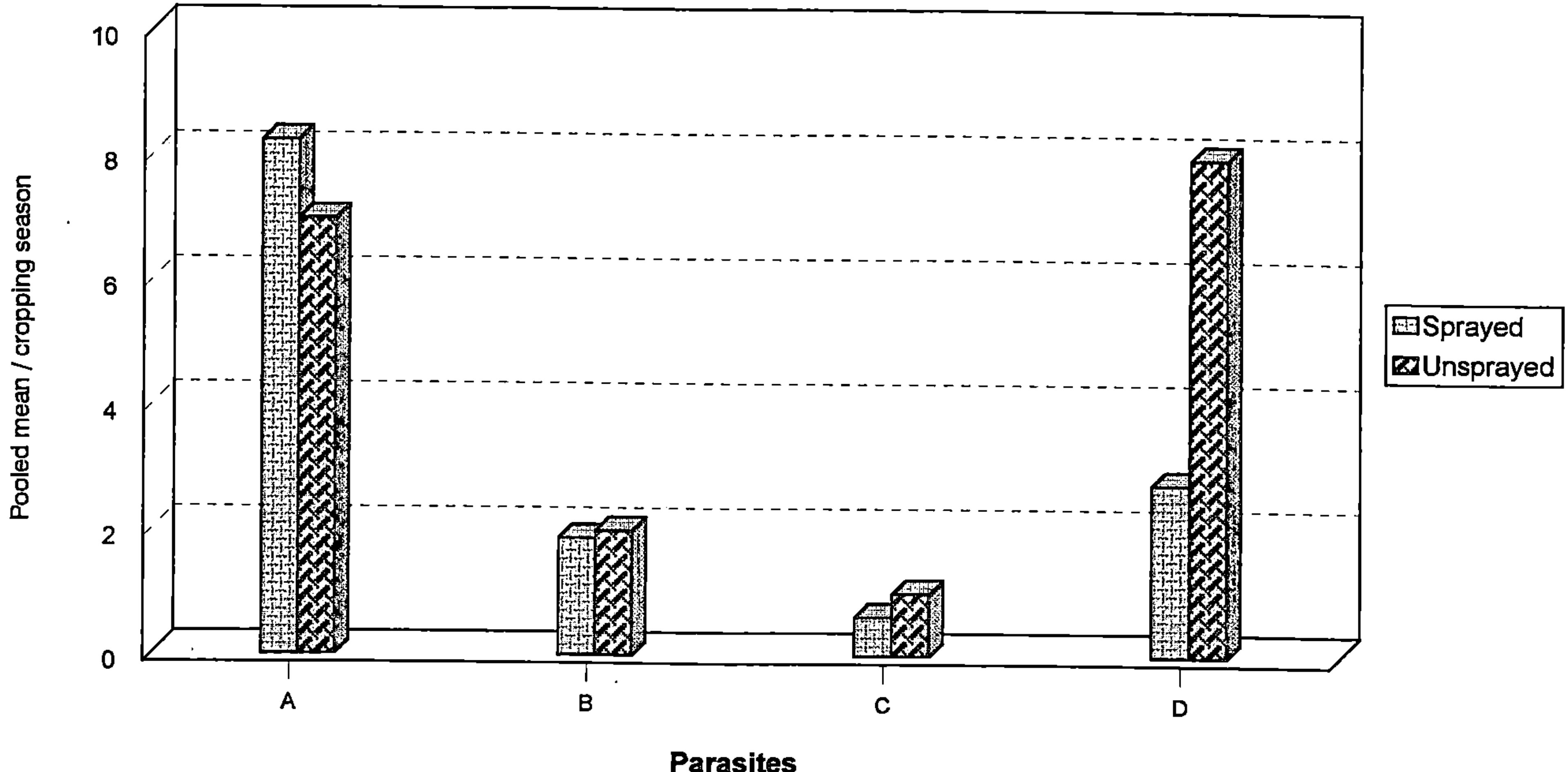
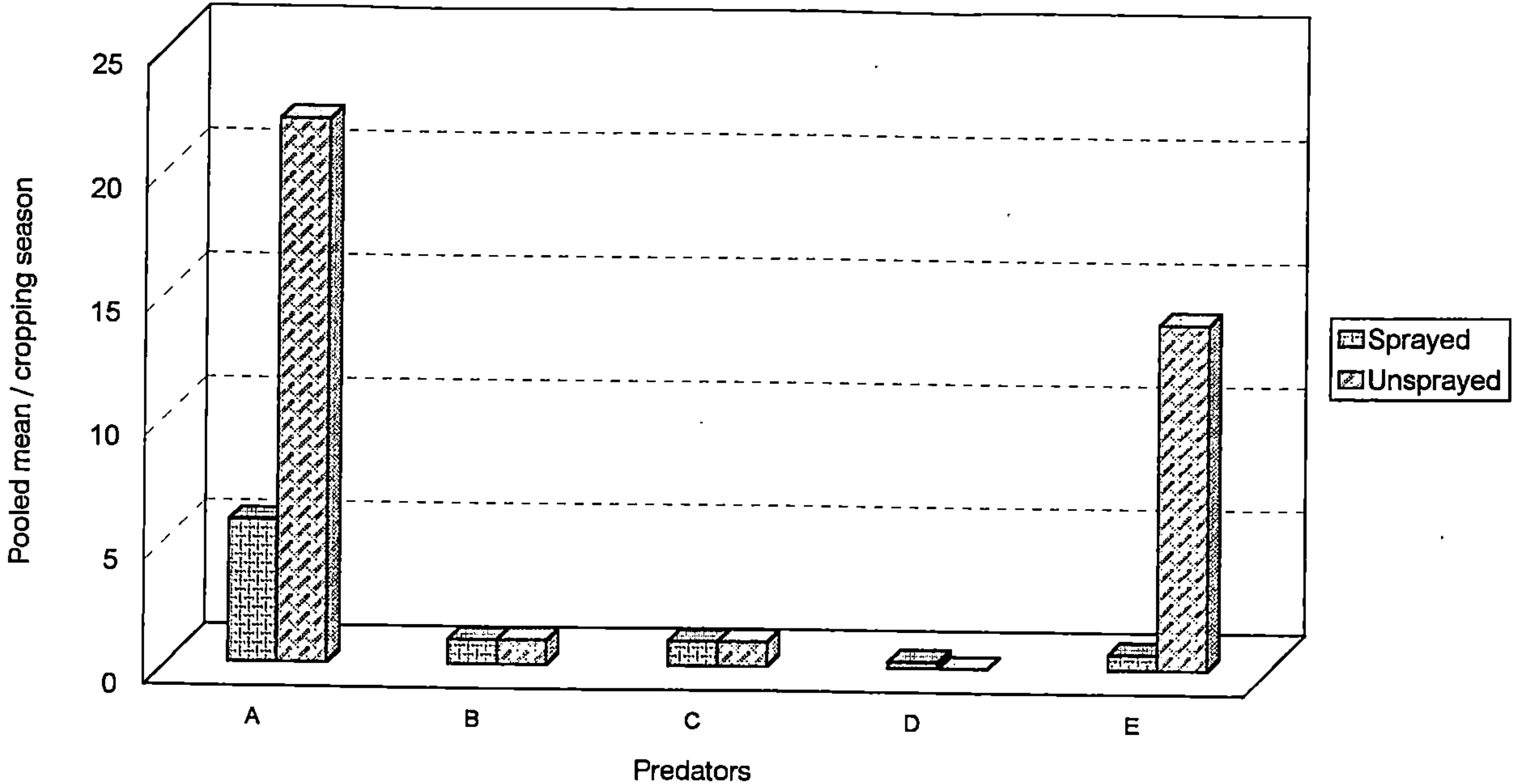


Fig. 1 Mean number of parasites during kharif season



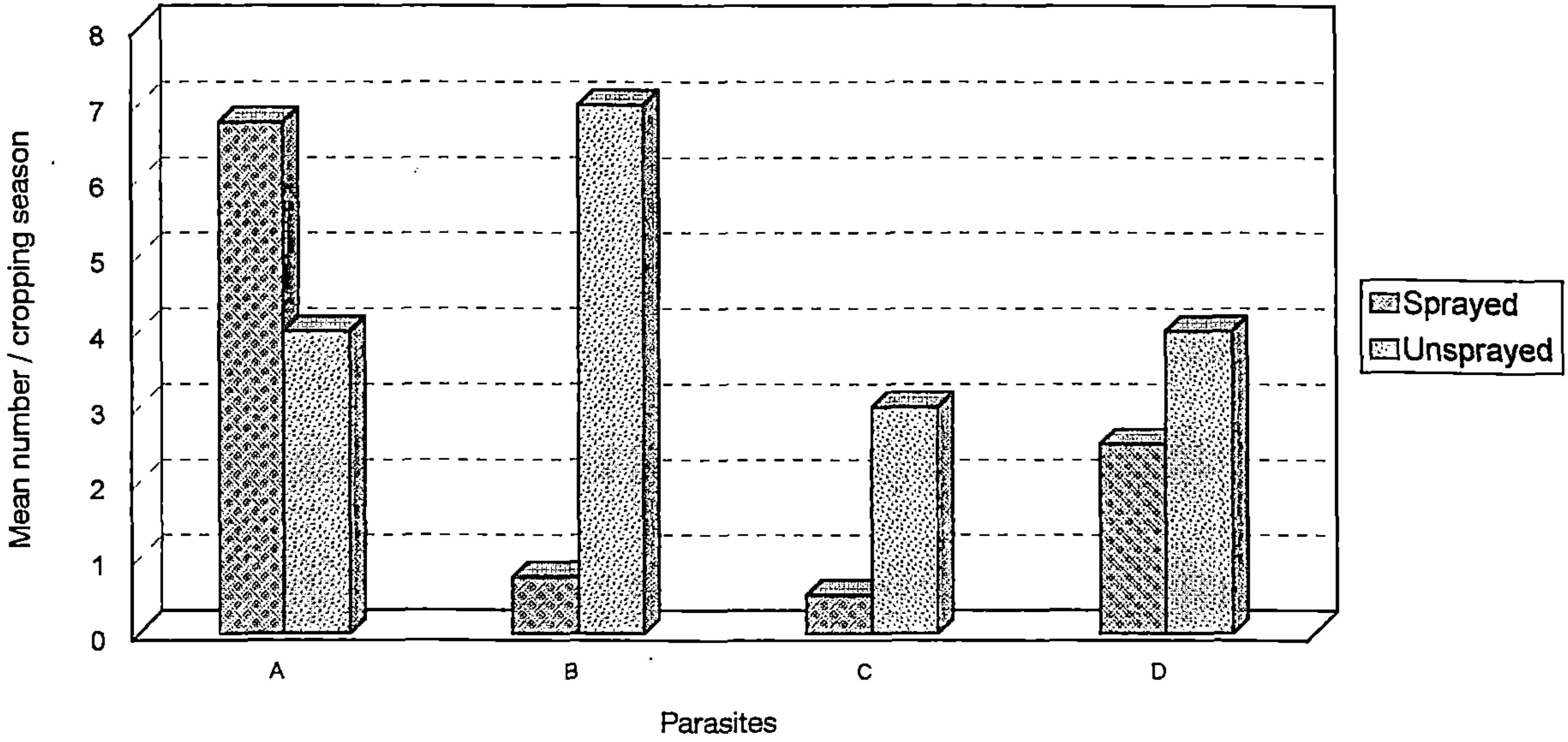
A -*Argyrophylax nigrotibialis*
C- *Goniozus triangulifer*
B - *Charops* sp
D - *Tomosvaryella subvirescens*

Fig. 2 Mean number of predators during kharif season



A - *Menochilus sexmaculatus* B- *Micraspis crocea* C - *Scymnus* sp
D - *Salius* sp E - *Xanthogramma scutellarae*

Fig. 3 Mean number of parasites during rabi season



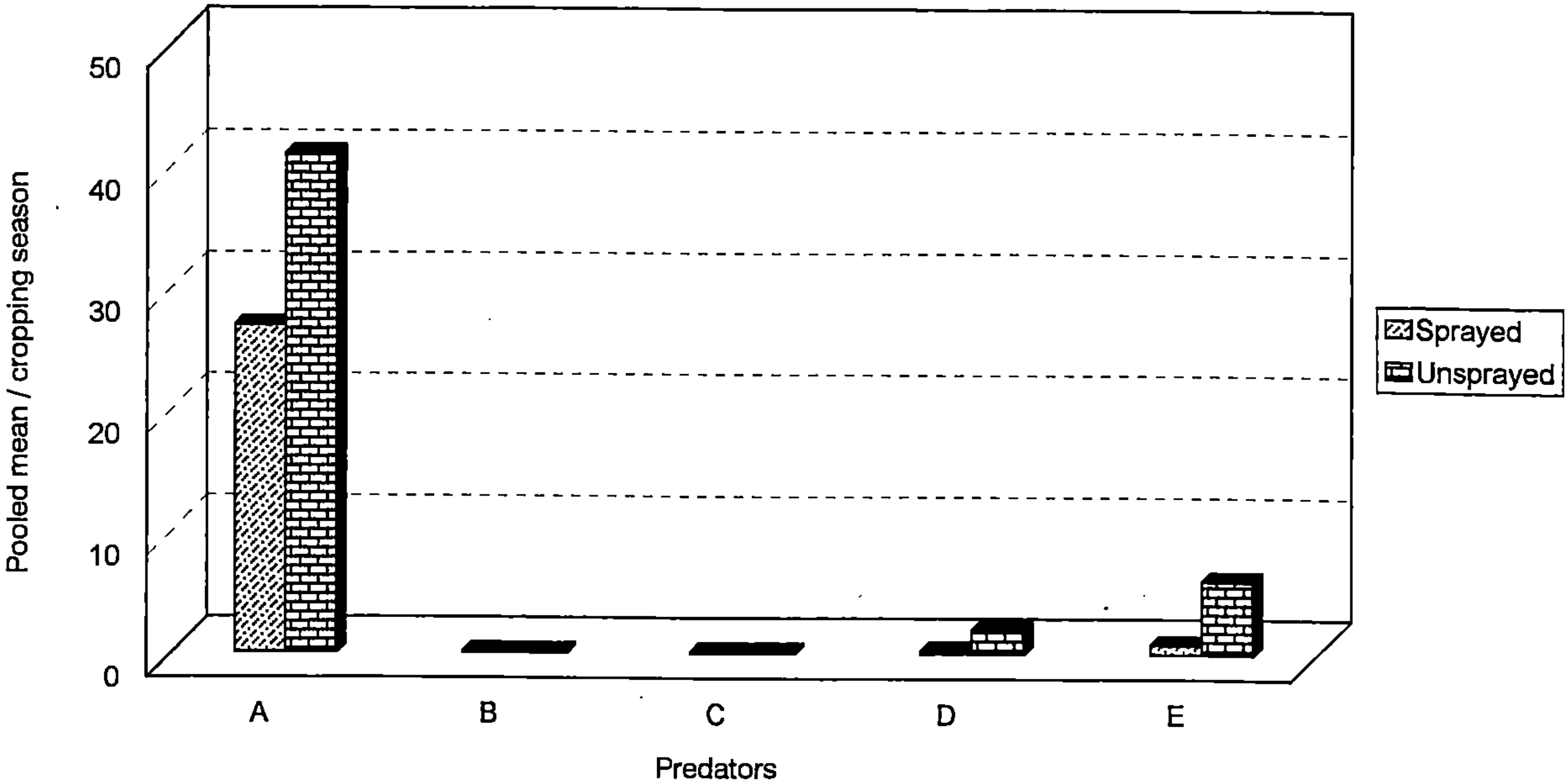
A -*Argyrophylax nigrotibialis*

B - *Charops* sp

C - *Goniozus triangulifer*

D - *Tomosvaryella subvirescens*

Fig. 4 Mean number of predators during rabi season



A - *Menochilus sexmaculatus* B- *Micraspis crocea* C - *Scymnus* sp
D - *Salius* sp E - *Xanthogramma scutellarae*

of botanicals and malathion and the results of statistical analysis are given in Table 8.

Aphid infestation was noted in the plots only from the third week after sowing. There was no aphid incidence in plots treated with 2 per cent tobacco decoction. In all the other treated plots, there was significantly lower aphid population than control (42.55).

During the fourth week after sowing, there was an increase in the population of aphids in general. There was significantly lower aphid population in plots that received fortnightly release of *C. carnea* @ 50 and 100 and neem oil emulsion 10 per cent when compared to control (38.38) and the mean values in the treatments were 0, 0.30 and 2.14 respectively. All the other treatments were on par with the control plot.

During the fifth week after sowing, a complete erase in the aphid population was noted in the plots treated with 2 per cent tobacco decoction at fortnightly intervals and the combined application of both the botanicals along with *C. carnea* @ 50 at fortnightly intervals. In plots where *C. carnea* were released @ 100 per plot at monthly intervals and in plots where malathion 0.05 per cent was given on need basis also there was reduction in aphid population when compared to previous week. However, the treatments were not significantly different from that of the control plot (67.39).

Table 8 Mean number of aphids per five centimeter shoot length on vegetable cowpea treated with *C. carnea*, neem oil, tobacco decoction and malathion at different intervals, after sowing

Treatments	Mean number of aphids per 5 cm shoot length							Pooled mean
	weeks after sowing							
	3	4	5	6	7	8	9	
C. carnea @ 50/plot at f.i.	1.94 (1.72)	0 (1)	3.97 (2.23)	1.98 (1.73)	0 (1)	0.63 (1.28)	0.63 (1.28)	11.13 (3.48)
C. carnea @ 50/plot at m.i.	0.63 (1.28)	25.41 (5.14)	62.64 (7.98)	68.65 (8.35)	32.12 (5.75)	14.64 (3.95)	9.95 (3.31)	212.58 (14.61)
C. carnea @ 100/plot at f.i.	1.64 (1.62)	0.30 (1.14)	12.52 (3.66)	8.40 (3.07)	7.86 (2.98)	3.07 (2.01)	1.20 (1.40)	46.00 (6.86)
C. carnea @ 100/plot at m.i.	10.55 (3.40)	7.47 (2.91)	3.81 (2.19)	10.39 (3.38)	34.92 (5.99)	49.58 (7.11)	11.56 (3.54)	148.16 (12.21)
N.O.E., 10% spray at f.i.	4.07 (2.25)	2.14 (1.77)	13.90 (3.86)	24.50 (5.05)	15.13 (4.02)	2.86 (1.96)	0 (1)	98.07 (9.95)
T.D., 2% spray at f.i.	0 (1)	7.47 (2.91)	0 (1)	0 (1)	16.32 (4.16)	11.59 (3.55)	5.50 (2.55)	44.58 (6.75)
Malathion 0.05% (n.b.a.)	0.30 (1.14)	8.64 (3.10)	0.78 (1.33)	0.55 (1.24)	1.78 (1.67)	2.73 (1.93)	0.63 (1.28)	23.67 (4.97)
N.O.E.+*C. carnea* @ 50/plot at f.i.	0.55 (1.24)	8.64 (3.10)	0 (1)	0 (1)	10.84 (3.44)	6.55 (2.75)	2.14 (1.77)	34.22 (5.94)
T.D + *C. carnea* @ 50/plot at f.i.	3.64 (2.15)	8.56 (3.09)	0 (1)	1.78 (1.67)	10.10 (3.33)	2.32 (1.82)	0.30 (1.14)	30.22 (5.60)
Malathion 0.05 (n.b.a)+*C.carnea* @ 50/plot at f.i.	3.00 (2)	20.28 (4.61)	35.65 (6.05)	12.14 (3.62)	8.00 (3)	4.04 (2.24)	3.20 (2.05)	101.12 (10.10)
Untreated control	42.55 (6.60)	38.38 (6.28)	67.39 (8.27)	94.30 (9.76)	5.96 (2.64)	62.90 (7.99)	49.02 (7.07)	395.01 (19.90)
$F_{(10,20)}$	5.15**	1.31	1.06	1.40	0.45	3.57**	5.00**	1.53*
S.E.	0.71	1.42	2.68	2.53	2.25	1.18	0.79	5.59
C.D.	2.08	4.19	7.90	-	-	3.49	2.34	11.59

Figures within the parantheses are $\sqrt{x+1}$

N.O.E. - Neem oil emulsion, T.D. - Tobacco decoction, f.i - fortnightly intervals, m.i - monthly intervals, n.b.a. - need based application, During the sixth week after sowing, the plots which were treated with tobacco decoction at fortnightly intervals and neem oil emulsion along with *C. carnea* @ 50 per plot at fortnightly intervals respectively maintained the same effect as in the previous week. The plots treated with malathion 0.05 per cent need based application continued to show reduction in aphid population during this period (0.55) but there was no significant difference between treatments and control (94.30).

There was no significant difference in the population of aphids among treatments during the seventh week after sowing.

A reduction in the aphid incidence was observed during the eighth week after sowing, compared to the previous week. Only the plot where *C. carnea* was released @ 100 per plot at monthly intervals (49.58) showed significantly higher population and was on par with that of the untreated control. Rest of the treatments were effective in controlling the aphid population to a significant level and the mean population ranged from 0.63 to 14.64.

A complete reduction of aphid population was observed in the plots treated with neem oil emulsion 10 per cent at fortnightly intervals during the ninth week after sowing. All the treatments showed significant difference when compared to untreated control (49.02). The mean population in the treated plot ranged from 0 to 11.56. Among the treatments, the plots treated with tobacco decoction along with *C. carnea* @ 50 per plot at fortnightly intervals and the plot treated with neem oil emulsion 10 per cent and malathion 0.05 per cent (need based application) were on par.

The statistical analysis of the pooled mean showed that the plots treated with *C. carnea* @ 50 per plot at fortnightly intervals, the plots that received tobacco decoction 2 per cent, the plots where both the botanicals were applied along with *C. carnea* @ 50 per plot at fortnightly intervals and malathion 0.05 per cent treatment harboured significantly lower aphid population when compared to control (395.01). The pooled mean population in the treated plots ranged from 11.13 to 46. All the other treatments were on par with control.

4.2.2 Effect of *C. carnea*, neem oil, tobacco decoction and malathion on pod bugs

The data relating to the mean number of pod bugs collected per five sweep nets at different intervals after the treatments and the results of statistical analysis are presented in Table 9.

During the third week after sowing, the mean number of pod bugs in the treated plots significantly varied from that of the control plot (1.94). The mean values in the treated plots ranged from 0 to 0.30. During the next week, showed a

Table 9 Mean number of pod bugs per 5 sweep nets on vegetable cowpea treted with C. carnea, neem oil, tobacco decoction and malathion at different intervals after sowing

Treatments	Mean number of pod bugs/5 sweep nets									Pooled mean
	weeks after sowing									
	3	4	5	6	7	8	9	10	11	
C. carnea @ 50/plot at f.i.	0 (1)	0.30 (1.14)	0.30 (1.14)	1.49 (1.58)	2.30 (1.82)	0.55 (1.24)	2.10 (1.76)	1.94 (1.72)	1.31 (1.52)	11.61 (3.55)
C. carnea @ 50/plot at m.i.	1.59 (1.61)	1.63 (1.62)	0 (1)	0.30 (1.14)	2.32 (1.82)	0.91 (1.38)	1.00 (1.41)	0.30 (1.14)	0.55 (1.24)	9.30 (3.20)
C. carnea @ 100/plot at f.i.	0 (1)	0 (1)	0 (1)	0 (1)	0.55 (1.24)	0.30 (1.14)	1.63 (1.62)	0.91 (1.38)	1.31 (1.52)	5.08 (2.47)
C. carnea @ 100/pot at m.i.	0.30 (1.14)	0 (1)	0 (1)	0 (1)	0.30 (1.14)	0.63 (1.28)	1.00 (1.41)	0.63 (1.28)	0.30 (1.14)	3.25 (2.06)
N.O.E., 10% spray at f.i.	0.30 (1.14)	0.30 (1.14)	0 (1)	0.55 (1.24)	0.91 (1.38)	0.63 (1.28)	0.30 (1.14)	0 (1)	0 (1)	3.28 (2.07)
T.D., 2% spray at f.i.	0 (1)	0.30 (1.14)	0.30 (1.14)	0 (1)	0.55 (1.24)	0.55 (1.24)	0 (1)	0 (1)	0.30 (1.14)	2.05 (1.75)
Malathion 0.05% (n.b.a.)	0.30 (1.14)	1.60 (1.61)	0.30 (1.14)	0 (1)	1.17 (1.47)	1.49 (1.58)	1.31 (1.52)	0.63 (1.28)	1.31 (1.52)	8.44 (3.07)
N.O.E.+C. carnea @ 50/plot at f.i.	0.30 (1.14)	0.30 (1.14)	0 (1)	0 (1)	0.55 (1.24)	0 (1)	0 (1)	0 (1)	0 (1)	1.17 (1.47)
T.D + C. carnea @ 50/plot at f.i.	0.30 (1.14)	0 (1)	0 (1)	0 (1)	6.25 (2.69)	0.63 (1.28)	0 (1)	0.30 (1.14)	0.30 (1.14)	7.94 (2.99)
Malathion 0.05 (n.b.a)+C.carnea @ 50/plot at f.i.	0.30 (1.14)	0.55 (1.24)	0 (1)	0.63 (1.28)	1.85 (1.69)	0.91 (1.38)	0.30 (1.14)	1.59 (1.61)	1.00 (1.41)	7.30 (2.88)
Untreated control	1.94 (1.72)	1.21 (1.49)	0.30 (1.14)	1.94 (1.72)	2.55 (1.88)	3.13 (2.03)	4.48 (2.34)	1.64 (1.63)	2.26 (1.80)	19.90 (4.57)
$F_{(10,20)}$ value	3.21**	1.65	0.65	3.37*	2.66*	1.56	3.88**	3.75**	3.91**	9.19**
S.E.	0.13	0.19	0.09	0.14	0.28	0.22	0.21	0.14	0.13	0.42
C.D.	0.40	-	-	-	0.82	-	0.62	0.40	0.39	0.87

Figures within the parantheses are $\sqrt{x+1}$

N.O.E. - Neem oil emulsion, T.D. - Tobacco decoction, f.i - fortnightly intervals, m.i - monthly intervals, n.b.a. - need based application

slight increase in the population build up of the pest, but no significant difference between the treatments was observed. The mean population of pod bugs ranged from 0 to 1.63.

During the fifth week after sowing, though there was a negative trend in their population build up as a whole, the untreated control did not significantly vary from other treated plots.

During the sixth week after sowing, the treatments of *C. carnea* @ 50 per plot at fortnightly intervals showed an increase in the pod bug population (1.49) and was on par with the untreated control plot (1.94). The population of pod bugs were significantly reduced in other treatments and the mean incidence ranged from 0 to 0.63.

It was observed that the pod bug population in the seventh week after sowing on the whole increased and the plot treated with tobacco decoction along with *C. carnea* @ 50 at fortnightly intervals suddenly sho t up (6.25) and was on par with the control plot (2.55). Other treatments were on par and recorded only lower incidence than the above two.

During the eighth week after sowing, there was no significant difference among the treatments. The pod bugs persisted in the field for three more weeks. During the ninth week after sowing, the untreated control showed significantly highest pod bug population (4.48). Among the treatments, the botanicals when applied alone and along with *C. carnea* were on par and the mean values ranged from 0 to 0.30.

During the 10th week after sowing, there was an decreasing trend in the population of the pod bugs in the plots treated with *C. carnea* alone irrespective of the number released (0.91 to 1.94). The above treatments were on par with the untreated control. All the other treatments showed significantly lower population.

A significant difference was observed between the treated and untreated plots during the eleventh week after sowing also. The botanicals alone and along with *C. carnea* showed significantly lower pod bug population (0 to 0.30).

The pooled mean indicated that the treated plots were significantly superior to that of the untreated control (19.90). Among the treatments, the plots which received *C. carnea* only at monthly intervals @ 50 and 100 per plot, the plots treated with neem oil emulsion 10 per cent, the one with tobacco decoction 2 per cent and the plot where neem oil emulsion 10 per cent along with *C. carnea* showed significantly lower pod bug population. The pooled mean population in the above treated plots ranged from 1.17 to 3.28.

4.2.3 Effect of *C. carnea*, neem oil, tobacco decoction and malathion on the pod borer population in vegetable cowpea

The data relating to the mean number of pod borer infested pods per plant and the results of statistical analysis are given in Table 10.

The pod borer infestation commenced only from the seventh week after sowing and lasted upto eleventh week after sowing. Throughout the cropping season, the treated plots showed significantly lower pod borer incidence compared to the untreated plots.

There was no significant difference between the treated plots and untreated with respect to the damaged pods during seventh, eighth, ninth and tenth week after sowing.

During the 11th week after sowing, the plots treated with *C. carnea* @ 50 and 100 at monthly intervals showed higher pod borer population and was on par with the control plot (2.61). The plots treated with *C. carnea* @ 50 and 100 at fortnightly intervals, the plots treated with neem oil 10 per cent, tobacco decoction 2 per cent, malathion 0.05 per cent need based application and these three treatments along with *C. carnea* @ 50 at fortnightly intervals showed significantly lower pod borer infestation; their mean population ranged from 0 to 1.

Table 10 Mean number of pods damaged by pod borers on vegetable cowpea treated with C. carnea, neem oil, tobacco decoction and malathion at different intervals after sowing and yield per plot on number and weight basis

Treatments	Mean number of damaged pods per plant					Pooled mean	Mean yield	
	weeks after sowing							
	7	8	9	10	11		Number of pods	Weight of pods
C. carnea @ 50/plot at f.i.	0 (1)	0.30 (1.14)	1.17 (1.47)	0 (1)	1 (1.41)	2.61 (1.90)	12.54 (156.21)	26.69 (711.39)
C. carnea @ 50/plot at m.i.	0 (1)	0.30 (1.14)	0 (1)	1.94 (1.72)	1.17 (1.47)	3.40 (2.10)	9.50 (89.22)	17.81 (316.06)
C. carnea @ 100/plot at f.i.	0 (1)	0 (1)	0.55 (1.24)	0.30 (1.14)	0.63 (1.28)	1.40 (1.55)	11.16 (123.46)	26.03 (676.63)
C. carnea @ 100/plot at m.i.	0 (1)	0.30 (1.14)	1.49 (1.58)	1.31 (1.52)	1.64 (1.63)	4.89 (2.43)	15.04 (225.28)	39.71 (1575.49)
N.O.E. 10% spray at f.i.	0 (1)	0.55 (1.24)	0.63 (1.28)	0.55 (1.24)	0.30 (1.14)	2.05 (1.75)	14.51 (209.48)	36.55 (1335.11)
T.D. 2% spray at f.i.	0 (1)	0.30 (1.14)	0 (1)	0.30 (1.14)	0 (1)	0.55 (1.24)	16.84 (282.47)	46.62 (2172.18)
Malathion 0.05% (n.b.a.)	0 (1)	0 (1)	0 (1)	2.33 (1.82)	0.91 (1.38)	3.13 (2.03)	13.52 (181.92)	31.61 (997.99)
N.O.E.+C. carnea @ 50/plot at f.i.	0 (1)	0.91 (1.38)	0.38 (1.49)	0.55 (1.24)	0 (1)	1.78 (1.67)	14.11 (198.05)	35.97 (1292.69)
T.D. + C. carnea @ 50/plot at f.i.	0.55 (1.24)	0.78 (1.33)	1.21 (1.49)	0.30 (1.14)	0.63 (1.28)	3.91 (2.22)	16.52 (271.91)	46.95 (2203.05)
Malathion 0.05 (n.b.a)+C.carnea @ 50/plot at f.i.	0 (1)	0.30 (1.14)	0.55 (1.24)	0.99 (1.41)	0.63 (1.28)	2.89 (1.97)	13.08 (170.16)	29.11 (846.59)
Untreated control	0.91 (1.38)	1.94 (1.72)	2.32 (1.82)	2.96 (1.99)	2.61 (1.90)	10.90 (3.45	13.38 (178.15)	34.37 (1179.96)
$F_{(10, 20)}$	1.95	1.35	1.81	2.01	2.99*	3.33**	0.75	0.85
S.E.	0.09	0.18	0.19	0.23	0.15	1.05	3.26	13.32
C.D.	-	-	-	-	0.45	0.84	6.77	27.64

Figures within the parantheses are $\sqrt{x+1}$
N.O.E. - Neem oil emulsion, T.D. - Tobacco decoction, f.i - fortnightly intervals,
m.i - monthly intervals, n.b.a. - need based application

The pooled data indicated that the maximum number of damaged pods during the cropping season was in the untreated control plot (10.90). All the treated plots recorded significantly lower pod borer infestation compared to untreated control plot.

4.2.4 Effect of *C. carnea*, neem oil, tobacco decoction and malathion on the natural enemy population of the pests of vegetable cowpea

4.2.4.1 Effect on *M. sexmaculaus*

The results of the statistically analysed data on the mean number of *M. sexmaculatus* are given in Table 11.

During the third and fourth weeks after sowing, there was no significant difference between treated and untreated plots.

There was a significant difference between the treated plots during the fifth week after sowing. A significantly lower population of *M. sexmaculatus* were seen in the plots treated with both the botanicals individually, the one with malathion 0.05 per cent and the plot treated with neem oil emulsion along with *C. carnea* @ 50 per plant at fortnightly intervals (0.91 to 1.94). In all the other treatments, *M. sexmaculatus* was comparatively more and was on par with untreated control (3.32).

Table 11 Mean number of predatory coccinellids (*Menochilus sexmaculatus*) per 5 sweep nets on vegetable cowpea treated with C. carnea, neem oil, tobacco decoction and malathion at different intervals after sowing

Treatments	Mean number of M. sexmaculatus / 5' sweep nets							Pooled mean
	weeks after sowing							
	3	4	5	6	7	8	9	
C. carnea @ 50/plot at f.i.	0.91 (1.38)	1.00 (1.41)	2 (1.73)	2.61 (1.90)	1.31 (1.79)	2 (1.52)	2 (1.73)	14.32 (3.65)
C. carnea @ 50/plot at m.i.	0.91 (1.38)	1.64 (1.63)	3.78 (2.19)	2.30 (1.82)	2.82 (1.95)	2.61 (1.90)	1.94 (1.72)	18.47 (4.18)
C. carnea @ 100/plot at f.i.	1.64 (1.63)	1.31 (1.52)	2.32 (1.82)	2.32 (1.82)	2.89 (1.97)	2.65 (1.91)	2.32 (1.82)	17.56 (4.07)
C. carnea @ 100/plot at m.i.	1.64 (1.63)	1.94 (1.72)	2.32 (1.82)	0.30 (1.14)	1.21 (1.48)	2.65 (1.91)	1.64 (1.63)	13.96 (3.60)
N.O.E. 10% spray at f.i.	1.21 (1.49)	1.31 (1.52)	1.21 (1.49)	1.21 (1.49)	2.22 (1.79)	1.31 (1.52)	1.31 (1.52)	10.05 (3.17)
T.D. 2% spray at f.i.	0.63 (1.28)	1.00 (1.47)	1.94 (1.72)	2.61 (1.90)	3.58 (2.14)	1.59 (1.61)	0.30 (1.14)	14.40 (3.66)
Malathion 0.05% (n.b.a.)	0.55 (1.24)	1.31 (1.52)	0.91 (1.38)	1.94 (1.72)	1.74 (1.66)	2.32 (1.82)	1.31 (1.52)	12.56 (3.40)
N.O.E.+C. carnea @ 50/plot at f.i.	1.00 (1.41)	1.00 (1.41)	0.91 (1.38)	2.32 (1.82)	2.32 (1.82)	1.64 (1.82)	1.00 (1.63)	11.43 (3.23)
T.D + C. carnea @ 50/plot at f.i.	1.31 (1.52)	1.00 (1.41)	2.32 (1.82)	2 (1.73)	1.64 (1.63)	1.00 (1.41)	0.91 (1.38)	12.22 (3.35)
Malathion 0.05 (n.b.a)+C.carnea @ 50/plot at f.i.	1.78 (1.67)	1.64 (1.63)	2.32 (1.82)	2.30 (1.82)	2.82 (1.95)	3.62 (2.15)	1.59 (1.61)	18.81 (4.22)
Untreated control	2.26 (1.80)	0.55 (1.24)	3.32 (2.08)	1.94 (1.72)	0.30 (1.14)	2.65 (1.91)	2.65 (1.91)	17.00 (4)
$F_{(10,20)}$	1.06	1.43	2.76*	0.97	1.82	3.59**	2.82*	2.44
S.E.	0.17	0.11	0.15	0.23	0.20	0.12	0.13	0.90
C.D.	-	-	0.46	-	-	0.35	0.39	-

Figures within the parantheses are $\sqrt{x+1}$

N.O.E. - Neem oil emulsion, T.D. - Tobacco decoction, f.i - fortnightly intervals, m.i - monthly intervals, n.b.a. - need based application

During the eighth week after sowing, a significant difference was observed among the treated plots. Maximum number of *M. sexmaculatus* seen in the plots where malathion was applied along with *C. carnea* @ 50 per plot. The mean population ranged from 1.00 to 3.62, and the other treatments showed significantly lower population.

During the ninth week after sowing the plots treated with 2 per cent tobacco decoction at fortnightly intervals and both the botanical insecticides along with *C. carnea* @ 50 recorded comparatively lower population (0.30 to 1.00). The mean number of *M. sexmaculatus* ranged 1.31 to 2.65.

On the whole the pooled data subjected to analysis showed no significant difference among the treatments.

4.2.4.2 Effect on *X. scutellarae*

The mean number of adults of *X. scutellarae* per five sweep nets and the results of statistical analysis are prsented in Table 12.

During the entire cropping period though there was adult *X. scutellarae* in all the plots, there was no significant difference among the treated plots with regard to the syrphid population.

Table 12 Mean number of syrphid (*Xanthogramma scutellarae*) per 5 sweep nets from vegetable cowpea treated with C. carnea, neem oil, tobacco decoction and malathion at different intervals after sowing

Treatments	Mean number of *X. scutellarae* / 5 sweep nets							Pooled mean
	weeks after sowing							
	3	4	5	6	7	8	9	
C. carnea @ 50/plot at f.i.	0 (1)	0 (1)	2 (1.73)	2.22 (1.79)	0 (1)	0.55 (1.24)	0.55 (1.24)	8.29 (2.70)
C. carnea @ 50/plot at m.i.	0 (1)	0.55 (1.24)	1.94 (1.72)	0.99 (1.41)	1.17 (1.47)	0.55 (1.24)	0.91 (1.38)	7.86 (2.62)
C. carnea @ 100/plot at f.i.	0.91 (1.38)	0.63 (1.28)	0.55 (1.24)	1.31 (1.52)	0.78 (1.33)	2 (1.73)	0.91 (1.38)	8.84 (2.80)
C. carnea @ 100/plot at m.i.	0.63 (1.28)	0.91 (1.38)	0.91 (1.38)	0.30 (1.14)	0.30 (1.14)	1.21 (1.49)	0 (1)	6.66 (2.38)
N.O.E. 10% spray at f.i.	0 (1)	0.55 (1.24)	0.91 (1.38)	0.63 (1.28)	0.78 (1.33)	0 (1)	0 (1)	4.76 (1.94)
T.D. 2% spray at f.i.	0 (1)	0.63 (1.28)	1.59 (1.61)	1.49 (1.58)	1.17 (1.47)	0.91 (1.38)	0 (1)	8.08 (2.66)
Malathion 0.05% (n.b.a.)	0 (1)	1.31 (1.52)	0.30 (1.14)	0.91 (1.38)	0.55 (1.24)	0.55 (1.24)	0.63 (1.28	6.57 (2.36)
N.O.E.+C. carnea @ 50/plot at f.i.	0 (1)	0.91 (1.38)	1.31 (1.52)	0.91 (1.38)	1.00 (1.41)	0.30 (1.14)	0 (1)	6.48 (2.34)
T.D + C. carnea @ 50/plot at f.i.	0 (1)	0.30 (1.14)	1.94 (1.72)	1.31 (1.52)	0 (1)	0 (1)	0.30 (1.14)	6.20 (2.28)
Malathion 0.05 (n.b.a)+C.carnea @ 50/plot at f.i.	1.21 (1.49)	0.78 (1.33)	2.32 (1.82)	1.74 (1.66)	1.40 (1.56)	1.94 (1.72)	0.91 (1.38)	12.49 (3.39)
Untreated control	0.78 (1.33)	0.55 (1.24)	1.49 (1.58)	0.55 (1.24)	0 (1)	0.63 (1.28)	1.00 (1.41)	5.86 (2.42)
$F_{(10,20)}$	2.05	0.41	1.29	0.58	0.87	0.24	1.47	0.62
S.E.	0.13	0.21	0.19	0.25	0.22	0.18	0.15	0.45
C.D.	-	-	-	-	-	-	-	-

Figures within the parantheses are $\sqrt{x+1}$

N.O.E. - Neem oil emulsion, T.D. - Tobacco decoction, f.i - fortnightly intervals, m.i - monthly intervals, n.b.a. - need based application

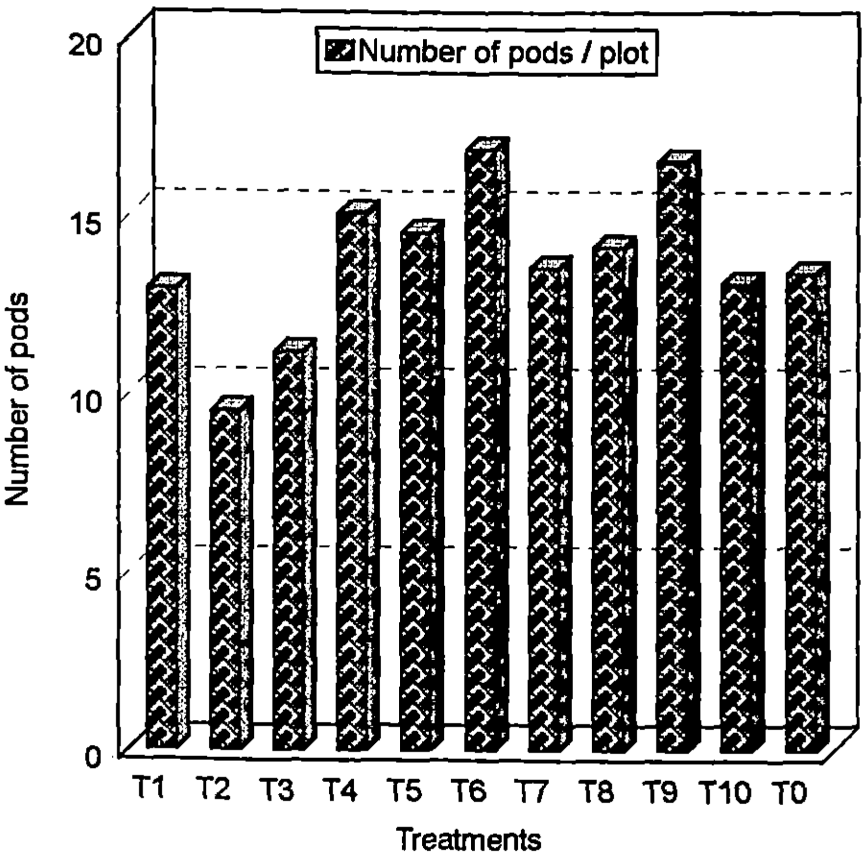
Table 13 Mean number of *Chareps* sp. per 5 sweeps from vegetable cowpea treated with *C. carnea*, neem oil, tobacco decoction and malathion at different intervals after sowing

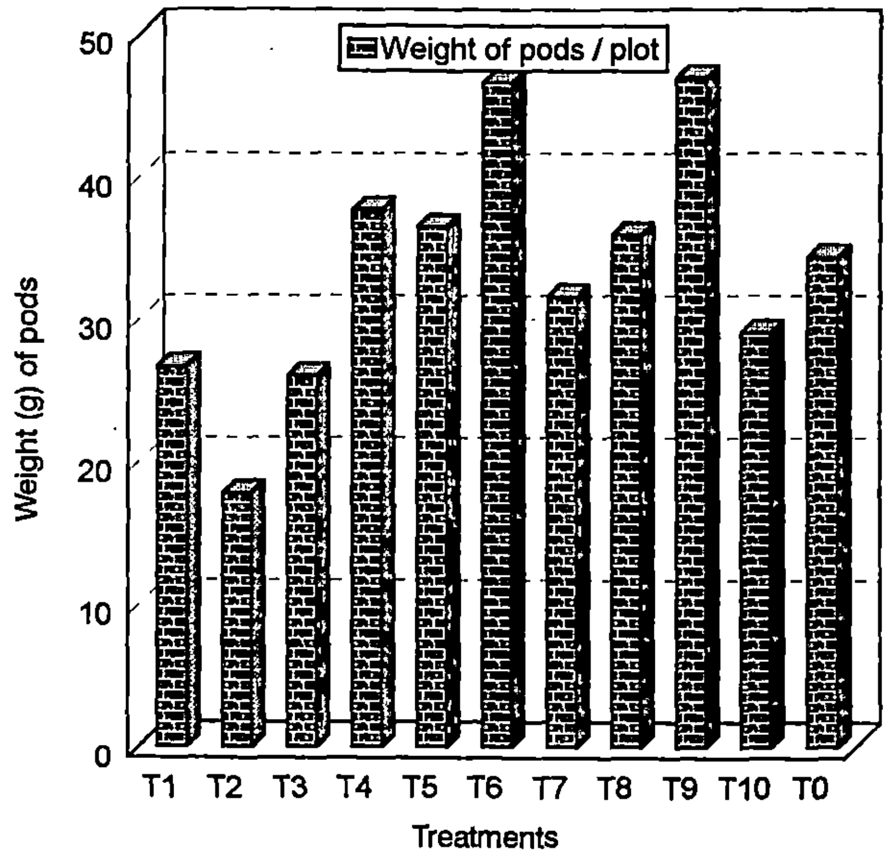
Treatments	Mean number of *charops* / 5 sweep nets — weeks after sowing 3	4	5	6	7	8	9	Pooled mean
C. carnea @ 50/plot at f.i.	0 (1)	0 (1)	1.64 (1.62)	1.64 (1.62)	0.30 (1.14)	0.30 (1.14)	0 (1)	6.02 (2.24)
C. carnea @ 50/plot at m.i.	0 (1)	0 (1.24)	2.48 (1.87)	0.55 (1.24)	0.63 (1.28)	0.55 (1.24)	0.30 (1.14)	6.52 (2.35)
C. carnea @ 100/plot at f.i.	0 (1)	0.55 (1.24)	0 (1)	0.55 (1.24)	1.21 (1.49)	0.91 (1.38)	0.30 (1.14)	6.62 (2.37)
C. carnea @ 100/plot at m.i.	0.30 (1.14)	0.30 (1.14)	0.63 (1.28)	0.30 (1.14)	0.30 (1.14)	0.55 (1.24)	0 (1)	4.53 (1.88)
N.O.E. 10% spray at f.i.	0 (1)	0 (1)	0.55 (1.24)	1.21 (1.49)	0 (1)	0 (1)	0 (1)	3.76 (1.66)
T.D., 2% spray at f.i.	0 (1)	0 (1)	0.30 (1.14)	1.21 (1.49)	0.63 (1.28)	0 (1)	0 (1)	4.24 (1.80)
Malathion 0.05% (n.b.a.)	0 (1)	1.31 (1.52)	0.30 (1.14)	0.91 (1.38)	0.30 (1.14)	0.30 (1.14)	0.30 (1.47)	4.76 (1.94)
N.O.E.+C. carnea @ 50/plot at f.i.	0 (1)	0 (1)	0.63 (1.28)	0.30 (1.14)	0.30 (1.14)	0 (1)	0 (1)	3.22 (1.49)
T.D + C. carnea @ 50/plot at f.i.	0 (1)	0 (1)	0.91 (1.38)	1.64 (1.62)	0 (1)	0 (1)	0 (1)	4.65 (1.91)
Malathion 0.05 (n.b.a)+C.carnea @ 50/plot at f.i.	0.55 (1.24)	0.30 (1.14)	0.91 (1.38)	1.49 (1.58)	0.91 (1.38)	1.94 (1.72)	0.55 (1.24)	9.12 (2.85)
Untreated control	0.30 (1.14)	0 (1)	1.84 (1.69)	0 (1)	0 (1)	0.30 (1.14)	0.63 (1.28)	5.20 (2.05)
$F_{(10,20)}$	0.79	2.71*	1.24	1.11	2.15	1.90	0.90	1.25
S.E.	0.09	0.09	0.24	0.21	0.11	0.16	0.11	0.65
C.D.	-	0.29	-	-	-	-	-	-

Figures within the parantheses are $\sqrt{x+1}$

N.O.E. - Neem oil emulsion, T.D. - Tobacco decoction, f.i - fortnightly intervals, m.i - monthly intervals, n.b.a. - need based application

Fig. 5 Number and weight of cowpea pods harvested from plots treated with *C. carnea*, neem oil, tobacco decoction and malathion





T1 - *C. carnea* @ 50 / plot at f.i.
T2 - *C. carnea* @ 50 / plot at m.i.
T4 - *C. carnea* @ 100 / plot at f.i.
T4 - *C. carnea* @ 100 / plot at m.i.
T5 - N.O.E. 10 % spray at f.i.
T6 - T.D. 2 % spray at f.i.
T7 - Malathion 0.05 % (n.b.a.)
T8 - N.O.E. + *C. carnea* @ 50 / plot at f.i.
T9 - T.D + *C. carnea* @ 50 / plot at f.i.
T10 - Malathion 0.05 (n.b.a) + *C. carnea* @ 50 / plot at f.i.
T0 - Untreated control

4.2.4.3 Effect on *Charops* sp.

The mean population of *Charops* sp. per 5 sweep nets collected and the statistically analysed data, are presented in Table 13.

Though *Charops* sp. were seen in the fields, their population was only to a lesser extent and no significant difference was observed between the treated and untreated plots except during the fourth week after spraying.

4.2.5 Yield

The effect of different treatments on yield in terms of number and weight are presented in Fig.5 and Table 10.

Maximum number of pods were recorded in plots treated with tobacco decoction 2 per cent alone and along with *C. carnea* and were higher (282.47 and 271.91 respectively), when compared to the control (178.15). Weightwise also these two plots showed higher yield. (2172.18 and 2203.05 g) than control (1179.96) but all the treated plots were on par with that of control.

"Confidence, like art, never comes from having all the answers; it comes from being open to all the questions."

Earl Gary Stevens

DISCUSSION

5. DISCUSSION

The present day situation demands knowledge about bioagents, one of the ecological foundations for sustainable agriculture. It is ironical that we recognize few native organisms as pests, but are ignorant of native natural enemies. Conservation being an important component of biocontrol, adequate information on the native natural enemies is highly essential.

The green lacewing *Chrysoperla carnea* is available under different ecosystems in India. Recognizing the predatory potential, *C. carnea* is now being mass multiplied and utilized for pest suppression in cotton, sunflower and fruit crops.

Vegetable cowpea grown and marketed in Kerala is often loaded with insecticides (Mathew *et al.*, 1995) due to the unilateral dependence on pesticides by the farmers to tackle the pests in the flowering and pod formation stages. Identification of native natural enemies, pesticide resistant natural enemies, if any and determination of suitability of *C. carnea* to the vegetable ecosystem in Kerala will contribute towards developing ecofriendly management programme for vegetable cowpea in the state. Under the situations, the present project entitled 'Biocontrol of pests of vegetable cowpea (*Vigna unguiculata* sub sp. *sesquipedalis* (L.) Verdcourt) was carried out with the objective to identify natural enemies in insecticide sprayed vegetable cowpea in farmers' fields and unsprayed vegetable cowpea and determining the role of *C. carnea* and botanicals viz., neem oil emulsion, tobacco decoction and malathion and their combinations in managing the pests.

5.1 Monitoring of pests and natural enemies

The changing agricultural practices necessitates a continuous review of the pest complex of a crop under a particular set of agroclimatic conditions in order to fix priorities for evolving suitable pest management practices. Hence monitoring of pests in vegetable cowpea was included in the present investigations.

The pea aphid *A. craccivora*, pod borers, *H. armigera*, *L. boeticus* and *M. testulalis*, pod bugs *C. gibbosa*, *R. pedestris* (Table 1) were recorded during kharif and rabi, 1996. Earlier the occurrence of these pests in cowpea was reported from Kerala and elsewhere (Mathew *et al*., 1971; Visalakshi *et al*., 1976; Mensah, 1988; Ofuya, 1989). The pea aphid, pod borers and pod bugs were observed as persistant pests in both insecticide sprayed and unsprayed ecosystems. The American serpentine leaf miner was recorded only in the insecticide sprayed plots in farmers' fields.

Results presented in 4.1.1.1.1 revealed that *A. craccivora* was a regular pest of vegetable cowpea and was invariably present in the insecticide sprayed and unsprayed vegetable cowpea plots during kharif and rabi. The population of aphids commenced from the early vegetative phase of the crop in both kharif and rabi in the insecticide sprayed fields. As far as the aphids in the unsprayed crop was concerned, they (4.1.2.1.1) were not seen upto 35 days after sowing in the kharif crop, thereafter there was a spurt in the aphid population. During the week prece ding this increase, there was heavy rainfall and afterwards there was an increase in the temperature and relative humidity (Appendix 1). These conditions might have favoured the multiplication of cowpea aphids. The aforesaid influence of abiotic factors on population build up of aphids was observed by Dixon (1985) and Varatharajan *et al.* (1995). A similar trend was observed in the aphid incidence in the unsprayed rabi crop also.

The occurrence of american serpentine leaf miner was noticed in kharif and rabi crops in the insecticide sprayed plots. The infestation was observed from the very beginning of the crops and persisted for five weeks and thereafter the infestation was reduced. The unsprayed crop raised in the Instructional Farm, Vellayani was free from the attack of american serpentine leaf miner during kharif and rabi season. Earlier the pest was found to ravage insecticides sprayed cowpea plants in the Instructional Farm, Vellayani also

(Reghunath and Gokulapalan, 1996). Srinivasan *et al.* (1995) identified few indigenous parasitoids viz., *Hemiptrasenus varicornis* and an eucoilid parasitoid to affect *L. trifolii* in South India. They opined that augmenting the promising parasitoids besides restricting the application of selective insecticides to enable the build up of resident natural enemies are the ways to check the horizontal spread of *L. trifolii*. In the present investigation no natural enemy has been identified. Still, the recent wide spread oocurence of american serpentine leaf miner in the insecticide sprayed ecosystems in Thiruvananthapuram and the present observation of the leaf miner in the farmers' fields alone may be due to the adverse effect of insecticides on the natural enemies and needs further investigation.

The pod bugs found in the insecticide sprayed fields during kharif and rabi were *C. gibbosa* and *R. pedestris*. Both these bugs were reported earlier as the coreids that posed serious problems (Mensah, 1988; Ofuya, 1989). These bugs were present throughout the cropping period with a slight increase in population after the flowering stage (Table 9). These findings are in conformity with the reports of Mensah, 1988. In the unsprayed crop, the pod bug incidence was seen only for a week commencing from the seventh week after sowing, when the crop was in the late pod formation stage both in the kharif and rabi, the population being low in the rabi season.

The pod borers appeared in the crop coinciding with the formation of flowers and then persisted for another month. The pod borer attack was low during both the seasons in the insecticide treated fields. In the unsprayed crop, the pod borers appeared late in the crop during both seasons, the incidence being higher in the rabi season (Table 2).

The coccinellids *M. sexmaculatus*, *M. crocea* and *Scymnus* sp. were recorded from both insecticide sprayed and unsprayed ecosystems. *M. sexmaculatus* was earlier recorded as a promising predator of several species of aphids viz., *A. craccivora*, *A. gossypii*, *Dactynotus compositae* Threshold, *Lipaphis erysimi* and *Rophalosiphum maidis* (Gautam, 1984). The adults of *M. sexmaculatus* were found throughout the kharif and rabi seasons in the insecticide sprayed crops. Though the grubs of *M. sexmaculatus* was found in aphid colonies, the population peaks of aphids and the predatory larvae was not found to coincide. According to Bhaskaran and Veeravel (1989) *M. sexmaculatus* possess a high predatory potential and the predator appeared in the egg plant after the colonisation of aphids. They further found that multiple peaks of aphids were matched by peaks of coccinellids. The deleterious effects of the insecticides may be the reason for the retardation in the population growth of the predatory grubs and the consequent non synchronised population peaks. Contrary to this, in the unsprayed ecosystem, the population of *M. sexmaculatus* was higher and there was synchronization of the population peaks of the aphids and the predators. The coccinellid predator *Scymnus* sp. was observed in kharif and rabi seasons in the unsprayed ecosystems. Gautam (1994) has mentioned that *Scymnus* sp. is an important predator of *L. erysimi* and *R. maidis* in kharif and rabi and summer crops. The aforementioned parasites and predators except *X. scutellarae* even though present only in low levels were recovered from areas subjected to continuous and heavy insecticide application which points to the fact that they are insecticide tolerant species and offer scope for being utilized in pest management programmes through conservation by regulating insecticide applications or by augmentation.

Results mentioned in 4.1.1.2 and 4.1.2.2 indicate that, next to coccinellids, the syrphid *X. scutellarae* is the important predator present. The larva of this predator was found invariably in the aphid colonies during kharif and rabi in the insecticide sprayed plots even though the population was much low. The occurrence of *X. scutellarae* in aphid colonies in Thiruvananthapuram district has been reported by Reji Rani (1995) and Sitaraman, (1966).

The ant *S. geminata* was observed as a predator of *A. craccivora* in the farmers' fields. According to Debach and Rosen (1991) the ants probably constitute one of the most important predatory group and are important in natural control.

A. nigrotibialis was observed to parasitize larvae of *H. armigera*. Earlier *A. nigrotibialis* was recorded as the dipteran natural enemy infesting paddy hoppers. Fairly good number of *A. nigrotibialis* was observed in sweep nets during kharif and rabi in farmers' fields, and in the unsprayed plots. An unidentified hymenopteran was also found to parasitize *H. armigera*.

The dipteran pipunculid *T. subvirescens* parasitized the leaf hopper *Sundapteryx biguttula biguttula* in the insecticide sprayed plots. Previously there was no record of this parasite on leaf hoppers.

The parasitoids and predators recorded were comparatively more during the rabi season than in the kharif season. The higher activity of the natural enemies might be due to the higher population of the pests, the food source, during the rabi season.

The hymenopteran parasitoid *Charops* sp. was recorded from both insecticide sprayed and unsprayed fields and was associated with aphids. *Charops* as effective parasitoid of *H. armigera* was reported earlier (Joginder *et al.*, 1990). The abundance and activity of insect population within a field are closely associated with the nature of the surrounding crop also. The present observation of *Charops*, *A. nigrotibialis*, *T. subvirescens* in the sweep nets might be due to this influence, as the experiment fields were raised near paddy fields.

In the present studies, *G. triangulifer* was found in aphid colonies both in insecticide sprayed and unsprayed ecosystems, though few in numbers.

The results presented in 4.1.3.1 indicated that the pest incidence was more in the unsprayed plots than in the insecticide sprayed plots. Moreover the pests were found throughout the crop seasons in the insecticide sprayed plots whereas the pests were present only for a shorter period in the unsprayed plots. During the period when the aphids appeared in the field in unsprayed plots, the climatic conditions viz., relative humidity and temperature were highly conducive and consequently the population sho t up which accounted for the significant differences in the pooled mean but it could be seen from the results that the population build up was checked by the natural enemies present then. Ultimately though the population of pests was high in unsprayed plots their impact might not have reflected much on the yield. The findings of Ofuya (1995b) that the population of aphids developing from nine adult apterae @ 35 young ones per adult of *A. craccivora* in one week was completely controlled by a pair of *Menochilus* sp. within the following weeks is also supportive to the present findings. The incidence of american serpentine leaf miner was totally absent in the unsprayed plots.

As far as the natural enemies were concerned, their adult and larval population were significantly higher in the unsprayed plots indicating that the insecticide sprays adversely affected the existence of natural enemies. Rotrekl (1994) was also of the same view that insecticides produced marked fall in the natural enemy population directly or indirectly by removing the food source.

5.2 Management of cowpea pests using the predator *C. carnea*, neem oil, tobacco decoction and malathion

From the results presented in para 4.2.1 it is clear that fortnightly release of *C. carnea* @ 50 per plot considerably reduced the aphid population and this treatment recorded the lowest incidence of aphids while the monthly releases of *C. carnea* at 50 and 100 per plot were ineffective. Heinz *et al* (1988) observed that regular releases of *C. carnea* checked aphids in Marygold. Contrary to this Edelson *et al*. (1993) found that inundative release of eggs or larvae of *C.carnea* were ineffective in reducing aphid populations but were effective with more number of releases in controlling lepidopteran pests of Broccoli in Southern Texas.

Among the botanicals, only 2 per cent spray of tobacco decoction when applied at fortnightly intervals could reduce the aphid population to substantial levels over the weeks.

Neem oil emulsion 10 per cent gave effective protection only upto one month after sowing. Ho and Kibuka (1983) was also of the view that neem oil at higher concentration gave better protection at early vegetative stages only. Both the botanicals in combination with *C. carnea* effectively checked aphids throughout the cropping season. Studies conducted by Salem and Matter (1991) also revealed that neem seed oil had no detrimental effects on *C. carnea*. The ecological selectivity of neem seed oil is well established (Ho and Kibuka, 1983; Krishnaiah and Kalode, 1984; Thakur *et al*., 1988). Malathion 0.05 per cent applied on need basis reduced the aphid population. This was in line with the findings of Sudharma *et al*., 1987; Chauhan *et al*., 1988; El-Ghar *et al*., 1994. The pooled mean for the aphid population in the combined application of malathion 0.05 per cent and *C. carnea* was higher and was on par with the untreated control. It is evident from the data (Table 8) that this higher value is attributed to the high aphid population prior to insecticidal application which decreased substantially following the insecticidal spray.

Inspite of the absence of flowers or pods the pod bugs were seen from the early vegetative period in a lower intensity but with no significant difference in the population with respect to the various treatments up to seven weeks of the crop growth. Mensah (1988) opined that pod bugs are destructive post flowering pests of cowpea. In the observations taken during the later phase of the crop, the pod bug population varied significantly in the various treatments, the least being in plots treated with botanicals alone or in combination with *C. carnea*. The findings are in conformity with that of Chari *et al*., 1990; Singh, 1990. An over all assessment of the results revealed that external interference by way of chemicals, botanicals or bioagents is required to tackle these sucking pests as untreated control harboured significantly higher population of pod bugs. Among the various treatments neem oil emulsion 10 per cent along with *C. carnea* proved to be the best. This was closely followed by tobacco decoction 2 per cent.

As far as the pod borers were concerned, though the infestation commenced from the seventh week after sowing, owing to their low population no significant difference was seen between various treatments. However during the eleventh week after sowing, there was significant difference between treated and untreated plots and also between various treatments. Tobacco decoction 2 per cent and neem oil emulsion 10 per cent, with *C. carnea* recorded cent per cent control of pod borers; Karel and Mghogho (1985) were also of the opinion that untreated plots harbour more pod borers. *C. carnea* @ 50 and 100 at fortnightly and monthly intervals were effective against pod borers. The present findings are supportive by the findings of Lingren *et al*. 1968; Manjunath *et al*. 1976 and Manjunath 1993 who found that *C. carnea* significantly reduced infestation of pod borers like *H. armigera*. Malathion 0.05 per cent alone and along with *C. carnea* also reduced pod borers significantly. Wilkinson *et al*. (1975) had reported the high tolerance of *C. carnea* to insecticides like malathion, endosulfan etc.

The population of *M. sexmaculatus* was though significantly low in the observations taken at fifth, eigth and ninth week after sowing, the pooled data indicated no significant difference in the population of *M. sexmaculatus* with respect to the plots treated with neem oil emulsion 10 per cent, 2 per cent tobacco decoction and malathion. However Lowery and Isman (1995) were of the view that neem products prevented the adult eclosion of coccinellids. Kaethner (1991) found that neem products increased the mortality of coccinellid. El-ghar *et al*. (1994) stated that insecticides reduced the population of insect predators. As the population of syrphids and *Charops* were very low, the impact of the different treatments could not be revealed.

There was no significant increase in the yield in terms of weight of the pods and number of pods harvested, but it is clear from the results (Table 10) that in all the treatments, there was significant reduction in the number of pod borer damaged pods. Besides it may be noted that pod bugs and aphid infestation is much reflected on quality rather than on yield. Visalakshi *et al*. (1976) have also observed that the pod bug attacked seeds shrink and shrivelled up and become discoloured. Further the skin surface of such pods presented a rugged appearance. Naturally in the market they fetch only low price. Moreover now there is a general awareness among the public about the consequences of pesticide syndrome, and the result is a preference for products obtained from unsprayed fields. In such a situation, the self-perpetuating bioagent *C.carnea* and the ecofriendly botanicals can be depended upon for the management of pests of cowpea. In the field situations at Vellayani *Oecophylla smaragdina* was observed as a hyper predator of *C. carnea*. Therefore environmental modifications for exploiting the maximum performance of *C. carnea* by eliminating the predators like *Oecophylla smaragdina* may also be considered. As the insecticide malathion is not adversely affecting *C. carnea* and as the residues of this insecticides remains only for about three days in vegetable cowpea, malathion on need basis can be used as a component in pest management programme of vegetable cowpea.

SUMMARY

6. SUMMARY

Vegetable cowpea, *Vigna unguiculata* sub sp. *sesquipedalis* (L.) Verdcourt is an important vegetable grown in Kerala. Enormous quantities of insecticides applied quite frequently to control the pests of this crop in the vegetable growing areas in Thiruvananthapuram District is paving way to serious health hazards. The sole dependence on insecticides by the farmers is due to the lack of an alternative and effective technology to manage the pests. Biocontrol has been proved successful in tackling many crop pests in India and abroad, Conservation of natural enemies find an important place in biocontrol programmes.

Before initiating any biocontrol programme, as it is essential to know the pests and natural enemies in the cowpea ecosystem, a detailed monitoring was done on the pests and natural enemies associated with vegetable cowpea in the insecticide sprayed plots in farmers' fields during kharif and rabi, 1996 in two locations viz., Kalliyoor and Palappur in Thiruvananthapuram District which are areas known for high pesticide usage. During this period, monitoring was also done on natural enemies associated with unsprayed vegetable cowpea raised in the Instructional Farm and the results were compared using students 't' test. The damage caused by the pests was

assessed in terms of the mean number of aphids per five centimeter shoot length, the mean number of leaves mined by the american serpentine leaf miner, the number of pod bugs per five sweep nets, and the number of damaged pods per plant. The observations were taken from ten observational plants per plot, leaving aside two border rows from either side. The salient findings are mentioned here.

a) The pests that got established in the insecticide sprayed as well as unsprayed plots were the same except the leaf miner and they were the pea aphids *A. craccivora*, the pod bugs *C. gibbosa* and *R. pedestris* and the pod borers *M. testulalis*, *H. armigera* and *L. boeticus*.

b) The aphids were seen throughout the cropping period in the sprayed fields during kharif and rabi seasons. The peak infestation was during the fourth week after sowing. The aphid population was slightly higher in the rabi season. The unsprayed fields were free from the aphid infestation for the first 35 days after sowing. A sudden increase in the aphid population was noted thereafter and this was due to the conducive climatic conditions such as relative humidity and maximum temperature which was preceded by heavy rains.

c) The american serpentine leaf miner was present throughout the cropping period in the sprayed field in both during kharif and rabi. The infestation of the miner was more during the early stages of the crop. In the unsprayed plots there was no incidence of the american serpentine leaf miner.

d) In the insecticide sprayed plots, the pod bugs were seen throughout the cropping period, with an increase in their intensity during the later stages of the crop ie post flowering stage. On the contrary, the pod bug population in the unsprayed plots was seen only from the seventh week after sowing coinciding with the late flowering stage.

e) As far as the pod bores were concerned, both in the insecticide sprayed and unsprayed plots they appeared only during the flowering stage of the crop and persisted for one month.

f) The predators identified in the insecticide sprayed fields were the coccinellids *M. sexmaculatus*, *M. crocea* and *Scymnus* sp. the syrphid, *X. scutellanae* a scoleid *Sallus* sp. [illegible] and a carcinophorid *E. stali*. The parasitoids were the tachinid, *A. nigrotibialis*, the ichneumonid *Charops* sp, a bethylid *G. triangulifer* and a pipunculid *T. subvirescens*. The unsprayed plot also had the same species of natural enemies with an exception of *E. stali*.

g) In the insecticide treated plot, the coccinellids were present in more numbers as compared to other natural enemies and they were present throughout the cropping period. The coccinellid population was not found to synchronise with the population of its host, the aphid. As far as the unsprayed fields were concerned, the coccinellid population was comparatively more and their population synchronised with the aphid population. The non synchronisation might be due to the deleterious effect of the insecticidal sprays on the coccinellids.

h) The syrphid *X. scutellarae* was next in abundance to the coccinellids in both insecticide sprayed as well as unsprayed fields. The larvae of this predator were seen in the aphid colony during both the seasons.

The other parasitoids and predators though present throughout the cropping period during both the seasons were present in low levels only. The predators and parasitoids were more during the rabi season than that during the kharif season.

The comparison between the sprayed and unsprayed plots revealed that though the aphid population shoot up in the unsprayed plots due to conducive climatic conditions, they were effectively checked by the natural enemies. There was significantly lower population of natural enemies in the insecticide sprayed plots indicating that the deleterious effects of the insecticidal sprays affected the build up of the natural enemies.

The green lacewing *C. carnea* used as an effective predator against soft bodied insects in various crops in Tamil Nadu, Karnataka etc. was mass multiplied and released at different rates with botanicals neem oil, tobacco decoction and insecticide malathion on need basis to study their versatility in controlling the cowpea pests and their compatability with the aforesaid pest control measures. The results obtained are briefly enumerated.

a) *C. carnea* @ 60 per plot at fortnightly intervals was effective in controlling pea aphid. It was also found that among the botanicals, tobacco decoction 2 per cent when sprayed at fortnightly intervals effectively reduced the aphid population.

b) The pod bug population varied significantly among various treatments only during post flowering period and was controlled effectively by the botanicals, neem oil 10 per cent and 2 per cent tobacco decoction either alone or along with *C. carnea* when applied at fortnightly intervals.

c) As far as the pod borers were concerned, lowest incidence was recorded in the plots treated with tobacco decoction 2 per cent spray at fortnightly intervals. All the other treatments also showed significant superiority in controlling pod borers.

d) The natural enemies, *M. sexmaculatus*, *X. scutellarae* and *Charops* sp. were present throughout without any significant difference among the treatments.

e) As far as the yield was concerned, there was no significant difference among the treatments, but there was significantly lower pod borer infested pods in treated than in untreated plots. Though the infestation by aphids and pod bugs were not reflected in the yield, they would only fetch lower market price due to the poor quality of the pods as they get shrivelled and discoloured due to the infestation.

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* Originals not seen

APPENDIX

APPENDIX- I

Weather parameters during 1996-1997

Peirod	Temperature (°c)	Relative humidity (%)	Rainfall (mm)
Ist cropping season			
1st week	22.4	90	-
2nd week	23.4	90	-
3rd week	23.0	77	-
4th week	20.4	100	-
5th week	23.2	93	16.6
6th week	20.4	90	7.0
7th week	22.4	90	-
8th week	21.8	87	0.4
2nd cropping season			
1st week	22.8	96	27.1
2nd week	23.0	95	11.0
3rd week	24.0	89	-
4th week	22.0	83	-
5th week	21.4	90	22.2
6th week	23.6	95	1.0
7th week	21.2	95	4.0
8th week	22.8	83	-

BIOCONTROL OF PESTS OF VEGETABLE COWPEA

(*Vigna unguiculata* sub sp. *sesquipedalis* (L.) Verdcourt)

BY

BINDU, S.S

ABSTRACT OF THE THESIS
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ABSTRACT

ABSTRACT

Monitoring of the incidence of pests and their natural enemies was carried out in the heavily insecticide sprayed vegetable cowpea plots in farmers' fields in two locations viz. Kalliyoor and Palappur in Thiruvananthapuram District and in the unsprayed crop raised in the Instructional Farm, College of Agriculture, Vellayani, during kharif and rabi, 1996.

The results of the monitoring revealed that the pea aphid, *A. craccivora*, the pod bugs *R. pedestris* and *C. gibbosa* and the pod borers *H. armigera*, *L. boeticus* and *M. testulalis* were the major pests that attacked vegetable cowpea both in the insecticide sprayed as well as in the unsprayed plots. The pea aphid was persistent in the insecticide sprayed fields where as in the unsprayed fields, they were not seen upto 35 days after sowing, in both kharif and rabi season. The pod bugs and pod borers were seen throughout the cropping period with increase in the post flowering period in both sprayed and unsprayed crop. Attack of the american serpentine leaf miner *L. trifolii* was observed only in the insecticide sprayed fields and was present in rabi as well as in the kharif seasons

The parasitoids that were encountered were *A. nigrotibialis*, *Charops* sp., *Salius* sp. and *T. subvirescens*

and the predators were *M. sexmaculatus*, *M. crocea*, *Scymnus* sp., *E. stali*, *S. geminata* and *X. scutellarae*. The population of the natural enemies was higher during the rabi season than that during kharif season.

The population of the pests and natural enemies in the insecticide sprayed and unsprayed plots were compared using students 't' test and the results revealed that the pest were more in the unsprayed plots but the population was higher only for a shorter period and it was effectively checked by the natural enemies, the population of which synchronized with that of the pests. There was significantly higher population of natural enemies in the unsprayed plots when compared to unsprayed plots.

The role of the green lacewing *C. carnea* in the management of the vegetable cowpea pests was studied through replicated field trials conducted at College of Agriculture, Vellayani during 1996. The impact of biorationals viz., neem oil and tobacco decoction and insecticide, malathion on the predator *C. carnea* and in their effectiveness in management of cowpea pests was also studied in the field experiment.

C. carnea released @ 50 per plot at fortnightly intervals effectively checked the aphid population. Among the botanicals, tobacco decoction 2 per cent was found to be effective in controlling the aphids, pod bugs and pod borers.

Neem oil emulsion 10 per cent when applied at fortnightly intervals was also found to be significantly superior to the untreated control. However the infestation by aphids and the pod bugs was less in all the treatments when compared to control. Though the control plot did not show significant reduction in yield, the quality of the produce was reduced due to the pest infestation. *C. carnea* @ 100 per plot at fortnightly and monthly intervals were effective against pod bugs. The pod borers were effectively checked by *C. carnea* @ 50 and 100 per plot. In general the monthly release of *C. carnea* was comparatively less effective in controlling the pests. The botanicals did not show any deleterious effect on *C. carnea*.

When the yield was assessed in terms of weight and number of pods harvested, significantly higher yield was recorded only in plots treated with tobacco decoction 2 per cent when compared to untreated control.