MANAGEMENT OF INSECT PESTS OF GHERKIN (*Cucumis anguria* L.) WITH PARTICULAR REFERENCE TO THE FRUIT BORER, *Diaphania indica* (Saunders) (LEPIDOPTERA : PYRALIDAE)

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DEPARTMENT OF ENTOMOLOGY

UNIVERSITY OF AGRICULTURAL SCIENCES

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CERTIFICATE

This is to certify that the thesis entitled "MANAGEMENT OF INSECT PESTS OF GHERKIN WITH PARTICULAR REFERENCE TO THE FRUIT BORER, *Diaphania indica* (Saunders) (LEPIDOPTERA : PYRALIDAE) submitted by Mr. K. C. RAVI for the degree of DOCTOR OF PHILOSOPHY in AGRICULTURAL ENTOMOLOGY to the University of Agricultural Sciences, Bangalore, is a bona-fide record of research work done by him during the period of his study in the University under my guidance and supervision and that no part of thesis has been submitted for the award of any degree, diploma, associateship, fellowship or other similar titles.

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INTRODUCTION

I. INTRODUCTION

Gherkin (*Cucumis anguria* L.), belonging to the family Cucurbitaceae, is commonly called 'West India Gherkin' or 'Bur Gherkin'. It is also known as "Pickle cucumber" as the fruits are used for preparing pickles- a delicacy relished by people in America, Australia and Europe. The crop is believed to have originated in South America. It is a slender, rough trailing vine producing oval or oblong fruits (Bailey, 1916). The crop is best suited to tropical situations and demands care-to-infant if it has to sustain itself for economic production.

In general, the crop does not demand uncommon cultivation. The seeds are sown at a distance of 30 cm between them in rows set 90 cm apart form each other. After 25-30 days, branches produced are trained vertically on to ropes tied to stakes. Likewise, subsequent branches put forth by the vine, are also trained (Plate 1).

Plants start producing fruits when they reach an age of 20-25 days depending on the season. Two to three cm long fruits are plucked. Fruits are harvested till the end of the crop period. In general, a crop lasts for 90 days. The fruits thus harvested are processed in vinegar or brine solution. Such processed fruits are exported to America, Australia, Europe and other countries. The crop brings in considerable foreign exchange to the country.

As cultivation of gherkin is highly labour intensive, it is being grown in developing countries. The net income for the farmer is around Rs. 15,000-20,000 for one season with a yield of 2-3 tons per acre. This


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depends on the inputs provided, the farm practices and the post harvest handling. Thc prices depend on the grades- smaller ones fetching higher returns (Dattatreyulu, 1996).

The crop, which fetches high returns, has attracted several farmers around Bangalore and in many parts of Karnataka to cultivate. It is also being commercially grown in the neighbouring states of Tamilnadu and Andhra Pradesh.

Like other crops, gherkin is also not spared by insects. Many insect herbivores feed on different parts of the vine. Since the crop has been recently introduced to India, there are no reports available on the pest complex. Segeren (1983) has reported the incidence of *Diaphania nitidalis* and aphids as major pests of this crop from Surinam. Similarly, from Southern Sweden, Mattson (1987) observed the occurrence of *Delia platuria, D. florida, Thrips fuscipennis, Bourletiella hortensis, Lygus pratensis, Aphis gossypii, Empoasca vitis, Tetranychus urticae, Anthocoris hemorum, Acolothrips intermedius* on gherkins. Barring these two, there is no further information on the insect pests of this crop from any other part of the world.

The attack by pests, besides affecting the growth and development, greatly affects the export value of the crop. It has to be noted here that fruit is the commercial product, and hence, even the slightest damages could result in rejection of the entire consignment. Thus the potentiality to inflict severe losses to both the farmers and the entrepreneurs is imminent. This would bring down the export returns to the country to a large extent. To avoid the damage caused by the pests, necessary measures should be undertaken at an appropriate time.

Further, necessary care should be taken to reduce the use of chemicals with long residual action. Hence, there has been a great pressure on selecting chemicals with short residual action. More importantly, need based approach should receive prime attention. Adequate Integrated Pest Management (IPM) strategies should be developed.

Preliminary survey conducted to study the important pests occurring on gherkins revealed that the fruit borer, *Diaphania indica* (Saunders), is the most notorious pest of this crop. Though the insect often feeds on leaves, damage done to them is not of economic importance. However, its occasional encounter with fruits can lead to irrecoverable losses. As mentioned earlier, even a slight injury could greatly affect the foreign returns to the country. Besides, *D. indica, Helicoverpa armigera* (Hubner); the serpentine leaf miner, *Liriomyza trifolii* (Burgess), the fruit fly, *Bactrocera cucurbitae* (Coquillet), aphids, mites were also observed. Hence, the present investigation was carried out to study the pest complex and their potential on gherkins, and to devise suitable management practices. Following were the objectives of the investigation :

1. To study the distribution patterns of *Diaphania indica* and to develop an effective sampling plan for population estimation.
2. To study the seasonal incidence of insect and mite pests occurring on gherkins.
3. To study the biology of *D. indica*.

4. To identify the susceptible stage of the crop to *D. indica.*
5. To estimate the amount of loss caused by *D. indica* on gherkins.
6. To develop eco-friendly integrated management practices for major insect pests of gherkins.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Information on insect and mite pests of gherkin in India and abroad are limited to the reports of Segeren (1983) and Mattson (1987) as mentioned earlier.

However, literature is available on the pests of cucumber (*Cucumis sativus* L.), a close relative of gherkin and other cucurbit hosts both from India and abroad. The same is reviewed in this chapter.

2.1 Larval distribution of *Diaphania* spp. and population sampling:

No information is available on larval distribution of *Diaphania indica* (Saunders) or of any stages of the pest particularly on gherkins. As the cultivation practice followed is completely different from other crops, the workers have chosen simple sampling procedures for the estimation of the population of this pest.

Pandey (1975) studied the number of larvae and pupae of *D. indica* on seven cucurbits when the population outbreak occurred on *Cucurbita melo* during 1970 in UP. Ten plants of each host were selected at random to study the distribution of the caterpillars on different cucurbits. Based on the data obtained he concluded that the *C. melo* had large population of the pest than others.

Twenty plants of three different cucurbits viz., water melon, sweet melon and cucumber were selected at random by Ba-Angood (1979) to study the distribution of the insect on different parts of the plant (stem, leaves, flowers and fruits). His results showed that eggs, larvae and pupae were observed in more numbers on watermelon. More number of larvae and pupae were recorded on leaves and fruits.

Perez *et al.*,. (1982) selected nine plants in each treatment of 1.2 x 0.5 m area to assess the effectiveness of different chemicals on *D. nitidalis*. Sindlinger and Foerster (1984) studied the occurrence of larvae of *D. nitidalis* on different parts of the cucumber (*C. sativus*) plant. They concluded that first and second instar larvae were found mainly on the shoots and flowers and on fruits already penetrated by the later instar larvae. Third and fourth instar larvae showed significant preference for fruits over shoots and flowers.

Edelson (1986) sampled cantaloupe fields during three growing seasons to determine the incidence of insect pests. He compared between two sampling methods(visual observations and a combined suction/visual technique) and three sample area sizes(1x1, 2x and 3x3 m) during two seasons to determine sampling precision and efficiency. He concluded that largest size area sampled resulted in lowest relative variation (RV) and relative net precision (RNP) values for both techniques. He also opined that the required number of samples associated with differing degrees of precision for both methods and all sample areas was very large.

The spatial pattern of the five larval stages of *D. nitidalis* within reproductive structures of summer squash was studied to develop a sampling method for assessing its population. Sampling green staminate flower buds >5cm in length was more reliable for detecting infestations than smaller green staminate flower buds, blooming flowers and fruits. Flower buds provided more efficient (large reservoir of larvae), reliable and acceptable data on sampling. Fruit damage was positively correlated with flower bud damage and larval counts. The between plant spatial distribution pattern was variable between samples but suggested a singly contagious (overdispersed) larval dispersion (Brewer and Story, 1987).

2.2 Insect pests occurring on gherkin and other cucurbits

Several workers have reported the incidence of insect pests belonging to various orders that attack cucurbits. Most of the workers have opined that many of the pests are found commonly on all cucurbit host species. Except for some differences, their incidence, nature of damage, biology etc., are similar on all the hosts (Ayyar, 1923 and 1963; Butani, 1975; Nair, 1975; York, 1975; Segeren, 1983; Grafius, 1984; della-Giustina, 1981; Ali *et al.*, 1992; Ram and Pathak, 1984; Pareek and Kavadia, 1994 and Ke, *et al.*, 1986 and 1988).

Ayyar (1923) cited fruit flies as major pests of melons and has also reported that leaf caterpillar, *Diaphania (Glyphodes) indica* (Saunders), and leaf beetle, *Aulacophora* sp, cause substantial damage. Same author in his book (1963) has mentioned that the epilachna beetle (*Epilachna* sp); leaf caterpillar, *Margaronia indica*; pumpkin beetles, *Aulacophora foveicollis* (Lucas), *A. atripennis* (Fabr.) and *A. stevensi* Baly ; stink bugs, *Aspangopus janus* Fabr. and *A. brunneus* B.; fruit flies, *Dacus* sp. and *Chaetodacus* sp. as major and plant lice, *Aphis gossypii* Glover; gall fly, *Lasioptera falcata* (Fabr.); dark weevil, *Baris* sp and green mosquito as minor pests of cucurbit crops.

Butani (1975) has listed pumpkin beetles, *A. foveicollis, A. intermedia* Jac. and *A. cincta* as the most serious pests followed by melon fruit fly, *Bactrocera cucurbitae* (Coquillet), ethiopian melon fly B. *ciliatus* (Loew), guava fruit fly, B. *diversus* (Coquillet), baluchistan melon fly, *Myriopardalis pardalina* Bigot and aphid, *A. gossypii.* The other pests listed are *D. indica* and *D. caesalis* (Walker), banded blister beetle, *Mylabris pustulata* (Thn.); water melon weevil, *Acythopius citrulii* Marshall and Ak grass hopper, *Poecilocerus pictus* Fabr.

Nair (1975) has listed several pests belonging to different orders infesting cucurbit crops in India. They are: *A. gossypii* Glover (Aphididae); *Creontides pallidifer* Walker (Miridae); *Hishimonas phycitis* Distant and *Empoasca binotata* Pruthi (Cicadellidae); *Aspangopus janus* Fabr., *A. brunneus* Thn. and *A. obsevus* Fabr. (Pentatomidae); *Gampsocoris pulchellus* (Dall.) (Berytidae) and *Leptoglossus australis* (Fabr.) (Coreidae) under Hemiptera; *Mellitia eurytion* Westw. (Aegeridae); *D. indica* (Saunders) (as *Margaronia indica* (Pyralidae); *Sphenarches caffer* Zell. (Pterophoridae); *Pericallia ricini* Fabr. (Arctiidae) and *Anadevida (=Plusia) peponis* Fabr. (Noctuidae) under Lepidoptera; *Lasioptera falcata* Fabr. and *Neolasioptera cephalancrae* Mani (Cecidomyidae); *B. cucurbitae, B. ciliatus, Myopardalis pardalina* Bigot, *B. hageni* (DeMeij), *B. zonatus* (Saunders), *B. diversus* (Coquillet) and *B. brevistylus* B. and *Hylemia* sp under Diptera; *Holotrichia insularis* Bren. (Melalonthinae: Scarabaeiidae); *Henosepilachna vigintioctopunctata* Fabr., *Epilachna dodecastigma* (Wied.) *and E. septima* Dieke (Coccinellidae); *Aulacophora foveicollis* (Lucas), *A. lewsi* Baly, *Lema pracusta* (Fabr.), *L. semiregularis* Jac., *L. signatipennis* Jac. and *Galerucida bicolor* Hope (Chrysomelidae); *Mylabris pustulata* Thn. (Meloidae); *Acythopius citrulii* Marshall (Curculionidae) under Coloeptera and *Tetranychus neocaledonicus* Andre under Acarina.

Aphis gossypii, Anasa tristis DeGeer, *Leptoglossus australis, Acalymma vittatum* (Fabr.), *Diabrotica undecimpunctata* Barber, *A. foveicollis, Diaphania nitidalis* (Stoll), *D. hyalinata* (L.), *Mellitia cucurbitae* Harris, *B. cucurbitae, B. dorsalis* and *Tetranychus urticae* Koch have been listed as pests of cucurbit crops of New World by York (1975).

Segeren (1983) has reported *Diaphania nitidalis* and aphids as major pests of gherkins in Surinam.

Graffius (1984) observed several pests attacking cucumber, melon, squash and pumpkin which have resulted in reduction in the yields. *Trialeurodes vaporarium* (Westw.), *Aphis gossypii, Liriomyza trifolii* (Burgess), and mite, *Tyrophagus* sp were observed as pests of aerial parts of cucumber cultivated under cover by della-Giustina (1981).

Bland and Knausenberger (1985) grouped melon worms (*Diaphania hyalinata*) and melon aphids (*A. gossypii*) as major pests of cantaloupe (*Cucumis melo*) from the weekly samples collected in Virginia Islands. He reported fire ants (*Solenopsis geminata* (Fabr.)) as secondary pests that became serious by tending aphids. He has also collected two ichneumonids, one chalcid and one tachinid parasitoid from melon worm pupae. He opined that one of the ichneumonids, *Agypon caribbaem* can be considered as a potential biological control agent.

Ali *et al.*,. (1992) reported the incidence of sucking pests *Thrips tabaci* Lind., *Bemisia tabacil* Glover, *Tetranychus turkestani* (U. N.) and *A. gossypii* on cucurbits.

Mattson (1987) noticed the occurrence of *Delia platura, D. florilega, Thrips fuscipennis, Bourletiella hortensis, Lygus pratensis, Aphis gossypii, Empoasca vitis, Tetranychus urticae, Anthocoris hemorum, Aeolothrips intermedius* besides a Bdellid and *Amblyseius zwoelferi* on gherkins in Southern Sweden.

Srivatsava *et al.,* (1976) reported that pumpkin beetles (*Aulacophora* sp) cause considerable damage to cucurbits in Rajasthan. The fruit fly, *B. cucurbitae* (Coquillet) caused losses ranging from 50-72 per cent (Lal and Singh, 1969; Narayanan and Batra, 1960, Kushwaha *et al.,* 1972). In addition, epilachna beetle (Tewari, 1986), aphid (Ayyar,

1963), jassid, *Amrasca biguttula biguttula* (Ishida) (Pareek and Noor, 1980), vegetable mite, *Tetranychus neocaledonychus* (Sharma and Pande, 1986) and cutworm (Kushwaha *et al.,* 1972) are also reported to cause damage to cucurbits.

2.3 Seasonal incidence

2.3.1 Caterpillar pests

The first record of the incidence of *Diaphania indica* was made by Hampson (1896) on cotton leaves. In India, this pest was recorded for the first time by Lefroy and Howlett (1909) on cucurbits but there was no mention on the seasonal incidence of the pest. The general description of the life stages was reported by Fletcher (1914) in the plains of India, Burma and Ceylon on some cucurbits viz., snake gourd, cucumber, ash gourd (*Cucurbita pepo),* ridge gourd (*Lufa* sp.) and kaddu (*C. moschata).* Ayyar (1923 and 1963) reported its incidence on melon and other cucurbitaceous crops and has also described briefly some of its life stages.

Besides these, some of the important records available on this pest were that of Pruthi (1936), Gosh (1925) from Burma and Annon. (1940). Sevastopulo (1947) observed this pest feeding on cotton leaves. May (1946) found it to be most common on water melon with larval and pupal periods lasting for three weeks and five days respectively.

Patel and Kulkarni (1956) studied the bionomics of *D. indica* and reported that the pest is predominant during August - September. The caterpillars occur on the crop from first fortnight of June to the second fortnight of November. The pest initially infested on parwar (*Trichosanthus diocia* Roxb.) and subsequently on tondi (*Coccinia indica*).

Pandey (1975) reported the outbreak of *D. indica* on seven cucurbits in the months of June, July and August in 1970 in Uttar Pradesh, India. The black light trap catches *of D. indica* peaked during early August to early September in China(Ke *et al.,* 1988).

Peter and David (1991c) studied the bionomics of this pest using partial life tables. Their findings revealed peak incidence of the pest in April-September while it was lowest in November-February. They attributed this fluctuation in population to the changes in the population of its parasites.

Two closest relatives of *D. indica* the melon worm, *D. hyalinata* and the pickle worm, *D. nitidalis,* also attack several cucurbit hosts and cause damage similar to *D. indica.* These two are distributed in the New World viz., Canada, USA, Mexico and Brazil and are active during April, May or June (York, 1975). The larvae are found on cultivated plants during the winter in South Florida while they appear during spring in Central Florida (Pena *et al.,* 1987a). Lorini and Foerster (1987) observed the pest during December in high numbers in Brazil. Sorenson (1993) has reported *D. nitidalis* as the most destructive pest of cucumber, summer squash and cantaloupes, during mid-June to mid-August, the pest was observed in high numbers, feeding on growing tips, flowers and fruits.

Information available on the seasonal incidence of gram pod borer, *Helicoverpa armigera* on cucurbits is scanty. However, Pareek and Kavadia (1994) have noticed the pest feeding on ridge gourd fruits during Kharif in 1981 in Rajastan. A brief note on the incidence of this pest on some cucurbits is provided by Graffius (1984).

2.3.2 The Serpentine Leaf miner, *Liriomyza trifolii* (Burgess)

Population fluctuation of *L. trifolii* and other closely related species have been studied in the United States of America (Oatman and Michelbacher, 1958; Jensen and Koehler, 1970; Chandler and Thomas, 1983; Chandler, 1985). Lorini (1984) reported the occurrence of *L. sativae* Blanchard on cucumber and studied the population fluctuation, parasitism and residues of pesticides in the fruits.

In India, *L. trifolii* was reported for the first time at Annual Castor Research Workers group meeting held at Hyderabad during 1991 (Directorate of Oil Seed Research, 1991). Later, Lakshminarayana *et al.* (1992) have reported its incidence on various crops including cucurbits. Viraktamath *et al.* (1993) have reported its incidence in the states of Gujarat, Maharastra, Karnataka, Andhra Pradesh, Tamil Nadu and Union Territory of Delhi and have also given a list of host plants of the leaf miner.

Jagannatha (1994) has studied the seasonal incidence of this pest on tomato and cucurbits in Bangalore. He has observed high populations during March-November and September-October on cucurbits. The lowest population was recorded during May and November. He concluded that the population of the pest was positively correlated with temperature and sunshine hours and negatively correlated with rainfall and relative humidity.

Intensive survey was conducted to assess the incidence and severity of *L. trifolii* in different states of South India during November 1992 and February 1993 (Srinivasan *et al.*, 1995). The pest was recorded on 70 host plants including cucumber on which it was relatively severe. The severity of damage varied depending on the plant height. Leaves in the top canopy had fewer mines compared to leaves

in the middle and bottom canopy. A few indigenous parasitoids were recorded on the pest.

2.3.3 Sucking pests

Aphis gossypii is one of the major pests of cultivated cucurbits worldwide and is known to occur in higher numbers during dry weather (York, 1975). This pest is active throughout the year in India with maximum activity during April-June (Butani, 1975). Pareek and Kavadia (1994) recorded its incidence from first week of March to the end of April and from third week of July to the end of November in Kharif crop in Ziad in Rajasthan.

Ali *et al.* (1986) have shown that the level of infestations of thrips, whitefly, mites and aphids varies depending on the changes in environmental conditions, planting dates etc., on different cucurbits.

Kim *et al.*,.(1986) have investigated the colonisation of aphid species and their seasonal fluctuation on some vegetable crops including cucurbits and have found *A. gossypii* attacking cucumber. They also reported that aphid population increases with increase in temperature.

2.4 Influence of crop age on the pest incidence :

A study on the colonisation and abundance of arthropods on cucumber (*Cucumis sativus* L.) at various stages of plant growth was carried out in the Phillipines during 1989 by Bergonia and Cervancia (1992). Insect pests, pollinators, parasitoids and predatory arthropods associated with cucumbers were monitored. Colonisation was generally influenced by plant age. The population density of arthropods increased from seedling to vegetative and reproductive plant stages and decreased as the crop senesced.

2.5 Nature of damage :

The reports available state that only the larvae of *D. indica* are destructive. They feed on lower surface of leaves leaving the epidermis of the opposite side in the form of a thin papery translucent membrane. The larvae bind two adjacent leaves or fold up a single leaf and feed by remaining inside. The damaged patches then dryout, leading to distortion of the leaves. The larvae also attack tender fruits and its boring rendered the fruits useless (Patel and Kulkarni, 1956 , Ke *et al.*, 1986). Larvae also attacked flowers and flower buds (Butani, 1975). Larvae were seen feeding in dangerous proportion on pumpkin fruits (Ba-Angood, 1979).

Patel and Kulkarni (1956), Butani (1975) and Ke *et al.*, (1986) have described the nature of damage caused by several insect pests. The nature and extent of damage caused by leafminers are reported by several workers both in India (Lakshminarayana, 1992; Viraktamath *et al.*, 1993 and Jagannatha, 1994) and abroad (Chandler, 1985 and Lorini, 1984).

2.6 Effect of insecticides on the plant :

Cucurbits are known to be sensitive to chemicals. The phytotoxicity of phosphomidon, dimethoate, thiometon, endosulfan, malathion, methyl parathion, DDVP and endrin, each 0.03 and 0.04 % emulsions, and carbaryl as 10 % dust was studied on bottle gourd and cucumber. Parathion at two concentrations and endrin at 0.03 % were toxic to cucumbers. DDVP, carbaryl, malathion, endosulfan, thiometon and phosphomidon were found safer on all the cucurbits (Sood *et al.*, 1966). Ogawa *et al.*, (1982) analysed the residues of DDVP, MEP and PAP in cucumber leaves in China, Japan.

Bangerth (1990) reported that treatments reducing fruit drop (ethephon, neem and carbaryl) affected the polar transport out of fruits in an opposite direction in cucumbers and other fruits and vegetables.

Methomyl was tested for its residue in the fruits of cucumbers. It was found that rinsing treated fruits with tap water removed considerable amounts of methomyl. Residues reached 0.6 mg/kg level in cucumber fruits after seven days of spraying and decreased steadily over the 21 day study period. It was suggested that an interval of 14 days should be maintained between sprayings (Ahmed and Ismail, 1995). Madan *et al.*, (1996) studied the residue level of different pesticides after four days of spraying in farm vegetable samples and found dimethoate below detectable level in bitter gourd and smooth gourd.

2.7 Biology of *Diaphania indica*

Considerable effort has been made to study the biology of *D. indica* on some cucurbits. The first report on the biology of this pest was made by Patel and Kulkarni (1956). Their study revealed that eggs (0.799 mm long and 0.488 mm broad) were laid either singly or in groups. The incubation period was three days at room temperature. The larvae passed through 4-5 instars having a duration of 9-14 days. The larvae possessed two distinct stripes. Larval duration from first to fifth instar was 2.85, 2.0, 1.85, 2.19 and 4.15 days, respectively. Pupal period ranged from five to seven days. The total adult life ranged between 3-7 days with 1.63, 1.88 and 1.13 days, respectively for pre-oviposition, oviposition and post oviposition. Each female on an average laid 159.1 eggs in her life.

Butani (1975) mentioned that the larvae of *D. indica* feed on the leaves, flowers, flower buds and fruits. He pointed out that pupation

takes place inside the leaf fold and the female lays 22-366 eggs singly or in batches.

According to Pandey (1975) who studied the effect of seven different cucurbit hosts on the development of *D. indica,* the larval duration was least (9-10 days) on *Citrulus vulgaris* and highest on *Luffa* spp. (11-12 days). Pupal period and adult longevity ranged between 6-11 days and 8-12 days, respectively on the hosts tested. The mean larval weight ranged between 38 to 62 mg. The percentage pupation was between 70-100 and the percentage moth emergence was between 78-100. However, there was no development of the larva on *Momordica charantia* due to the presence of toxins which inhibited the larval feeding.

Tripathi and Pandey (1976) induced *D. indica* to feed on the leaves of *Zinnia* sp which has not been known to be its host. Third instar larvae confined only with *Zinnia* leaves did not feed for 18 h, but the larvae confined with cucumber leaves fed on them immediately and consumed three times more leaf area before pupation than did the larvae on *Zinnia.* He later analysed the nutritional status of both the plants and concluded that *Zinnia* is sufficiently nutritious to support the development of *D. indica* but lacks some attractants present in cucurbits.

Field and laboratory studies carried out on the biology and food preference of *D. indica* revealed that at fluctuating temperatures of 25-35.9 ^{0}C, the egg, larval and pupal periods were 3.5, 11.5 and 6.2 days, respectively. Field studies showed that the insect preferred *Cucumis melo* to *Citrulus vulgaris* and *Cucumis sativus.*

Ke *et al.* (1986) observed mating to take place on the day of emergence of the pest and on an average each female laid 510 and 340

eggs on *Cucurbita pepo* during August and September, respectively. The studies on the biology of *D. indica* showed that the most preferred food of larvae was *Benincasa hispida* followed by those of cucumber, *Luf'a* spp, bottle gourd and *Citrulus vulgaris*. *Cucurbita moschata* and bottle gourd were the least preferred hosts. Adult females laid a mean of 480.9 eggs/100 leaves on *Lufa* sp. but only 20 eggs/100 leaves on bottle gourd (Ke *et al.*, 1988).

The studies on development of *D. indica* larvae on four different cucurbit hosts viz., ivy gourd, cucumber, bitter gourd and musk melon showed no significant differences in the life cycle of the pest among the hosts. However, the host habitat influenced parasitism of *D. indica*. Analysis of measurements of head capsules width of the larvae of *D. indica*, revealed that the provisional range of head capsule width were, 0.227, 0.374, 0.580, 0.906 and 1.372 mm for first, second, third, fourth and fifth instar larvae, respectively which would help in identifying the particular instar of the larvae (Peter and David, 1991b). An average of 52.88 degree days (thermal units) above 12.92 ^{o}c were required from oviposition to hatching with 212.76 and 107.55 degree days for larval stage and adult eclosion, respectively (Peter and David, 1992a).

Peter and David (1992b) screened eighteen cultivated cucurbits for development of *D. indica*. Based on the results, they classified muskmelon, long melon, water melon, pumpkin, squash and ivy gourd as the most preferred hosts and cucumber, small gourd, snake gourd, ash gourd, round gourd, melon and ridge gourd as moderaterly preferred hosts, while, bitter gourd, bottle gourd, chow-chow, pointed gourd and sponge gourd were the least preferred hosts. *D. indica* failed to develop on spiny gourd. They opined that all the cucurbits are potential hosts but some are better than others.

Krishnaprasad and Rai (1978) while studying the effect of different host plants on the duration of life stages of *D. indica* found that there were lot of variations in duration of the developmental stages on different hosts. They concluded that ridge gourd was the most preferred and bitter gourd was the least preferred hosts. The difference between ridge gourd and other hosts was significant for pupal period and total life cycle. However, no differences were found in the egg and larval development among the hosts studied.

Several workers have studied the biology of the melon worm, *D. hyalinata* and pickle worm, *D. nitidalis*, the two close relatives of *D. indica*. These species attack cucurbit plants and cause severe damage (Reid and Cuthert, 1956; York, 1975; Elsey, 1980; Mendes and Bert, 1983; Pena *et al.*, 1987a). In general the egg, larval, pupal durations and adult longevity varied between 3-5, 12-16, 7-12 and 8-9 days, respectively (Elsey, 1980).

2.8 Estimation of amount of loss due to pests

Literature on estimation of losses due to pests on gherkin and related crops is scanty. Singh and Gill (1979) have estimated the per cent damage caused by *Aulacophora* on muskmelon. They found that the use of carbaryl increased the mean number of leaves and length of stem per plant besides considerable increase in yield. Further, there was the least damage to the crop by the beetles in the treated plots.

2.9 Management of pests of gherkins :

Literature on management aspects of pests of gherkin is very scanty. Segeren's (1983) is the pioneering work on the control of pests of cucumber and gherkin in Surinam. He conducted two field

experiments on these crops using six insecticides against *D. nitidalis*. He obtained best control of pickle worm with carbaryl 0.17 % in both the experiments (< 5 % infestation) followed by trichlorphon and fenvalarate. He also observed good control of aphids with carbaryl, mevinphos and pirimiphosmethyl. Ali *et al.*, (1992) recommended integrated pest management for different crop pests including gherkins in Sri Lanka.

2.9.1 Caterpillar pests :

Very little information is available on the management aspects of *D. indica*. Hand-picking and destruction of the caterpillars and application of contact insecticides were suggested by Patel and Kulkarni (1956). Butani (1975), besides hand picking and mechanical destruction, has suggested spraying of 0.02 % lindane or 0.05 % DDVP or 0.2 % carbaryl or 0.05 % endosulfan or dusting with 4 % carbaryl for the control of *D. indica* caterpillars.

Kuruvilla and Jacob (1981) studied the pathogenicity of the entomophagous fungus, *Paecilomyces farinosus* on the larvae of *D. indica* in the laboratory. The results of the experiments showed that the fungus could be used as a potential bio-control agent.

Effect of some insecticides on *D. indica* infesting cucumber was tested by Ito (1984).

Peter and David (1989) carried out field trials with 12 insecticides on *Coccinia indica* to test their toxicity to the larvae of *D. indica*. Cypermethrin was superior against the larvae followed closely by deltamethrin and fenvalarate. Triazophos, phosalone and carbaryl were found to be equally good in persistence as well as initial toxicity. Methomyl and quinalphos were found to have good

immediate toxicity but not persist. The order of residual toxicity based on LT_{50} values were cypermethrin >triazophos >fenvalerate >deltamethrin >phosalone >carbaryl >monocrotophos >endosulfan >methyl parathion >quinalphos >methomyl >chlorpyriphos.

Schreiner (1991) studied the damage threshold for *D. indica* on cucumbers in Gaum. He opined that carbaryl, dimethoate and *B. thuringiensis* were effective in reducing the population of *D. indica* on cucumbers. The yield loss increased as the population increased above one larva per leaf.

Although the work done on *D. indica* is meagre, sufficient work has been carried out on the other two caterpillars viz., *D. hyalinata* and *D. nitidalis* which are also equally serious on cucurbits.

Sarmiento and Zarate (1973) obtained best results with 0.15 % carbofuran and a mixture of 0.05 % parathion and 0.375 % DDT applied twice at an interval of 11 days. Also, 0.09 % methomyl, monocrotophos and 0.07 % endosulfan resulted in good control while, 0.255 % carbaryl and 0.05 % methamidophos gave poor control. Two commercial preparations of *B. thuringiensis* viz., Dipel and Bactopeine were found effective against *D. hyalinata* on cucumber (Delphanque and Greener, 1974 and 1975).

Perez *et al.* (1982) concluded that use of 50g/ha cypermethrin, 7.5g/ha deltamethrin , 90g/ha fenvalarate and 900g/ha carbaryl significantly reduced the populations of *D. nitidalis* on cucumbers and the yields were also high in insecticide treated plots. In another experiment acephate, dimethoate and methamidophos effectively controlled the populations of *D. nitidalis* on cucumbers (Acosta *et al.*, 1986). Similar results were obtained with acephate, chlorpyriphos and methomyl (Lorini and Foerster, 1987).

In recent years search is being made to develop and use safer insecticides having very low side effects for the management of pests. In this direction, use of plant products is promising. Simple crude water extracts of seeds of the neem tree, *Azadiracta indica* gave good control of *D. hyalinata* and other pests on cucumber (Dreyer and Hellpap, 1991). Mineral oil in combination with *B. thuringiensis* and detergent was highly effective in reducing the populations of *D. hyalinata* and *D. nitidalis* (Webb, 1994).

Use of light traps (Lara *et al.*, 1977, Link and Costa, 1989), reflective film mulches (Schalk *et al.*, 1979) and pickle worm sex pheromones were tested against both *D. nitidalis* and *D. hyalinata* and were effective in combating the menace of the pest.

Several botanical insecticides alone and in combinations, inorganic insecticides, NPV and *B. thuringiensis* have been found effective against *H. armigera* (Dubey *et al.*, 1991; Sinha, 1993; Sachan and Lal, 1993, Sarode *et al.*, 1995a and 1995b).

2.9.2 Leaf miner :

Different methods for the control of leafminer, *L. trifolii,* have been tried by several workers. Lyra *et al.*, (1989) determined the effectiveness of twelve insecticides against *L. trifolii* on onion from seedling to harvest. Among these, deltamethrin, azinphos-ethyl and parathion-methyl + mevinphos were the most effective in the first year and were the only treatments used in the second year. Ritchter and Tsegaye (1988) found that methamidophos, dimethoate and deltamethrin were highly toxic to the larvae of *L. trifolii* reared on *Phaseolus vulgaris* in the laboratory.

Use of neem (*Azadiracta indica*) products particularly on leafminers which are developing resistance to most of the insecticides has drawn the attention of several workers. Sprays of neem seed extract did not completely repel adults but deterred them from feeding and ovipositing (Stein and Parrella, 1985). Methanol and ethanol extracts of neem had higher insecticidal activity against ovipositing females when sprayed plants were exposed to them (Meisner *et al.*, 1986). Soil drenches of one and two ppm azadirachtin applied to infested chrysanthemum significantly reduced the female fecundity and male longevity (Parkman and Peinkowskwi, 1990).

Neem seed extract when applied against larvae at 0.2-0.4 per cent concentration permitted pupation but caused malformation in pupae and significantly reduced the adult emergence (Stein and Parrella, 1985). Foliar drenches of neem extracts were effective when complete coverage of the foliage was achieved (Larew, 1988).

Neem extract has long term effect on the agromyzid population. It is compatible with non-target organisms. It has low mammalian toxicity and therefore is useful as an important component in the integrated control programme of this pest (Stein and Parrella, 1985).

A laboratory experiment was conducted to test the toxicity of neem oil against leafminer, *L. trifolii* on cucumber. Concentrations of 1-1.25 % caused >80% larval and pupal mortality while 1.5 % did not significantly by further increase in the mortality (Azam, 1991).

2.9.3 Thrips

Thrips are one of the major vectors of cucurbit diseases. Experiments have been conducted by several workers to manage this pest. Stenseth (1986) opined that the predatory mite, *Amblyseius*

cucumeris, cypermethrin, fenvalerate and permethrin did not give expected control as polybutene mixed with deltamethrin. Several workers have tested different methods to control the incidence of *Thrips palmi* (Kobayashi *et al.*, 1985; Ikeda *et al.*, 1984; Goats, 1985).

Some insecticides were tested to determine the susceptibilities of *T. palmi* collected from cucumber. The populations collected from different fields showed susceptibility to cypermethrin, fenobucarb and methidathion (Morishita, 1993).

2.9.4 Aphid

Ohsawa and Watanabe (1987) and Kasem and Yakob (1985) studied the effect of insecticides on the cotton aphid, *A. gossypii* and *Tetranychus telarius* on cucumber respectively. They obtained good control by using DDVP and phosalone.

2.9.5 Minor pests

Considerable emphasis has been laid on the management of minor pests of cucurbits viz., aphids, mites, thrips, leaf hoppers and whiteflies. Noor and Pareek (1978) found that carbaryl at 0.17 % proved to be the most effective against red pumpkin beetle, *A. foveicollis*, at different intervals. Segeren (1983) conducted two field experiments on cucumber and gherkin against aphids. He obtained good control of aphids with carbaryl, mevinphos and pirimiphosmethyl. Diazinon, trifluralin and alachlor were tried successfully against banded cucumber beetle, *Diabrotica balteata* (Greene *et al.*, 1992).

2.10 Monitoring of fruit fly population

There are many methods suggested by different workers for the monitoring the population of the fruit flies. One of the effective methods is the use of attractants, as the males seek the females with the help of chemicals emitted by them. Cue-lure (4-(-p-actoxyphenyl)-2-butanone) is one of the synthetic pheromones which is employed effectively for trapping male *B. cucurbitae*. Several workers have used cue-lure and have achieved effective control of the flies.

Steiner and Lee (1954) conducted large area tests of male-annihilation method for oriental fruit fly (*B. dorsalis*) using methyl eugenol along with methyl parathion in Hawai. According to them the population of the fruitfly was reduced by 68-100 % in 28 months. However, suppression of *Bactrocera dorsalis* by this method resulted in marked increase in the population of Mediterranean fruit fly, *Ceratitis capitata.*

Nishida (1958) conducted an experiment to determine the effects of yeast hydrolysate on the behaviour of the melon fly, *B. cucurbitae* in the field. The results showed that the number of flies present or found dead was greater when yeast hydrolysate bait was applied to non-host plants. In general positive responses were found to be associated with high population density. The application of bait to host plants, cucumber and cantaloupe, did not result in movement of flies to these crop plants from nearby untreated corn plants.

A new synthetic lure, 4-phenyl-2-butanone was developed for attracting male melon fly *B. cucurbitae.* This lure proved to be most powerful than anisylacetone (Beroza, 1960)

Doolittle *et al.*(1970) compared the attractiveness of mixtures of cuelure and 4(-p-hydrophenyl)-2-butanone to the melon fly. The results indicated that there were no differences in the attractiveness to the mixtures of 5, 20 and 50 % 4-(-p-hydroxyphenyl)-2-butanone in cuelure over a three month period. He attributed this to the presence of phenol which might have acted synergistically when it is mixed with cue-lure.

Chu *et al.*,. (1994) used traps baited with cuelure or methyl eugenol for monitoring *Bactrocera* spp. in nature during December 1993. The number of flies caught per trap averaged 2237.2/day with cuelure over a three days in an area of 2 ha. *B. frauenfeldi* comprised 99.9 % of the catch with cuelure. Smaller numbers of *B cucurbitae* and *B. xanthodes* were also caught. This was again tried for one month in 2 ha area with 21 traps and the numbers of flies attracted decreased significantly.

Seventeen commercial products and 11 plant extracts were tested as attractants for *B. cucurbitae*. Yeast hydrolysate was the most attractive (71.97 % capture for females and 80.4 % for males) followed by molasses (69.4 and 78.2 % for females and males respectively). Among plant extracts cantaloupe and netted melon were the most effective for females and males respectively. Attractiveness increased to 84.2 % and 81.2 % respectively for female and male when yeast hydrolysate and molasses were mixed (Liu and Chen, 1995).

Shelly and Villalobos (1995) conducted laboratory tests to assess the effect of the cuelure on the mating behaviour of males of *B. cucurbitae*. Exposure to cuelure resulted in a short-term mating advantage. In wild flies, treated males that fed on cuelure on the day of testing, or one day prior to testing, mated more frequently than

males that had no prior exposure to cuelure. Exposure to cuelure also increased the mating success of mass reared, irradiated males relative to unexposed wild males. Cuelure appeared to enhance mating performance. A field study revealed that irradiated males exposed to cuelure one week prior to release were less likely to be captured. The findings suggested that exposure of sterile males to cuelure might improve the effectiveness of sterile insect release as well as enable simultaneous control programmes of sterile insect release and male annihilation.

2.11 Natural enemies

2.11.1 *Diaphania indica*

Several natural enemies are reported to attack the larvae of *D. indica* infesting many host plants. Various workers both in India and elsewhere have listed 22 species of parasitoids and three species of predators (Table 1).

Sindlinger (1984) reared a tachinid parasitoid from *D. nitidalis*. Bland and Knausenberger (1985) reared two icneumonids, one chalcid and one tachinid parasite from the pupae of *D. hyalinata* and suggested *Agrypon caribbeam* (Ichneumonidae) as potential biocontrol agent against *D. hyalinata*. Marsh (1986) recorded an unidentified species of braconid, *Cardiochiles* sp. in Dolombia, Venezuela and Trinidad which parasitised *Diaphania* sp. and the same is being mass reared and released for the control of *D. hyalinata* and *D. nitidalis*.

Ke *et al.* (1986; 1988) attributed the reduction in the population of *D. indica* to the attack by natural enemies viz., *Trichogramma confusum*, *Apanteles* sp and *Scenochrops* sp.

Table 1: Natural enemies reported of *Diaphania indica*.

Host Stage	Natural Enemy	Family	References
	Parasitoids		
Larva	*Apanteles taragamae* Viereck	Braconidae	Bhatnagar (1948)
	A. stantoni (Ashmead)		
	A. oblique Wilkinson		
	A. mahaeralis Wilkinson		Chaterjee and Mishra (1979)
	*A. hemara** Nixon		Nixon (1965)
	*A. africans**		Peter and David (1991c)
	A. sp.*		
	Bracon hebetor * Say		Ayyar (1923)
	*Phaenerotoma hendecasisella** Cameron		
	Chelonus sp*		Peter and David (1991c)
	*Campoletis chlorideae**Uchida		Manjunath *et al.*,(1989)
	*Thrathala flavoorbitalis** Cameron		Beeson (1941)
	*Pristomerus testaceus**Morley		
	Cardiochiles diaphaniae on *D. nitidalis* and *D. hyalinata*		
	*Elasmus brevicornis**Gahan	Elasmidae	Verma and Hayat (1986)
	*Goniozus senorius**Gordh	Bethylidae	Gordh (1989)
	Tetrasticus israeli Mand	Eulophidae	Nadarajan and Jayaraj (1977)
	T. pantnagarensis Khan		Peter and David (1991c)
Pupa	*Xanthopimpla punctata* (F>)	Ichneumonidae	Chaterjee and Misra (1979)
	Scenocharops sp.		
	Brachymeria lasus (Walker)	Chalcididae	
	B. margaroniae Joseph, Narendran and Jay		
Predators			
	Solenopsis geminata F.*		Peter and David (1991c)
	Oxyopes shweta Tikader*		
	Oxyopes. sp. Pocock*		
Disease			
	Nosema sp		

Similarly, Peter and David (1991b) have also opined that the parasites were responsible for the population fluctuation of *D. indica*.

Pena *et al.* (1987b) have surveyed the native parasites of the pickle worm, D. nitidalis and D. hyalinata in Central and Southern Florida.

Peter and David (1990a, 1990b, 1991a, 1992a, 1992b) reported the biology of several hymenopteran parasites of *D. indica* viz., *Apanteles machaeralis* Wilkinson, *Elasmus brevicornis* Gahan, *Goniozus senorius* Gordh, *Phenerotoma hendecasisella* Cameron and *A. taragamae* Viereck .

MATERIAL AND METHODS

III. MATERIAL AND METHODS

Studies on the seasonal incidence of insect and mite pests of gherkin, distribution pattern, biology and loss estimation due to *Diaphania indica* (Saunders) and management practices were carried out during 1995-97 both in the laboratory and in the field. The laboratory studies were conducted in the Department of Entomology, University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (G.K.V.K.), Bangalore. The field studies were made in the following localities either on the experimental farms or on the farmers fields.

a) **G.K.V.K.** : The research farm of the UAS located about 17 km North of Bangalore near on the National Highway-7.

b) **Hosakote** : Farmers field 6 km, West of Hoskote town, Bangalore rural district.

c) **Hedeginabele** : This is an experimental farm of Oceania Peninsula (India)Limited, 5 Km east of Malur in Kolar district.

d) **Malur** : Farmers fields about 8 km (west of Malur) and 5 km (West of Malur) form Malur town in Kolar districts.

e) **Masti** : Farmers fields in Nidumakanapalli (18 km west of Masti) and Kesaragere village (4 km, north of Masti, Malur taluk).

f) **Hansbhavi** : A farmer's field in Hansbhavi town, Hirekerur taluk in Dharwad district.

g) **Lingapura** : A farmer's field in Lingapura village near Byadgi, Dharwad district.

h) **Mundwad** : A farmer's field 15 km from Mundargi town, Dharwad district.

In all these localities the crop was raised following standard agronomical practices. The vines were trained vertically on to the ropes tied between two poles when they were 3 weeks old. The distance between the rows was 90 cms whereas the row length varied from 5 m to 20 m depending on the width of the field.

3.1 Standardization of sampling plan based on distribution pattern of *D. indica*

Development of an effective sampling plan for the estimation of population of a pest is a basic requirement. Since there was no literature available on the sampling procedure for *D. indica* on gherkin, a study was carried out to develop sampling technique for this pest and also others occurring on gherkins. The study was conducted on farmers fields at Hansbhavi (field I) and Lingapura (field II).

In both the places the crop was grown in an area of 0.2 ha and the age of the crop was 45 days and 60 days respectively at Hansbhavi and Lingapura. The crop at Hansbhavi was well maintained and healthy whereas at Lingapura the crop was nearing senescence and was not very healthy. However, in both the fields fruits were being harvested during the study period.

The sampling technique was assessed by ascertaining distribution of *D. indica* larvae in the field.

At both the locations, alternate rows were sampled. Samples from first row upto 17th row in the first field and 13th row in the second field were collected covering 25% of the total area planted with gherkin. Ten meter length was measured from one end of each row and at every alternate meter length a 1m x 1m quadrat was set up. Each of these quadrats covered tall trained vines. Each quadrat was divided in to two vertical subquadrats of 0.5 m sq (1 m length and 0.5 m height) each. This resulted in a total of 85 sampling units (quadrats) in field I and 65 sampling units in field II. Observations on the numbers of *D. indica* and other caterpillar pests were recorded in each subquadrat, on different parts viz., leaves, buds, flowers and fruits of the vine as also the number of different parts.

The data so obtained, were utilized to study the distribution pattern of *D. indica* on different plant parts. Initially, the number of different plant parts were correlated with the number of larvae using subquadrat values. Later, the values were pooled in each quadrat and Pearson's product movement correlation was worked out (Snedecor and Cochran, 1937).

The relative abundance of different plant parts in the bottom and top subquadrats was checked using a student t-test. Similarly, the number of larvae occuring on each plant part was also tested for the similarity of means using t-test (Snedecor and Cochron, 1937). The total number of larvae occuring in top and bottom subquadrats was pooled to get the number of larvae in each quadrat. These three data sets were analysed to ascertain which of the two subquadrats is the best indicator of the population size in each quadrat.

Mean number of larvae per unit was calculated for each of the four plant parts considered in each subquadrat. Data were subjected to nested ANOVA to understand the relative abundance of larvae on the plant parts in top and bottom subquadrats.

Mean and the variance was calculated for each level of sampling, such as subquadrats, quadrats and transects for both locations. Variance to mean ratio was also worked out to ascertain the nature of distribution of *D. indica* larvae (Southwood, 1978).

Further, to decide the mean number of quadrats to be sampled, two approaches were followed-

1. Data of successive quadrats were pooled to estimate mean and coefficient of variation (CV%) per quadrat.

2. Alternatively, data were pooled over randomly selected quadrats from one to n samples covering 25% of the sample subquadrats (Southwood, 1978).

These values were plotted to ascertain the variations in mean and the trend of CV(%). Visually, a point of inflection was identified on the nature of curve. The number of quadrats pooled upto that point was considered as the minimum number of samples required.

3.2 **Sampling method for different insect pests of gherkins**

3.2.1 **Lepidopteran caterpillars**

Based on the results obtained from the distribution patterns of *D. indica* on gherkin, the following sampling methods were used. The same method was extended for other lepidopteran caterpillars.

In crops more than 3-4 weeks old, 1m length of the vine was randomly selected in different rows and in crops older than four weeks, a sample unit of 0.5 m. sq. in a row of gherkin crop was chosen. In each of these sampling units buds, leaves, flowers and fruits were meticulously examined for the presence of larvae of different species and recorded. Twenty five such sampling units were used for each field (0.2-0.4 ha).

3.2.2 **Serpentine leafminer, *Liriomyza trifolii*** :

From the middle of the sampling unit (0.5 m^2) ten randomly selected leaves were plucked and placed individually in a polythene bag tied with an elastic band. The petiole of each leaf was wrapped with wet cotton to maintain turgidity. These bags were maintained in the laboratory for a period of two weeks. The number of adult flies and parasitoids that emerged were identified and recorded.

3.2.3 . **Aphids and mites**

Ten randomly selected leaves were plucked from the entire field of 0.2-0.4 ha and were examined for the presence of aphids and mites with the help of 10x lens. The actual number of aphids or mites was converted into a score following the scale given below :

No. of aphids/mites per leaves	Score
0	0
1-25	1
26-50	2
51-75	3
76-100	4
> 100	5

3.3 **Seasonal incidence of insect and mite pests of gherkin** :

Regular surveys were conducted in the farmers fields at fortnightly intervals during the cropping season for recording the incidence of various pests. This survey was done not only in localities mentioned above but also in other localities in the districts of Bangalore Rural and Kolar. The sampling procedures mentioned in sections 3.2 were followed. In the district of Dharwad, visits were made once in two months for recording the incidence of various pests. The data for each pest were correlated with the weather parameters viz., mean maximim temperature, mean minimum temperature, total rainfall and mean relative humidity to study the relationship between the seasonal incidence and the weather parameters.

3.3.1 **Occurrence of *D. indica* on varieties of gherkin**

To test the relative incidence of *D. indica* on two varieties of gherkin viz., Calypso and Nun, a study was carried out at Hedeginabele. The varieties were grown in an area of 0.2 ha each. Observation were made on 40 days on incidence of *D. indica*. Fifty sampling units (0.5m height x 1m

length) were selected at random in each variety. The number of larvae in each sampling unit was counted and the data were analysed using simple t-test.

3.4 **Biology of *D. indica* on gherkin and other cucurbit hosts**

3.4.1. **Maintenance of stock culture of *D. indica* in the laboratory**

The larvae of *D. indica* were collected from the gherkin fields and brought to the laboratory and transferred to small plastic containers individually. The lids of the containers were provided with fine (0.2 cm) perforation for aeration. Tissue paper was placed at the bottom of the container to absorb the moisture from the fruits and the larval excreta. These larvae were provided with pieces of gherkin or cucumber fruits depending on their availability. For pupation rolled tissue paper was provided when the larvae reached pre-pupal stage. After pupation, the pupae were collected and sexed under a microscope based on the location of genital openings. The male and female pupae were kept in separate containers.

After the eclosion, equal number of male and female moths were transferred to insect rearing cages. Aqueous solutions of honey (20%) and Horlicks® (20%) were provided as sugar and protein sources for the adults. Gherkin plant (10 to 15 days old) grown in pots were provided for egg laying. First and second instar larvae were reared on leaves of gherkins and later instar larvae on fruits of gherkin or cucumber.

3.4.2 **Biology of *D. indica* in the laboratory**

Biology of *D. indica* was studied in the laboratory on leaves, flowers and fruits parts of gherkin (*Cucumis anguria*). Further, fruits of other cucurbit hosts viz., coccinea (*Coccinea indica*), chow-chow (*Sechium edule*) and cucumber (*Cucumis sativus*) were used to study the comparative biology. The materials used for studying the biology are shown in Plate 2.

Neonates first instar larvae were transferred on to tender gherkin leaves. When the larvae reached the second instar, they were transferred on to flowers, leaves and fruits of gherkin and on to fruits of cucumber, coccinea and chow-chow. The duration of different larval instars and pupal periods were recorded. These observations were made on ten larvae. Fresh food was given everyday. Rolled papers served as sites of pupation for grownup larvae.

The fully formed pupae were separated individually and sexed and the sex ratio was calculated.

Measurements of all the developmental stages was made under a stereoscopic microscope with the help of standardized occular micrometer placed in one of the eyepieces.

3.5 **Susceptibility of gherkin to *D. indica***

3.5.1 **Susceptible stage of gherkin**

To test the incidence of *D. indica* on a particular stage of the crop, studies were conducted at Nidumakanpalli and Byadgi.

PLATE 2 Experimental set up for the study of biology of *Diaphania indica*

At Nidumakanapalli the crop was grown in an area of 3.2 ha. Here staggered planting was undertaken and hence of 15, 30, 45 and 60 days old crop was available at any one time. Each of the crop stage was grown in an area of 0.4 ha.

At Byadgi, the crop was raised by different farmers and hence the fields were scattered unlike in the case of Nidumakanapalli. The distance between each of the crop stage was about 200m on an average. When the study was undertaken the different stages of the crop were 20, 35, 40, 50 and 60 days.

Procedures adopted for observation was same at both the location. Twenty five sampling units of 0.5m sq. at random were considered for recording the observations. In addition, the number of the plant parts were also recorded and were pooled to get the total.

However, in 15 and 20 days old crops the observations were recorded just from 1 m row length, since the vine was not long enough to be trained and hence were left on the ground.

The data thus obtained were converted into number of larvae per plant part and subjected for one-way ANOVA separately for different fields.

3.5.2 **Preferred portion of gherkin fruit**

To study the part/portion of the fruit preferred by *D. indica* larvae, fruits which were bored and/or scraped were collected from the factory and brought to the laboratory. Observations regarding the length of the

fruit and portion of the fruits damaged were recorded. The fruits were classified into different size categories according to their length and the entire length of the fruit was then divided equally into three parts. The region bearing the entrance hole of the larva was considered as the portion preferred by the larva. About 800 fruits were examined for this study.

3.6 **Per cent fruit damage due to *D. indica***

To estimate the loss incurred due to *D. indica*, a study was conducted at Hedeginable where different insecticides viz., dichlorvos (0.07%), *Bacillus turingiensis*(0.02%), carbaryl(0.1%), NSKE(4%) and HSKE(4%) were used along with untreated check against this pest.

A similar type of experiment was conducted at Mundwad using different insecticides viz., dichlorvos (0.07%), Dipel (0.02%), carbaryl (0.1%), methomyl (0.05%), phosalone (0.05%) and bioneem plus an untreated check.

The percent fruits damaged (bored and scraped by the larvae which were considered unfit for consumption) in each treatments was recorded on the day before spraying and at three days interval for four times after spraying. The data was subjected to factorial RCBD analysis.

3.7 Management of pests of gherkins

Eight field experiments with different insecticidal combinations were laid out during the study period to find out their efficacy in containing different pests of gherkin. However, major emphasis was on

the control of the fruit borer, *D. indica.* The chemicals used, their concentrations and source of supply are given in the Table 2.

In all the experiments, one unsprayed border row on either side in each treatment was maintained. The observations were recorded from the middle center rows in the center of the plots before and after the spray in each treatment.

Since all the experiments were conducted on the farmers fields the plot size in different experiments varied which have been described below along with the method of observations followed for each pest :

a) Fruit borer, *D. indica* : The observations on the presence of live larvae were recorded from three sampling units of 0.5 m^2 at random in each treatment.

b) Serpentine leafminer, *L. trifolii* : A single leaf was selected from middle of the sampling unit (0.5 m^2) for recording the number of adults emerging from each leaf. Ten such leaves were plucked at random from each treatment. Observations were made as described in sec 3.2 .

c) Aphids, *Aphis gossypii* : The number of aphids from ten randomly lomly selected leaves in each treatment were counted.

d) Thrips, *Thrips palmi* : Ten terminal buds randomly selected. Each bud was tapped five times on a black card board (30 x 30 cms). The number of thrips falling on the board was counted and recorded.

Table 2 : Insecticides used for the management of insect pests of gherkin

Sl. No.	Insecticide	Concentration used	Manufacturer
1.	Dichlorovas 76 EC	0.07 %	Hindustan Ciba-Geigy Ltd.
2.	Dipel 8L	0.02 %	Lupin Agro Chemicals (India) Ltd.
3.	Carbaryl 42 flo	0.1 %	Rhone-Poulenc (India) Ltd.
4.	Carbaryl 42 flo	0.06 %	Rhone-Poulenc (India) Ltd.
5.	Methomyl 12.5 L	0.05 %	E.I. DuPont De Memours & Co.
6.	Methomyl 12.5 L	0.03 %	E.I. DuPont De Memours & Co.
7.	Phosalone 35 EC	0.05 %	Rhone-Poulenc (India) Ltd
8.	Deltamethrin 2.8 EC	0.01 %	Hoechst Schering
9.	Triazophos 40 EC	0.05 %	Agro Evo Ltd.
10.	HSKE	4 %	
11	NSKE	4 %	
12	Bioneem	0.03 %	West Coast biochem Ltd.
13.	Nimbicidine	0.04 %	West Coast biochem Ltd.
14.	Cypermethrin 25 EC	0.05 %	Zeneca Ltd.
15.	Dimethoate 30 EC	0.01 %	Rallis India Ltd.
16.	HNPV	100 LE	Pest Control India Ltd.

Experiment 1

This was laidout at Hedeginabele during February 1996. The plot size for each treatment was 15 m^2. There were ten treatments with four replications as follows :

T1	Dicholrovas
T2	Dipel
T3	Carbaryl
T4	HSKE
T5	Deltamethrin
T6	NSKE
T7	Nimbicidine
T8	Phosalone
T9	NPV
T10	Control

Experiment 2 :

This was laidout at Hedeginabele during July 1996 and there were ten treatments. Each treatment had a plot size of 15 m^2. The treatments were replicated thrice.

T1 - Dicholrovas
T2- Dipel
T3- Carbaryl
T4 Methomyl
T5- Phosalone
T6- Deltamethrin
T7- Triazophos
T8- alternate use of Deltamethrin and Carbaryl
T9- jaggery
T10- Control

In this experiment jaggery at 0.5 ml was added in all the treatments as standard check with an objective to find the build up of

populations of lepidopteran caterpillars. An untreated control was also used find the effect of jaggery when used alone.

Experiment 3 :

Two field experiments with eight treatments were carriedout at Irabanahalli (plot size 10 m^2) and Abbenahalli (plot size 14 m^2) during August 1996 and September 1996, respectively . At Irabanahalli, the crop was trailed on the ground and at Abbenahalli normal vertical trailing was maintained. The treatments were replicated thrice and were :

T1 Dicholrovas
T2 - Dipel
T3 - Carbaryl 0.1%
T4 - Methomyl 0.05%
T5 - Phosalone
T6 - Carbaryl 0.06%
T7 - Methomyl 0.03%
T8 - control

Experiment 4 :

This was carriedout at Mundwad during January 1997. Seven treatments (each had a plot size of 16 m^2) were replicated for three times.

T1 - Dicholorvas
T2 - Dipel
T3 - Carbaryl
T4 - Methomyl
T5 - Phosalone
T6 - bioneem
T7 - control

Experiment 5 :

The experiment was laidout at Hedeginabele during July 1996 where the treatment plot size was 12 m^2. Six treatments were chosen and were replicated four times.

T1 - Dicholrovas
T2 - Dipel
T3 - Carbaryl
T4 - Phosalone
T5 - HSKE
T6 - Control

Experiment 6 :

This was conducted at Hedeginabele during July 1996 on a different variety of gherkin viz., Nun. The plot size for each treatment was 12 m^2. Six treatments were selected and replicated for four times.

T1 - Dicholorvas
T2 - Dipel
T3 - Carbaryl
T4 - NSKE
T5 - HSKE
T6 - Control

Experiment 7 :

In this experiment only two chemicals were chosen. This was conducted at Bidarahalli September 1996. Three treatments were replicated seven times. The plot size was 10 m^2 per treatment.

T1 - Carbaryl
T2 - Methomyl
T3 - Control

Experiment 8 :

This experiment was laid out against thrips at Hedeginabele during April 1996. The crop was trailed on the ground. Five treatments were selected and replicated thrice. The plot size for each treatment was 15 m^2.

T1 - Dimethoate
T2 - Cypermethrin
T3 - Deltamethrin
T4 - HSKE
T5 - Control

3.8 Monitoring fruit fly, *Bactrocera cucurbitae*

3.8.1. Evaluation of different traps and method of dispensing cue-lure for trapping *B. cucurbitae*

Efficacy of different types of traps namely, sticky trap, water trap and Mc-Pheil traps was evaluated for trapping *B. cucurbitae* at GKVK in a cucurbit garden (10 m^2) with the following treatments treatments.

T1- White plastic circular tray (26 cm dia) containing a mixture of 2000 ml of water 0.06 ml of cue-lure and 0.08 ml of dichlorvos (Plate 3) placed on ground.

T2- Same as T1 but without dichlorvos.

T3- White plastic circular tray (26 cm dia) with 2000 ml of water. Cue-lure (0.06 ml) and dichlorvas (0.08 ml) dispensed on separate cotton wads placed on an earthern plat form in the middle of tray at a height of 5 cm from the water level.

PLATE 3 Material used for trapping fruit flies under field conditions
A : Plastic container
B : bottle containing cue lure

T4- Yellow sticky trap with a cotton wad dipped in cue-lure + dichlorvos.

T5- Mc-Pheil trap hung at 1.5 m above ground.

The traps were so arranged that the distance between them was 10 m. Their position was changed daily (Fig. 1). The fruit flies trapped were brought to the laboratory and counted after identifying them under a microscope. The experiment was run for ten days. Data were subjected for RCBD analysis.

3.8.2 Effectiveness of cue-lure over days

This experiment was carried out at GKVK in the kitchen garden, Division of Horticulture, UAS, GKVK, Bangalore. In all the treatments, cue-lure (0.06 ml) was dispensed in 2000 ml of water to which 0.08 ml of dichlorovas was added in a plastic container. The chemicals unchanged (T1), changed in every four days (T2) and were replenished every day (T3). Observations regarding the number of fruit flies trapped, was counted everyday.

3.8.3 Evaluation of different baits and fruits

3.8.3.1. Fish meal and banana

Baits prepared using fish meal, banana and yeast were evaluated for their efficacy in trapping *B. cucurbitae.* Cuelure was used as a standard. The experimnet was conducted in a gherkin field at GKVK with following treatments. These were replicated four times.

T1- Fish meal + yeast + dichlorovas

T2- Banana + yeast + dichlorovas

T3- Cuelure liquid + dichlorovas

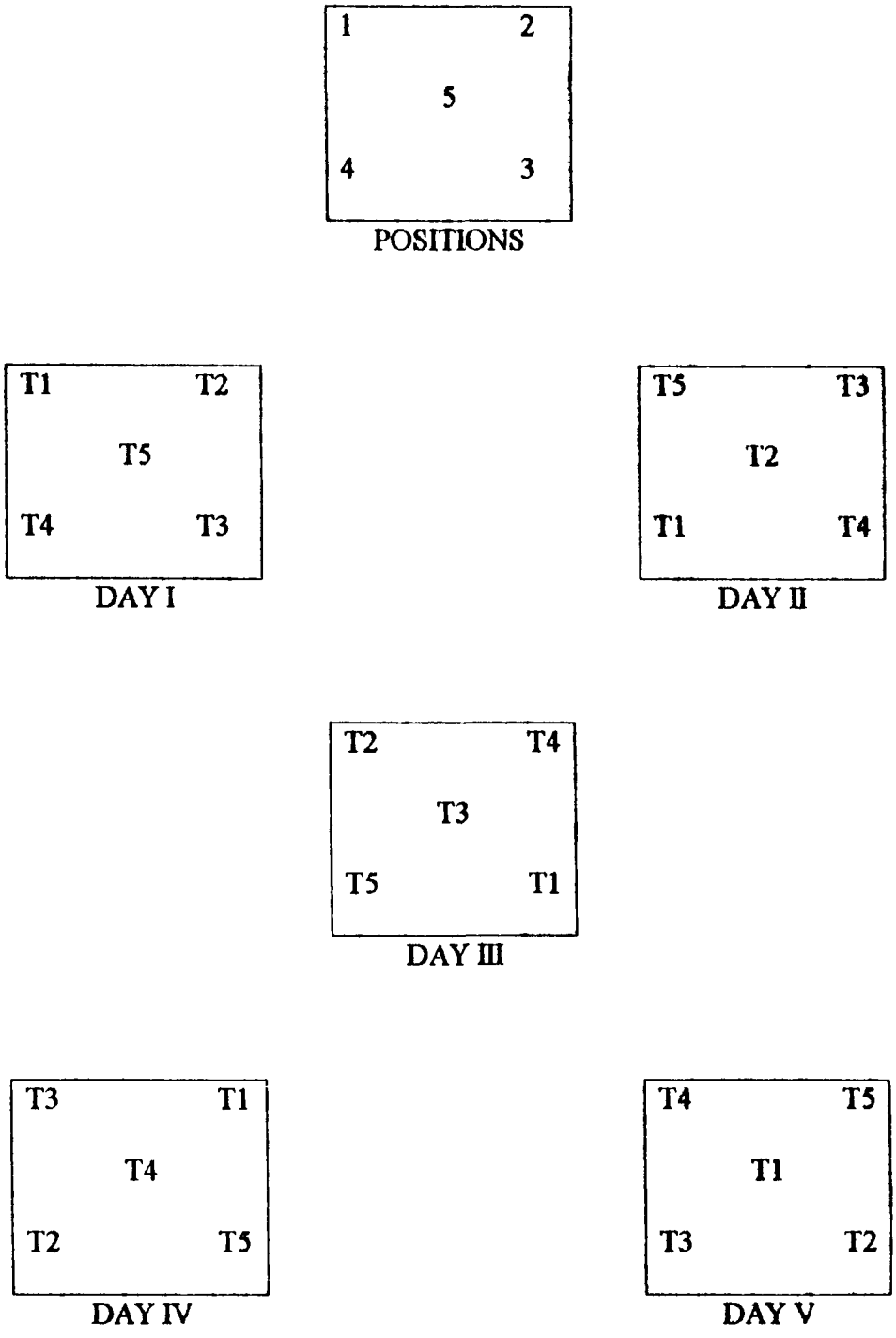

Fig.1 Positions used for monitoring fruit fly population in different traps at GKVK

T4- Cuelure pellets + dichlorovas

T5- dichlorovas

The baits were placed in a semi-transparent 0.5 litre plastic container with holes of 2.5 cm made in each direction. They were set up with lids open at a height of 1.5m above ground. The flies trapped were collected daily identified and recorded. The data were subjected to RCBD analysis.

3.8.3.2.Different fruit pulp and juices

An experiment was setup to study the attraction of fruit flies to different baits and also to test the effect of two insecticides when mixed with attractant of the fruit flies. The treatments used for the experiment are listed below :

T1. Wheat flour + Molasses + methomyl (50g : 5g : 50 ml)

T2. Rice flour + Molasses + methomyl (50g : 5g : 50 ml)

T3. Barley flour + Molasse + methomyl (50g : 5g : 50 ml)

T4. Banana + Yeast + methomyl

T5. Papaya + Yeast + methomyl

T6. Citrus + Yeast + methomyl

T7. Molasses + methomyl

T8. Mixed fruit juice (Pine apple + Grapes + Banana in equal quantities) + methomyl

T9. Methomyl

T10. Gehrkin fruit + methomyl

T11. Cuelure + methomyl

T12. Fish meal + methomyl

T13. Wheat flour + Molasses + dichlorovos (50g : 5g : 50 ml)

T14 Rice flour + Molasses + dichlorovos (50g : 5g : 50 ml)

T15 Barley flour + Molasse + dichlorovos (50g : 5g : 50 ml)

T16 Banana + Yeast + dichlorovos

T17 Papaya + Yeast + dichlorovos

T18 Citrus + Yeast + dichlorovos

T19 Molasses + dichlorovos

T20 Mixed fruit juice (Pine apple + Grapes + Banana in equal quantities) + dichlorovos

T21 dichlorovos

T22. Gehrkin fruit + dichlorovos

T23. Cuelure + dichlorovos

T24. Fish meal + dichlorovos

The fruits after peeling the skin were crushed and mixed with two pinches of yeast extract. Hundred milli litre of the mixed juice was used in the treatment T8 and T20. Two gherkins fruits of size 2.5" was used in T10 and T22. A drop of cuelure in 100 ml of water and 50 g of fish meal with two pinches of yeast extract formed another set of treatments. All the above mentioned treatment were placed in water proof paper plates of diameter 15 cm individually. One drop of each insectiside was added to each set. Two such sets were used in the experiment. These treatments were replicated thrice using random number table.

The plates were kept in the middle of the gherkin rows and others leaving three rows in between. The observations were recorded once in two days and the experiment was repeated twice. The number of fruit flies trapped in the plates was recorded. The data was analysed using RCBD analysis.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the studies on various aspects of insect pests of gherkin and their management are presented here.

4.1 **Distribution pattern of Diaphania *indica***

4.1.1 Distribution of plant parts and larvae of *D. indica*

4.1.1.1. Plant parts

The abundance of leaves, buds, flowers and fruits of gherkin was age dependent as well as on the agronomic practices followed which became obvious in the observations made at two localities namely, Hansbhavi and Lingapura. At Hansbhavi, the observation made on a crop of 45 days old and was well maintained whereas at Lingapura the crop was 65 days old and poorly maintained. Leaves, flowers, buds and fruits of gherkin varied greatly in their abundance both at Hansbhavi and Lingapura.

Leaves, were more abundant both at Hansbhavi (47.23 ± 11.77/ m^2) and Lingapura (34.85 ± 2.73/ m^2) than any other plant parts when the distribution was considered across quadrats. The distribution within a quadrat was similar between the top (24.84 ± 7.55/ 0.5 m^2) and bottom (25.57 ± 8.2255/ 0.5 m^2) subquadrats at Hansbhavi. However, at Lingapura the abundance of leaves in the top subquadrat (20.29 ± 6.77/ 0.5 m^2) and bottom subquadrat (14.52 ± 8.48/ 0.5 m^2) differed. Over all density of leaves was higher at Hansbhavi compared to Lingapura.

Flowers were more abundant per quadrat (7.73 ± 4.29/ m^2) than the buds (3.84 ± 1.88/ m^2) and fruits (6.41 ± 2.77/ m^2) at Hansbhavi.

They were also more abundant in the top (4.27 ± 2.73/ 0.5 m^2) than in the bottom (3.44 3.16/0.5 m^2) subquadrat. On the other hand at Lingapura, flowers (4.23 ± 3.65/ m^2) were less abundant than the fruits (5.40 ± 4.28/ m^2) and more abundant than the buds (1.90 ± 1.41/ m^2). Within a quadrat, however, the top subquadrat (2.29 ± 2.11/ 0.5 m^2) had greater numbers of flowers than the bottom (1.90 ± 2.39/ 0.5 m^2) subquadrat as at Hansbhavi. The top subquadrat (1.32 ± 1.04/ 0.5 m^2) had more number of buds than the bottom subquadrat (0.60 ± 0.97/ 0.5 m^2). Abundance of fruits also followed similar patters (Table 3 and Fig. 2) at both the localities.

Pooled values for all plant parts considered followed similar pattern of greater abundance in the top subquadrats than the bottom at Lingapura, while at Hansbhavi, all the plant parts in all were equally abundant (Table 3 and Fig. 2) in the top and bottom subquadrats.

4.1.1.2. Distribution of larvae of *D. indica*

Larval numbers on the leaves (bottom + top subquadrats) were 2.52 ± 2.05 at Hansbhavi and 3.15 ± 3.20 at Lingapura in the one m^2 quadrats. Number of larvae on the top subquadrat was relatively more both at Hansbhavi (2.44 ± 1.54/0.5 m^2) and Lingapura (2.21 ± 2.45/0.5 m^2) compared to the bottom subquadrat. The corresponding number in the bottom subquadrat were 1.14 ± 1.27 and 0.93 ± 1.31, respectively. Larval numbers on the buds also followed a similar trend. However, the number of larvae in the quadrats both at Hansbhavi (1.69 ± 1.99/ m^2) and Lingapura (0.03 ± 0.17/0.5 m^2) was much lower on the buds than the number of larvae on the leaves. The pattern of occurrence of larvae on the buds in the top and bottom subquadrats followed the pattern similar to that on leaves (Table 3 and Fig. 2). However, this trend was not evident on the flowers where the number

Table 3 : Abundance of different plant parts of gherkin and the larvae of *Diaphania indica* on them at Hansbhavi and Lingapura during November 1995 in quadrats (B+T- 1 m^2) and sub quadrats (Bottom and Top - 0.5 m^2 each)

	Leaves						Buds						Flowers						Fruits					
	B		T		B + T		B		T		B + T		B		T		B + T		B		T		B + T	
	LVN	LN	LVN	LN	LVN	LN	BN	LN	BN	LN	BN	LN	FLN	LN	FLN	LN	FLN	LN	FRN	LN	FRN	LN	FRN	LN
Hansbhavi (n = 85)																								
Mean	25.57	1.14	24.84	2.44	47.23	2.52	1.05	0.28	2.85	1.44	3.84	1.69	3.44	1.14	4.27	0.08	7.73	0.22	2.32	0	4.03	0.01	6.41	0.01
SD	8.22	1.27	7.55	1.54	11.77	2.05	1.16	0.66	1.52	1.86	1.88	1.99	3.16	0.41	2.73	0.27	4.29	052	1.60	0	2.48	1.10	2.77	0.10
S^2/x	2.63	1.42	2.65	1.74	2.93	1.68	1.28	1.56	0.81	2.45	0.91	2.34	2.99	1.20	1.72	0.94	2.39	1.20	1.10	0	1.52	1.16	1.20	1.16
Lingapura (n = 65)																								
Mean	14.52	0.93	20.29	2.21	34.85	3.15	0.60	0	1.32	0.03	1.90	0.03	1.90	0.01	2..29	0.09	4.23	0.09	2.60	0.04	2.81	0.07	5.40	0.12
SD	8.48	1.31	6.77	2.45	2.73	3.20	0.97	0	1.04	0.17	1.41	0.17	2.39	0.12	2.11	0.34	3.65	0.34	2.77	0.21	2.51	0.27	4.28	0.36
S^2/x	4.95	1.84	2.26	2.73	3.93	3.26	1.57	0	0.82	1.00	1.04	1.00	3.00	1.51	2.11	1.27	3.16	1.24	2.94	1.10	2.24	1.02	3.40	1.08

LN = Number of larvae
LVN = Number of leaves
BN = Number of buds
FLN = Number of flowers
FRN = Number of fruits
B = Bottom
T = Top

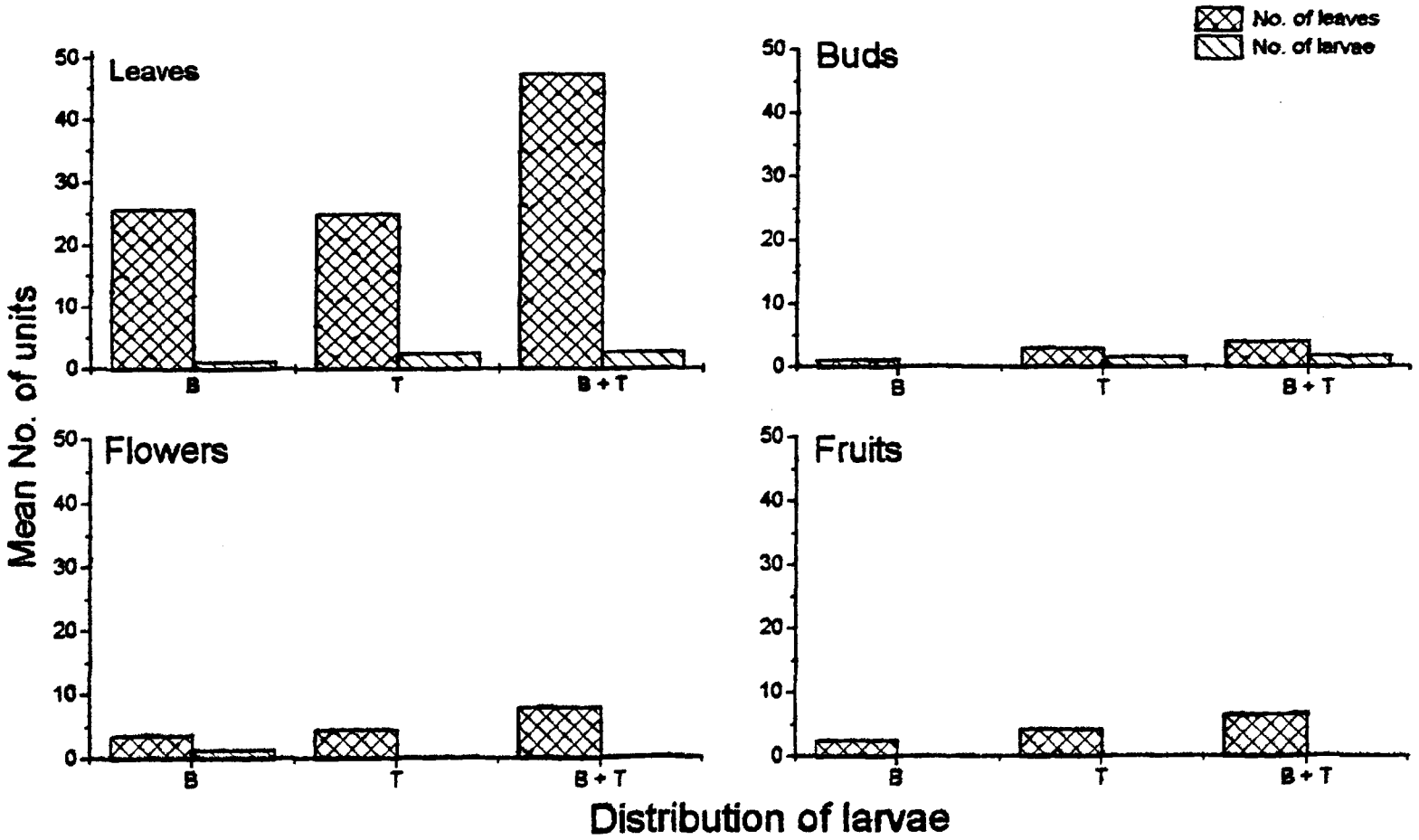

Fig. 1 Distribution pattern of *Diaphania indica* larvae on different plant parts (B=Bottom half; T=Top half) of gherkins at Hansbhavi

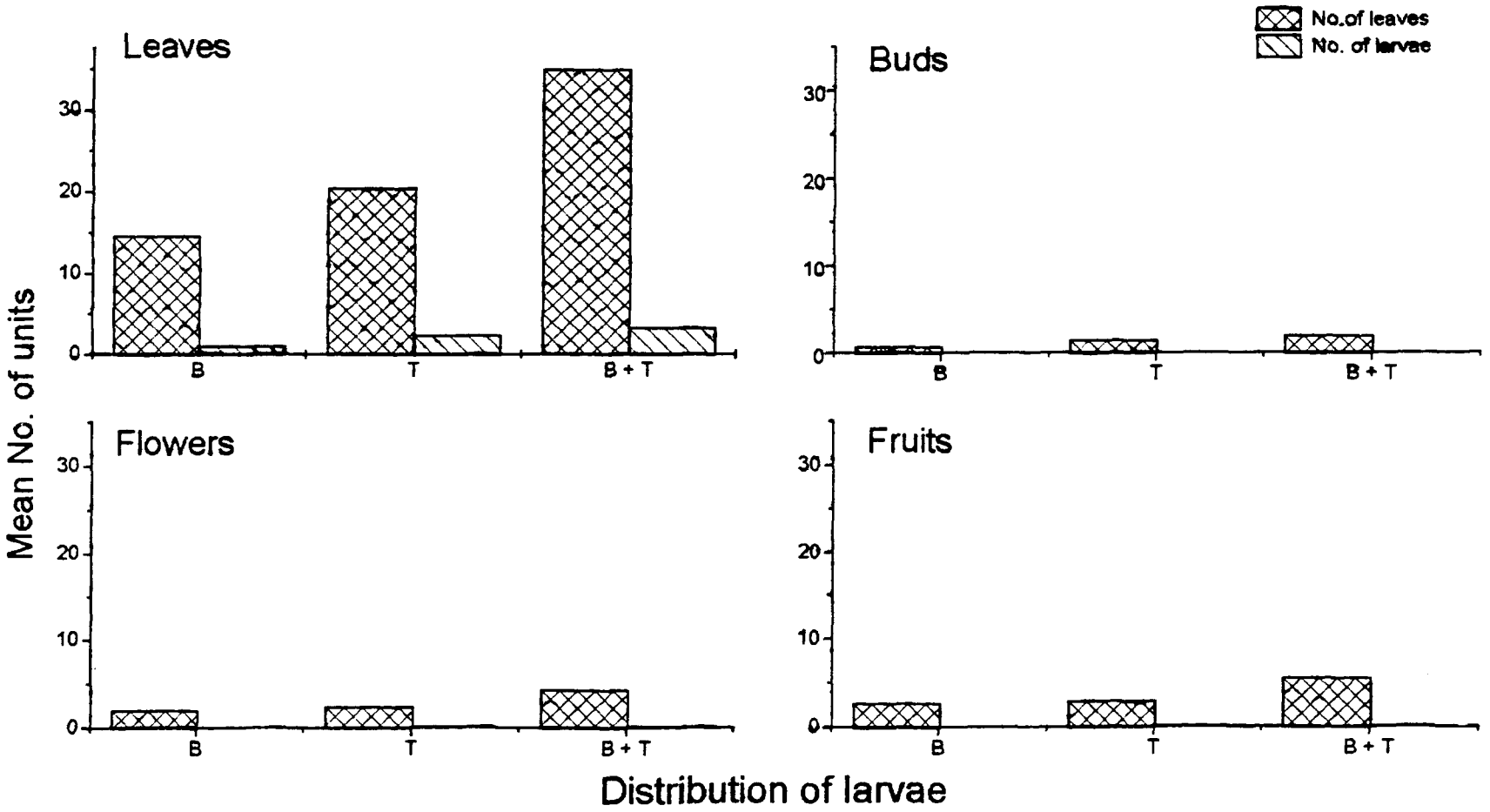

Fig. 3 Distribution pattern of *Diaphania indica* on different plant parts (B=Bottom half; T=To
of gherkin at Lingapura

of larvae in the bottom subquadrat was 1.14 ± 0.41 compared to 0.08 ± 0.27 number of larvae /0.5 m^2 in the top subquadrat. But at Lingapura, the top subquadrat had 0.09 ± 0.34 larvae/0.5 m^2 on the flowers while the bottom subquadrat had 0.01 ± 0.12 larvae/0.5 m^2. The total number of larvae (bottom + top subquadrats) per (one / m^2) quadrat on flowers was 0.22 ± 0.52 and 0.09 ± 0.34, respectively at the two localities. The lowest number of larvae recorded per quadrat was on fruits (0.01 ± 0.10) at Hansbhavi. The lowest number of larvae per quadrat (one /0.5 m^2) were recorded at Lingapura was however on buds. The top subquadrat tended to have greater number of larvae than the bottom subquadrat irrespective of plant parts.

Variance to mean (s^2/x) ratio calculated for the larval numbers was almost always >1, except in the case of buds which had a value of 0.99 at Lingapura indicating a general aggregated distribution of the larvae (Table 3 and Fig. 3). This pattern was evident even at subquadrat level for the different plant parts. At Hansbhavi, top subquadrat for flowers (s^2/x = 0.94) and at Lingapura, bottom and top subquadrats for buds (s^2/x =1) and top and bottom subquadrats for fruits (s^2/x = 1.02, 1.01, respectively) were the exceptions which indicated a uniform distribution of the larvae of *D. indica*.

The pooled values for larval numbers at Hansbhavi, were 1.00 ± 1.30 for bottom subquadrat, 2.41 ± 2.51 for the top subquadrats, 3.41 ± 3.81 for entire the quadrat, 21.94 ± 5.02 for the transect. The respective Figures for larval numbers at Lingapaura were 1.50 ± 1.41, 2.90 ± 2.64, 4.41 ± 3.30, 16.92 ± 8.16 (Table 4). The aggregated distribution of the larvae (s2/x >1) was evident at all levels of sampling at both the localities.

Table 4 : Abundance of different plant parts of gherkin and larvae of *Diaphania indica* at Hansbhavi and Lingapura, sampled at different levels

	Subquadrat (0.5 m^2)				**Quadrat (1 m^2)**		**Transect (1x 5m^2)**	
	B		**T**					
	Pl. N.	LN.	Pl. N.	LN.	Pl. N.	LN.	Pl. N.	LN.
Hansbhavi (N=85)								
x	32.60	1.00	32.98	2.41	65.60	3.41	328.52	21.94
SD	10.16	1.30	11.34	2.51	21.50	3.81	41.37	5.02
S^2/X	3.16	1.69	3.89	2.61	3.68	3.57	5.21	1.15
Lingapura (N=65)								
x	19.61	1.50	26.69	2.90	46.41	4.41	232.38	16.92
SD	12.25	1.41	9.75	2.64	17.70	3.30	40.17	8.16
S^2/X	7.65	1.33	3.56	2.40	6.75	2.47	6.94	3.94

B - Bottom
T - Top
Pl. N. - Number of plant parts
L.N. - Number of larvae

4.1.1.3. Relationship between the abundance of *D. indica* in the bottom and top subquadrats.

Bottom and top subquadrats varied in the abundance of larvae of *D. indica* at both the locations examined (Tables 5 and 6). Top subquadrat supported as much as 68% and 66% of the larvae at these two localities. It was observed that the number of larvae found in the bottom subquadrat was strongly correlated with those observed in the top subquadrat (r=0.7437) and the pooled values for the bottom and the top subquadrats (r=0.635) at Hansbhavi. But the highest positive relationship was between the larval abundance in the top subquadrat with that the entire quadrat (Table 6). The pattern was almost identical even at Lingapura.

4.1.1.4. Relative abundance of *D. indica* larvae on different plant parts.

Although the total number of larvae on the leaves was highest in the two subquadrats sampled both at Hansbhavi and Lingapura (Table 7), it was observed that the buds supported the highest number of larvae compared to their abundance. As many as 0.63 to 0.82 larvae were found per bud at the two localities. This was followed by flowers which supported 0.38 to 0.64 larvae per flower. Fruits supported 0.39 to 0.59 larvae per fruit. Leaves supported the least number of larvae. Almost similar pattern was observed for the abundance of larvae on fruits and flowers in the two subquadrats considered with buds invariably supporting the highest number of larvae per unit plant part. The nested ANOVA conducted for number of larvae per unit plant part involving the two subquadrats (Bottom and Top) as the groups and different plant parts as the subgroups (Table 7) clearly indicated that the plant parts differed in their larval abundance at Hansbhavi, similar results were obtained at Lingapura. Though the larvae tended to be

Table 5 : Relationship between the abundance of plant parts and the larval load on leaves, buds, flowers and fruits of gherkin in top and bottom sub-quadrats and quadrats (B + T) as observed at two locations during November 1995

	Plant part	Sample units	N	'r' values	'p' values
Hansbhavi					
	Buds	Bottom	85	0.48*	2.25 E-6
		Top	85	0.35*	0.001
		B + T	85	0.35*	0.001
	Leaves	Bottom	85	0.26*	0.01
		Top	85	0.44*	<0.011
		B + T	85	0.35*	<0.01
	Flower	Bottom	85	0.19	NS
		Top	85	0.27*	0.01
		B + T	85	0.18	NS
	Fruits	Bottom	85	0.001	NS
		Top	85	0.03	NS
		B + T	85	-0.01	NS
Lingapura					
	Buds	Bottom	65	0.00	NS
		Top	65	0.036	NS
		B + T	65	-0.049	NS
	Leaves	Bottom	65	0.38*	0.001
		Top	65	0.22*	0.06
		B + T	65	0.26*	0.03
	Flower	Bottom	65	0.05	NS
		Top	65	0.19	NS
		B + T	65	0.08	NS
	Fruits	Bottom	65	0.11	NS
		Top	65	0.07	NS
		B + T	65	0.02	NS

NS = Non Significant

Table 6 : Correlation between the number of larvae of *Diaphania indica* on gherkin in the two sub quadrats and the entire quadrats, at Hansbhavi (N= 85) (top right corner) and Lingapura (N= 65) (bottom left corner) for the population censuses during November 1995

	B	**T**	**BT**
B	-	0.447*	0.734*
T	0.253	-	0.936*
BT	0.635*	0.908*	-

* All values were significant at p = 0.05
B = Number of larvae in bottom subquadrat
T = Number of larvae in top subquadrat
BT = Number of larvae in quadrat

Table 7 : Mean number of larvae of *Diaphania indica* on different plant parts in bottom (B) and top (T) subquadrats of gherkin sampled at Hansbhavi and Lingapura during November 1995

	Hansbhavi			Lingapura		
	B	**T**	**B + T**	**B**	**T**	**B + T**
Leaves	0.14^{a}	0.35^{a}	0.03^{a}	0.28^{a}	0.24^{a}	0.01^{a}
Buds	0.82^{d}	0.63^{bc}	0.33^{b}	0.73^{d}	0.78^{d}	0.11^{c}
Flower	0.64^{bc}	0.55^{b}	0.001^{a}	0.39^{b}	0.50^{c}	0.02^{a}
Fruits	0.59^{bc}	0.51^{b}	0.005^{a}	0.39^{b}	0.49^{c}	0.08^{b}
Mean	0.50	0.45		0.59	0.51	
F- test		*	*		*	*
CD		0.08	0.05		0.05	0.05
Sem ±		0.04	0.03		0.03	0.02

NESTED ANOVA

Source of variation	df	Cal- F value	CD	df	Cal- F value	CD
Bottom and top subquadrats (groups)	1	0.153 NS	-	1	15.08 *	0.049
Plant parts considering subquadrats(subgroups)	6	102.29 **	0.057	6	37.26 *	0.049
Error	672			512		
Total	679			519		

numerically more abundant in the bottom subquadrat at Hansbhavi, and in the top subquadrat at Lingapura. The nested ANOVA indicated no difference between the two subquadrats at both the localities.

4.1.2. **Sampling plan**

4.1.2.1. Within transect sampling

For the evaluation of the sample size within a transect the mean number of larvae per quadrat and the variance was computed. The mean did not vary with sample size (Table 8) both at Hansbhavi and Lingapura. When CV (%) was considered it decreased with increase in number of quadrats (sample sizes) within each transect. Both at Hansbhavi and Lingapura, it was observed that CV (%) dropped to <25% when more than three quadrats were considered.

4.1.2.2 Between transect sampling

a). Systematic sampling : Samples taken row after row (successive transects) with the five quadrats in each transect showed marginal variations in the mean number of *D. indica* larvae per transect between different sample sizes both at Hansbhavi and at Lingapura (Table 9 and Fig 4). Similar to the within transect samples, CV (%) calculated for the means also decrease with increase in number of transects sampled. The curves fitted for the two locations indicated <25 % CV (%) beyond a sample size of three transects indicating three transects, to be the ideal sample size.

b). Random sampling : Random samples of transects followed the pattern of systematic sampling at both the locations. Mean number of larvae per tansect at both Hansbhavi and Lingapura varied marginally, but were not found to deviate strongly and remained more or less same with increase in number of transects sampled (Table 10

Table 8 : Number of larvae in a quadrats at Hansbhavi and Lingapura during Nov.1995

	Quadrat numbers				
	1	**2**	**3**	**4**	**5**
Hansbhavi (N=85)					
Mean	1.38	1.38	1.38	1.38	1.38
SD	0.72	0.48	0.29	0.17	0
CV(%)	94.2	51.56	36.15	21.6	0
Lingapura (N=65)					
Mean	2.21	2.29	2.21	2.21	2.21
SD	0.48	0.30	0.19	0.20	0
CV(%)	88.7	48.21	34.17	23.23	0

Table 9: Mean number of larvae of *Diaphania indica* per transect on gherkin vines at different levels of sampling when sampled systematically, at Hansbhavi and Lingapura

Larval parameters	Number of transects										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**13**	**17**
Hansbhavi (N=85)											
Mean	7.7	7.1	7.0	7.05	6.50	7.1	6.7	6.7	6.9	6.9	7.0
SD	3.92	2.42	1.59	1.36	1.30	1.09	0.91	0.95	0.50	0.35	0.16
CV(%)	50.9	34.0	22.7	19.2	20.0	15.3	13.5	14.11	7.20	5.05	2.20
Lingapura (N=65)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**12**		
Mean	10.90	10.70	10.9	10.6	11.5	10.9	10.6	10.4	10.9		
SD	6.45	3.32	4.36	1.75	2.53	1.70	1.70	1.23	0.56		
CV(%)	59.10	31.0	40.0	16.5	22.0	15.50	16.03	11.8	5.10		

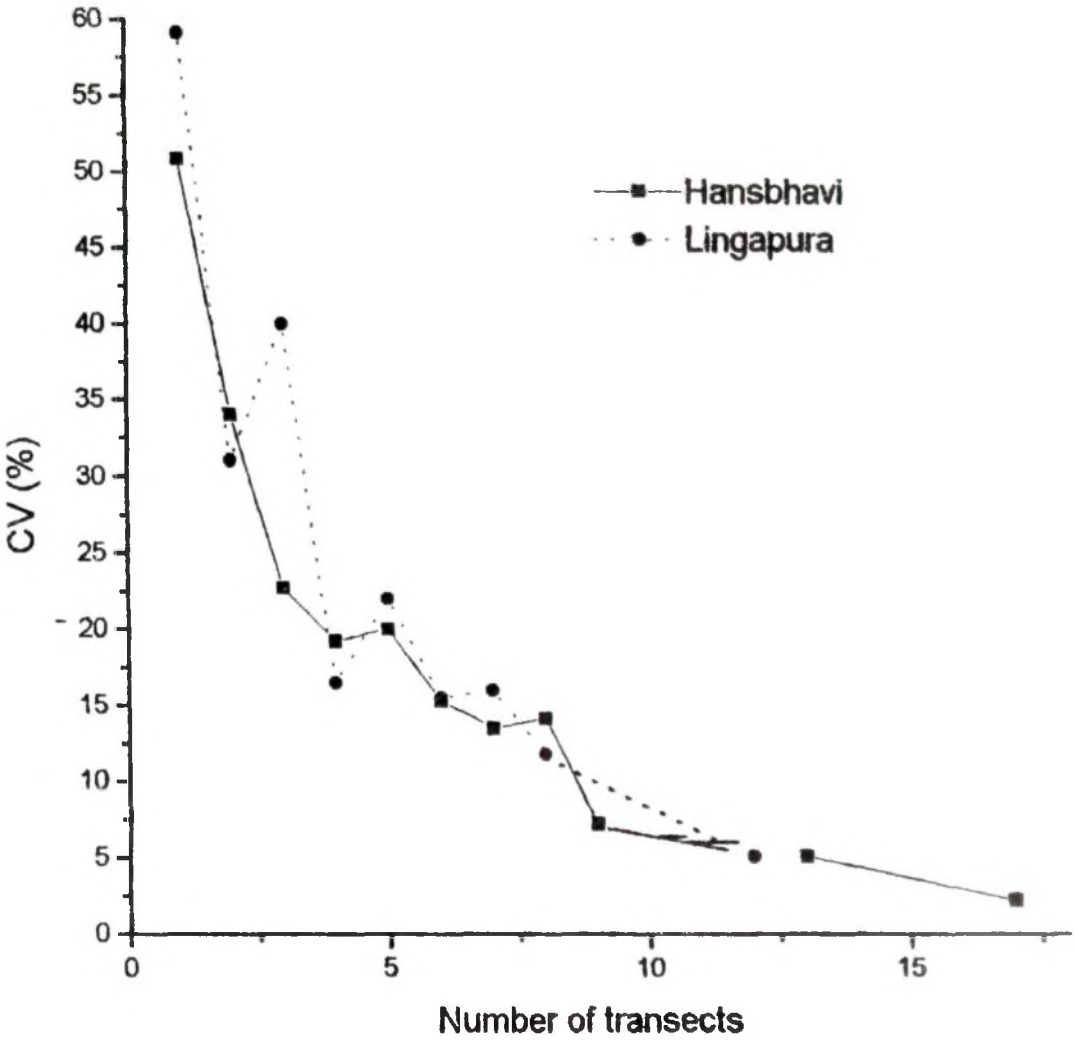

Fig. 4 Mean number of *Diaphania indica* larvae per transect when sampled systematically

Table 10 : Number of larve in rows when sampled randomly at Hansbhavi and Lingapura during November 95

No. of rows	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
										Hansbhavi (N=85)											
Mean	1.80	4.70	7.10	12.80	13.10	15.20	18.30	22.40	20.0	28.9	30.3	27.2	32.2	39.1	34.2	40.3	44.0	44.4	47.9	52.7	55.5
SD	1.40	3.03	3.45	5.67	5.14	4.27	5.84	6.64	5.33	7.06	6.27	3.99	6.67	7.34	9.41	9.60	3.97	5.86	6.09	6.84	5.44
CV (%)	77.77	64.57	48.56	44.30	39.28	27.32	31.96	29.69	36.65	24.44	20.71	14.68	20.71	18.77	27.51	23.82	9.03	13.21	12.71	12.98	9.81
										Lingapura (N=65)											
Mean	3.60	6.20	11.80	12.70	14.00	16.20	23.30	25.30	29.5	29.2	31.70	39.50	46.60	46.3	53.90						
SD	3.38	5.86	4.81	5.17	5.29	8.32	5.71	7.63	6.91	8.06	11.25	14.50	9.64	10.88	8.68						
CV (%)	93.95	94.54	40.78	40.77	37.79	51.40	24.50	30.13	23.44	27.64	35.41	36.70	20.74	23.50	16.11						

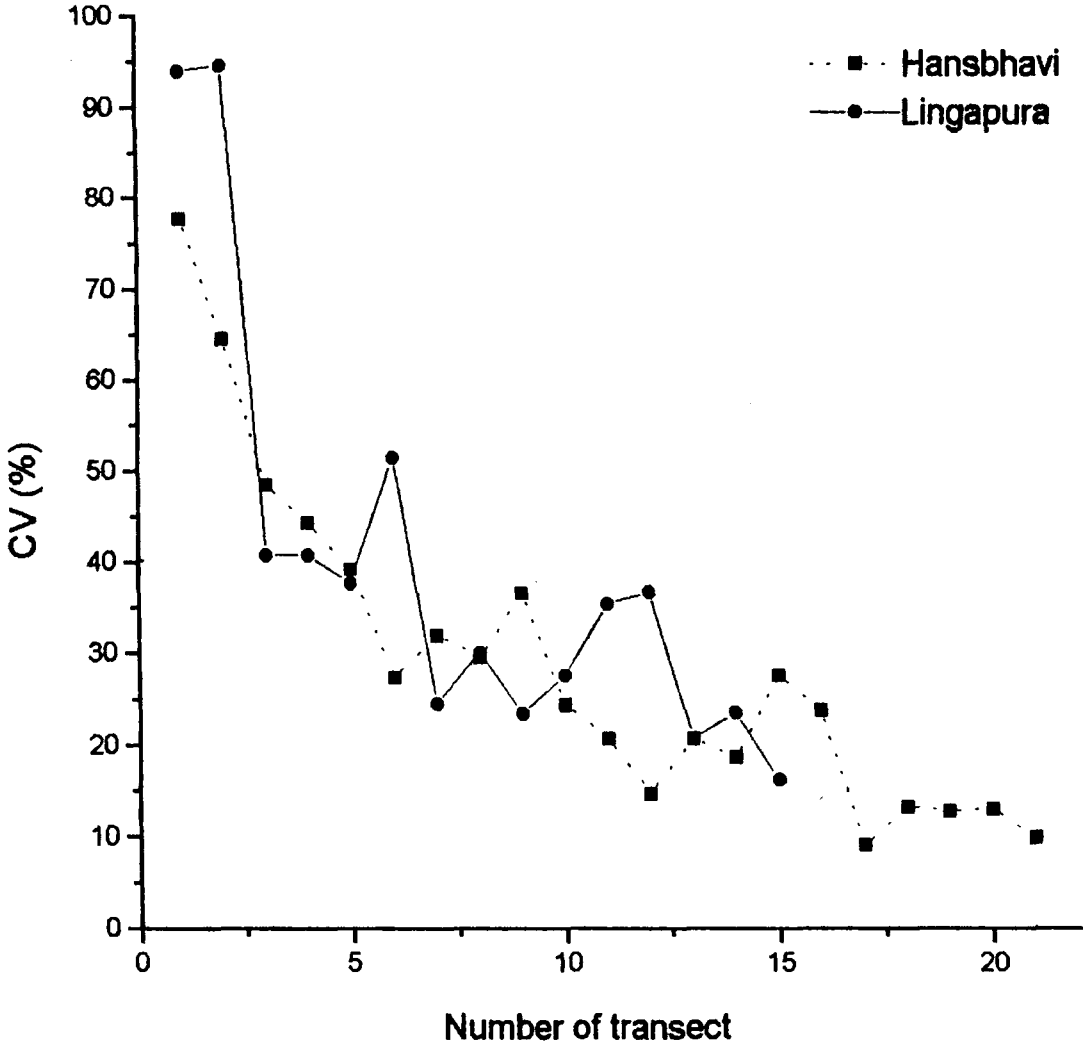

Fig. 5 Mean number of *Diaphania indica* larvae per transect when sampled randomly

and Fig. 5). The CV(%) decreased similarly as in systematic sampling but the rate of dropping with increase in sample size was low. At both the locations < 25 % CV was observed at sample sizes of 9-10 transects.

4.2 Insect pests observed on gherkins

Insect and mite pest and the parasitoids recorded on the larvae of *D. indica* recorded on gherkins during the study period are presented in tables 11 and 12, respectively.

4.3 Seasonal incidence of gherkin pests

The incidence of different insect and mite pests of gherkin from August 1995 to March 1997 is given in table 13. Seasonal variation in population of the major pest are described hereunder:

4.3.1 The fruit borer, *Diaphania indica*

Diaphania indica occurred throughout the year in all the area where the crop was studied. However, the population density varied with the season (Fig. 6). Its population reached a peak during August (2.19/ 0.5 m^2). The pest population started increasing from June (0.61/0.5 m^2) onward and remained high during July (1.78/0.5m^2), September (1.62/0.5 m^2) and October (1.52/0.5 m^2). Moderate infestation (0.50/0.5 m^2) was recorded during November, December and April. The population was lower during January (0.27/0.5 m^2) and March (0.15/0.5 m^2) and the lowest infestation was recorded during February (0.10/0.5 m^2)

Table 11: Insect pests observed on gherkin

Insects	Family	Order	Stage of the crop affected	Parts of the vine affected	Plate No.
Diaphania indica (Saunders)	Pyralidae	Lepidoptera	Vegetative (V) & Reproductive (R)	All the parts	
Helicoverpa armigera Hubner	Noctuidae	Lepidoptera	R	Flower &Fruits	
Chrysodeixis chalcitis (F.)	Noctuidae	Lepidoptera	V & R	Leaves	4
Hyposidra talaca	Geometridae	Lepidoptera	V & R	Leaves	5
Aspangopus janus (F.)	Dinidoridae	Hemiptera	V & R	Leaves	6
Nezara viridula (F.)	Pentatomidae	Hemiptera	V & R	Leaves	
Spilostethus pandurus	Lygaeidae	Hemiptera	V & R	Leaves	
Cletus sp.	Coreidae	Hemiptera	V & R	Leaves	
Geocoris sp.	Lygaeidae	Hemiptera	V & R	Leaves	
Aphis gossypii (Glover)	Aphididae	Hemiptera	V & R	All the parts	
Hishimonus phycitis (Distant)	Cicadellidae	Hemiptera	V & R	Leaves	
Thrips palmi (Kirby)	Thripidae	Thysonoptera	V & R	All the parts	
Liriomyza trifolii (Burgess)	Agromyzidae	Diptera	V & R	Leaves	7
Bactrocera cucurbitae (Coquillet)	Tephritidae	Diptera	R	Fruits	8
Aulacophora foveicollis Lucas	Chrysomelidae	Coleoptera	V & R	Leaves	9
Tetranychus urticae Koch.	Tetranychus	Acari	V&R	Leaves	

PLATE 4 Adult of *Chrysodeixis chalcitis*

PLATE 5 Adult of *Hyposidra talaca*

PLATE 6 Adult of *Aspongopus janus*

PLATE 7 Adult of *Liriomyza trifolii*

PLATE 8 Adult of *Bactrocera cucurbitae*

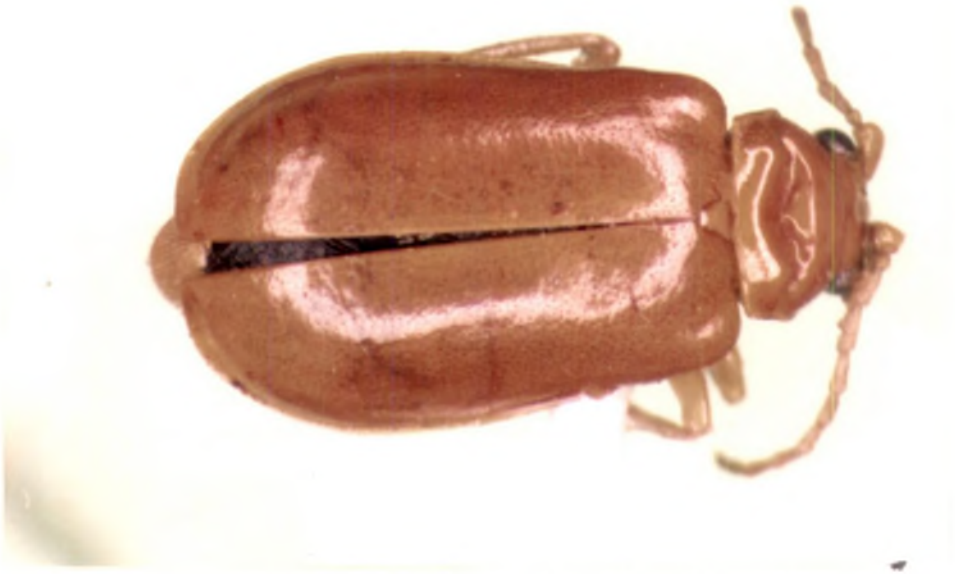

Table 12 : Parasitoids recorded on *Diaphania indica*

Parasitoid	Family	Order	Stage of *D. indica*	Palte#
Colesia sp.	Braconidae	Hymenoptera	Larva	10 &11
Species A	Braconidae	Hymenoptera	Larva	12 &13
Species B	Braconidae	Hymenoptera	Larva	14
Ichneumonid (Species C)	Ichenumonidae	Hymenoptera	Larva	15 & 16

PLATE 10 Cocoons of the braconid parasitoid, *Cotesia* sp. on larva of *Diaphania indica*

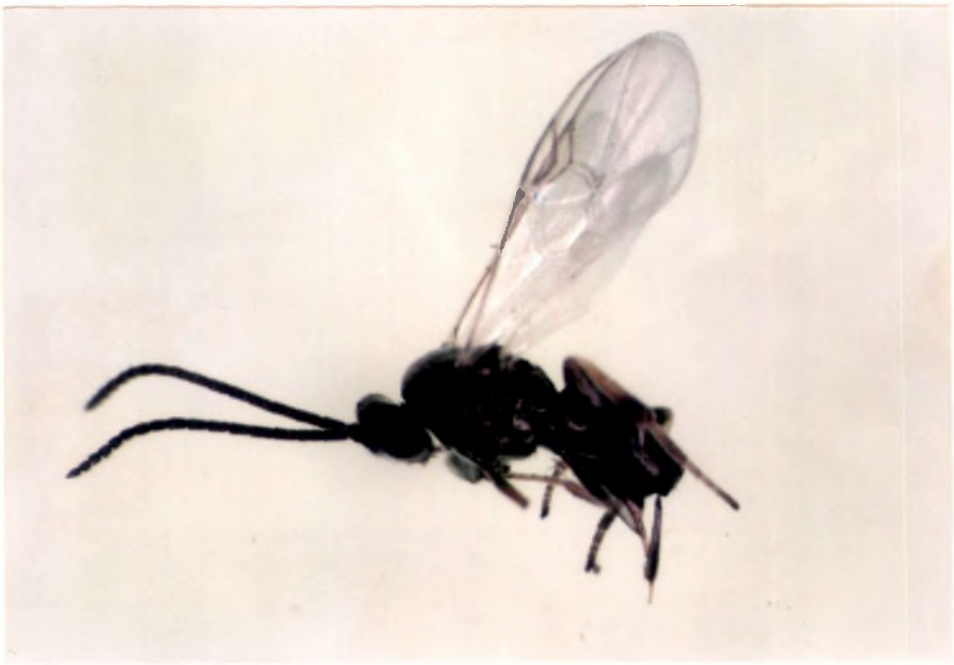

PLATE 11 Adults of *Cotesia* sp.

PLATE 12 Cocoon of unidentified braconid parasitoid (species A) on the larva of *Diaphania indica*

PLATE 13 Adult of unidentified braconid parasitoid (Species A)

PLATE 14 Adult of unidentified braconid parasitoid (species B) on the larva

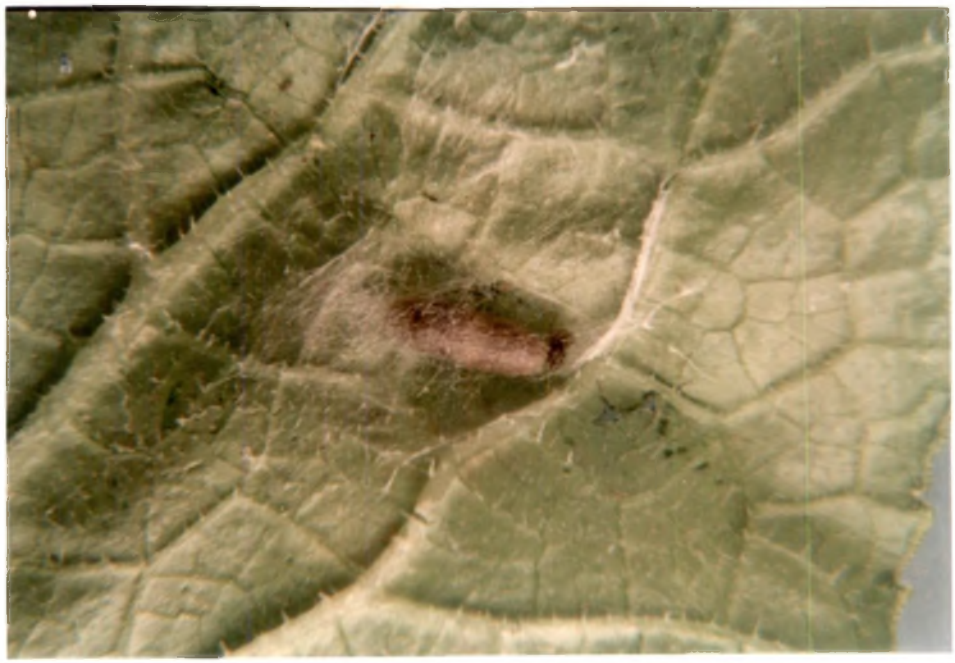

PLATE 15 Cocoon of unidentified ichneumonid parasitoid (species C) on the larva of *Diaphania indica*

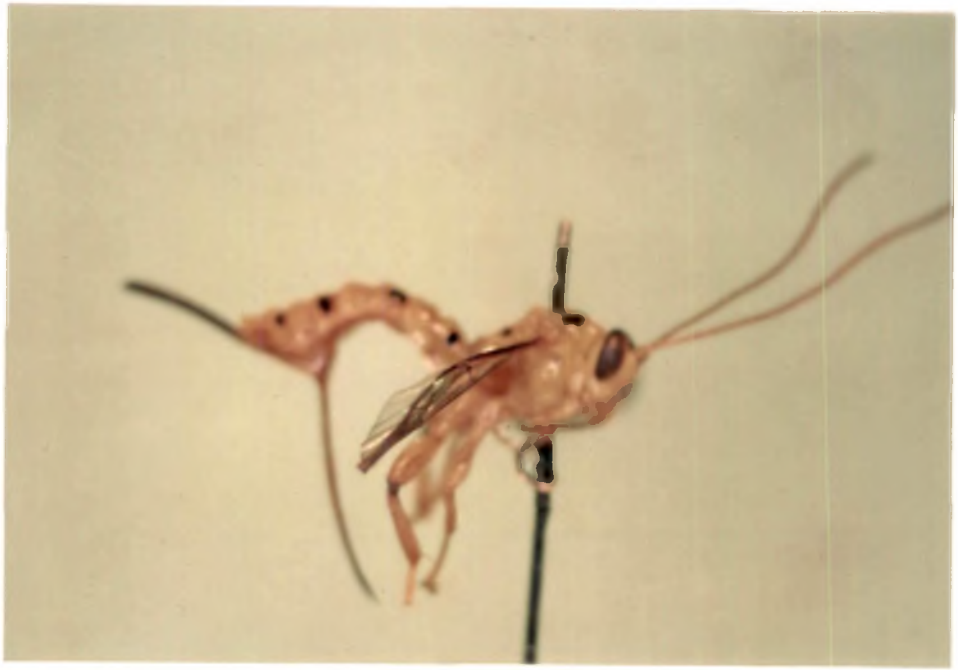

PLATE 16 Adult of unidentified ichneumonid parasitoid

Table 13 : Seasonal incidence of different insect and mite pests of gherkin (pooled data) for the year 1995-97

Months	*D. indica* 1	*H. armigera* 1	*C chalcitis* 1	*L. trifolii* 2	*A.gossypii* 3	*T. urticae* 3
January	0.27	0.03	0.03	21.75	0.15	0.32
February	0.10	0.03	0.00	60.00	0.16	0.20
March	0.15	0.31	0.03	68.00	0.50	0.65
April	0.50	0.08	0.00	43.80	0.07	0.70
May	0.47	0.20	0.08	56.00	0.06	0.33
June	0.61	0.04	0.00	24.00	0.36	0.13
July	1.78	0.16	0.06	7.00	0.32	0.02
August	2.19	0.26	0.06	18.40	0.06	0.06
September	1.62	0.18	0.07	43.66	0.10	0.13
October	1.52	0.03	0.02	24.71	0.18	0.11
November	0.50	0.06	0.00	36.00	0.00	0.02
December	0.50	0.09	0.06	18.22	0.32	0.21

1 - Number of larvae/0.5 m^2
2 - Number of adults /leaf
3- Scores/leaf (for details of scoring see 3.2.3)

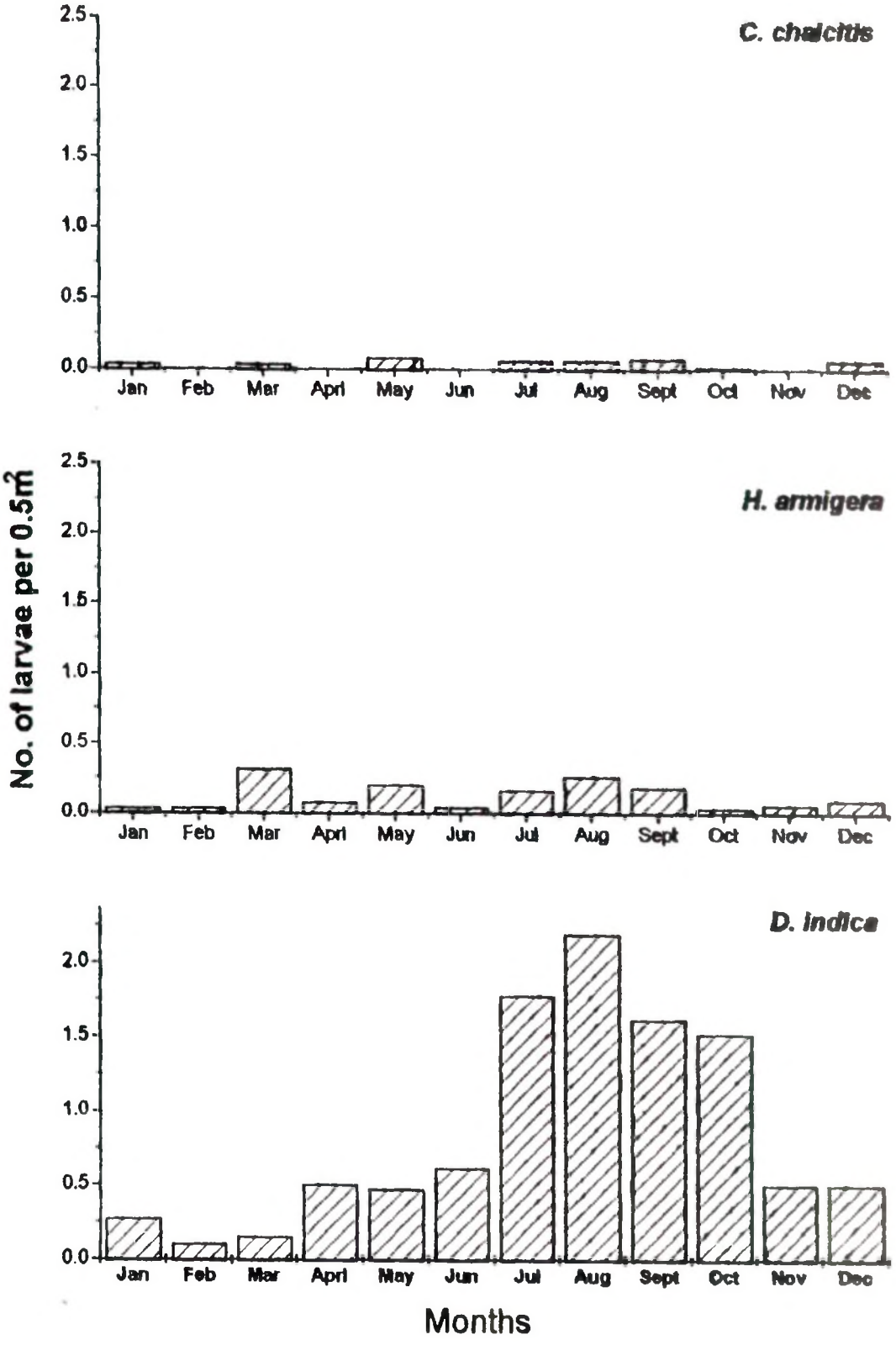

Fig. 6 Seasonal incidence of lepidopteran caterpillars on gherkin

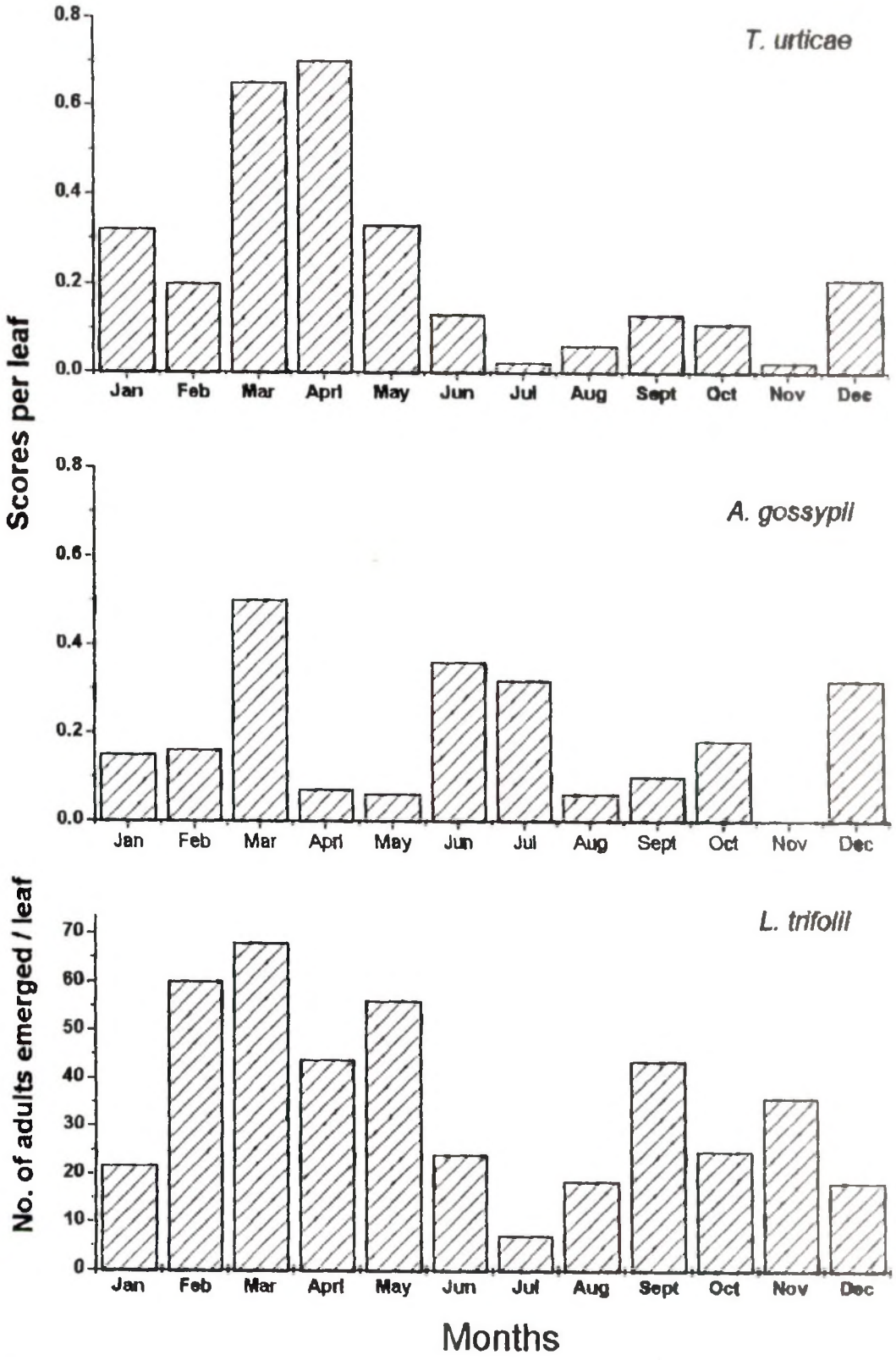

Fig. 7 Seasonal incidence of insect and mite pests of gherkin

4.3.1.1 **Population of *Diaphania indica* during different years**

The data showed that infestation followed similar trend during different years of the study (Table 13). The highest infestation was observed during August in both 1995 (3.34 larvae/ 0.5 m^2) and 1996 (2.76 larvae / 0.5 m^2).

During 1995, the pest population reduced drastically after August (3.34 larvae / 0.5 m^2). Similarly, in 1996 also, peak population was recorded during August (2.76 larvae / 0.5 m^2) and a second peak during October (2.13 larvae / 0.5 m^2) with a slight fall in the infestation during September (1.50 larvae / 0.5 m^2).

4.3.1.2. **Influence of crop age on the incidence of *Diaphania indica***

In general, the infestation was highest on 16-30 days old crop (1.23 larvae / 0.5 m^2) and then onwards it decreased (Table 15). The lowest population was recorded on 0-15 days old crop (0.35 larvae / 0.5 m^2).

4.3.1.3. **Incidence of *Diaphania indica* on different crop age of gherkin at different locations**

The highest population of 4.88 larvae / 0.5 m^2 (crop age 16-30 days) was recorded at Lakkur (Field 1, Tables 14, 15 and 16 and Fig. 8) on 28 days old crop during August 1995. As age of the crop increased *D. indica* population decreased to 0.92 larvae / 0.5 m^2 (72 days old crop) during October 1995. The lowest population (1.24 larvae / 0.5 m^2) was observed on the 61- 75 days old crop. This trend was also

Table 14 : Seasonal incidence of different insect and mite pests on gherkin during 1995-97

Months	*D. indica*	*H. armigera*	*C. chalcitis*	*L. trifolii*	*A. gossypii*	*Tetranychus*
	Number of larvae/ 0.5 m^2			No. of adults emerging/ leaf	Score/ leaf	
1995						
August	3.34	0.64	-	-	-	-
September	1.78	0.25	-	-	-	-
October	0.71	0.02	0.01	31.00	0.00	0.23
November	0.48	0.02	0.00	39.33	0.33	0.03
December	0.28	0.04	0.00	18.20	0.42	0.62
1996						
January	0.27	0.03	0.03	22.75	0.15	0.57
February	0.10	0.03	0.00	40.00	0.16	0.20
March	0.15	0.31	0.13	68.00	0.50	0.67
April	0.47	0.06	0.00	46.00	0.27	0.70
May	0.46	0.20	0.08	49.33	0.06	0.33
June	0.61	0.04	0.00	24.00	0.36	0.13
July	1.78	0.16	0.06	7.00	0.32	0.02
August	2.76	0.10	0.06	18.40	0.06	0.06
September	1.50	0.09	0.08	43.66	0.03	0.20
October	2.13	0.03	0.04	20.00	0.07	0.02
November	0.56	0.16	0.36	24.00	0.00	0.00
December	0.60	0.14	0.13	18.25	0.25	0.00
1997						
January	2.20	0.03	0.00	128.00	0.10	0.11
February	0.50	0.02	0.00	94.66	0.00	0.06

Table 15 : Incidence of *Diphania indica* and *Liriomyza trifolii* on gherkin at different locations

Locations	Age of gherkin (days)	*D. indica* (No. of larvae/0.5m^2)	*L. trifolii* (No. of adults emerged/leaf)
Lakkur			
Field I	28	4.88	-
	42	1.80	-
	59	1.68	-
	72	1.24	-
	44	2.32	-
Field II	30	1.88	-
	62	0.72	33
	77	0.50	50
Nesaragere	20	0.48	31
	32	0.76	64
	48	0.30	33
	63	0.60	11
	79	0.56	34
Doddashivara	30	0.00	18
	39	0.16	27
	44	0.36	2
Nimbekaipura	4	0.04	28
	24	0.00	12
	38	0.00	38
	51	0.10	67
	64	0.20	28
	78	0.15	42
Lagumenahalli	12	0.50	17
	26	0.10	15
	43	0.20	67
	61	0.00	84
	76	0.30	93
Jadigenahalli	10	0.50	33
	16	0.36	46
	22	0.16	63
	36	0.10	66
	44	0.60	31
	51	0.70	51
	62	0.24	26
	69	0.40	22
	76	1.20	24

Table (Contd.)

Locations	Age of gherkin (days)	*D. indica* (No. of larvae/0.5m^2)	*L. trifolii* (No. of adults emerged/leaf)
Kesaragere	22	1.00	12
	32	0.56	6
	40	0.80	8
	47	3.76	2
	53	3.44	24
	58	1.00	12
	61	1.80	19
	66	0.92	8
	73	1.52	29
Abbenahalli			
Field I	29	1.88	30
	40	3.20	16
	52	0.96	18
Field II	45	0.96	38
	60	0.60	14
Avalahalli			
Field I	35	3.00	21
	53	1.36	25
	66	0.56	24
Field II	25	0.36	9
	34	0.48	12
Mundwad	14	2.56	-
	22	1.60	147
	29	1.00	192
	36	0.60	77
	43	0.48	98
	48	0.48	96
	56	0.40	111

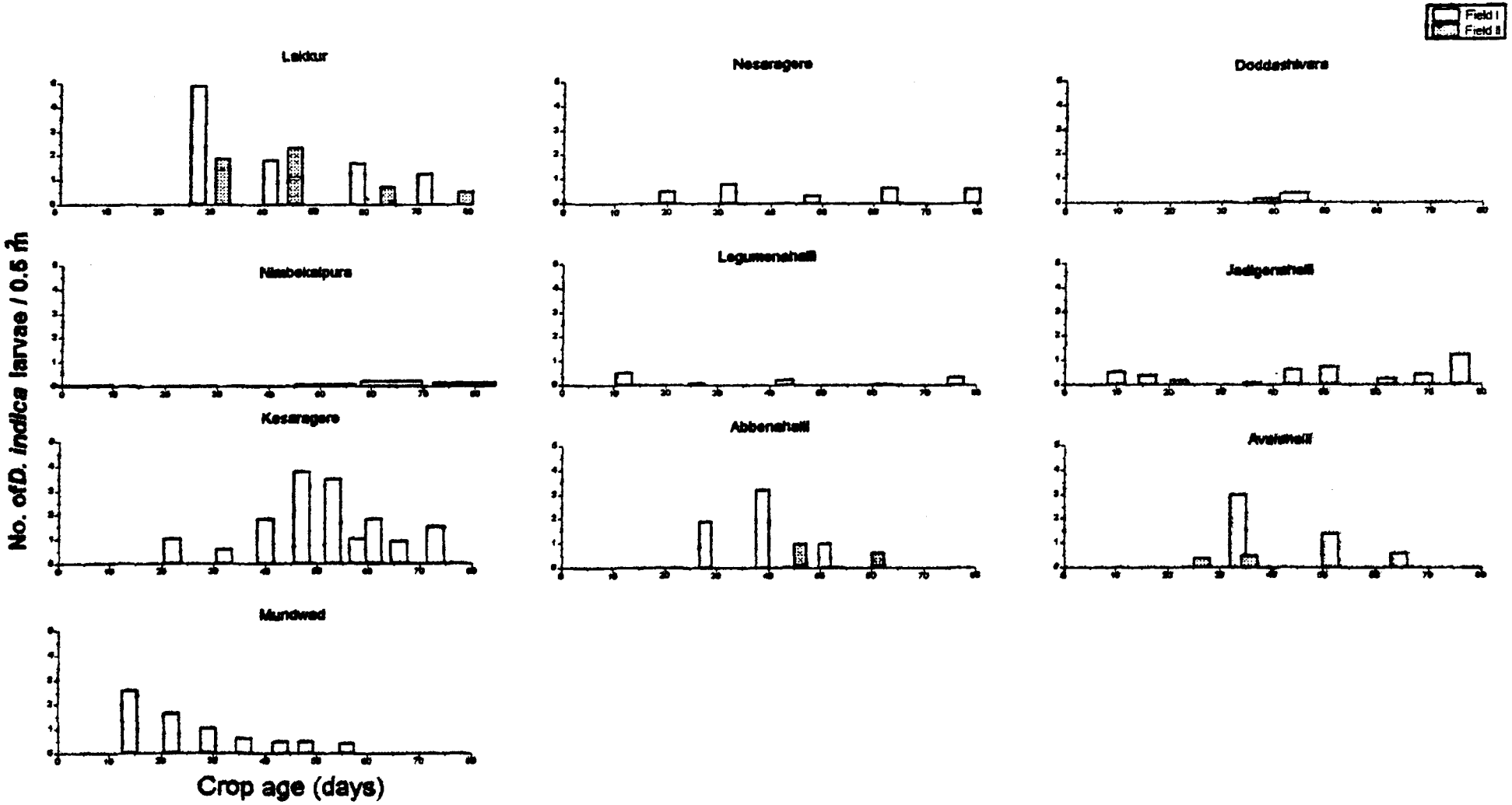

Fig. 8 Incidence of *Diaphania indica* on gherkin at different crop age at different location

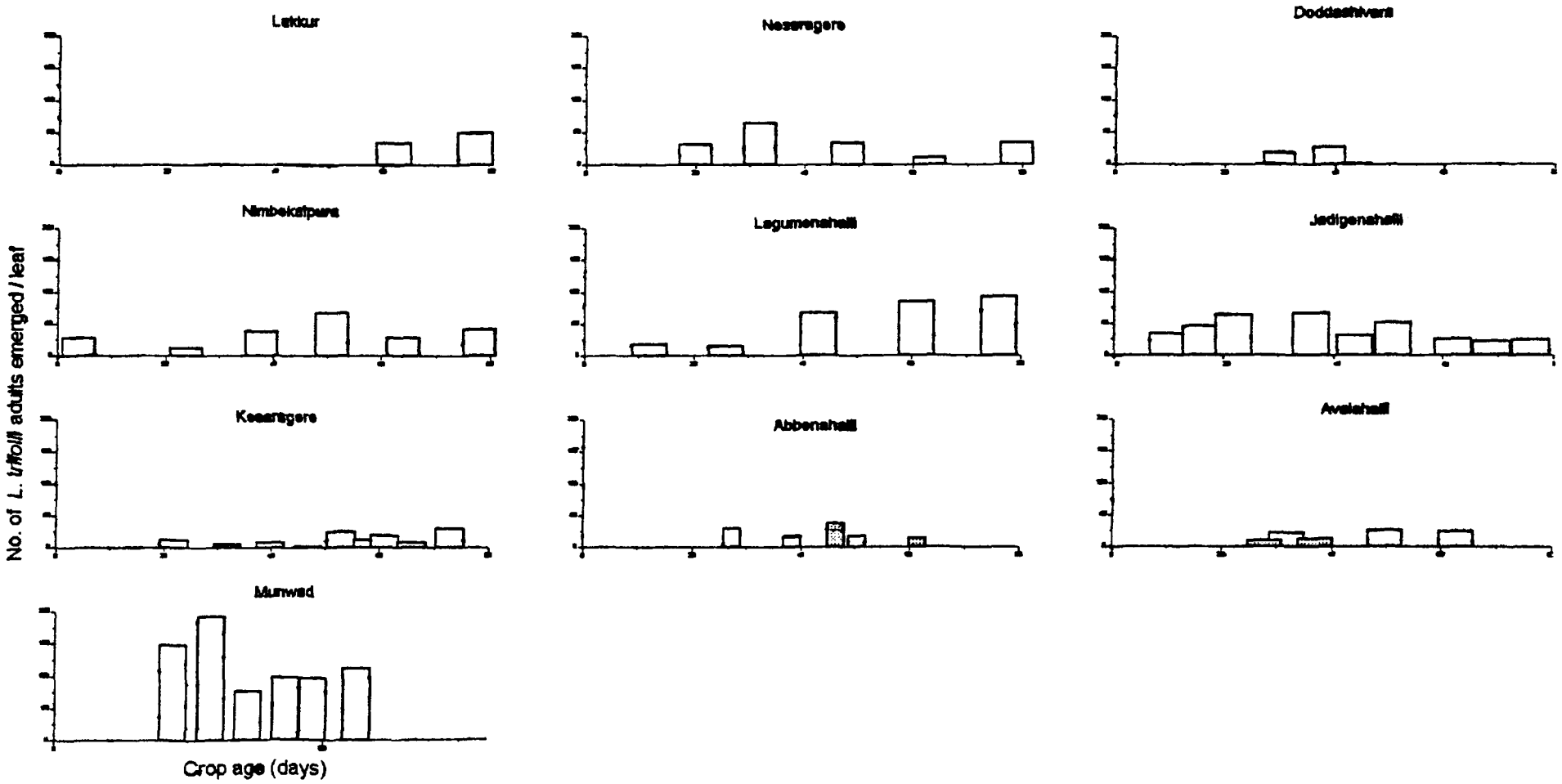

Fig. 9 Incidence of *Liriomyza trifolii* on gherkin at different crop age at different location

Table 16 : Incidence of *Diaphania indica* and *Liriomyza trifolii* on different age groups of gherkin at different locations

Location	Age groups of gherkin (in days)											
	0-15		16-30		31-45		46-60		61-75		76-90	
	1	2	1	2	1	2	1	2	1	2	1	2
Lakkur												
Field I	-	-	4.88	-	1.80	-	1.68	-	1.24	-	-	-
Field II	-	-	1.88	-	2.32	-	0	-	0.72	33	0.50	50
Nesaragere	-	-	0.48	31	0.76	64	0.30	33	0.56	11	0.56	34
Doddashivara	-	-	0	18	0.26	29	-	-	-	-	-	-
Nimbekaipura	0.04	28	0	12	0	38	0.10	67	0.20	28	0.15	42
Lagumenahalli	0.50	17	0.10	15	0.20	67	0.20	0	0.30	84	0	93
Jadigenahalli	0.50	33	0.26	109	0.35	97	0.70	51	0.32	48	0	24
Kesaragere	-	-	1.00	6	1.18	8	2.73	38	1.41	56	-	-
Abbenahalli	-	-	1.88	30	3.20	16	0.95	18	-	-	-	-
Avalahalli												
Field I	-	-	-	-	3.00	21	1.36	25	0.56	24	-	-
Field II	-	-	0.56	-	0.48	-	0.76	-	-	-	-	-
Mundwad	-	98	1.30	239	0.54	175	0.44	107	-	-	-	-
Mean	0.35	26	1.23	27.14	1.16	38.88	0.75	39.12	0.59	40.57	0.40	48.60

1- Number of *D. indica* larvae / 0.5 m^2

2- Number of *L. trifolii* adults emerging / leaf

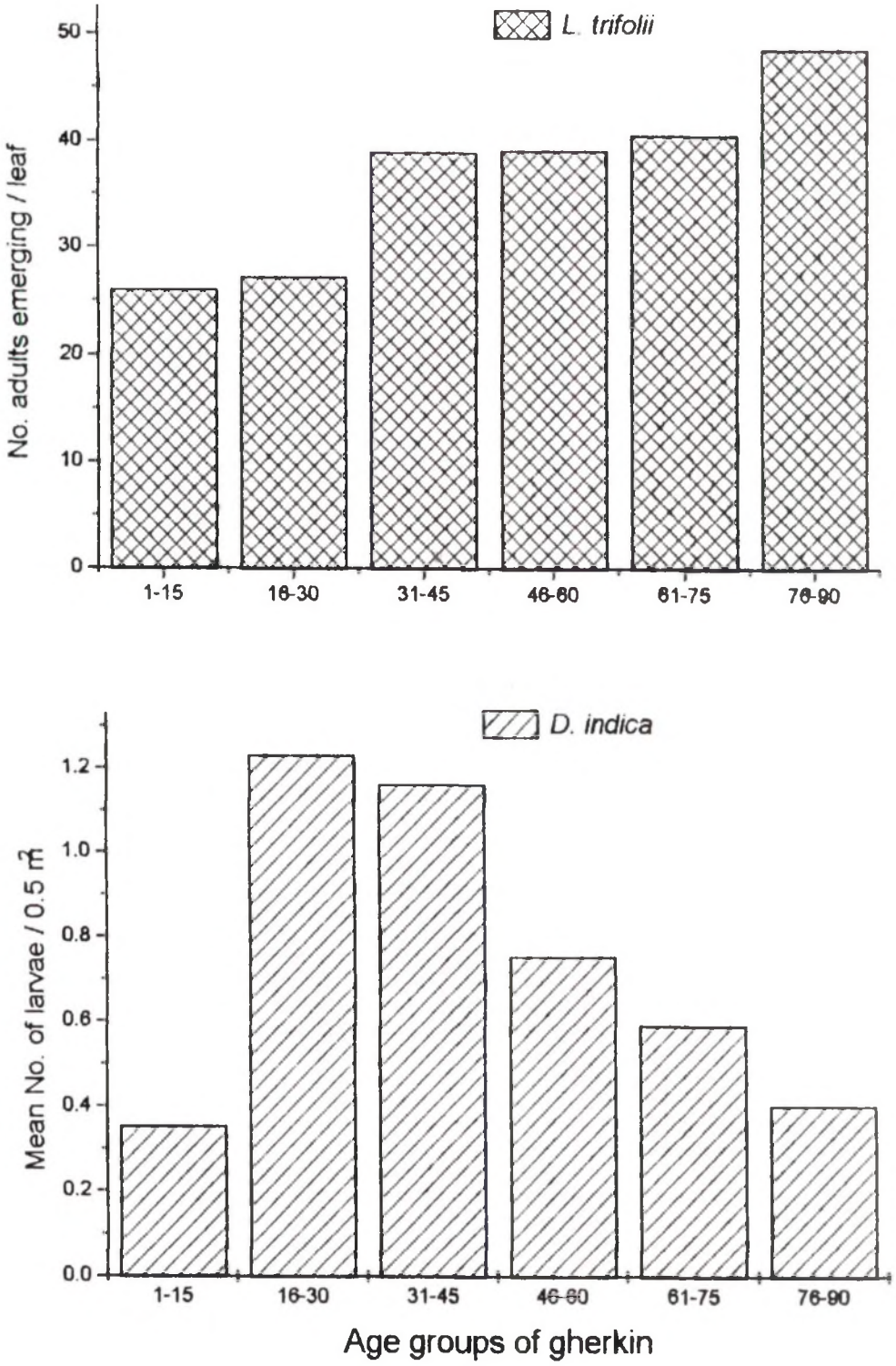

Fig.10 Incidence of *Diaphania indica* and *Liriomyza trifolii* on different age group of gherkin (Pooled data for field observation at different localities

observed in Field II of the same locality. The highest population of 2.32 larvae / 0.5 m^2 was recorded on 31-45 days old crop during September.

The population at Kesaragere was recorded during July and August 1996 on 29 days old crop. However, the population was comparatively low (1.00 larvae/ 0.5 m^2). The population increased and reached a peak of 3.76 larvae / 0.5 m^2 when the crop was 47 days old, thereafter the population decreased with a slight increase when the crop was 61 and 73 days old. Here the highest population of 2.73 larvae / 0.5 m^2 was observed.

At Abbenahalli, the peak population (3.20 larvae / 0.5 m^2) was recorded during September when the crop was 40 days old. Then the population declined drastically. However, in other fields of the same locality, the population was lower when the crop was 45 and 60 days old during the same period. At this place, the highest population of 3.20 larvae/ 0.5 m^2 was observed on 31-45 days old crop.

The highest population of 3.00 larvae/ 0.5 m^2 was recorded during October at Avalahalli when the crop was 35 days old. Thereafter, it decreased and lower populations were recorded when the crop was 53 and 66 days old during October and November , respectively. In another field of the same locality, very low populations of 0.36 and 0.48 larvae/ 0.5 m^2 were recorded on 45 and 60 days old crops, respectively during December. The highest population (3.00 larvae/ 0.5 m^2) was recorded on 31-45 days aged crop.

At Jadigenahalli, the population was low throughout the crop period between April and June 1996 with the lowest being 0.10 larvae/ 0.5 m^2 when the crop was 36 days old. Moderate population was recorded on crops 10, 44 and 51 days where the population was 0.50,

0.60 and 0.70 larvae/ 0.5 m^2 respectively. However, the highest population (1.20 larvae/ 0.5 m^2) was recorded when the crop was 76 days old during June 1996. Population was the highest (0.70 larvae/ 0.5 m^2) on 46-60 days old crop.

At Lagumenahalli, the population ranged between 0.0-0.50 larvae/ 0.5 m^2 during January-March 1996 when crop age ranged from 12 days to 66 days.. At 61st day there was no incidence of the pest.

Nimbekaipura recorded the lowest population during the study period. The observations made during January-March showed the highest population in this locality with 0.20 larvae/ 0.5 m^2 on 64 days old crop. There was no incidence of the pest on 16-30 and 31-45 days old crop. The highest population (0.20 larvae/ 0.5 m^2) was recorded in the age group of 61-75 days old crop.

At Doddashivara, the crop was free from *D. indica* till 30 days. Even afterwards the infestation level was low and did not exceed 0.76 larvae/ 0.5 m^2 till harvest.

The population started decreasing with crop age at Mundwad during January and February, 1997 with the highest population of 2.56 larvae/ 0.5 m^2 when the crop was 14 days old (0-15 days old crop).

4.3.2. **The gram pod borer, *Helicoverpa armigera***

The populations of *H. armigera* was low at all the localities during the study. However, the population was found throughout the year with a peak of 0.31 larvae/ 0.5 m^2 during March 1996. The population was moderate during May (0.20 larvae/ 0.5 m^2), July (0.16

larvae/ 0.5 m^2), August (0.26 larvae/ 0.5 m^2) and September (0.18 larvae/ 0.5 m^2). In the remaining months, it was very low. The lowest population of 0.03 larvae/ 0.5 m^2 was recorded during January, February and October (Table11 and Fig. 6).

4.3.2.1 **Population of *Helicoverpa armigera* during different months**

The highest population (0.64 larvae/ 0.5 m^2) was recorded during August 1995 followed by September (0.025 larvae/ 0.5 m^2), October and November (0.02 larvae/ 0.5 m^2) and December (0.04 larvae / 0.5 m^2) (Table 13).

However, during 1996, highest population was recorded in March (0.31 larvae/ 0.5 m^2). Moderate populations were observed during May (0.20 larvae/ 0.5 m^2) followed by July and November (0.16 larvae/ 0.5 m^2), December (0.14 larvae/ 0.5 m^2), August (0.10 larvae/ 0.5 m^2) and September (0.09 larvae/ 0.5 m^2) in that order. During other months it was very low. Similarly, during 1997 also, the population was very low in both January (0.03 larvae/ 0.5 m^2) and February (0.02 larvae/ 0.5 m^2) months.

4.3.3 **Semilooper, *Chrysodeixis chalcitis***

This pest was observed only in the month of October (0.01 larvae/ 0.5 m^2) during 1995. However, in 1996, the highest population was observed during November (0.36 larvae / 0.5 m^2) (Table 11 and Fig. 6). In October and January, the populations were very low (0.03 larvae/ 0.5 m^2).

4.3.4. **The Serpentine leaf miner, *Liriomyza trifolii***

This pest was observed throughout the year and was very serious on many occasions (Table 11 and Fig. 7). The population of the pest during January was 22.75 (adults emerging/ leaf) which suddenly shot upto to 60.00 (adults emerging/ leaf) in February and reached the highest number (68.00 adults emerging /leaf) in March. Thereafter, it decreased. A slight increase during May (56.00 adults emerging /leaf) was observed. The infestation was lowest in July (7.00 adults emerging /leaf) which then increased in August (18.40 adults emerging /leaf) and a second peak was observed during September (43.66 adults emerging /leaf). The infestation was moderate during October (24.71 adults emerging /leaf), November (36.00 adults emerging /leaf) and December (18.22 adults emerging /leaf).

4.3.4.1 **Population of *Liriomyza trifolii* in different years**

During 1995, the population of the pest was 31.00 (adults emerging /leaf) in October which reached a peak in November (39.33 adults emerging /leaf) and was lowest during December (18.20 adults emerging /leaf)(Table 13).

In the year 1996, the infestation was moderate during January (22.75 adults emerging /leaf) which went on increasing in February (40.00 adults emerging /leaf) to reach the maximum in March (68.00 adults emerging /leaf). Thereafter, it decreased. The lowest infestation was recorded during July (7.00 adults emerging /leaf). In August, the infestation increased for the second time in the year with number of adults emerged per leaf being 18.40.

In 1997, the highest population of the flies was recorded during January (128.00 adults emerging /leaf) which decreased to 94.88 (adults emerging /leaf) in February. This population was highest ever recorded during the study period.

4.3.4.2. **Incidence of *Liriomyza trifolii* at different locations**

As the age of the crop progressed, the infestation also gradually increased (Tables 14, 15 and 16; Fig. 9). The lowest population was observed on crop less than 15 days old (26.00 adults emerging /leaf) which increased thereafter.

At Lakkur, during October 1995, the population was 33.00 and 50.00 on 62 and 77 days old crop, respectively.

In Nesaragere, the infestation was (31.00 adults emerging /leaf) in 20 days old crop which increased to 64.00 adults (emerging /leaf) when the crop was 32 days old during November. This decreased to 33.00 and 11.00 when the crop age was 48 and 63 days, respectively during December, 1995. However, there was a slight increase in the infestation (34.00 adults emerging /leaf) during January when the crop was 79 days old.

At Doddashivara, during December, the population of the leafminer was 18.00 adults emerging /leaf in 30 days old crop which increased to 27.00 adults emerging /leaf in 39 days old crop and thereafter it decreased drastically to 2.00 adults emerging /leaf when the crop was 44 days old.

At Nimbekaipura, the infestation was as high as 28.00 adults emerging /leaf even in 4 days old crop which came down to 12.00

(adults emerging /leaf) in 24 days old crop during January. Later, the population increased and reached a peak (61.00 adults emerging /leaf) in 51 days old crop which then dropped to 28.00 (adults emerging /leaf) in 64 days old crop in April.

Increase in the infestation of the pest population with the crop age was evident in Lagumenahalli. The number of adults emerging per leaf was 17.00, 15.00, 67.00, 84.00 and 93.00 in 12, 26, 43, 61 and 76 days old crop respectively during February and March, 1996.

At Jadigenahalli, the population ranged between 22.00-66.00 (adults emerging /leaf) over a crop period of 59 days. The infestation in 10 days old crop was 33.00 adults emerging /leaf which reached a peak (66.00 adults emerging /leaf) in 36 days old crop during May 1996. In June, it remained almost constant in crops of age 62, 69 and 76 days.

In Kesaragere, the pest population was low in the crop whose age ranged between 22 and 73 days during July and August. The highest population (29.00 adults emerging /leaf) was observed in 73 days old crop followed by 24.00 adults emerging /leaf in 53 days old crop. The population remained low in this area throughput the crop period and it was as low as 2.00 (adults emerging /leaf) in 47 days old crop.

At Abbenahalli, the population decreased from 30.00 (adults emerging /leaf) in 29 days old crop to 16.00 and 18.00 when age of the crop was 40 and 52 days respectively in the first field. The situation was similar in the second field in same locality where the number of adults emerging /leaf decreased from 38.00 (45 days old crop) to 14.00 (60 days old crop).

At Avalahalli, the infestation remained almost constant in 35 days (21.00 adults emerging /leaf) and 53 days (25.00 adults emerging /leaf) old crop in October 1996 and 66 days (24.00 adults emerging /leaf) old crop in November in the first field. Similarly, in the second field, the population did not vary in 25 days (9.00 adults emerging /leaf) and 34 days (12.00 adults emerging /leaf) old crop during December.

Very high population in the study period was observed at Mundwad during January and February 1997. As high as 147.00 (adults emerging /leaf) were recorded in 14 days old crop which went upto 192.00 (adults/ leaf) when the crop age was 22 days. Later on, there was reduction in the population when the crop was 36 days (77.00 adults emerged per leaf) which increased to 98.00 and 96.00 (adults emerging /leaf) in 43 and 48 days old crop. Fifty six day old crop recorded as high as 111.00 (adults emerging /leaf). The population in January was 128.00 (adults emerging /leaf) which drastically reduced to 94.66 (adults emerging /leaf) in February 1997.

4.3.5 **Aphid, *Aphis gossypii***

The population score of aphids was very high (0.50/ leaf) in March and it gradually declined till January (0.15/ leaf) (Table 11 and Fig. 9). Lower population was recorded during April (0.07/ leaf) and August (0.06/ leaf). The pest was absent during November. In 1995, the population of aphids was high during December (0.42/ leaf) and in November it was 0.33/ leaf. It was absent in October. Whereas, in 1996, the highest population was recorded in March (0.50/ leaf). The population was moderate in January (0.15/ leaf) and February (0.16/ leaf). The lowest population was observed during September (0.03/ leaf) (Table). No aphids were noticed during

November. However, in 1997 it was present only in January (0.10/ leaf) and absent in February.

4.3.6. **The red spider mites, *Tetranychus urticae***

The population score of the mite during January was 0.32/ leaf. This dropped to 0.20/ leaf in February and increased in March (0.65/ leaf) and reached peak (0.70/ leaf) in April. Later, there was gradual reduction in population (Table 11 and Fig. 9). The lowest population was recorded in July (0.02/ leaf). There was a slight increase in the population in September (0.13/ leaf) which again reduced to the lowest in November (0.02/ leaf).

The population of the mites was the highest (0.62/ leaf) in December and lowest (0.03/ leaf) in November and was moderate in October (0.23/ leaf) in 1995. However, in 1996 the population was high during January (0.57/ leaf), March (0.67/ leaf) and April (0.70/ leaf). Moderate population was observed during May (0.33/ leaf), February and September (0.20/ leaf) and June (0.13/ leaf). Lower population was recorded during July (0.02/ leaf) and September (0.02/ leaf). There were no mites during November and December. In 1997, the population of the mites was 0.11 and 0.06/ leaf in January and February, respectively.

4.4 **Relationship between seasonal incidence of gherkin pests and the weather parameters**

Data on the seasonal incidence of all the pests was correlated with the weather parameters and the results are presented in Table 17.

Table 17 Relationship between weather parameters and seasonal incidence of insect and mites pests of gherkins

Weather parameters/pests	*D. indica*	*H. armigera*	*C. chalcitis*	*L. trifolii*	*A. gossypii*	*Tetranychus*
Monthly Mean Max. Temperature (°C)	-0.258	0.385 NS	0.383 NS	0.666**	0.222 NS	0.006 NS
Monthly Mean Max. Temperature (°C)	0.348 NS	0.153 NS	-0.102 NS	0.154 NS	0.001 NS	-0.241 NS
Total Rain fall (mm)	0.411 NS	-0.231 NS	-0.037 NS	0.005 NS	-0.255 NS	-0241NS
Monthly Mean Relative Humidity (%)	0.621 *	-0.727 NS	-0.387 NS	-0.649 NS	-0.727 *	-0.696*

NS - Non -significant at p =0.05

• - Significant at p=0.05

** - Significant at p=0.05

4.4.1 ***Diaphania indica***

When relationship between the seasonal incidence and the weather parameters was studied, the population of *D. indica* showed significant positive correlation with the relative hemidity (r=0.6208). It did not show any significant relationship with mean minimum temperature (r = 0.3484) and total rainfall (r = 0.4108).

4.4.2 ***Helicoverpa armigera***

Poplation of this pest showed significant negative correlation with mean relative humidity (r = -0.7274). There was no significant relationship with other weather parameters.

4.4.3. ***Chrysodeixis chalcitis***

Population of semilooper showed non-significant relationship to all the weather parameters tested.

4.4.4. ***Liriomyza trifolii***

Population of leafminers showed highly significant positive correlation with temperature (r = 0.6656) while it showed significant negative correlation with the mean relative humidity (r = -0.6487).

4.4.5. ***Aphis gossypii***

Population of aphids showed significant negative correlation with mean relative humidity (r = -0.7274).

4.4.6. ***Tetranychus urticae***

Population of this pest also showed significant negative correlation with the mean relative humidity (r = -0.6963).

4.5 **Nature of Damage**

4.5.1. ***Diaphania indica***

Larvae were the only destructive stage of the pest. They were found attacked almost all the parts of the vine at all the stages of the crop (Plate 17). However, in general, leaves were attacked more when compared to other parts. Larvae fed on the under surface of the leaves within the leaf fold covered by thin silken thread. The first and second instar caterpillars scraped the under surface of the leaves leading to skelitanisation. The affected leaves had papery appearance. The later instar larvae fed on the leaves either partially or completely. While feeding on single leaf, they folded the leaf by bringing the leaf margins together and remained inside (Plate 18).

The caterpillars also bored into the fruits (Plate 19) and devoured part or complete fruits. They also entered the fruits and remained inside feeding. The larvae bored fruits of all ages and size (Plate 20). Occasionally early instar larvae also attacked young fruits. The larvae did not web the fruits when they were feeding on them. However, occasionally when the leaves were adjacent to the fruits, they webbed the fruits and leaves together.

The caterpillars also attacked buds irrespective of their instars (Plate 21). However, early instar larvae were rampant on buds. The larvae webbed the buds with adjacent young leaves by silken threads. The caterpillars did not spare flowers and both male and female flowers

PLATE 17 Young gherkin seedling severely damaged by *Diaphania indica* larva

PLATE 18 Larvae of *Diaphania indica* folding gherkin leaf

PLATE 19 Larva of *Diaphania indica* feeding on gherkin fruit

PLATE 20 Gherkin fruits damaged by larvae of *Diaphania indica*

PLATE 21 Buds and leaves of gherkin damaged by *Diaphania indica*

PLATE 22 Flower and fruit of damaged by larva of *Diaphania indica*

were attacked by them. The larvae attacked flowers and devoured them either partially or completely (Plate 22).

4.5.2 *Helicoverpa armigera*

The caterpillars attacked both fruits and flowers. On fruits, the larvae remained outside and bored the fruit partially by thrusting their head inside (Plate 23).

The larvae fed on flowers either partially or completely (Plate 24). Very rarely young larvae attacked buds.

4.5.3 *Chrysodeixis chalcitis*

The larvae remained generally on the under surface of the leaves and consumed the entire leaf. All the instars of the larvae were found feeding on the leaves (Plate 25).

4.5.4. *Liriomyza trifolii*

The pest attacked all the leaves without any discrimination. Females made series of punctures on the upper surface and fed on the exuding sap. The larvae upon hatching, mined beneath upper epidermis feeding its way through mesophyll. Narrow mines gradually broadened with the increase in size of the larva. The mine was highly contorted and turned whitish. Under severe infestation, different mines criss-crossed and turned papery white. The affected plants showed burnt appearance (Plate 26).

4.5.5. *Aphis gossypii*

Both nymphs and adults attacked undersurface of the leaves and sucked the sap. The attacked leaves turned yellow in colour. There

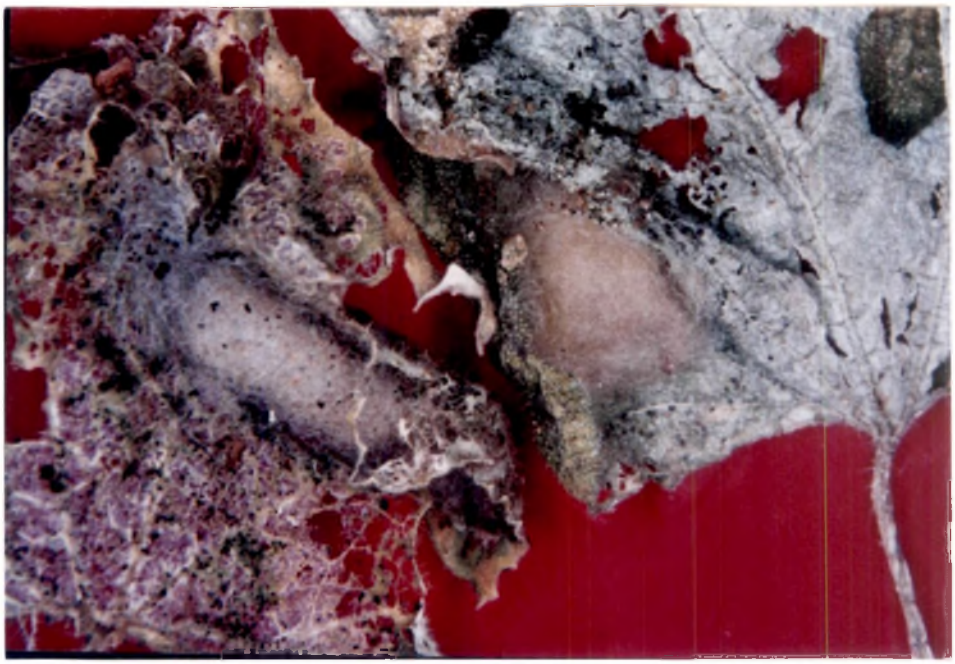

PLATE 23 *Helicoverpa armigera* larva on gherkin fruit

PLATE 24 *Helicoverpa armigera* larva on gherkin flower

PLATE 25 Larva of *Chrysodeixis chalcitis*

PLATE 26 Gherkin leaf severely damaged by *Liriomyza trifolii*

was downward curling and crumpling of affected leaves under heavy infestation. They were also observed feeding on buds and fruits.

4.5.6. **Mites**

Both nymphs and adults sucked the sap from the under surface of the leaves. Their feeding led to the formation of yellow specks on the upper surface. They produced slight to heavy webbing.

4.5.7. **Fruit fly, *Bactrocera cucurbitae***

Females make punctures on the fruit and lays eggs laid inside. As a result , the fruit exudes gummy like substance (Plate 27). Maggots feed on the fruit pulp upon hatching. Maggots come out of the fruit, drop down and pupate inside the soil.

4.5.8 **Thrips, *Thrips palmi***

Both adults and nymphs lacerate the surface tissues of the foliage and suck the exuding sap. The affected leaves show curling (Plate 28).

4.6 **BIOLOGY OF *Diaphania indica***

The studies on biology of *D. indica* on gherkins and its comparative biology on different plant parts and different host plants are presented hereunder:

4.6.1 **Gherkin leaves**

4.6.1.1. Developmental Stages

4.6.1.1.1. Eggs

Eggs are scale like, small measuring 0.081 ± 0.13 mm in diameter, translucent light greenish at the time of oviposition and

PLATE 27 Oozing from gherkin fruits due to oviposition by fruit flies

PLATE 28 Curled gherkin leaves due to feeding by *Thrips palmi*

gradually turn light yellow towards hatching (Plate 29). They are of different shape depending on the surface on which they are laid and whether laid singly or in groups. When eggs are found in group they are overlapping. They are often with blunt edges and have pentagonal reticulation visible when viewed under microscope. The egg period lasted for 3.00 ± 0.46 days (Table 18).

Egg laying started from third day onwards and the highest number of eggs were laid on seventh day. Thereafter, it decreased drastically and females stopped laying the eggs (Fig. 11).

4.6.1.1.2. Larva

There were five larval instars occupying 14.05 ± 0.5 days. A breif description of each instar along with their measurements and duration are presented here (Table 18).

4.6.1.1.2.1. I Instar larva

The larva is pale green in colour soon after hatching, slowly turns green after feeding. The head of the larva is dark green. The duration of this instar lasted for 3.30 days. The larvae measured 2.21± 4.58 mm in length (Plate 30).

4.6.1.1.2.2. II Instar

They are green in colour and two inconspicuous longitudinal white bands appeared on the dorso-lateral side of the body running from thorax to the last abdominal segment. This instar lasted for 2.52 ± 0.02 days. The larvae measured 4.60 ± 10.67 mm in length (Plate 31).

Table 18: Biology of *Diaphania indica* on gherkin leaves

Stages		No. of days	Measurement (mm)
EGG	Incubation period	3.00 ± 0.46	0.081 ± 0.13
LARVA	I Instar	3.30 ± 0.0	2.21 ± 4.58
	II Instar	2.52 ± 0.02	4.60 ± 10.67
	III Instar	3.50 ± 0.08	11.20 ± 14.69
	IV Instar	2.20 ± 0.24	17.20 ± 19.52
	V Instar	3.70 ± 0.40	20.50 ± 10.25
	Total larval duration	15.22 ± 0.58	-
	% Larval survival	100 %	-
PUPA	Pupal duration	11.10 ± 0.28	14.44 ± 0.07
	% Pupation	100%	-
	% Moth emergence	80	-
ADULT	Adult life span	7.50 ± 1.05	-
	Sex ratio (M : F)	1 : 0.14	-
	Fecundity	116.5 eggs/ female (60-323 eggs/ female)	-
		28.25 eggs/ day	-
	Pre-oviposition period (days)	3.00 ± 1.26	-
	Oviposition period (days)	3.20 ± 0.41	-
	Post-oviposition period (days)	1.33 ± 0.52	-

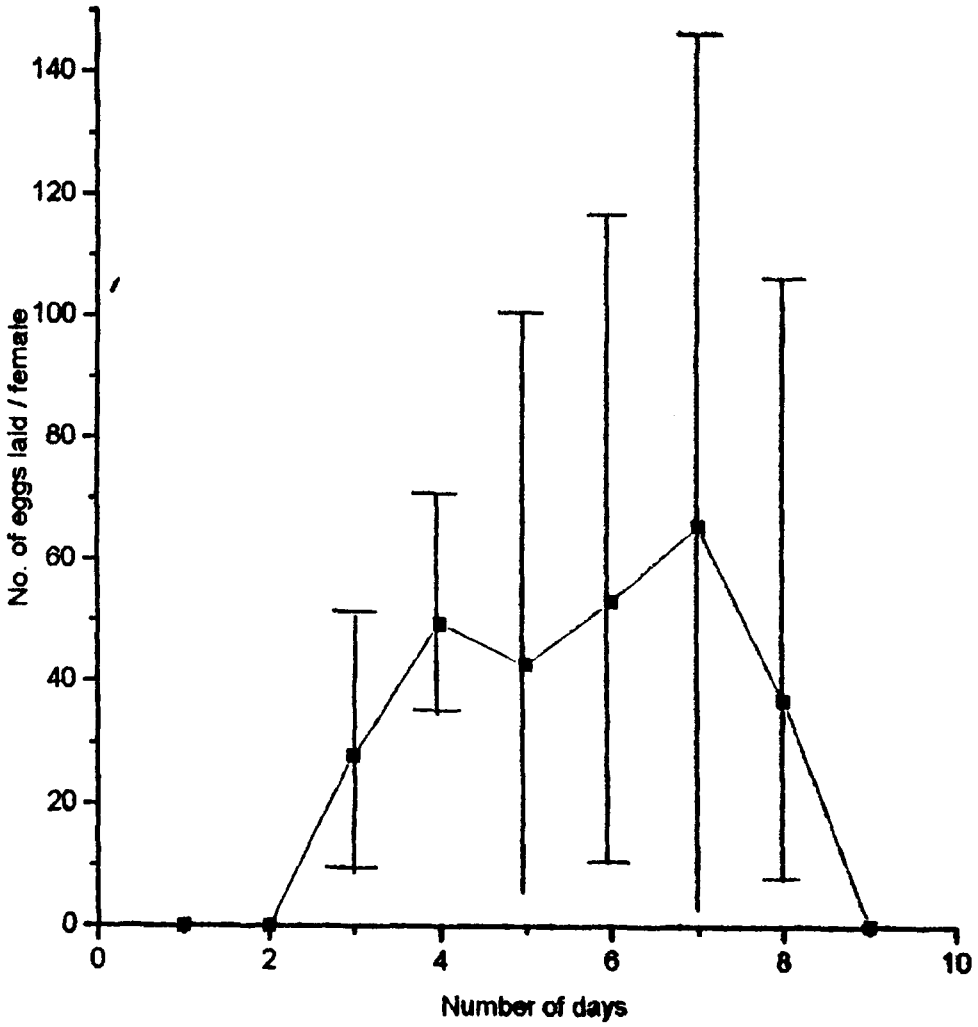

Fig. 11 Daily fecundity of *Diaphania indica*

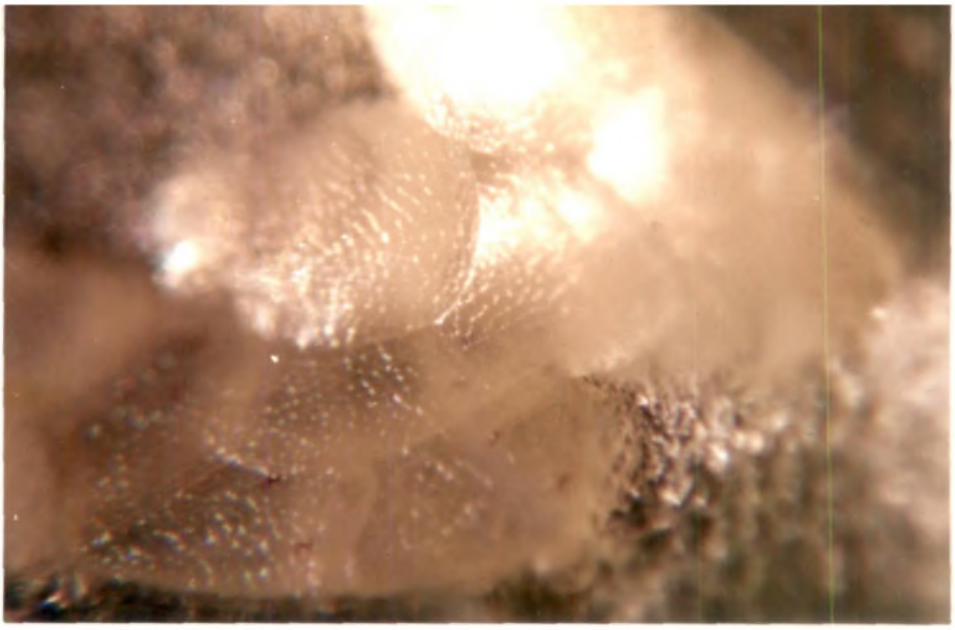

PLATE 29 Eggs of *Diaphania indica*

PLATE 30 I - instar larva of *Diaphania indica*

4.6.1.1.2.3. III Instar

The larvae were dark green in colour with characteristic conspicuous lateral white band on the dorsal surface of the body. The larval duration was 3.50 ± 0.08 days. They measured 11.20 ± 14.69 mm in length (Plate 32).

4.6.1.1.2.4. IV Instar

They resembled III instar larvae in appearance and measured 17.20 ± 19.52 mm in length. Their duration lasted for 2.20 ± 0.24 days (Plate 33).

4.6.1.1.2.5. V Instar

They attained a length of 20.50 ± 10.25 mm and appeared green with yellowish tinge. They were widest at mid length of the abdomen and tapered towards both the ends (Plate 34). Towards the end of the larval instar, the two white bands gradually disappeared and the larvae turned pale green in colour. The duration of this instar was 3.70 ± 0.40 days. Before pupation the larvae stopped feeding and encased themselves in a silken cocoon and remained inside in this stage for two days. This stage was non-feeding, sedentary, whitish green in colour and was hard (Plate 35).

4.6.1.1.2.7. Larval behavior

The first instar larvae fed on younger leaves by scraping the chlorophyll content. They produced thin silken threads with the help of which they dropped down from the plant surface. Second instar larvae also fed similarly resulting in skelitanisation of the leaves. They were also capable of producing silken threads. They folded the leaves together by silken thread.

PLATE 32 III - instar larva of *Diaphania indica*

PLATE 33 IV - instar larva of *Diaphania indica*

The third, fourth and fifth instar larvae had similar feeding habit. They cut the leaves and fed upon them. They also folded two adjacent leaves and remained within and fed. The larvae were more active during night time. However, they were feeding in the day time also. But during day they remained within the leaf folds or within webbed buds or webbed flowers or within the fruits.

4.6.1.1.3. Pupa

The pupae were typically obtect measuring 14.44 ± 0.07 mm length and were formed with the loose silken cocoon webbed by the last instar larva (Plate 36). Initially they were dark green in colour and later turned brown and towards the end i.e., a day prior to emergence, two black spots appeared on the head region and black bands developed along the margins of the wing pads and at the posterior end of the abdomen. The pupal period lasted for 11.63 ± 0.26 days and per cent pupation was 100%.

4.6.1.2. Adult

Adults are very attractive moths with whitish wings and abdomen. Head, thorax and margins of both the wings are covered by a dark purplish coloured band which was continuos. The legs are long and white coloured. Tips of the abdomen bear a brush like appendage consisting of flattened, curved yellow coloured scales at the base and light brown at the tip (Plate 37). The moths held their brushes above the body level and slowly waved them in circular fashion. It was very difficult to distinguish the sexes at this stage.

Mating was observed during dawn. Moths were sitting back to back, with their abdomen coupled together. The abdominal tufts of

PLATE 35 Prepupa of *Diaphania indica*

PLATE 36 Pupae of *Diaphania indica*

both the sexes were open and moths were continuously moving their antennae. Mating period lasted for 8-10 minutes.

The adult life span was 7.50 ± 1.05 days. The pre-oviposition, oviposition and post-oviposition periods were 3.00 ± 1.26, 3.20 ± 0.41 and 1.33 ± 0.52 days respectively. There was 80.00% moth emergence. The male to female sex ratio was 1 : 0.14.

Female laid eggs either singly or in groups of two or more. On an average each female laid about 116.5 eggs (8-147) during her life span and 28.25 eggs per day.

4.6.2. Comparative biology of *Diaphania indica*

4.6.2.1. On different parts of gherkin

4.6.2.1.1. Larva

As the larvae were reared on leaves upto second instar, there was no change in their duration. The duration of third instar also remained same (3.50 ± 0 days) on all the parts. The fourth larval duration was longer on fruits (2.54 ± 0.04 days) compared to that on flowers and leaves (2.20 ± 0.24 days on both the parts). The final instar larvae took longer time on leaves (3.71 ± 0.40 days) followed by flowers (3.70 ± 0.40 days) and fruits (3.55 ± 0.52 days) to complete development (Table 19).

There was no significant difference in the total larval duration when reared on different parts of the gherkin. On leaves and flowers the total larval duration was 15.19 days whereas, on fruits it was 15.36 days. No larval mortality was observed on leaves. However, on flowers and fruits the larval survival was 90%.

Table 19 : Comparative biology of *Diaphania indica* when reared on different plant parts of gherkin

Plant parts	Larva							Pupa			Sex ratio (M : F)
	Larval Instars					Total larval duration	Larval survival (%)	Pupal duration (days)	% Pupation	% Moth Emergence	
	I	II	III	IV	V						
Leaves	3.30± 0.0	2.52± 0.02	3.50± 0.08	2.20± 0.24	3.71± 0.40	15.19	100	11.10	100	80.0	1 : 0.14
Flowers	3.30± 0.0	2.52± 0.02	3.50± 0.07	2.20± 0.24	3.70± 0.40	15.19	90	11.14	90	62.5	1 : 1.33
Fruits	3.30± 0.0	2.52± 0.02	3.50± 0.07	2.54± 0.04	3.55± 0.52	15.36	90	11.25	90	88.9	1 : 1
F-test						NS		NS			

4.6.2.1.2. Pupa

There was no significant difference in the pupal duration (Table 19) on leaves (11.10 days), flowers (11.41 days) and fruits (11.25 days). Per centage pupation was 100% on leaves followed by fruits and flowers (90%).

Per cent moth emergence was highest in pupae reared from fruits (88.90%) followed by leaves (80%) and was the least on pupae reared on flowers (66.2%).

4.6.2.1.3. Adult sex ratio

Male to female ratios were equal (1 : 1) on fruits whereas fewer females developed (1 : 0.14) on leaves and more females developed (1 : 1.33) on flowers.

4.6.2.2. On different cucurbit hosts

4.6.2.2.1. Larva

The larval duration remained same till II instar as they were reared on gherkin leaves. Even the third instar larval duration was also almost same on all the fruits with the highest duration being on chow-chow (3.54 ± 0.06 days) and the least on gherkins (3.50 ± 0.07 days). However, the larval duration varied from fourth instar onwards. The duration of fourth instar was the highest on chow-chow (2.70 ± 0.33 days) followed by coccinea (2.60 ± 0.20 days) and gherkin (2.50 ± 0.04 days). It was the least on cucumber (2.35 ± 0.23 days). Fifth instar larval duration lasted longer on coccinea (5.40 ± 0.83 days) followed by chow-chow (4.45 ± 1.10 days) and cucumber (4.10 ± 0.43 days). It was the shortest on gherkin (3.55 ± 0.52 days) (Table 20).

Table 20 : Comparative biology of *Diaphania indica* when reared on different cucurbitaceous fruits

Host plants	Larva							Pupa			Sex ratio (M : F)
	Larval Instars					Total larval duration	Larval survival (%)	Pupal duration (days)	% Pupation	% Moth Emergence	
	I	II	III	IV	V						
Gherkin	3.30± 0.0	2.52± 0.02	3.50± 0.07	2.50± 0.04	3.55± 0.52	15.37[a]	90	11.25	90	88.9	1 : 1
Cucumber	3.30± 0.0	2.52± 0.02	3.51± 0.05	2.35± 0.23	4.10± 0.43	15.78[ab]	100	11.14	100	87.5	1 : 1
Coccinea	3.30± 0.0	2.52± 0.02	3.50± 0.08	2.60± 0.20	5.40± 0.83	17.32[c]	90	11.33	90	100.0	1 : 0.25
Chow-chow	3.30±0 .0	2.52± 0.02	3.54± 0.06	2.70± 0.33	4.45± 1.10	16.51[b]	90	10.88	90	88.9	1 : 1.33
F-test	-	-	-	-	-	*	-	NS	-	-	-
CD (0.05)	-	-	-	-	-	0.69	-	-	-	-	-
SEM	-	-	-	-	-	0.73	-	-	-	-	-

There was a significant difference in the total larval duration on fruits of different hosts. The total larval duration was significantly the shortest on gherkin (15.37 days) followed by cucumber (15.78 days) and chow-chow (16.51 days). It was significantly the highest on coccinea (17.32 days). All the larvae survived on cucumber (100%) whereas it was 90% on other hosts.

4.6.2.2.2. Pupa

There was no significant difference in the pupal duration on different hosts. A 10% pupal mortality was observed on gherkin, coccinea and chow-chow (Table 20). The moth emergence was 100% on coccinea followed by gherkin and chow-chow (88.9%). It was however, the least on cucumber (87.50%).

4.6.2.2.3. Adult sex ratio

Male to female ratio was 1 : 1 on both gherkin and cucumber. The ratio was male biased on coccinea (1 : 0.25) whereas it was female biased on chow-chow (1 : 1.33).

4.6.3. Field biology of *D. indica*

4.6.3.1. Eggs

In the field the eggs were located with difficulty on under surface of leaves, within buds and occasionally on flowers. They were small and could be located only with the help of 10 X lens. Their colour was very similar to the host plant colour except for light yellowish tinge in them. They could also be visible when they were viewed against the sunlight because of their glistening surface.

4.6.3.2. Larvae

The larvae were found on under surface of the leaves and were concealed under silken webbing. Early instar larvae (I and II instars) with persistent disturbance dropped from the plant and hung down with a thin silken thread. Most of the times they were observed scraping and feeding on the soft tissues like buds and young leaves. Occasionally they were also seen scraping flowers. The number of larvae on young leaves or buds was dependent on the number of eggs laid by the female on that leaf. Wherever more number of eggs were laid, the first instar larvae showed a gregarious nature. Second instar larvae were capable of cutting leaves into tiny bits and devoured. They also produced thin silk at the point of feeding. They scraped the fruit surface which lead to warty appearance of the fruits.

Later instar (III and IV) larvae were found concealed in leaf folds and completely devoured small young leaves, but on older leaves, they scraped and fed on the under surface leaving the midrib and major veins. The affected leaves were skelitanized. The larvae were capable of folding and webbing single leaf and two adjacent leaves firmly.

The larvae attacked fruits of all sizes and grades. They bored the fruit and consumed part of it depending on the size of the fruit. When the fruit was small (2.5-7.5 cm long), they entered inside the fruit and fed on the entire internal contents making the fruit hollow. Some times, the larvae made just small holes on the fruits at either ends (both at place where stalk is attached as well as at the point of attachment of corolla) or at the center. The holes made were very difficult to locate when at the ends. They did not produce any sort of

webbing when they were completely inside the fruits. However, thin to thick webbing of the fruits with adjacent leaves could be seen.

While feeding on flowers, some larvae produced webbing and remained inside the web and devoured the flowers.

The colour of larvae changed depending on the part of the vine they attacked. The larvae appeared dark green while feeding on leaves but turned pale green or yellow depending on whether they fed on fruits or flowers, respectively. However, the longitudinal bands remained whitish irrespective of the part of the vine.

Excreta could be seen on the leaf and other surfaces just below the site of larval feeding. The faeces were small round and were dark green when excreted afresh by the larvae feeding on leaves and upon drying, they turned dark brown which became dry and fragile. The larvae excreted whitish green round pebble like excreta while feeding on fruits and yellow coloured faeces were excreted when fed on flowers.

Fifth and final instar larvae towards the end stopped feeding and explored places for hiding. Generally, they folded the leaves into a tunnel shape and produced silk all around their body. Slowly, the intersegmental regions bulged.

4.6.3.3 Pupa

Initially, the pupa was dark green in colour with distinct wing pads and the pupae were obtect. They were within the silk web when found on leaves, in-between leaves and fruits, cracks and crevices of the stakes. When they were within the fruits they did not produced any silk. Most of the times, pupae were observed within the leaf folds. Pupae turned dark brown as the age

progressed. When disturbed they rotated their abdominal tips. Distinct black bands appeared on the wing pads which indicated the final day of the pupal period.

4.6.3.4 Adults

The adults were found active during dawn and during day they were very sensitive to disturbance. While spraying of insecticides, many adults were seen flying. They were sitting on the under surface of the leaves rotating their abdomen keeping their tuft of hairs open. During dawn, adults were seen flying in the field. However, they did not fly to longer distance. When disturbed, they flew for a short distance not exceeding two meters and settled.

4.6. Preference of *D. indica* on two varieties of gherkin

The results of simple t-test on population of *D. indica* on two varieties of gherkin (Calypso and Nun) showed no significant difference. The mean number of larvae/ 0.5 m2 were 1.88 1.69 and 2.18 1.96 on calypso and nun varieties, respectively.

4.8 **Susceptible stage of the crop at which *D. indica* is serious at one locality**

The results showed significant difference in the incidence of the larvae and the age of the crop (Table 21 a & b) (Fig 12). The incidence increased as the age progressed in both the localities. However, the larval population was on par on crops aged 15 and 30, 30 and 45, 45 and 60 days old crop. The incidence was significantly higher in 60 days old crop (x = 0.7292) followed by 45 days (x = 0.72), 30 days (x = 0.7120) and 15 days (x = 0.7032) in first locality.

Table 21 : Incidence of *Diaphania indica* at different ages of gherkin in various plots

a. Location - Byadagi

Plots in the location	Age of the crop (Days)	Mean number of larvae/ 0.5 m^2	
A	60	18.34	$(0.7336)^{c}$
B	50	18.16	$(0.7264)^{bc}$
C	40	18.02	$(0.7208)^{ab}$
D	35	17.78	$(0.7112)^{a}$
E	20	17.76	$(0.7104)^{a}$

b. Location - Nidumakanapalli

Plots in the location	Age of the crop (Days)	Mean number of larvae/ 0.5 m^2	
A	15	17.58	$(0.7032)^{a}$
B	30	17.80	$(0.7120)^{ab}$
C	45	18.00	$(0.7200)^{bc}$
D	60	18.23	$(0.7292)^{c}$

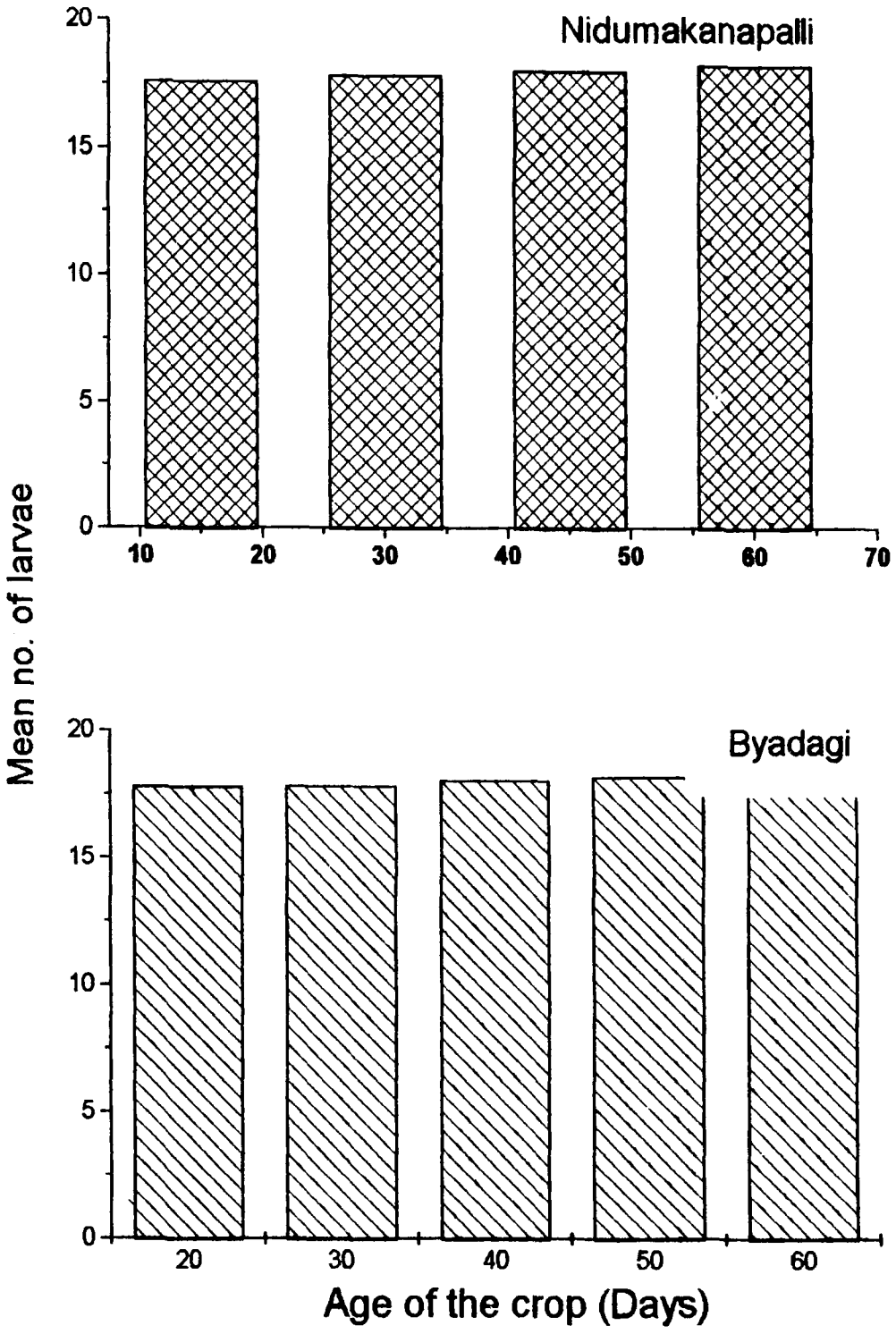

Fig. 12 Incidence of *Diaphania indica* at different age of gherkin

In the second locality, the larval number showed on par on crop aged 20, 35 and 40 days and the crop aged 40 and 50 days, 50 and 60 days. The significance was the highest in 60 days old crop followed by 50, 40, 35 and 25 days old crops with x values of 0.7336, 0.7264, 0.7208, 0.7112 and 0.7104, respectively.

4.9 **Gherkin fruit portion preferred by *D. indica***

Both chi^2 test and one way ANOVA results showed no significant difference between the preference by the larvae on the portion or part of the fruits preferred (Table 22).

4.10. **Per cent fruit damage due to *D. indica*** :

There was a significant difference in the per cent damage in the treatments which received insecticides. Further, a significant difference existed in the per cent fruit damage between before spray and days after spray. However, the interaction between the insecticides spray and per cent damage over days was non-significant (Table 23 and Fig. 13).

The per cent fruit damage was very less in the plots treated with carbaryl (3.37 %) followed by dichlorovos (5.50 %) and NSKE (15.37 %). However, the plots treated with *B. thuringiensis*, HSKE and untreated check showed increase in per cent fruit damage.

Over the days, the per cent fruit damage was very high on the day before spray (9.88 %) and was reduced after six, nine and 12 days after spray with per cent damages of 6.38 %, 7.36 % and 8.65 % respectively which were on par with each other. There was a highly

Table 22 : Preference of *Diaphania indica* larvae at different regions of the fruit

Regions Preferred	Mean No. of fruits
Bottom	43.92
Middle	21.89
Top	34.08
F- test	Non-Significant

Table 23: Per cent fruit damage caused by *Diaphania Indica* at Hedeginabele during Jul.96

Sl. No.	Treatments	B.S.	3 DAS	6 DAS	9DAS	12DAS	Total
1.	Dichlorovos	7.34 (12.83)	2.81 (9.36)	4.56 (12.06)	7.39 (15.53)	5.39 (12.83)	5.50 (13.01)b
2.	*B. thuringiensis*	7.84 (15.90)	8.04 (16.28)	7.29 (15.52)	9.58 (17.54)	8.70 (16.79)	8.29 (16.41)cd
3.	Carbaryl	4.12 (11.25)	0.62 (3.14)	4.31 (11.35)	6.24 (14.44)	1.59 (6.13)	3.37 (9.26)a
4.	NSKE	12.36 (20.27)	5.33 (12.12)	6.08 (14.01)	6.91 (15.02)	9.12 (15.40)	7.96 (15.37)c
5.	HSKE	14.26 (23.74)	5.22 (12.71)	7.82 (15.88)	7.92 (16.04)	15.33 (22.81)	10.11 (18.24)d
6.	Control	13.36 (21.07)	5.12 (12.86)	8.22 (16.16)	6.08 (13.08)	11.80 (19.47)	8.92 (16.53)cd
	Total (x)	9.88 (17.92)c	4.53 (11.08)a	6.38 (14.16) b	7.36 (15.27) b	8.65 (15.57) b	7.36 (14.08)

	F-Test	SEM ±	CD
Treatments	*	0.95	1.88
Days	*	0.87	1.72
Interaction	NS	-	-

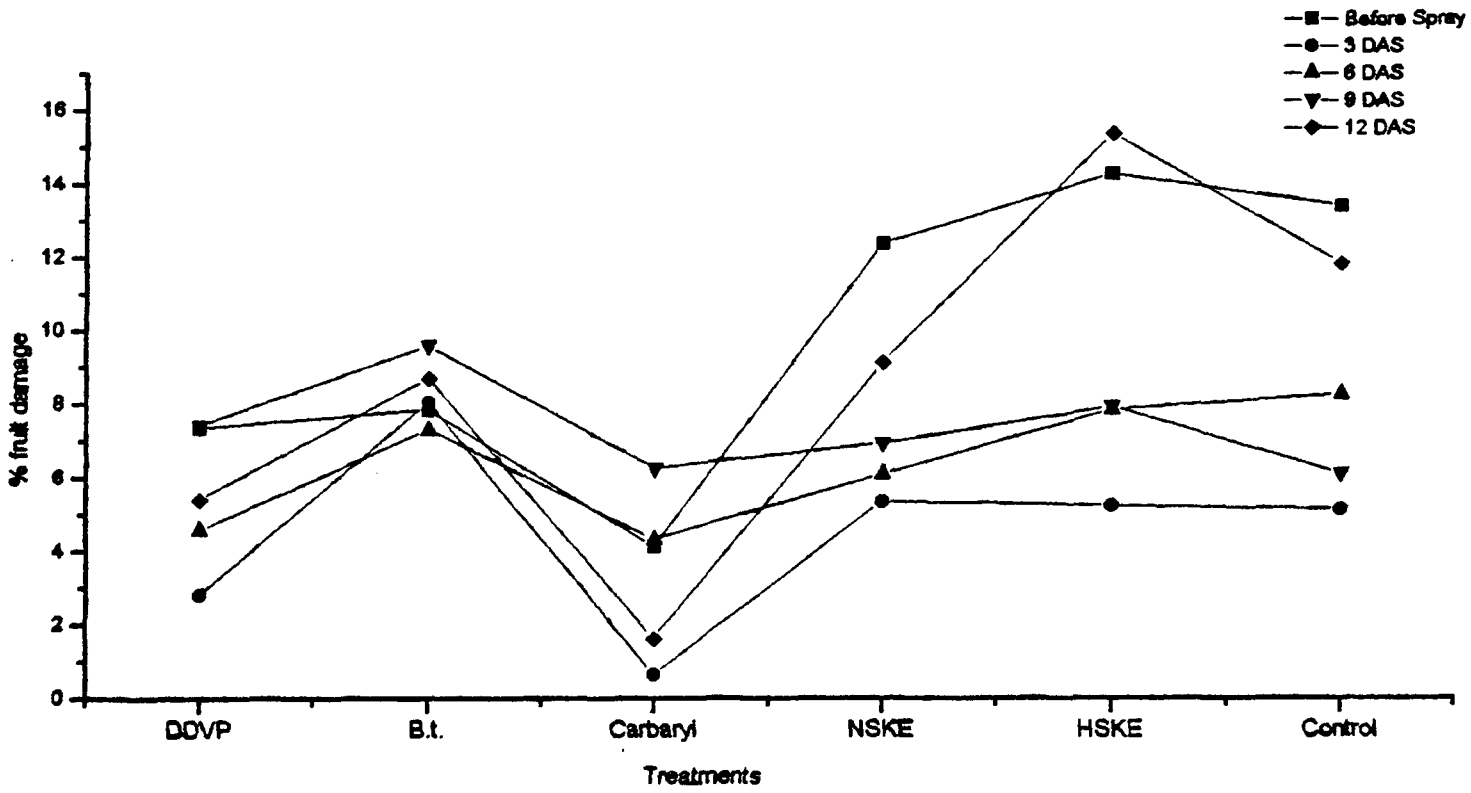

Fig 13 Per cent gherkin fruit damage caused by *Diaphania indica* at Hedeginabele

significant reduction in the per cent fruit damage on third day after the spray (4.53 %).

The results clearly showed a significant difference in the per cent fruit damage in the plots treated with different insecticides and daily fruit damage (Table 24 and Fig. 14).

The per cent fruit damage was very less in carbaryl and methomyl treated plots (1.43 % and 1.50 %) and were on par with each other. They were followed by dichlorovos (2.31 %) and *Bacillus thuringiensis* (2.28 %) which showed an on par significance. Phosalone was not very effective in reducing the per cent fruit damage (1.96 %). The per cent fruit damage was significantly higher in bioneem treatment and in untreated check where the per cent damages were 3.85 % and 4.58 % respectively which again were on par with each other.

The per cent damage done to the fruits was significantly high on the day before and a day after first spray of insecticides with 3.42 % and 3.33 % fruit damage respectively. The damage was less on three and five days after spray with 1.75 % and 1.79 % fruit damage respectively followed by 2.00 % on two days after spray. The per cent fruit damage was slightly high on the day before second spray (2.58 %). The fruit damage was 3.05 % on the day after second spray. However, the interaction between the days after spray and the per cent fruit damage was found insignificant.

4.11 **Management of pests of gherkin** :

4.11.1 **Experiment 1**

During this period, there was no incidence of *D. indica.* However, results are presented for *L. trifolii* and aphids which were prevalent.

Table 24 : Percent fruit damage caused by *Diaphania. Indica* at Mundwad during Jan.97

Days/ Insecticides	B.S.	1 DAS	2 DAS	3 DAS	5 DAS	6 DAS II S	1 DA II S	$\bar{X}$
Dichlorovos	1.64	3.15	2.98	2.66	1.23	1.95	2.56	2.31
	(9.02)	(9.75)	(9.39)	(7.27)	(5.11)	(7.81)	(9.02)	**(8.19)bc**
B. turingiensis	2.02	1.92	1.45	1.51	2.60	3.53	2.95	2.28
	(7.77)	(6.39))	(6.38)	(5.69)	(8.74)	(10.58)	(9.57)	**(7.94)c**
Carbaryl	3.53	3.74	0.85	0.86	0.00	0.36	0.66	1.43
	(10.77)	(10.82)	(4.13)	(4.20)	(0.00)	(1.91)	(3.74)	**(5.08)a**
Methomyl	3.56	3.55	1.23	0.57	0.37	0.67	0.56	1.50
	(10.22)	(10.78)	(6.12)	(3.46)	(2.00)	(3.75)	(2.42)	**(5.53)a**
Phosalone	3.34	2.48	1.39	2.27	0.79	1.88	1.56	1.96
	(10.39)	(8.76)	(5.16)	(6.07)	(2.90)	(6.33)	(5.78)	**(6.49)b**
Bioneem	6.05	4.99	2.81	1.83	3.95	4.66	2.65	3.85
	(14.00)	(12.76)	(7.43)	(6.26)	(11.23)	(12.17)	(7.61)	**(10.21)d**
Control	3.80	3.46	3.32	2.54	3.57	4.99	10.42	4.58
	(10.89)	(10.67)	(10.07)	(7.25)	(10.22)	(12.05)	(18.70)	**(11.21)e**
Total	3.42	3.33	2.00	1.75	1.79	2.58	3.05	
	(10.44)d	**(9.99)d**	**(7.02)b**	**(5.74)a**	**(5.74)a**	**(7.80)bc**	**(8.12)c**	

F-test- Significant
Figures in the paranthesis are Arc √Sine transformed values
Interaction- Non-significant

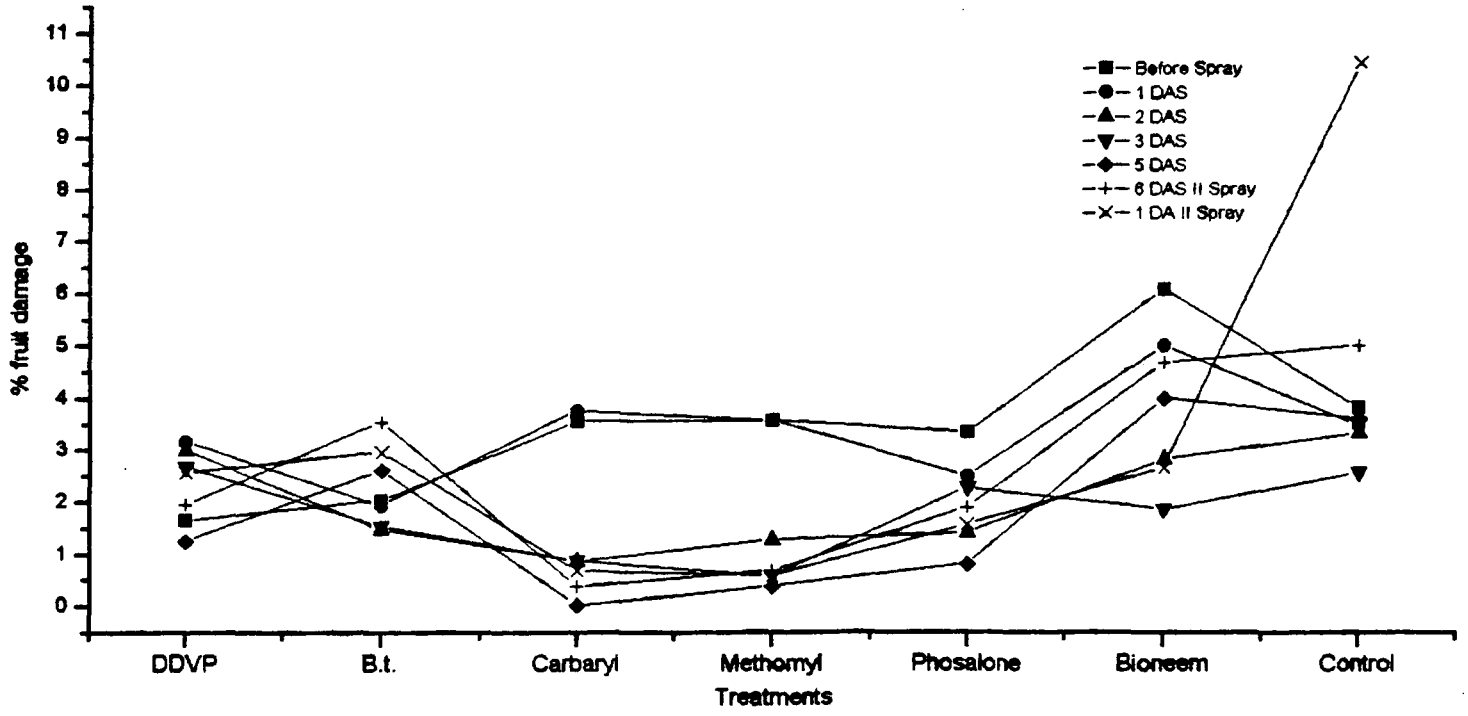

Fig. 14 Per cent gherkin fruit damage caused by *Diaphania indica* at Mundwad

a) *Aphis gossypii*

None of the treatments significantly affected aphid population till the third spray (Table 25 and Fig. 15). Seven days after third spray, there was significant difference in the population of aphids in various treatments. Dichlorovas (0.03), carbaryl (0.16), nimbicidine (0.03) and phosalone (0.00) were on par with each other and superior to control III (0.53).

A day after the fourth spray dichlorovas (0.26), carbaryl (0.20), deltamethrin (0.06), nimbicidine (0.38), phosalone (0.00), Control I(0.43), control II (0.23) and control III (0.43) were on par with each other. Control I(0.43), NSKE (1.03) and control III (0.43) were on par with each other.

Seven days after the fourth spray phosalone (0.00) had the least number of aphids. However, it was on par with deltamethrin (0.16), carbaryl (0.06) and dichlorovas (0.06) as far as the aphid population was concerned. These treatments were superior to control III (0.76). A day after fifth spray, phosalone (0.16) recorded significantly the lowest population of aphids. Carbaryl (0.50), dichlorovas (0.80) and deltamethrin (0.73) were the treatments of second order in suppressing the aphid population and were on par. HSKE (2.03) had the highest number of aphids among all the treatments followed by Control I(1.50).

b) *Liriomyza trifolli*

There was no significant difference among the treatments before the first, second and third sprays and after the first spray (Table 26 and Fig. 16).

After the third spray, deltamethrin (3.66) showed significantly the lowest number of adults emerging from the trated leaf. This was

Table 25 : Evaluation of selected insecticides and plant products against the population of aphids, *Aphis gossypii* during Feb. 1996

Sl No.	Treatments	I Spray		II Spray		III Spray		IV Spray		V Spray	
		BS	AS	BS	AS	BS	AS	BS	AS	BS	AS
1	Dichlorovos 0.07 %	0.00 (0.70)	0.06 (0.75)	0.03 (0.72)	0.06 (0.75)	0.00 (0.70)	0.67 (0.75)	0.03 (0.72)a	0.26 (0.87)a	0.06 (0.75)^{ab}	0.80 (1.13)b
2	Carbaryl 0.1 %	0.00 (0.70)	0.03 (0.72)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.06 (0.75)	0.16 (0.81)^{ab}	0.20 (0.83)a	0.06 (0.75)^{ab}	0.50 (0.99)b
3	HSKE 4 %	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.13 (0.78)	0.23 (0.84)	0.5 (0.99)c	0.90 (1.17)b	1.53 (1.40)d	2.03 (1.59)f
4	Deltamethrin 0.01 %	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.03 (0.72)	0.06 (0.75)a	0.06 (0.75)a	0.16 (0.81)^{ab}	0.73 (1.10)bc
5	NSKE 4 %	0.00 (0.70)	0.23 (0.85)	0.06 (0.75)	0.00 (0.70)	0.00 (0.70)	0.20 (0.83)	0.30 (0.89)bc	1.03 (1.20)c	1.01 (1.20)cd	1.13 (1.25)cde
6	Nimbicidine 0.04 %	0.00 (0.70)	0.03 (0.72)	0.00 (0.70)	0.00 (0.70)	0.03 (0.72)	0.03 (0.72)	0.03 (0.72)a	0.38 (0.92)^{ab}	0.46 (0.97)bc	1.03 (1.23)cd
7	Phosalone 0.05 %	0.00 (0.70)	0.00 (0.70)	0.06 (0.75)	0.00 (0.70)	0.03 (0.72)	0.06 (0.75)	0.00 (0.70)a	0.00 (0.70)a	0.00 (0.70)a	0.16 (0.81)a
8	Control I	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.33 (0.91)	0.33 (0.92)c	0.43 (0.94)^{ab}c	0.80 (1.12)c	1.50 (1.41)ef
9	Control II	0.00 (0.70)	0.16 (0.80)	0.06 (0.75)	0.00 (0.70)	0.00 (0.70)	0.20 (0.83)	0.36 (0.93)bc	0.23 (0.84)a	0.50 (0.99)bc	1.33 (0.35)de
10	Control III	0.00 (0.70)	0.00 (0.70)	0.10 (0.76)	0.67 (0.75)	0.67 (0.75)	0.30 (0.88)	0.53 (0.99)c	0.43 (0.94)^{ab}c	0.76 (1.12)c	1.33 (1.34)de
	F-test	NS	NS	NS	NS	NS	NS	*	*	*	*
	CD	-	-	-	-	-	-	0.10	0.30	0.38	1.44
	SEM	-	-	-	-	-	-	0.04	0.10	0.11	0.74

BS- Befote Spray AS- After Spray DAS- Days After Spray NS - Non-Significant *-Significant

Figures in the paranthesis are square root($\sqrt{x+0.5}$) transformed values
Means followed by the same letter are within the standardised `t` range

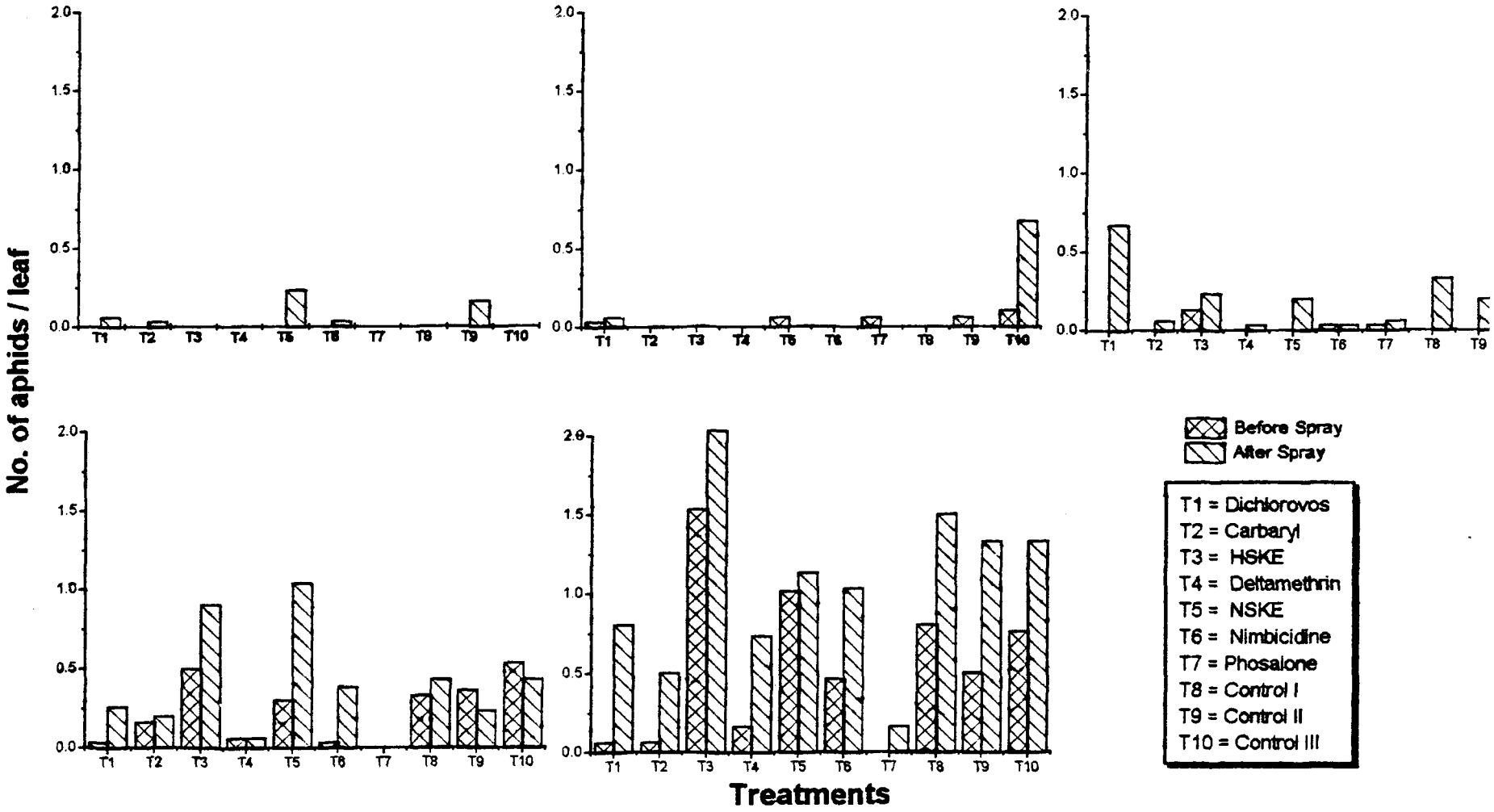

Fig. 15 Evaluation of selected insecticides on *Aphis gossypii* at Hedegonabele during Feb. 1996

Table 26 : Evaluation of selected insecticides and plant product against the population of *Liriomyza trifolii* at Hedeginabele during Feb 1996

Sl No.	Treatments	I Spray		II Spray		III Spray		IV Spray		V Spray		
		BS	AS	BS	AS	BS	AS	BS	AS	BS	AS	5 DAS
		Number of adults emerging / 10 leaves										
1	Dichlorovos 0.07 %	2.00 (1.55)	1.33 (1.34)	7.33 (2.77)	6.66 $(2.67)^{cd}$	8.33 (2.95)	14.33 $(3.75)^{bcd}$	12.66 $(3.52)^{ab}$	14.00 $(3.79)^{bc}$	12.00 $(3.18)^{bcde}$	9.66 $(3.48)^{bcd}$	28.00 $(5.33)^{cd}$
2	Carbaryl 0.1 %	3.66 (2.00)	5.33 (2.21)	4.00 (2.08)	4.66 $(2.25)^{bcd}$	12.66 (3.62)	25.00 $(4.91)^{d}$	29.33 $(5.40)^{f}$	26.00 $(5.17)^{e}$	12.66 $(3.41)^{bcde}$f	11.66 $(3.62)^{bcde}$	24.00 (4.86)
3	HSKE 4 %	2.00 (1.55)	3.33 (1.88)	3.33 (1.90)	4.66 $(2.24)^{bcd}$	13.00 (3.64)	21.33 $(4.64)^{cd}$	22.00 $(4.72)^{de}$	22.66 $(4.81)^{de}$	21.00 $(3.96)^{fg}$	15.33 $(4.49)^{de}$	36.66 $(6.04)^{d}$
4	Deltamethrin 0.01 %	2.66 (1.26)	1.00 (1.85)	3.66 (2.03)	1.33 $(1.34)^{a}$	6.33 (2.60)	3.66 $(2.00)^{a}$	6.00 (2.50)a	3.33 $(1.93)^{a}$	2.66 $(2.09)^{a}$	4.00 $(1.77)^{a}$	7.66 $(2.78)^{a}$
5	NSKE 4 %	4.33 (2.18)	3.66 (2.00)	4.33 (2.18)	3.33 $(1.90)^{ab}$	12.33 (3.56)	10.66 $(3.33)^{b}$	12.33 $(3.51)^{ab}$	10.33 $(3.28)^{b}$	10.00 $(2.84)^{b}$	7.66 $(3.23)^{b}$	15.00 $(3.90)^{ab}$
6	Nimbicidine 0.04%	1.33 (1.26)	3.00 (1.85)	2.66 (1.94)	4.33 $(2.12)^{bcd}$	9.00 (3.06)	13.00 $(3.64)^{bc}$	17.66 $(4.25)^{bcd}$	20.66 $(4.59)^{de}$	14.00 $(3.69)^{cdef}$	13.33 $(3.77)^{bcde}$	19.66 $(4.49)^{bcd}$
7	Phosalone 0.05 %	2.33 (1.54)	4.66 (2.17)	4.66 (2.21)	5.00 $(2.32)^{bcd}$	7.66 (2.83)	15.66 $(3.91)^{bcd}$	14.66 $(3.89)^{abc}$	17.00 $(4.12)^{cd}$	11.00 $(3.07)^{bcd}$	9.00 $(3.38)^{bc}$	17.33 $(4.17)^{bc}$
8	Control I	2.66 (1.77)	2.66 (1.71)	6.00 (2.52)	6.33 $(2.59)^{bcd}$	17.66 (4.16)	18.00 $(4.27)^{bcd}$	22.66 $(4.78)^{de}$	23.67 $(4.88)^{e}$	10.66 $(2.97)^{bc}$	8.33 $(3.34)^{bc}$	30.66 $(5.51)^{d}$
9	Control II	0.66 (1.05)	4.00 (1.88)	4.00 (2.08)	3.66 $(2.01)^{abc}$	12.33 (3.46)	23.00 $(4.84)^{cd}$	22.33 $(4.69)^{bcde}$	24.33 $(4.96)^{e}$	14.33 $(3.42)^{bcdef}$	11.33 $(3.84)^{bcde}$	34.00 $(5.81)^{d}$
10	Control III	2.00 (1.52)	2.66 (1.76)	7.33 (2.75)	7.33 $(2.79)^{d}$	18.00 (4.29)	21.33 $(4.63)^{cd}$	22.33 $(4.85)^{de}$	22.66 $(4.81)^{de}$	21.33 $(4.22)^{g}$	17.33 $(4.62)^{e}$	35.00 $(5.90)^{d}$
	F-test	NS	NS	NS	*	NS	*	*	*	*	*	*
	CD	-	-	-	0.75	-	1.22	1.10	0.71	1.03	1.03	1.13
	SEM	-	-	-	0.25	-	0.41	0.37	0.23	0.34	0.34	0.38

BS- Befote Spray AS- After Spray DAS- Days After Spray NS - Non-Significant *-Significant

Figures in the paranthesis are square root($\sqrt{x+0.5}$) transformed values

Means followed by the same letter are within the standardised 't' range

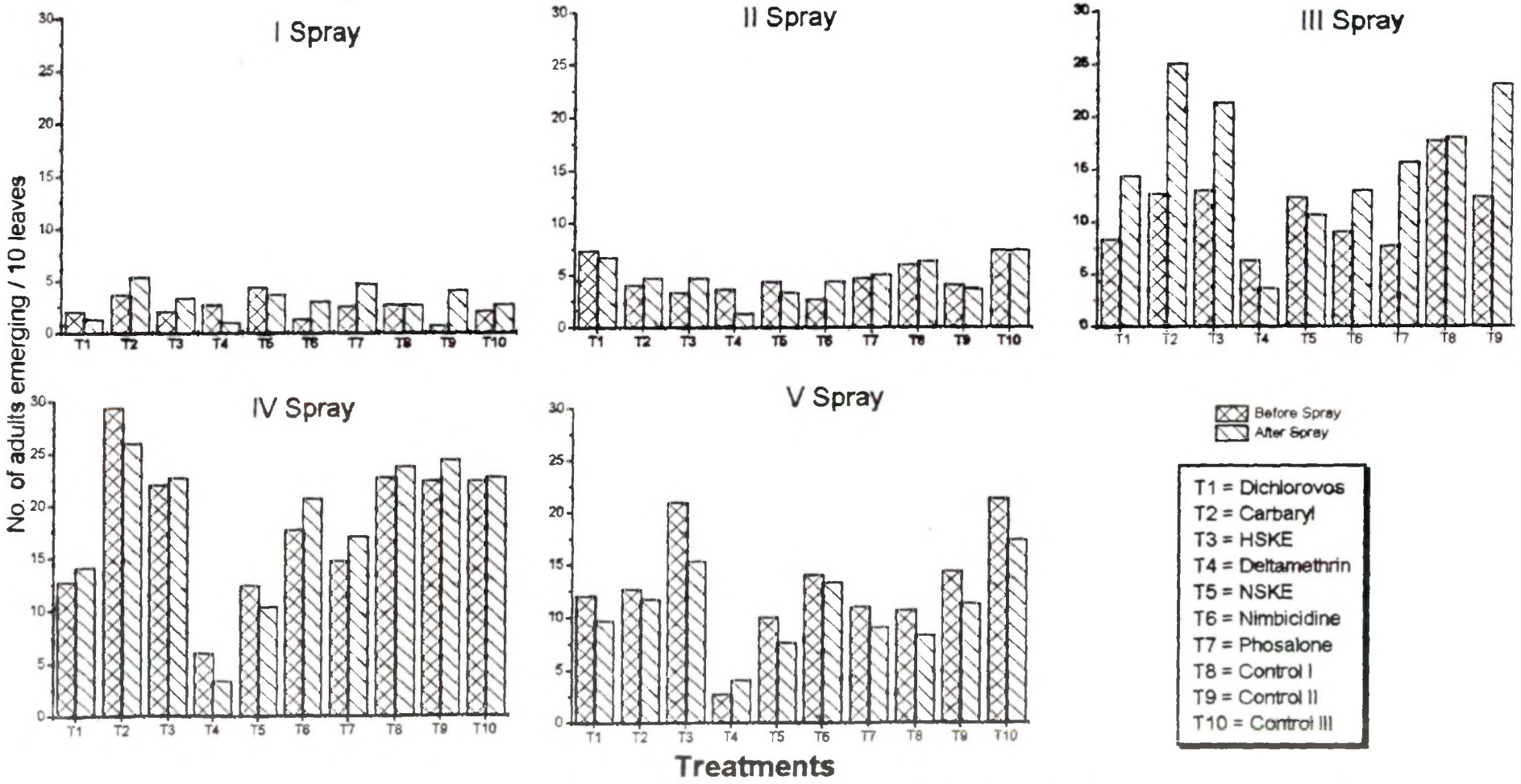

Fig. 16 Evaluation of selected insecticides on *Liriomyza trifolii* at Hedeginabele during Feb. 1996

followed by NSKE (10.66 adults emerging/ 10 leaves). The highest number of adults emerging from leaves treated with carbaryl(25.00) which was on par with untreated control III (21.33). A day before the fourth spray deltamethrin (6.00) maintained its superiority. However, it was on par with NSKE (12.33), dichlorovas (12.66) and phosalone (14.66). Carbaryl (29.33) continued to be the least effective chemical and had significantly higher population of adults emerging compared to the control III (22.33).

A day after the fourth spray, deltamethrin (3.33) maintained its superiority followed by NSKE and dichlorovas (14.00). Carbaryl (26.00) on the other hand was on par with control I(23.67) , control II (24.33) , control III (22.66), nimbicidine (20.66) and HSKE (22.66). A day before the fifth spray, a similar trend was observed except that HSKE (21.00) and control III (21.33) were on par which recorded the highest number of adults emerging per leaf.

A day after the fifth spray, deltamethrin (4.00) was significantly superior to other tratments. Control III (17.33) had the highest number of adults emerging per leaf followed by HSKE (15.33). The treatments phosalone (9.00), Control I(8.33) and dichlorovas (9.66) were significantly superior to control III (17.33) in reducing the number of adults emerging per leaf.

On fifth day after the fifth spray, deltamethrin (7.66) and NSKE (15.00) recorded significantly the least number of adults emerging from treated leaf. NSKE (15.00), carbaryl (24.00), nimbicidine (19.66), phosalone (17.33) were on par with each other. HSKE (36.66) was on par with control III (35.00).

4.11.2 **Experiment 2**

a) *Liriomyza trifolii*

Before the imposition of treatments the leafminer population was more or less uniform (Table 27 and Fig. 17). A day after the imposition of treatment the least number of adult emerged from the leaves treated with deltamethrin (3.00) followed by hostathion (4.00) and alternating sprays of deltamethrin and carbaryl (3.66). Methomyl (10.66), phosalone (10.33) and jaggery (10.66) were on par with control II(12.00). However, these differences were only ephemeral and seven days after the spray, there was no significant differences among the various treatments. A day after second spray, deltamethrin (8.00) and hostathion (9.66) were superior to other treatments in significantly suppressing the leafminer population. They were closely followed by dichlorovas (15.66). All other treatments except control I(26.33) and jaggery (23.66) which were on par with each other and were superior to control II (29.33) in suppressing the population of leafminer. Seven days after the second spray (before third spray), deltamethrin (20.33) maintained its superiority and was significantly superior over hostathion (30.33). Methomyl (38.66), phosalone (43.66), jaggery (42.66) and dichlorovas (38.00) were on par with each other but superior to control II (49.00). Surprisingly, in the treatment alternating deltamethrin with carbaryl (46.00), the population was on par with that in control II (49.00).

Seven days after the third spray, deltamethrin (36.33) remained significantly the superior treatment followed by hostathion (36.33). Dichlorovas (72.33), carbaryl (70.33) and methomyl (65.00) were on par and inferior to hostathion (36.33). control I(96.00) had the highest population of leafminers which was on par with control II (79.00). However, this trend did not last long and the population in all the treatments seven days after the spray was not significantly different.

Table 27 : Evaluation of selected insecticides and plant products against leaf miner, *Liriomyza trifolii*, population at Hedeginabele during July 1996

Sl No.	Treatments	I Spray		II Spray		III Spray		IV Spray		
		(No. of adults emerging per 10 leaves)								
		BS	AS	BS	AS	BS	AS	BS	AS	7 AS
1	Dichlorovos	9.33	6.33	17.66	15.66	38.00	31.33	72.33	74.00	78.00
	0.07%	(3.06)	$(2.59)^{c}$	(4.21)	$(4.12)^{b}$	$(6.19)^{cd}$	$(5.62)^{c}$	(8.26)	$(8.59)^{c}$	$(8.83)^{c}$
2	Carbaryl	12.33	6.33	24.33	18.66	36.00	27.66	70.33	73.66	88.00
	0.1 %	(3.53)	$(2.84)^{cd}$	(4.93)	$4.37)^{bc}$	$(6.00)^{bc}$	$(5.42)^{c}$	(8.09)	$(8.58)^{c}$	$(9.36)^{d}$
3	Methomyl	14.33	10.66	26.00	19.00	38.66	29.33	65.00	79.66	88.00
	0.05 %	(3.81)	$(3.33)^{f}$	(5.03)	$(4.54)^{c}$	$(6.21)^{d}$	$(5.44)^{c}$	(7.98)	$(8.92)^{c}$	$(9.37)^{d}$
4	Phosalone	14.66	10.33	22.33	19.66	43.66	36.33	84.33	92.00	72.66
	0.05%	(3.87)	$(3.27)^{ef}$	(4.81)	$(4.47)^{c}$	$(6.62)^{d}$	$(6.03)^{d}$	(8.85)	$(9.58)^{d}$	$(8.49)^{c}$
5	Deltamethrin	7.66	3.00	17.00	8.00	20.33	12.66	36.33	16.33	12.66
	0.01%	(2.81)	$(1.72)^{a}$	(4.17)	$(2.90)^{a}$	$(4.55)^{a}$	$(3.61)^{a}$	(5.83)	$(3.77)^{a}$	$(3.62)^{a}$
6	Hostothion	8.66	4.00	16.00	9.66	30.33	22.00	36.33	14.66	15.66
	0.05%	(3.02)	$(2.12)^{b}$	(4.05)	$(3.15)^{a}$	$(5.54)^{b}$	$(4.71)^{b}$	(5.83)	$(3.87)^{a}$	$(3.98)^{a}$
7	D-C-D	10.33	3.66	20.33	23.0	46.00	36.00	49.33	56.33	47.33
		(3.26)	$(2.02)^{b}$	(4.55)	$(4.84)^{d}$	$(6.76)^{e}$	$(6.02)^{d}$	(7.04)	$(7.47)^{b}$	$(6.88)^{b}$
8	Jaggery	12.66	10.66	25.66	23.66	42.66	42.66	78.33	101.00	140.66
	0.5g/l	(3.53)	$(3.33)^{f}$	(5.08)	$(4.88)^{de}$	$(6.52)^{d}$	$(6.53)^{e}$	(8.81)	$(10.04)^{de}$	$(11.84)^{e}$
9	Control I	9.33	8.66	21.66	26.33	45.66	50.00	96.00	121.33	122.33
		(3.06)	$(2.99)^{de}$	(4.66)	$(5.14)^{e}$	$(6.78)^{e}$	$(7.08)^{f}$	(9.77)	$(11.02)^{f}$	$(11.07)^{e}$
10	Control II	9.66	12.00	22.00	29.33	49.00	47.33	79.00	103.00	142.66
		(3.17)	$(3.50)^{f}$	(4.72)	$(5.44)^{e}$	$(7.01)^{e}$	$(6.90)^{e}$	(8.83)	$(10.16)^{e}$	$(11.95)^{e}$
	F-test	NS	*	NS	*	*	*	NS	*	*
	CD		0.28		0.29	0.43	0.37		0.54	0.55
	SEM±		0.13		0.13	0.20	0.17		0.26	0.26

BS- Before Spray AS- After Spray DAS- Days After Spray NS - Non-Significant *-Significant

Figures in the paranthesis are square root($\sqrt{x}$+o.5) transformed values

Means followed by the same letter are within the standardised 't' range

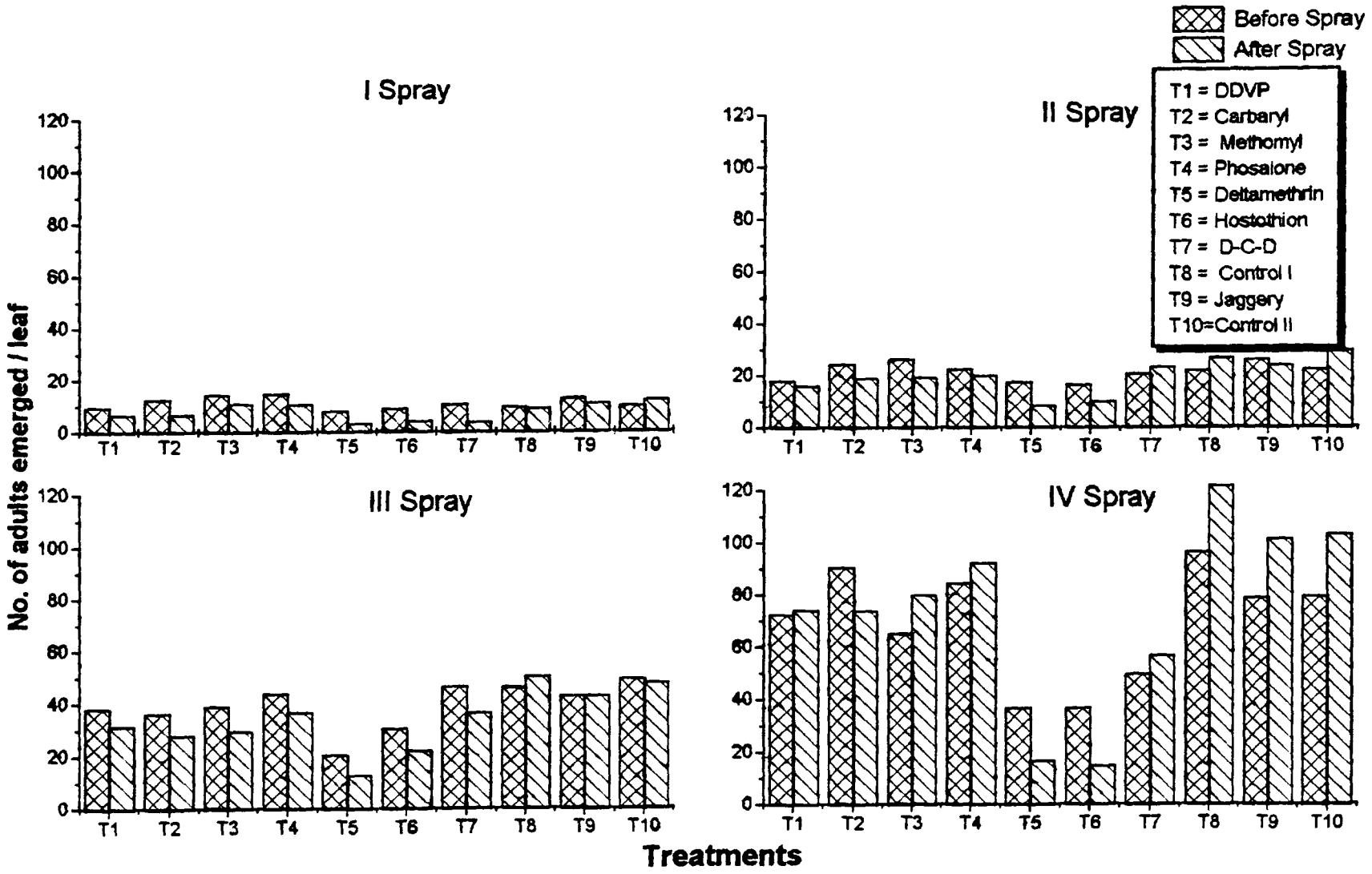

Fig. 17 Evaluation of selected insecticides on *Liriomyza trifolii* at Hedeginbele during July 1996

The population in all the treatments increased two to three folds [this was because of heavy rain received on second day after the spray].

A day after the fourth spray, both deltamethrin (16.33) and hostathion (14.66) significantly suppressed the population recording the least number of flies emerging. These were followed by treatment alternating deltamethrin and carbaryl (56.33). Carbaryl (73.66), methomyl (79.66) and dichlorovas (74.00) were on par with each other and superior to control II (103.00). Phosalone (92.00) was the least effective among the insecticides. Seven days after the fourth spray, deltamethrin (12.66) and hostathion (15.66) maintained their superiority closely followed by alternating treatments with deltamethrin and carbaryl (47.33). Dichlorovas (78.00) and phosalone (72.66) were on par with each other but superior to methomyl (88.00) and carbaryl (88.00) which were inturn superior to control II (142.66) in suppressing the leafminer population.

b) *Diaphania indica*

The population of *D. indica* started appearing during the second spray and seven days after second spray (Table 28 and Fig. 18). The highest population of 4.33 larvae /0.5 m^2 was observed in the plot treated with jaggery which was on par with control. All the treatments significantly reduced the population compared to the control. Carbaryl (0.00), methomyl (0.33), phosalone (0.33) and triazophos (0.33) were on par with each other in suppressing the *D. indica* population followed by dipel (0.66) which was on par with methomyl (0.33) and triazophos (0.33). Dichlorovas (2.00), deltamethrin (1.66) and treatment alternating with deltamethrin and carbaryl (1.33) were on par with each other. A day after third spray, all the treatments were significantly superior to treatment with jaggery (3.66) and control(4.00). Among the treatments carbaryl (0.33), methomyl (0.00),

Table 28 : Evaluation of selected insecticides and plant products against *Diaphania indica* population at Hedeginabele during July 1996

Sl No.	Treatments	I Spray		II Spray		III Spray		IV Spray		V Spray	
		(No. of larvae/0.5m^2)									
		BS	**AS**	**BS**	**AS**	**BS**	**AS**	**BS**	**AS**	**BS**	**AS**
1	Dichlorovos	0.00	0.00	1.00	0.33	2.00	2.00	3.00	1.66	2.66	1.33
	0.07 %	(0.70)	(0.70)	(1.09)	(0.87)	(1.55)^{c}	(1.46)^{cd}	(1.85)de	(1.78)bc	(1.77)^{de}	(1.34)^{c}
2	Dipel	0.00	0.00	0.00	0.00	0.66	1.33	2.00	1.00	3.00	1.00
	0.02 %	(0.70)	(0.70)	(0.70)	(0.70)	(0.99)^{b}	(1.16)^{b}	(1.48)bc	(1.16)b	(1.82)^{e}	(1.16)^{bc}
3	Carbaryl	0.00	0.00	0.33	0.00	0.00	0.33	1.33	0.33	1.00	0.00
	0.1%	(0.70)	(0.70)	(0.87)	(0.70)	(0.70)^{a}	(0.87)^{a}	(1.26)^{ab}	(0.87)a	(1.16)^{ab}	(0.70)^{a}
4	Methomyl	0.00	0.00	0.00	0.00	0.33	0.00	1.00	0.00	0.66	0.00
	0.05 %	(0.70)	(0.70)	(0.70)	(0.70)	(0.87)^{ab}	(0.70)^{a}	(1.16)^{a}	(0.70)^{a}	(1.04)^{a}	(0.70)^{a}
5	Phosalone	0.00	0.00	0.00	0.00	0.33	0.33	1.00	0.33	2.00	0.66
	0.05%	(0.70)	(0.70)	(0.70)	(0.70)	(0.87)^{a}	(0.87)^{a}	(1.16)^{a}	(0.87)^{a}	(1.55)^{cd}	(1.04)^{b}
6	Deltamethrin	0.00	0.00	0.00	0.33	1.66	2.66	3.33	2.33	4.33	5.33
	0.01%	(0.70)	(0.70)	(0.70)	(0.87)	(1.43)^{c}	(1.67)^{de}	(1.94)^{ef}	(1.67)^{cd}	(2.19)^{f}	(2.39)^{e}
7	Hostothion	0.00	0.00	0.00	0.33	0.33	0.33	2.33	3.00	5.33	5.00
	0.05%	(0.70)	(0.70)	(0.70)	(0.87)	(0.87)^{ab}	(0.87)^{a}	(1.67)^{cd}	(1.87)^{d}	(2.38)^{f}	(2.33)^{e}
8	D-C-D	0.00	0.00	0.66	0.00	1.33	3.00	4.33	1.00	1.33	2.00
		(0.70)	(0.70)	(1.04)	(0.70)	(1.34)^{c}	(1.87)^{e}	(2.19)^{f}	(1.16)^{b}	(1.34)^{bc}	(1.55)^{d}
9	Jaggery	0.00	0.00	0.33	2.00	4.33	3.66	5.66	6.00	8.00	7.00
	0.5g/l	(0.70)	(0.70)	(0.87)	(1.46)	(2.02)^{d}	(2.53)^{f}	(2.47)^{g}	(2.55)^{e}	(2.90)^{g}	(2.71)^{f}
10	Control	0.00	0.00	1.33	1.66	3.66	4.00	6.00	7.00	6.66	7.00
		(0.70)	(0.70)	(1.34)	(1.38)	(1.99)^{d}	(2.70)^{f}	(2.53)^{g}	(2.71)^{e}	(2.64)^{g}	(2.72)^{f}
	F-test	NS	NS	NS	NS	*	*	*	*	*	*
	CD	-	-	-	-	0.27	0.28	0.25	0.27	0.24	0.23
	SEM±		-	-	-	0.12	0.09	0.12	0.13	0.11	0.08

BS- Befote Spray AS- After Spray DAS- Days After Spray NS - Non-Significant *-Significant

Figures in the paranthesis are square root($\sqrt{x+0.5}$) transformed values

Means followed by the same letter are within the standardised 't' range

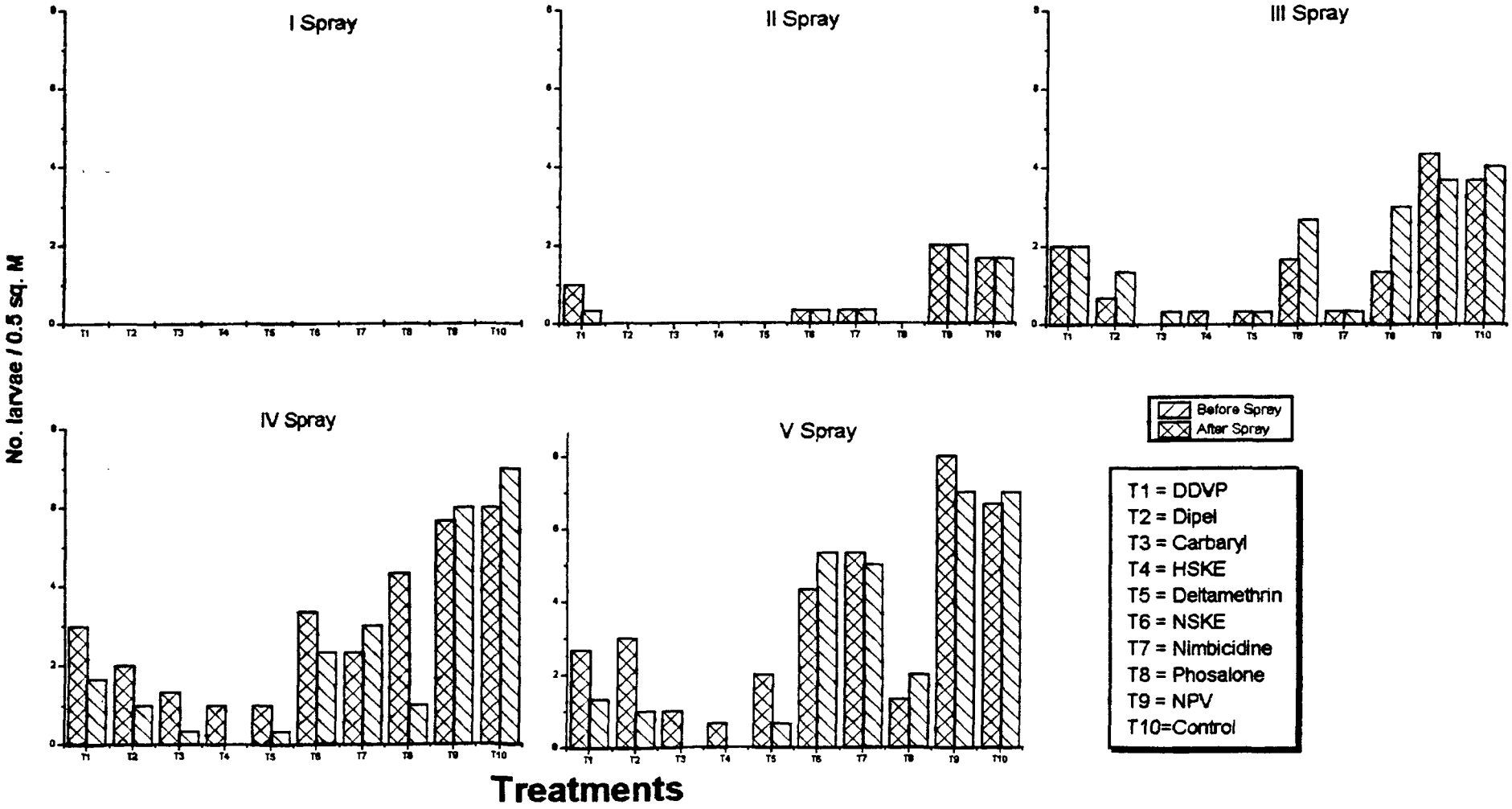

Fig.18 Evaluation of selected insecticides on *Diaphania indica* at Hedeginabele during July 1996.

phosalone (0.33) and triazophos (2.66) were significantly superior to other treatments and on par with each other. They were followed by dipel (1.33). Seven days after third spray, carbaryl (1.33), methomyl (1.00) and phosalone (1.00) maintained their superiority. Carbaryl (1.33) was also on par with dipel (2.00).

A day after the fourth spray, all the treatments were superior to jaggery (6.00) treatment and control (7.00) in suppressing *D. indica* population. Among the treatments, carbaryl (0.33), methomyl (0.00) and phosalone (0.33) gave significantly the highest suppression of the population. They were followed by dipel (1.00), treatment alternating deltamethrin with carbaryl (1.00) and dichlorovas (1.66). Seven days after the fourth spray, there was no significant difference in the treatments methomyl (0.66) and carbaryl (1.00) which recorded the least number of larvae. They were followed by alternating deltamethrin and carbayl (1.33). Phosalone (2.00) was on par with both alternating deltamethrin with carbaryl (1.33) on one hand and dichlorovas (2.66) on the other. Dipel lost its effectiveness and recorded 3.00 larvae /0.5 m2. The least effective among the insecticides at this stage were deltamethrin (4.33) and triazophos (5.33).

A day after the fifth spray, carbaryl (0.00) and methomyl (0.00) maintained their superiority over the other insecticidal treatments. Phosalone (0.66) and dipel (1.00) were the next best insecticides followed by dichlorovas (1.33). Alternating treatment of deltamethrin and carbaryl (2.00) was moderate. However, the least effective treatments were deltamethrin (5.33) and triazophos (5.00) at this stage. There was no significant difference in the population of *D. indica* larvae in treatment with jaggery (7.00) and control (7.00) suggesting that jaggery may not be an attractive material for *D. indica.*

4.11.3 **Experiment 3**

As mentioned in the material and methods, this experiment was taken at two locations and the results are presented for each location separately.

a) Irabanahalli

The *D. indica* population did not significantly differ in the experimental plots before the imposition of the treatments (Table 29 and Fig. 19).

A day after imposition of treatment all the insecticides reduced the larval population significantly compared to control. Among the treatments, carbaryl at 0.1% (0.66) and methomyl at 0.05% (0.00) were significantly superior to other treatments in suppressing the larval population. Methomyl (0.03%) (1.33) was on par with carbaryl (0.1%) (0.66), carbaryl (0.06%) (2.66) and phosalone (2.33). Dipel (5.33) was significantly inferior to methomyl and carbaryl at both the dosages but was on par with dichlorovas (3.33).

Five days after spray, there was considerable change in the effectiveness of different treatments. Carbaryl and methomyl at higher dosages were the superior most (1.33 and 0.66, respectively). Surprisingly, the effectiveness of dipel (2.66) improved considerably and was on par with these treatments and phosalone (4.33). The lower dosages of carbaryl (7.33) and methomyl (5.66) were on par. However, the lower dosage of carbaryl (7.33), dichlorovas (9.00) and control (12.00) were also on par with each other.

Table 29: Evaluation of selected insecticides against *Diaphania indica* at Irabanahalli during Aug. 1996

Sl. No.	Treatments	BS	1 DAS	5 DAS
		(No. of larvae /0.5m^2)		
1	Dichlorovos 0.07%	9.00 (3.07)	3.33 (1.95) ^{de}	9.00 (3.07) ^{de}
2	Dipel 0.02%	7.00 (2.70)	5.33 (2.40) ^{e}	2.66 (1.71) ^{ab}
3	Carbaryl 0.1%	9.00 (3.07)	0.66 (0.99) ^{ab}	1.33 (1.34) ^{a}
4	Methomyl 0.05%	10.66 (3.33)	0.00 (0.70) ^{a}	0.66 (1.05) ^{a}
5	Phosalone 0.05%	5.66 (2.48)	2.33 (1.64) ^{cd}	4.33 (2.18) ^{bc}
6	Carbaryl 0.06%	5.66 (2.41)	2.66 (1.77) ^{cd}	7.33 (2.78) ^{cde}
7	Methomyl 0.03%	7.66 (2.78)	1.33 (1.44) ^{bc}	5.66 (2.34) ^{bcd}
8	Control	9.66 (3.12)	10.66 (3.19) ^{f}	12.00 (3.50) ^{e}
	F-test	NS	*	*
	CD	-	0.58	0.69
	SEM ±	-	0.19	0.21

BS-Before Spray DAS-Days After Spray NS- Non-Significant *-Significant
Figures in the parenthesis are ($\sqrt{x}$+0.5) transformed values
Means followed by the same letter are within the standardised 't' range

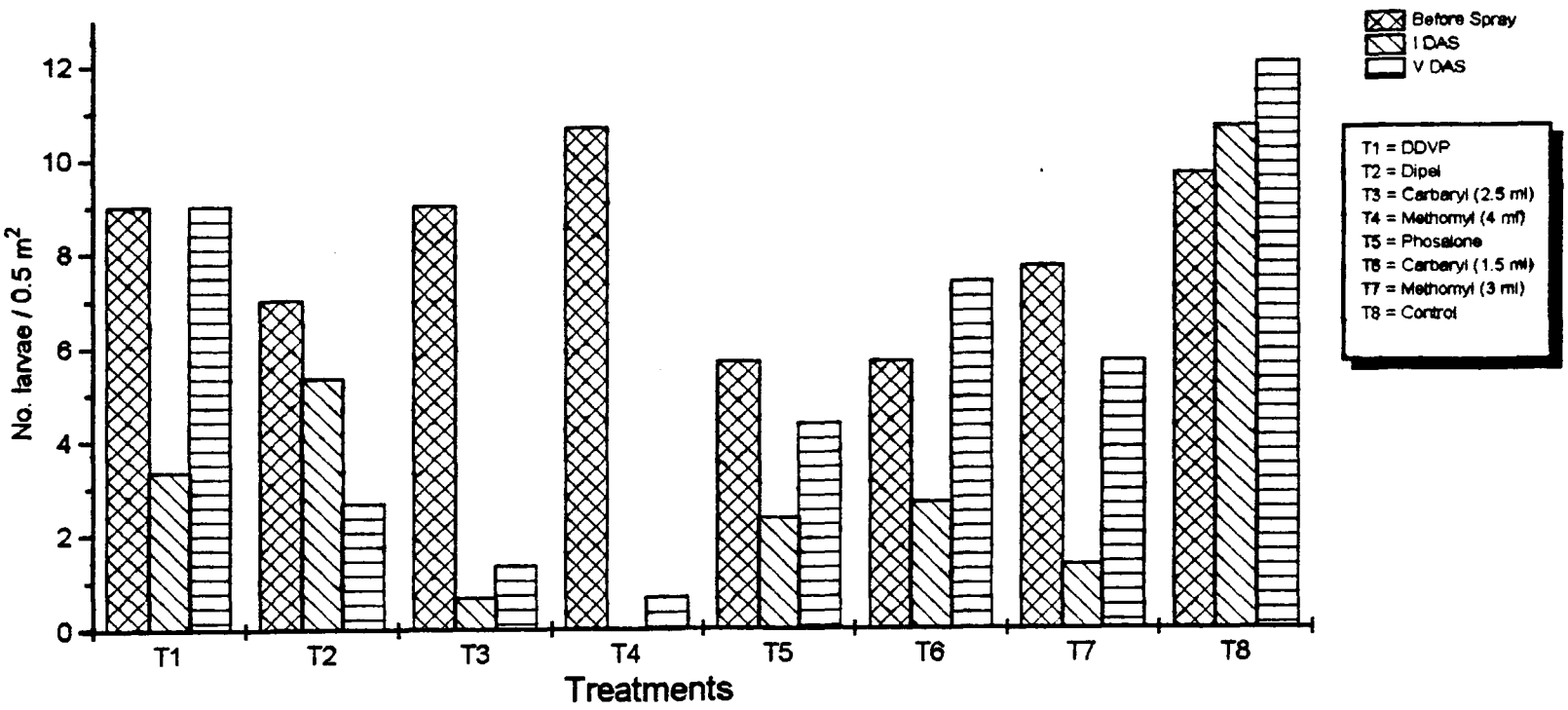

Fig. 19 Evaluation of selected insecticides against *Diaphania indica* at Irabanahalli

b) Abbenahalli

Results were similar to those found in Irabanahalli with minor differences. The observations were continued in this location on tenth day after the spray which gave an indication of persistence of effectiveness of the insecticides.

Carbaryl and methomyl at higher dosages continued to be most effective chemicals till ten days after spray (Table 30 and Fig.20). The toxicity of dipel improved on fifth and tenth day (3.00 and 7.33 larvae/ 0.5 m^2, respectively) and was next best treatment in suppressing the larval population on fifth and tenth day. Phosalone was on par with carbaryl and methomyl on a day after spray (2.33) but lost its effectiveness on fifth day (3.66) and became on par (3.66) with dipel (3.00) and on tenth day on par with higher dosage of carbaryl (3.33). Both carbaryl (17.00) and methomyl (14.66) at lower dosages and dichlorovas (14.33) were on par with control (19.00).

4.11.4 **Experiment 4**

In this experiment, carbaryl and methomyl treated plots had significantly lower population (0.33 and 0.00 respectively) after a day of the spray, followed by dichlorovos (2.33), phosalone(3.00) and dipel (4.00). Bioneem had moderate population (5.33) but significantly lower than the control (9.00) where the population was highly significant over other treatments (Table 31 and Fig. 21).

After the second spray also, carbaryl and methomyl had significantly lower population (0.00 and 0.33 respectively) and were on par with each other followed by dichlorovos (2.00) and phosalone (3.00). Bioneem (5.66) was on par with phosalone (5.33), dipel (6.66) and

Table 30: Evaluation of selected insecticides against *Diaphania indica* at Abbenahalli during Sept. 1996

Sl No.	Treatments	BS	1 DAS	5 DAS	10 DAS
		(No. of larvae/0.5m^2)			
1	Dichlorovos 0.07%	16.66 (4.14)	6.66 (2.64) ^{e}	6.33 (2.60) ^{d}	14.33 (3.84) ^{d}
2	Dipel 0.02%	15.00 (3.91)	5.33 (2.40) ^{de}	3.00 (1.87) ^{bc}	7.33 (2.78) ^{c}
3	Carbaryl 0.1%	20.33 (4.55)	0.66 (0.99) ^{ab}	1.66 (1.46) ^{ab}	3.33 (1.94) ^{ab}
4	Methomyl 0.05%	15.00 (3.91)	0.00 (0.70) ^{a}	1.00 (1.22) ^{a}	1.66 (1.44) ^{a}
5	Phosalone 0.05%	16.66 (4.11)	2.33 (1.64) ^{bc}	3.66 (2.03) ^{c}	6.33 (2.61) ^{bc}
6	Carbaryl 0.06%	20.66 (4.58)	3.00 (1.85) ^{cd}	3.66 (2.03) ^{c}	17.00 (4.11) ^{d}
7	Methomyl 0.03%	17.00 (4.16)	1.66 (1.44) ^{bc}	2.66 (1.71) ^{bc}	14.66 (3.88) ^{d}
8	Control	18.00 (4.29)	20.00 (4.52) ^{f}	14.33 (3.84) ^{e}	19.00 (4.41) ^{d}
F-test		NS	*	*	*
CD		-	0.67	0.39	0.76
SEM ±		-	0.22	0.12	0.25

BS-Before Spray DAS-Days After Spray NS- Non-Significant *- Significant
Figures in the parenthesis are ($\sqrt{x}$+0.5) transformed values
Means followed by the same letter are within the standardised 't' range

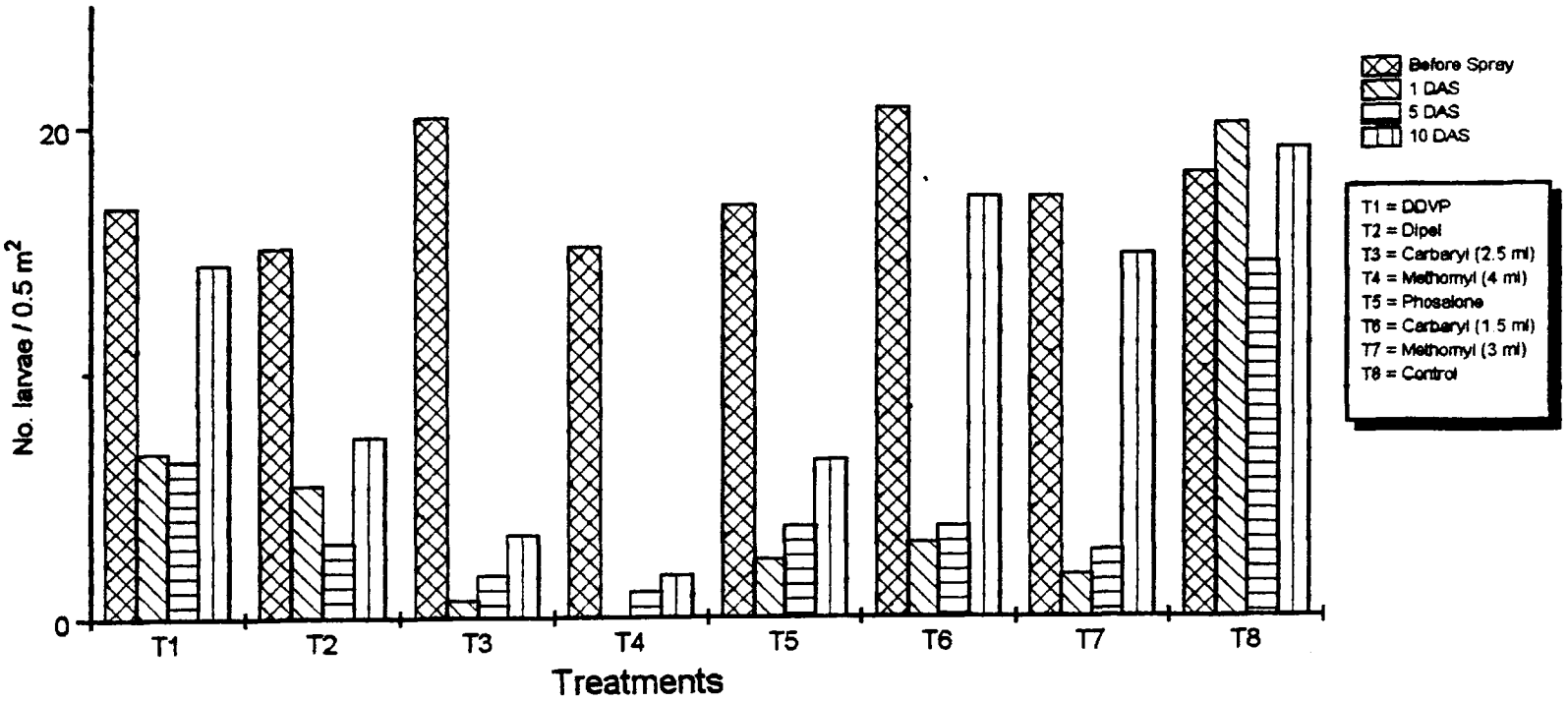

Fig. 20 Evaluation of selected insecticides against *Diaphania indica* at Abbenhalli

Table 31 : Evaluation of selected insecticides against *Diaphania indica* at Mundwad during Jan 97

Sl. No.	Treatments	I Spray		II Spray	
		(No. of larvae/0.5m^2)			
		BS	AS	BS	AS
1	Dichlorovos 0.07 %	6.00	2.33 $(1.67)^b$	5.33 $(2.40)^b$	2.00 $(1.55)^b$
2	Dipel 0.02 %	5.33	4.00 $(2.12)^{cd}$	6.66 $(2.66)^b$	4.66 $(2.44)^c$
3	Carbaryl 0.1 %	7.00	0.33 $(0.87)^a$	1.66 $(1.43)^a$	0.00 $(0.70)^a$
4	Methomyl 0.05 %	7.33	0.00 $(0.70)^a$	1.66 $(1.46)^a$	0.33 $(0.87)^a$
5	Phosalone 0.05 %	8.66	3.00 $(1.85)^b$	5.33 $(2.34)^b$	1.33 $(1.26)^a$
6	Bioneem 0.03 %	6.33	5.33 $(2.40)^d$	5.66 $(2.47)^b$	5.33 $(2.34)^c$
7	Control	7.66	9.00 $(3.05)^c$	10.66 $(3.33)^c$	9.33 $(3.07)^d$
	F-test	NS	*	*	*
	CD	-	0.28	0.32	0.62
	SEM±	-	0.12	0.14	0.28

BS- Befote Spray AS- After Spray DAS- Days After Spray

NS - Non-Significant *-Significant

Figures in the paranthesis are square root($\sqrt{x+0.5}$) transformed values

Means followed by the same letter are within the standardised 't' range

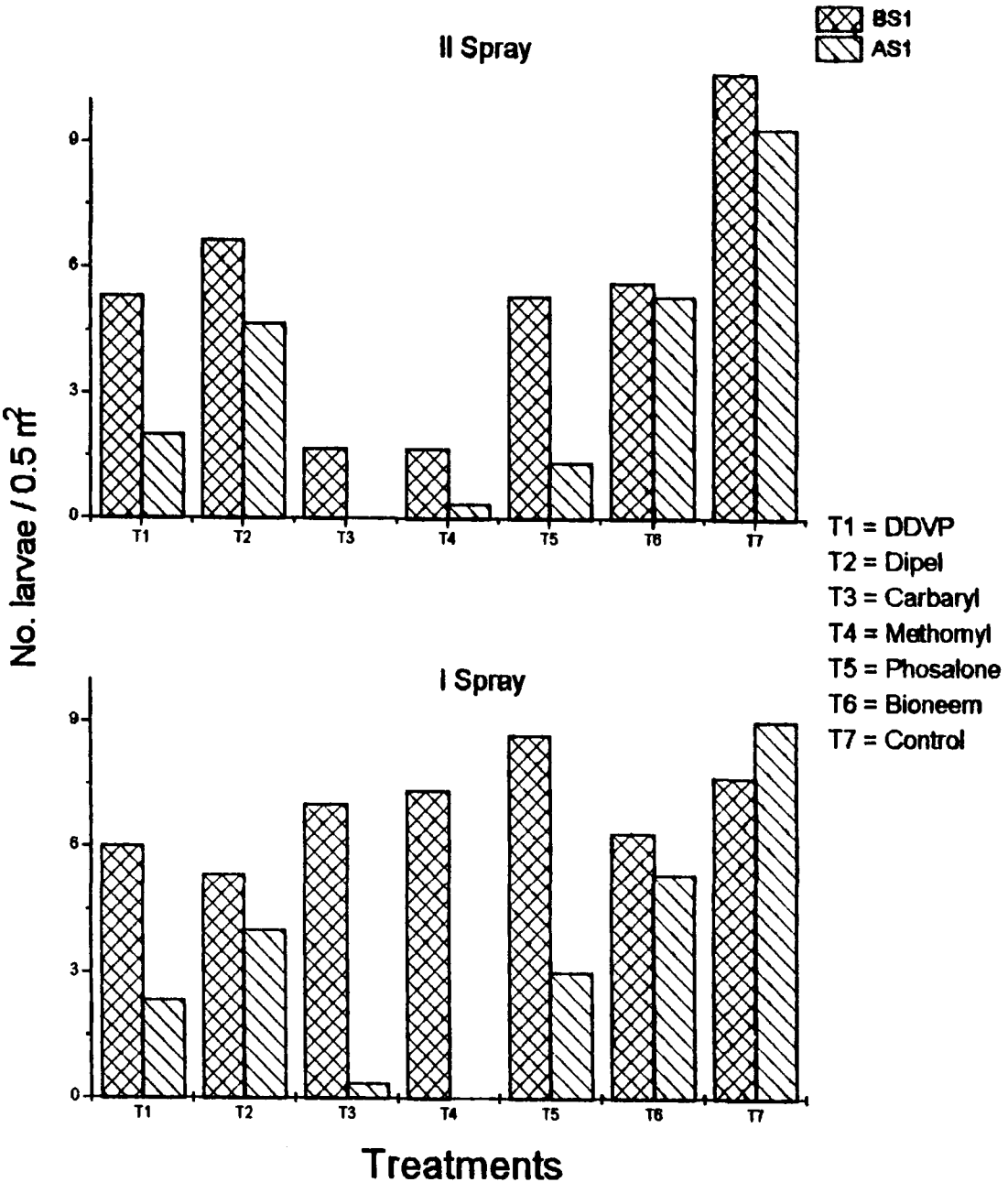

Fig. 21 Evaluation of selected insecticide against *Diaphania indica* at Mundwad

dichlorovas (5.33) seven days after spray and significantly superior to control. A day after second spray both dipel (4.66) and bioneem (5.33) were on par and superior to control in suppressing the larval population.

4.11.5 **Experiment 5** :

The results on the efficacy of insecticides against *D. indica* on the gherkin variety Calypso are presented in the Table 32 (Fig. 22). Significant differences were found among the treatments only after the insecticidal spray. All insecticidal treatments were significantly superior to control in suppressing the larval population. Both carbaryl and phosalone were effective in controlling the population of the pest after each spray and the population was reduced to 0.50 and 0.50 in carbaryl and 0.75 and 0.50 in phosalone treatments which were significantly superior to other treatments. This was followed by *B. turingiensis* with population of 1.50 and 4.00 after first and second sprays, respectively. Dichlorovos and HSKE were significantly on par in reducing the population of the pest with population of 3.00 and 3.75 and 2.50 and 4.50, respectively after first and second sprays.

4.11.6 **Experiment 6**

Carbaryl reduced the population of *D. indica* significantly (0.25 and 0.00 after I and II sprays, respectively compared to other treatments (Table 33 and Fig. 23). Dichlorovos, *B. turingiensis*, NSKE and HSKE were on par with each other with respect to reducing the population of *D. indica* larvae after the first spray. The population was significantly higher in the untreated check (6.50) compared to all the other treatments. However, after second spray the population was significantly on par in dichlorovos (2.25) and *B. turingiensis* (2.00)

Table 32 : Evaluation of selected insecticides against ***Diaphania indica*** on Calypso variety of gherkin at Hedeginabele during July 1996

Sl. No.	Treatments	I Spray		II Spray	
		BS	AS	BS	AS
		(No. of larvae/0.5m^2)			
1	Dichlorovos 0.07%	4.25 (2.05)	3.00 (1.85) ^{bc}	4.50 (2.08)	3.75 (2.01) ^{bc}
2	Dipel 0.02%	3.25 (1.92)	1.50 (1.38) ^{ab}	4.00 (2.07)	3.00 (1.83) ^{b}
3	Carbaryl 0.1%	3.50 (1.97)	0.50 (0.92) ^{a}	2.00 (1.46)	0.50 (0.96) ^{a}
4	Phosalone 0.05%	3.00 (1.81)	0.75 (1.09) ^{a}	1.75 (1.49)	0.50 (0.92) ^{a}
5	HSKE 4%	3.00 (1.84)	2.50 (1.72) ^{bc}	4.25 (2.10)	4.50 (2.18) ^{bc}
6	Control	3.50 (1.97)	4.25 (2.14) ^{b}	6.00 (2.43)	8.00 (2.82) ^{c}
	F-test	NS	*	*	*
	CD	-	0.72	0.81	0.43
	SEM ±	-	0.24	0.26	0.14

BS-Before Spray AS-After Spray

Figures in the parenthesis are ($\sqrt{x}$+0.5) transformed values

Means followed by the same letter are within the standardised 't' range

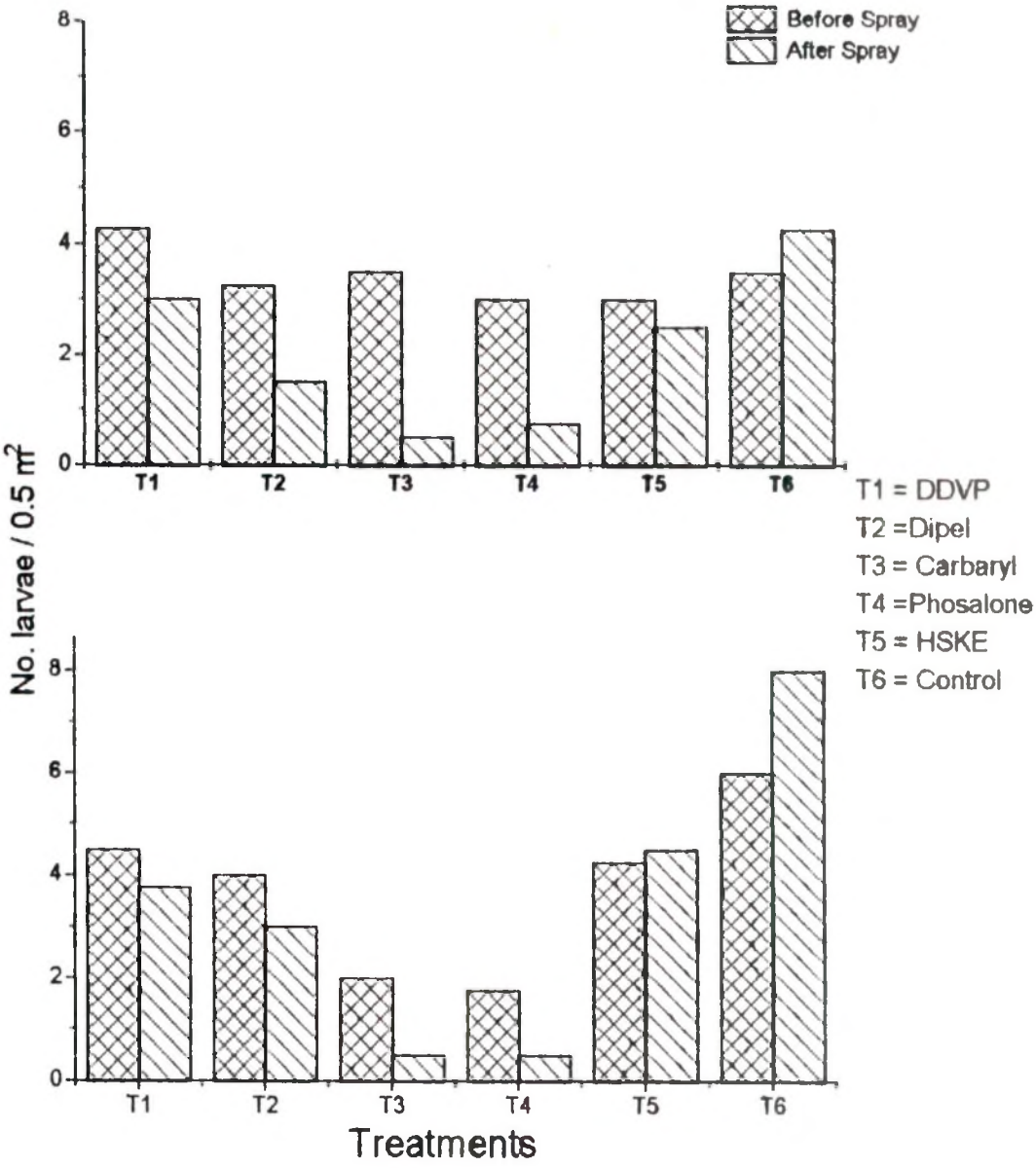

Fig.22 Evaluation of selected insecticides against *Diaphania indica* on Calypso variety of gherkin at Hedeginabele

Table 33 : Evaluation of selected insecticide and plant products against *Diaphania indica* on Nun variety of gherkin at Hedeginabele during July 1996

Sl No.	Treatments	I Spray		II Spray	
		BS	AS	BS	AS
			(No. of larvae/0.5m^2)		
1	Dichlorovos 0.07%	5.50 (2.37)	5.25 (2.33) ^{b}	3.75 (1.91) ^{ab}	2.25 (1.63) ^{b}
2	Dipel 0.02%	3.50 (1.97)	3.25 (1.91) ^{b}	2.50 (1.72) ^{ab}	2.00 (1.56) ^{b}
3	Carbaryl 0.1%	6.75 (2.61)	0.25 (0.83) ^{a}	1.50 (1.34) ^{a}	0.00 (0.70) ^{a}
4	NSKE 4%	4.25 (2.11)	5.00 (2.29) ^{b}	5.25 (2.34) ^{bc}	5.00 (2.32) ^{c}
5	HSKE 4%	4.25 (2.15)	5.25 (2.31) ^{b}	5.75 (2.46) ^{bc}	4.75 (2.27) ^{c}
6	Control	4.00 (2.05)	6.50 (2.59) ^{b}	7.75 (2.83) ^{c}	8.00 (2.90) ^{d}
	F-test	NS	*	*	*
	CD	-	0.72	0.81	0.43
	SEM ±	-	0.24	0.26	0.14

BS-Before Spray AS-After Spray NS- Non- Significant *-Significant
Figures in the parenthesis are square root ($\sqrt{x}+0.5$) transformed values
Means followed by the same letter are within the standardised 't' range

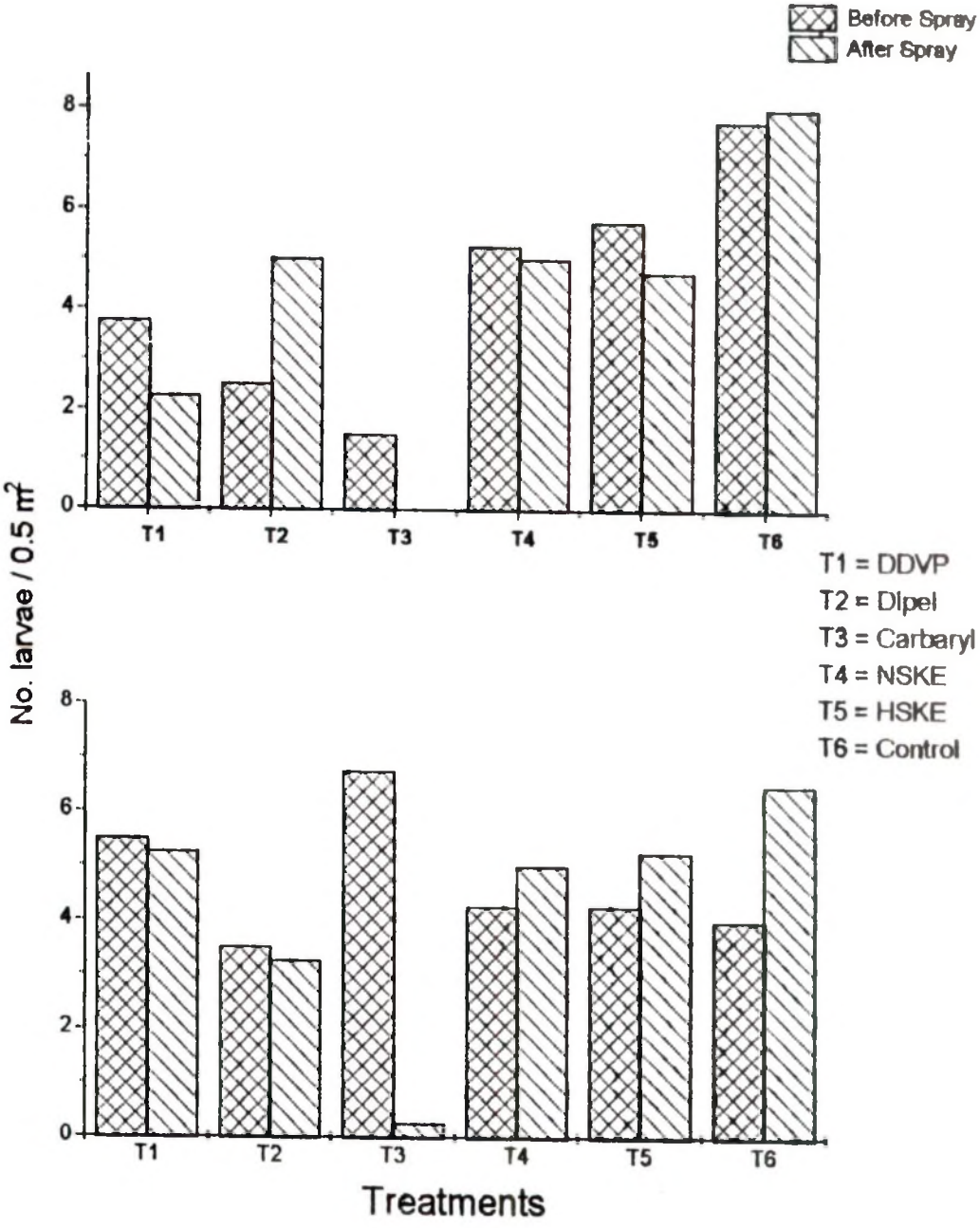

Fig. 23 Evaluation of selected insecticides against *Diaphania indica* on Nun variety of gherkin at Hedeginabele

treatments followed by NSKE (5.00) and HSKE (4.75) which was significantly different from the untreated check (8.00).

4.11.7 **Experiment** 7

This experiment was designed to find out the efficacy of carbaryl and methomyl over a period of 14 days. Carbaryl and methomyl were significantly superior in reducing the population of the pest after three, nine and fourteen days of the spray (Table 34 and Fig. 24). In control the population was significantly high compared with the insecticide treatments. Though there was significant difference between treated and untreated, with the lapse of time, the population increased in both the treatments.

4.11.8 **Experiment 8**

Thrips, *Thrips palmi*

The population of thrips was uniform in all the plots before spray and ranged from 91.25 to 123.25 thrips per terminal bud (Table 35 and Fig. 25).

One day after spray, all the treatments were superior to control (water spray) in reducing the thrips population. Cypermethrin and deltamethrin were the most superior treatment and were on par recording 52.00 and 60.75 thrips/ terminal bud, respectively. Next in order were dimethoate (68.00) and HSKE (65.50).

Four days after spray, dimethoate (32.00) and cypermethrin (36.75) were on par in suppressing the population of thrips and were significantly superior to HSKE (46.75) and deltamethrin (56.00). Deltamethrin was the least toxic among the insecticide tried.

Table 34 : Evaluation of selected insecticides against *Diaphania indica* at Bidarahalli during Sept. 1996

Sl No.	Treatments	BS	7 DAS	13 DAS	17 DAS
		(No. of larvae / 0.5 m^2)			
1	Carbaryl	11.85 (3.40)	0.42 (0.90) [a]	7.71 (2.25) [a]	12.00 (3.18) [a]
			(3.40)	(3.46)	
2	Methomyl	13.71 (3.75)	0.28 (0.85) [a]	6.57 (2.00) [a]	12.66 (3.41) [a]
3	Control	13.00 (3.64)	11.85 (3.48) [b]	13.85 (3.77) [b]	16.57 (4.12) [b]
	F-test	NS	*	*	*
	CD	-	0.42	0.37	0.49
	SEM ±	-	0.13	0.12	0.24

BS-Before Spray DAS-Days After Spray NS- Non-Significant *- Significant
Figures in the parenthesis are ($\sqrt{x}$+0.5) transformed values
Means followed by the same letter are within the standardised 't' range

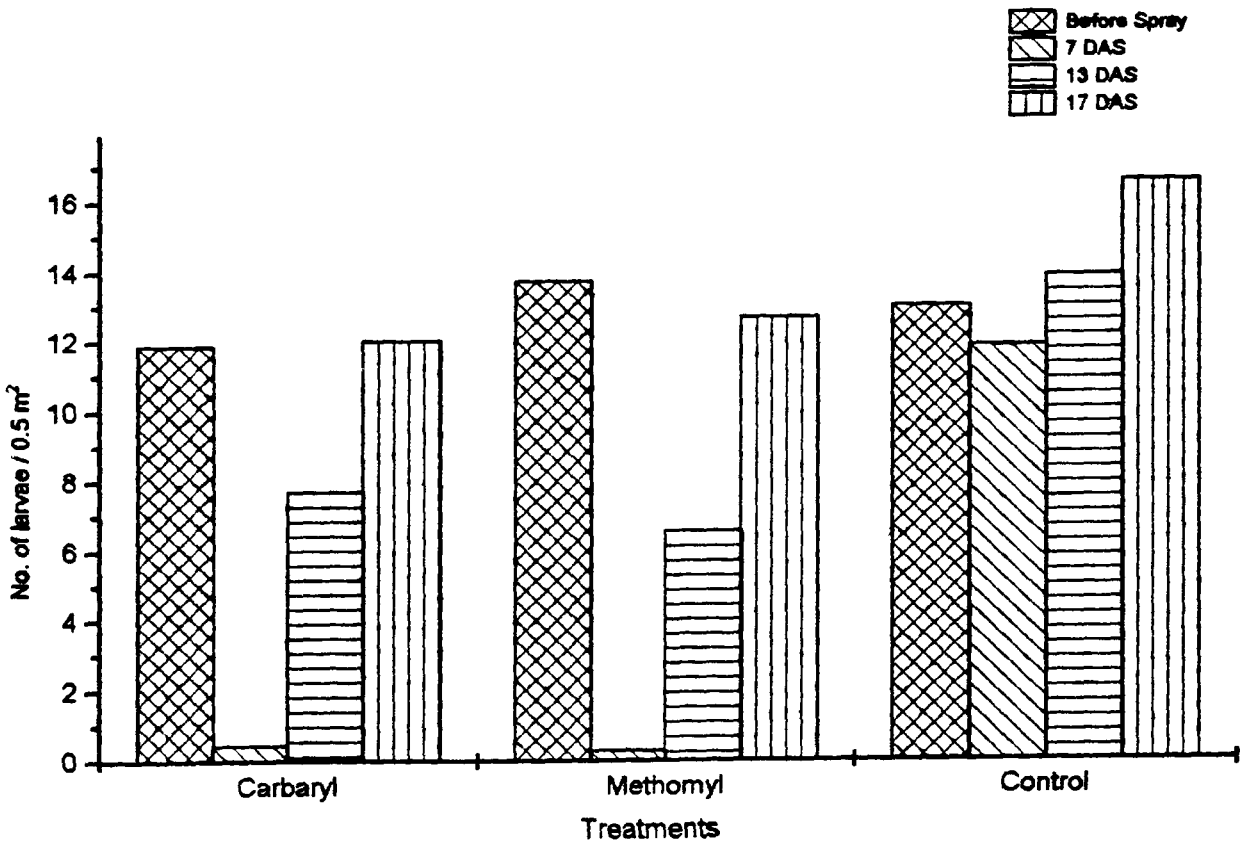

Fig. 24 Evaluation of Carbaryl and Methomyl for the control of *Diaphania indica*

Table 35 : Evaluation of selected insecticides on the population of *Thrips palmi* at Hedeginabele during April 1996

Sl. No.	Treatments	I Spray			II Spray			III Spray	
		Number of thrips / terminal bud							
		B.S.	1 DAS	4 DAS	B.S.	1 DAS	4 DAS	B.S.	1 DAS
1.	Dimethoate	123.25	68.00	32.00	48.00	22.25	8.00	20.00	7.25
		(11.01)	(8.15)^{b}	(5.67)^{a}	(6.70)	(4.69)^{a}	(2.91)^{a}	(4.52)	(2.71)^{a}
2.	Cypermethrin	95.50	52.00	36.75	76.00	45.75	12.75	19.50	12.25
		(9.78)	(7.17)^{a}	(5.97)^{a}	(8.69)	(6.62)^{d}	(3.62)^{b}	(4.45)	(3.53)^{b}
3.	Deltamethrin	91.25	60.75	56.00	43.00	36.25	17.75	22.25	13.00
		(9.43)	(7.77)^{a}	(7.49)^{c}	(6.54)	(6.03)^{c}	(4.26)^{c}	(4.76)	(3.61)^{b}
4.	HSKE	100.25	65.50	46.75	61.75	30.00	21.25	24.25	16.75
		(10.03)	(7.98)^{b}	(6.81)^{b}	(7.87)	(5.49)^{b}	(4.66)^{d}	(4.91)	(4.11)^{c}
5.	Water	103.75	134.00	128.00	68.75	63.50	33.00	20.25	23.00
		(10.18)	(11.55)^{c}	(11.22)^{d}	(8.31)	(7.99)^{e}	(5.76)^{e}	(4.54)	(4.84)^{d}
	F-test	NS	*	*	NS	*	*	NS	*
	CD	-	0.64	0.56	-	0.51	0.19	-	0.33
	SEM+	-	1.96	1.74	-	1.57	0.58	-	1.02

BS-Before Spray DAS-Days After Spray NS - Non-Significant * - Significant
Figures in the parenthesis are ($\sqrt{x}$+0.5) transformed values
Means followed by the same letter are within the standardised 't' range

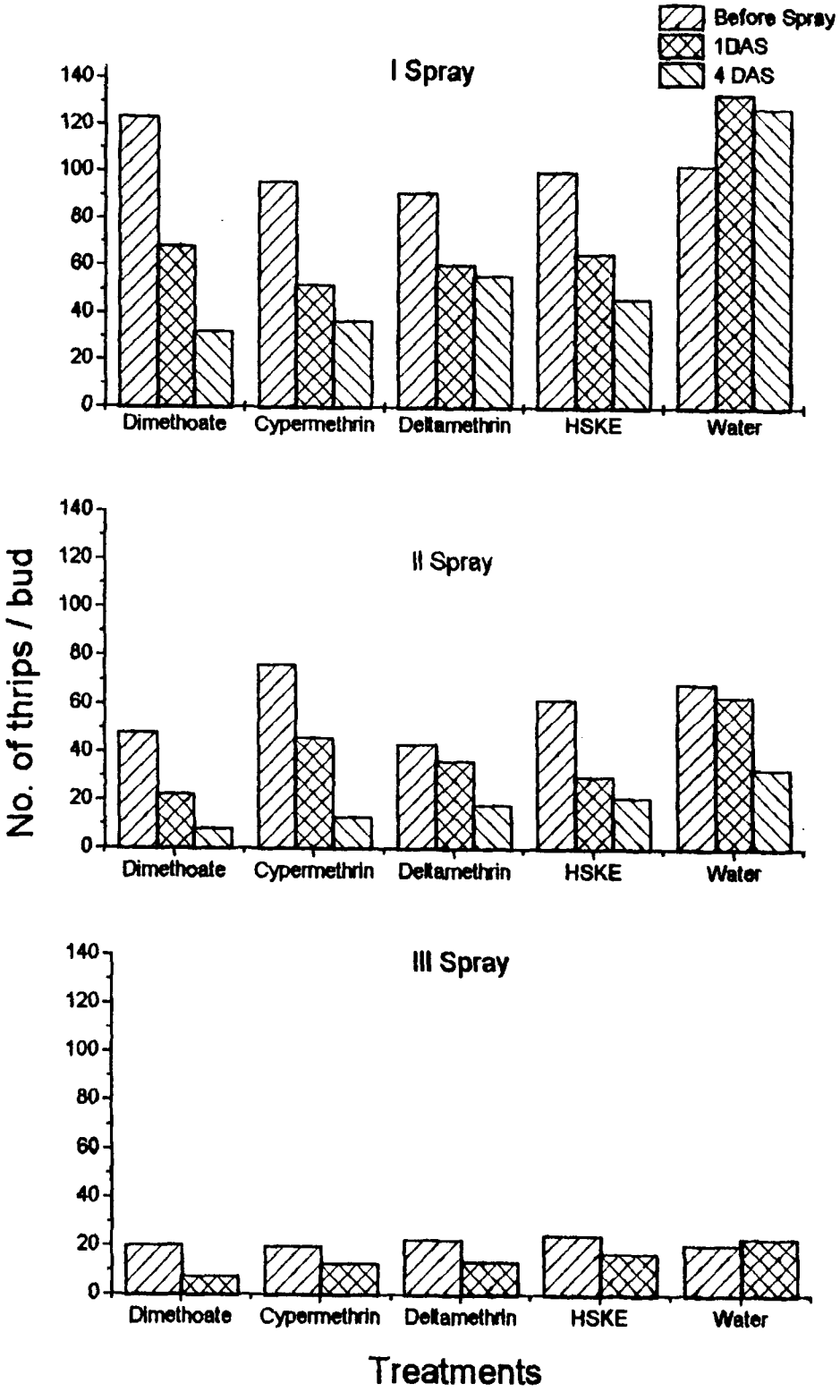

Fig. 25 Evaluation of selected insecticides on *Thrips palmi*

During this period, because of rain, seven days after spray, population of thrips in all the treatments was low and uniform. One day after second spray, dimethoate had the least number of thrips (22.5 thrips/ terminal bud) followed by HSKE (30.00). All the treatments were superior to water spray (63.50).

Four days after second spray, in general there was a decline in the thrips population in all the treatments. The control (water spray) recorded significantly the highest number (33.00 thrips / terminal bud). Dimethoate recorded significantly the least number of thrips (8.00) followed by cypermethrin (12.75) , deltamethrin (17.75) and HSKE (21.25) in decreasing order. These treatments were significantly different from each other in suppressing the population of thrips. Because of heavy rains received during this period, there was no significant difference in the thrips population one day before the third spray. One day after the third spray, all the insecticidal treatments showed significantly lower thrips population compared to control. Again, dimethoate had significantly the least number of thrips (7.25 thrips / terminal bud). Cypermethrin and deltamethrin were on par (12.25 and 13.00, respectively) and significantly superior to HSKE (16.75) in reducing thrips population.

4.12 **Monitoring fruit fly, *Bactrocera cucurbitae* populations** :

4.12.1 **Evaluation of different traps and ways of dispensing cue-lure** :

The results on the selection of traps for fruit flies are presented in Table 36 (Fig. 26). The interaction analysis showed significant differences in both the position of the trap and the types of the trap used.

Table 36: Number of fruit fly, ***Bactrocera cucurbitae*** trapped per day in different traps

Sl No.	Trap	Trap positions					Mean
		1	2	3	4	5	
1	Cuelure + Detergent	5.00 $(2.25)^{c}$	8.00 $(2.91)^{de}$	22.00 $(4.73)^{h}$	2.50 $(1.67)^{ab}$	3.00 $(1.87)^{ab}$	8.10 $(2.89)^{c}$
2	Cuelure	5.00 $(2.24)^{c}$	6.50 $(2.63)^{cd}$	7.50 $(2.82)^{de}$	1.50 $(1.40)^{a}$	1.50 $(1.40)^{a}$	4.40 $(2.10)^{b}$
3	Cuelure + Dichlorovos	103.50 $(10.07)^{k}$	47.00 $(6.84)^{i}$	48.00 $(6.87)^{i}$	55.00 $(7.37)^{j}$	47.50 $(6.85)^{i}$	60.20 $(7.60)^{e}$
4	Sticky Trap	8.50 $(2.99)^{c}$	15.50 $(3.99)^{fg}$	14.50 $(3.86)^{f}$	16.50 $(4.12)^{g}$	2.50 $(1.72)^{ab}$	11.50 $(3.33)^{d}$
5	Mc-Pheil Trap	6.50 $(2.62)^{cd}$	2.50 $(1.72)^{ab}$	3.00 $(1.87)^{ab}$	1.50 $(1.40)^{a}$	1.50 $(1.40)^{a}$	3.00 $(1.80)^{a}$
Mean		25.50 $(4.03)^{d}$	15.80 $(3.62)^{b}$	18.90 $(4.03)^{c}$	15.40 $(3.19)^{b}$	11.20 $(2.64)^{a}$	17.41 (3.91)

F-test- Significant

CD- Interactions-0.7 Traps-0.50 Positions-0.45

Figures in the paranthesis are square root ($\sqrt{\bar{x}+0.5}$) transformed values
Means followed by the same letter are within the standardised 't' range

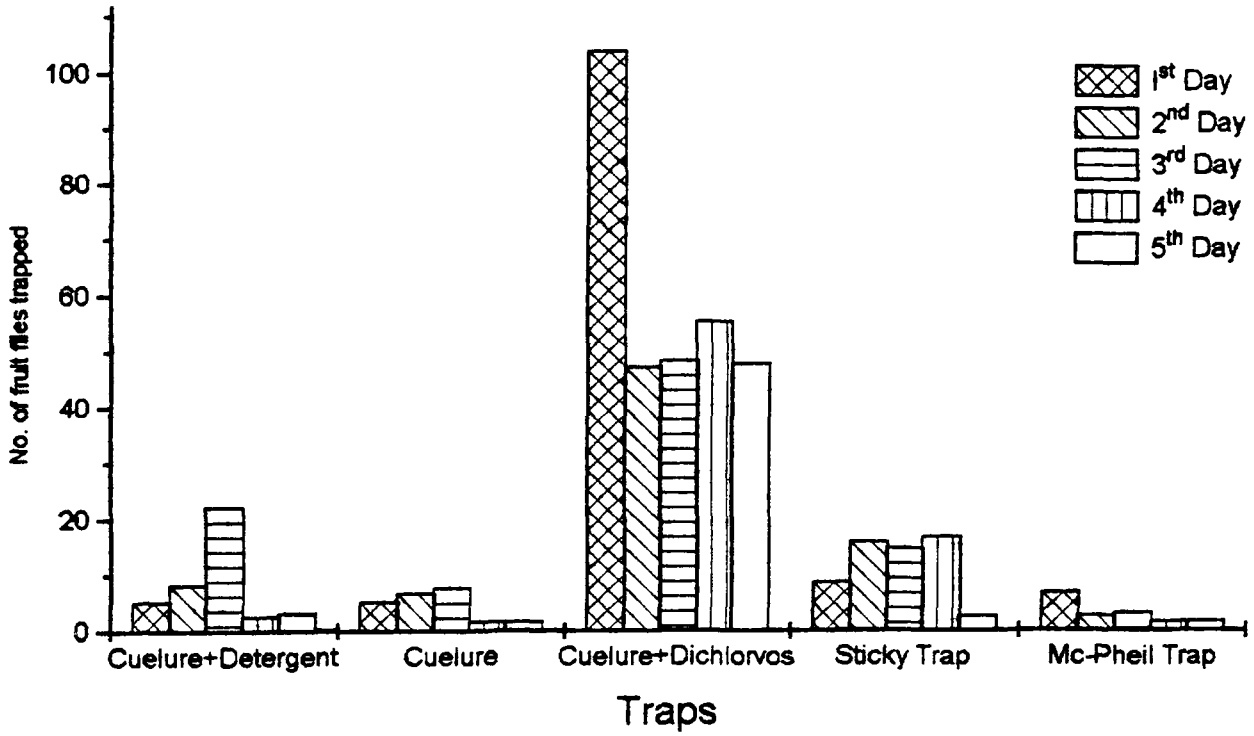

Fig.26 Evaluation of different traps design and method of dispensing in trapping *Bactrocera cucurbitae*

Significantly higher number of of fruit flies (60.20) were trapped in the trap containing cue-lure with dichlorovas. This was followed by sticky trap and cue-lure in water which trapped significantly lower number of flies (11.30 and 8.10, respectively). Mc-pheil trap and mere cue-lure, trapped the least number of flies (3.00 and 4.40, respectively).

A significant difference was also observed in the position of traps placed in the field. Positions, one and three trapped significantly more number of fruit flies (25.70 and 19.00 respectively) compared to positions two and four which trapped 15.90 and 15.40 fruit flies respectively. The least number of fruit flies were trapped at position five (11.20).

The interaction between the traps and positions was also significant with the highest number of fly being trapped in cue-lure + dichlorovos trap (103.50) at position one. Significantly lesser number (1.50) of fruit flies were trapped in cue-lure dispensed in water and Mc-Pheil trap at positions number four and five in both the traps.

4.12.2 **Efficacy of the trap over days**

The results on the effectiveness of cue-lure + dichlorovos trap showed the highest fly catches in the treatment where chemical was replenished every day (T3) (885 in eight days) followed the treatment where in the chemical was replenished once in four days (T2) (389). In the treatment wherein the chemical was not changed (T1) the fly catch was the least (200). Flies were trapped in higher numbers in T3 and the catch was always higher on all the days. In T2, the highest number of flies were trapped on the first day and it declined from second day onwards. In T1 fruit flies were trapped in large numbers on

the first day and there was a gradual reduction in the fly catch over five days and no flies were caught on seventh and eighth days (Fig. 27).

4.12.3 **Evaluation of different baits and fruits**

There was significant difference in the fly catches among different baits and fruits tried (Table 37 and Fig. 28). Liquid cue-lure attracted significantly higher number of flies compared to other treatments. This was followed by cue-lure (pellet) and banana which were on par with each other. However, fishmeal and dichlorovos alone were failed to attract fruit flies in all the experiments.

Among the treatments cue-lure with methomyl and cue-lure with dichlorovos attracted significantly the largest number of fruit flies in the three experiments (Table 28) and were on par. Although some fruits attracted a few of flies, there was no significant difference in the numbers of flies caught in them.

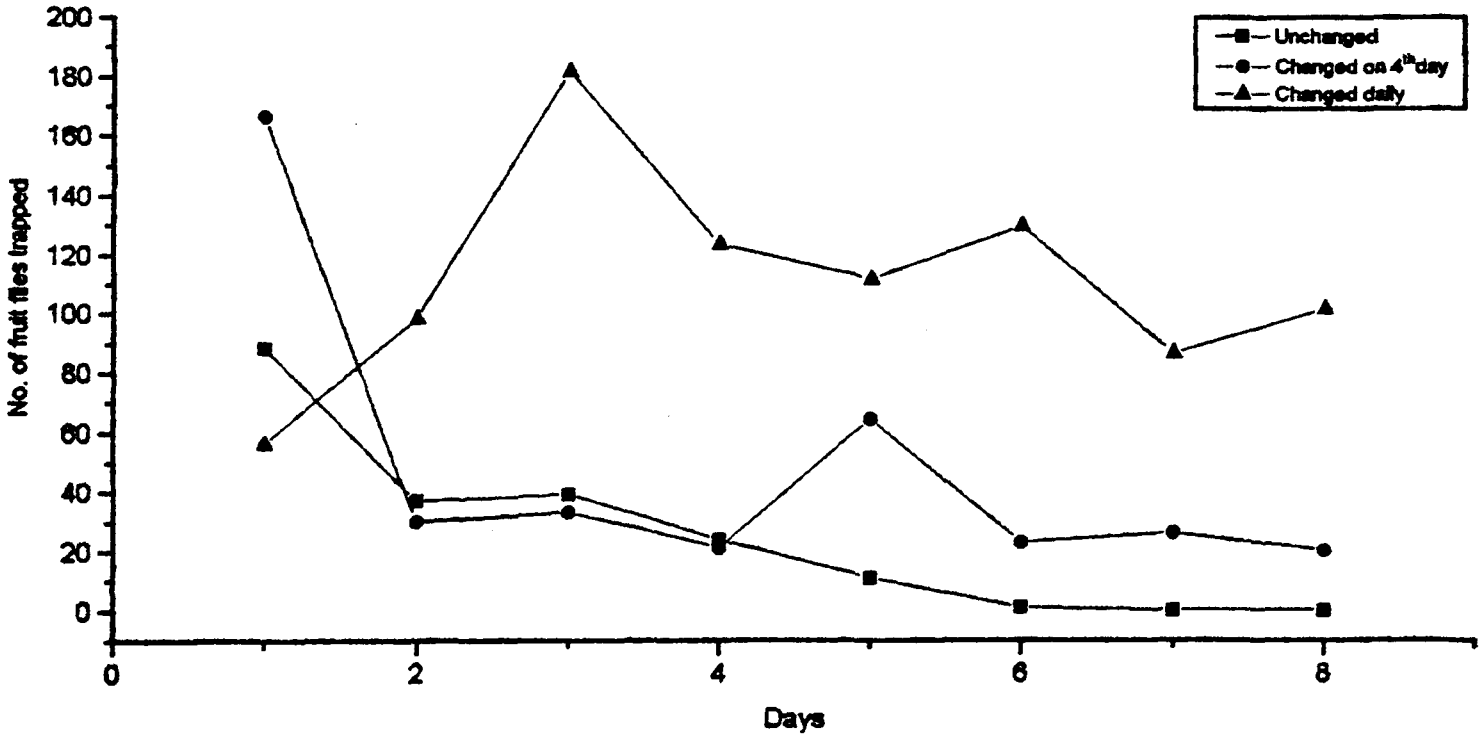

Fig. 27 Daily catches of *Bactrocera cucurbitae* to cuelure

Table 37: Evaluation of different lures for trapping of fruit fly, *Bactrocera cucurbitae* at GKVK (No. of flies trapped/day)

Sl No.	Lures	Experiment number			
		I	II	III	IV
1	Fish meal	0.00 (0.70)[a]	0.00 (0.70)[a]	0.00 (0.70)[a]	0.00 (0.70)[a]
2	Banana	2.25 (1.56)[bc]	1.75 (1.49)[b]	1.50 (1.49)[b]	0.75 (1.09)[b]
3	Cue lure (Pellets)	2.00 (1.50)[b]	2.25 (1.65)[b]	2.50 (1.65)[b]	1.75 (1.43)[b]
4	Cue lure (Liquid)	3.25 (1.92)[c]	3.50 (1.99)[c]	3.75 (1.99)[c]	3.75 (1.98)[c]
5	Control	0.00 (0.70)[a]	0.00 (0.70)[a]	0.00 (0.70)[a]	0.00 (0.70)[a]
	F-test	*	*	*	*
	CD	0.39	0.18	0.18	0.34
	SEM±	0.18	0.05	0.05	0.16

Figures in the paranthesis are square root ($\sqrt{x+0.5}$) transformed values

Means followed by the same letter are within the standardised 't' range

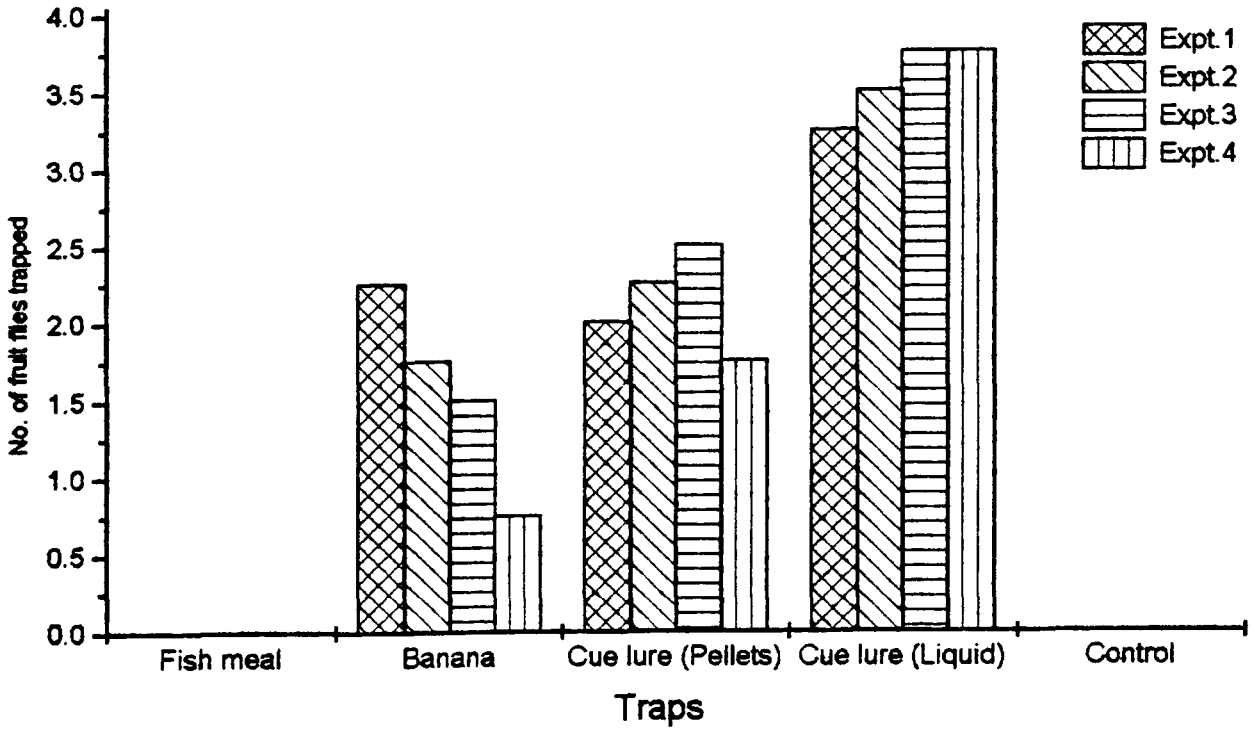

Fig. 28 Evaluation of different lures for trapping *Bactrocera cucurbitae*

Table 38: Testing of different lures for trapping of fruit fly, *Bactrocera cucurbitae* at Nesaragere (No. of flies trapped)

Sl No.	Experiments Lures	I	II	III
1	Wheat flour +Molasses + *M*	0.33(0.87)^{ab}	1.00 (1.16)^{b}	0.33 (0.87)^{a}
2	Rice flour +Molasses + *M*	0.66 (1.04)^{ab}	0.67 (1.04)^{ab}	0.00 (0.70)^{a}
3	Barley flour +Molasses + *M*	1.00 (1.16)^{ab}	1.00 (1.16)^{b}	0.67 (1.04)^{a}
4	Banana + Yeast + *M*	1.33 (1.28)^{b}	0.33 (0.87)^{ab}	0.33 (0.87)^{a}
5	Papaya + yeast + *M*	1.00 (1.17)^{ab}	0.00 (0.70)^{a}	0.67 (1.04)^{a}
6	Citrus + Yeast + *M*	1.00 (1.17)^{ab}	0.67 (1.04)^{ab}	0.00 (0.70)^{a}
7	Molasses + *M*	0.33 (0.87)^{ab}	1.00 (1.16)^{b}	0.33 (0.87)^{a}
8	Mixed fruit juice + *M*	0.66 (1.04)^{ab}	1.00 (1.17)^{b}	0.67 (1.04)^{a}
9	*M*	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.00(0.70)^{a}
10	Gherkin + *M*	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.00 (0.70)^{a}
11	Cuelure + *M*	6.66 (2.58)^{c}	7.67 (2.47)^{d}	9.00 (3.02)^{c}
12	Fishmeal + *M*	0.00 (0.70)^{a}	2.33 (1.67)^{c}	1.33 (1.34)^{b}
13	Wheat flour + Molasses + D	1.00 (1.09)^{ab}	0.33 (0.87)^{ab}	1.00 (1.16)^{a}
14	Rice flour + Molasses +D	1.33 (1.26)^{b}	0.33 (0.87)^{ab}	0.00 (0.70)^{a}
15	Barley + Molasses +D	0.67 (0.99)^{ab}	0.67 (1.04)^{ab}	0.67 (0.87)^{a}
16	Banana + Yeast + D	0.33 (0.87)^{ab}	0.00 (0.70)^{a}	0.33 (0.87)^{a}
17	Papaya + Yeast + D	0.67 (0.99)^{ab}	0.33 (0.87)^{ab}	0.33 (0.87)^{a}
18	Citrus + Yeast + D	1.33 (1.26)^{b}	0.67 (1.04)^{ab}	0.33 (0.87)^{a}
19	Molasses +D	0.00 (0.70)^{a}	1.00 (1.16)^{c}	0.33 (0.87)^{a}
20	Mixed fruit juice + D	1.33 (1.34)^{b}	0.33 (0.87)^{ab}	0.33 (0.87)^{a}
21	*D*	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.00 (0.70)^{a}
22	Gherkin +D	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.00 (0.70)^{a}
23	Cuelure + *D*	8.66 (2.92)^{c}	9.00 (3.01)^{c}	7.00 (2.70)^{c}
24	Fish meal + Yeast + D	1.00 (1.09)^{ab}	0.67 (1.04)^{ab}	1.00 (1.16)^{ab}
F-test		*	*	*
CD				
SEM		0.26	0.22	0.17

Figures in the paranthesis are square root($\sqrt{}$ x+o.5) transformed valuesMeans followed by the same letter are within the standardised 't' range

M- Methomyl D- Dichlorovos

DISCUSSION

V. DISCUSSION

The results on various aspects of insect and mite pests of gherkin are discussed in relation to other related crops and pests.

5.1 Distribution of gherkin plant parts and *D. indica* larvae

The larval numbers were more on the leaves irrespective of quadrats and subquadrats. However, larvae were more abundant in the top subquadrat than in the bottom at both the locations. This may be because of the fresh flush available in the top subquadrat when compared with the bottom. The leaves at the bottom half were relatively older and hence may not be preferred by the larvae.

Larval numbers on buds also followed similar pattern but were relatively less compared to those on leaves. More larvae were observed in the top subquadrat compared to the bottom subquadrat. This may largely be due to the greater availability of buds in the top subquadrat. As buds are the growing parts, they are concentrated mostly in the top subquadrat.

Number of larvae on flowers and fruits was very less which is probably because of their ephemeral habit. Fruits also carried poor infestation of *D. indica* larvae as they are harvested daily. This also makes it difficult to observe for the larvae. Fruits that were observed during the study period were 1-2 day old and were numerically insignificant when compared to other plant parts. Hence, larval abundance on them was also less compared to those on leaves and flower buds. Although, the information on this aspect is very less, the results are in conformity with Ba-Angood (1979) who observed larvae and pupae in large numbers on leaves and fruits. Sindlinger and

Foerster (1984) who studied on the occurrence of *D. nitidalis* on different plant parts, also reported similar results. These authors have observed that the first and second instar larvae occur mainly on shoots and flowers, and later instars on fruits. However, results of the present investigation showed that larvae are more abundant on leaves followed by buds and flowers and very few on fruits.

Variance to mean (s2/x) ratio calculated for the larval numbers and plant parts showed a general aggregated distribution (s2/x >1). Though there was variation in the magnitude of the ratio in both the localities, the trend was similar at both the localities. This clearly indicated that the aggregated distribution of plant parts may be responsible for similar distribution of the larvae. There is no information available on this aspect on cucurbits.

Results of the studies on the relationship between the abundance of *D. indica* in bottom and top subquadrat showed that there is variation in the larval abundance between the two subquadrats. The number of larvae found in the bottom subquadrat was strongly correlated with those in the top subquadrat. The trends were similar in both the localities. This shows that the values for the top subquadrat can be used as an indicator of the total larval abundance for the quadrat. The consistency in the proportion of larvae observed in bottom and top subquadrats at the two localities strengthen this relationship. This clearly indicates that any small unit of approximately $0.5m^2$ of the vine can be used as a sampling unit as long as division between the top and the bottom portions of the vine is maintained. This part of the study also is a novel approach in this line.

Results of nested ANOVA conducted to study the relative distribution showed that buds supported more number of larvae at both the locations. As discussed earlier leaves supported numerically more larvae, but the number of larvae per unit plant part was the highest for buds indicating the larval preference. This may have been because of the nutritional status and as it provides a congenial protected place for the larvae. Buds were followed by flowers and fruits in the context of larval preference. Leaves, supported the least number of larvae. The results were almost similar at both the locations except for some minor variations. Similarity in number of larvae per plant parts in the bottom and top portions indicated equal preference for the larvae between the two subquadrats. As mentioned earlier, Ba-Angood (1979) observed more number of larvae and pupae of *D. indica* on leaves. However, the present investigation reveals that, though this is true, when relative distribution is considered, buds had the highest proportional value.

The variation in the population abundance of D. *indica* between the two localities can be attributed not just to the locational differences but also to the age difference existing between the two crops. At Hansbhavi, as the crop was 45 days old and was still in its vegetative phase, there was apparently no dearth for the resources (i.e., plant parts) available to the larvae. However, at Lingapura, the crop was nearing senescence and hence very few suitable plant parts were probably available for the larvae. The larval abundance was therefore, lower at Lingapura. Bergonia and Cervancia (1992) observed arthropod population density to increase from seedling through vegetative upto reproductive stage and to decrease as the crop senesced. This appears to be true in the present case.

5.2 Sampling plan

Evaluation of sampling plan was conducted at both (Hansbhavi and Lingapura) the localities by using mean number of larvae as the unit per quadrat (0.5 m2). The results indicated that a sample size of 3-4 quadrats would be ideal for sampling *D. indica* larvae on gherkins within each transect (5 x 0.5 m2). Anything less than three quadrats per transect would prove insufficient to provide accurate results and anything more that would not be necessary. Hence, three quadrats per transect would be the ideal for sampling.

Systematic and random samples considering five quadrats as one unit (i.e., per quadrat) showed marginal variations in the mean per transect at both the localities. The best-eye-fit curves showed three transects to be the ideal sample size. However, because of the variations, systematic sampling would be more efficient than random sampling.

Considering the variations in both between and within transects, it can be concluded that 3-4 quadrats within each transect and 3-4 transects in an area of 0.2 hectares can be considered for systematic sampling of *D. indica* larvae on gherkins.

Several workers have devised their own sampling methodology for different caterpillar pests on cucurbits (Ba-Angood, 1979; Perez *et al*, 1982; Edelson, 1986; Brewer and Story, 1987). Their methods could not be adopted for gherkins as the crop is grown perpendicular to ground with considerable differences in the cultivation practices. Hence, a novel method of sampling was adopted for sampling *D. indica* on gherkins.

5.3 Seasonal incidence of gherkin pests

5.3.1 *Diaphania indica* : Occurrence of *D. indica* was recorded throughout the year. Highest population during the year was observed from June-October which peaked in August. Incidentally, these are the rainy months of the year. Lowest population during the year was observed from February-April which are the dry months of the year. Results of correlations revealed both rainfall and temperature to have no significant impact on the incidence of the pest population whereas the same showed significant positive correlation with relative humidity, thus indicating preference to-wards humid conditions. This can be explained by looking into the crop condition. As the crop is heavily irrigated, the microclimate in the field could be highly humid. Dense foliage which forms a thick mat could sustain the humidity. All these put together, might very well be favouring pest multiplication. Though the mean maximum temperature and rainfall had non-significant effects on population dynamics of *D. indica*, their influence individually or in combination could have some impact on the pest incidence as it is apparent that the pest does not prefer high temperature. Total rainfall might be influencing the pest population indirectly. During rainy season, the crop is known to grow better than in any other season. It is obvious that well grown crop is prone to pests and diseases and could thus explain the population build up.

Studies conducted by several workers on the seasonal incidence of *D. indica* on other cucurbits showed that the pest is predominant during the same months (August-October) as observed in the present investigation (Patel and Kulkarni, 1956; Pandey, 1975; Ke et. al., 1988 ; Peter and David, 1991b). However, no explanation has been extended for the population fluctuation.

High numbers of *D. nitidalis* and *D. hyalinata* were observed during different months in different regions (York, 1975; Pena *et al.*, 1987a and Lorini and Foerster, 1987).

The incidence during June-October may be due to intensive farming practices during March to November. Because of low temperature prevailing during December-February, the area under the crop is reduced. Hence, extensive cultivation of gherkins beginning from March would help population build up of *D. indica.*

Results of the survey, showed that pest incidence increases with crop age. The highest larval numbers was observed on 15-30 days old crop. Then onwards it decreased. The decrease in pest population after 30 days is mainly due to the use of insecticides which all the farmers follow according to the instructions given by the company personnel. Bergonia and Cervancia (1992) reported that colonisation of pests, pollinators and parasitoids on cucumber was generally influenced by age. The arthropod population density increased from seedling to vegetative and reproductive plant stages and decreased as crop senesced.

As there is no information available on the above mentioned aspect, the present investigation seems to be the foundation study.

Although incidence of the pest varied, in terms of its density, from locality to locality, dynamicity within each locality was mainly due to the season and crop age. There was no influence of locality on the population fluctuation.

b. *Helicoverpa armigera* : Population of the pest was the highest during March. When the incidence of *H. armigera* was correlated with

weather parameters, only relative humidity showed significant negative correlation. Other parameters did show any significance on the population.

c. *Chrysodeixis chalcitis* : The incidence of this defoliator was low and did not cause significant loss. However, it could become important when it attacks the crop at early stage itself. Its highest numbers were recorded during November. There was no significant correlation between its incidence and the weather parameters.

d. *Liriomyza trifolii* : The population of leafminers increased with an increase in crop age. The lowest population was observed on 0-15 days old crop which increased thereafter. This could be due to (I) increase in availability of foliage with an increase in crop age; (ii) suitable nutritional quality or (iii) pest multiplication and consequent build up. Till date, no reports are available on this crop. Hence, this study seems to be a pioneer work in this line.

Different locations appear to have no influence on the pest incidence. However, very high population observed at Mundwad was due to high temperature and low relative humidity prevailing there which could be favourable to the leafminer buildup. This was evident from the relationship existing between the pest incidence and weather parameters. Population incidence had significant positive correlation with temperature and negative correlation with relative humidity. Similar observations were made by Jagan^{n}atha (1994) on both tomato and cucumber.

e. Aphids and Mites : Very high populations of these pests were observed during March and April. Relative humidity appeared to play a significant role in the incidence of these pests. Incidence of both the

pests showed an inclination to temperature though, statistical analysis revealed that it was not significant. This indicates that increased temperature as well as decreased relative humidity favour the pest buildup. The results are in conformity with those reported by York (1975), Butani (1975), Pareek and Kavadia (1994), Ali *et al* (1992) and Kim *et al.*, (1986).

5.4 Susceptible stage of the crop for *Diaphania indica*

Studies conducted at both the localities showed significant difference between crop age and pest population. Larval population was the highest on 60 day old crop compared to the younger crop. The reason could be that, as the crop grows, it produces more and more leaves, flowers, fruits and buds on which the pest feeds and may keep building up its population. Results are well supported by those of Bergonia and Cervancia (1992) who reported that arthropod population density on cucumber increased from seedling to vegetative plant stages and decreased as the crop senesced. In the present investigation, as there was no crop nearing senescence, decrease in population was not observed.

5.5 Biology of *Diaphania indica* on gherkins

Results of the study revealed that the egg, larval and pupal period lasted for 3.00 ± 0.46, 14.05 ± 0.50 and 11.63 ± 0.26 days. Adults survived for 7.50 ± 1.05 days and the male to female sex ratio was 1 : 0.14. Females laid eggs either singly or in groups of two or more.

The study clearly indicates that gherkin serves as an important host for the pest. The results are in conformity with studies

conducted on the biology of this pest on different host plants by several workers with slight changes (Patel and Kulkarni, 1956; Butani, 1975; Pandey, 1975; Ba-Angood, 1979 and Ke *et al.*, 1986). The duration of the developmental stages was similar to the observation made by Ba-Angood (1979) at temperature of 25-35.9 °c.

The egg, larval and pupal measurements are close to those measured by Patel and Kulkarni (1956). Further, the head capsule measurements of different larval instars, are supported by Peter and David (1990b).

Several workers have studied the biology of the melon worm, *D. hyalinata* and the pickle worm, *D. nitidalis*, two of the closest relatives of the pumpkin caterpillar, *D. indica*. Their biology as reported by Reid and Cuthbert (1956), York (1975), Elsey (1980), Mendes and Bert (1983) and Pena *et al* (1987a) is similar to that of *D. indica*.

5.5.1 **Comparative biology of different parts of gherkin**

No considerable difference in the total larval and pupal duration on different plant parts viz., leaves, flowers and fruits suggests that nutritional differences existing between the different plant parts do not influence the duration for completing the immature stages.

However, no larval mortality and complete pupation by the larvae was observed when reared on leaves. Those reared on flowers and fruits which showed 90% larval survival and 90% pupation in addition to varied difference in percent moth emergence and adult sex ratio suggest that leaves either possess wholesome nourishment needed by the larvae or lack any factor that might hinder the development.

Till date, there is no information on the biology of *D. indica* on different plant parts. However, some workers have conducted studies on the biology of this pest on different host plants and have attributed the changes to difference in nutritional status of the plant (Pandey, 1975 and Tripathi and Pandey, 1976).

An interesting observation made by Ba-Angood (1979) is that *D. indica* preferred *Cucumis melo* to *Citrulus vulgaris* and *C. sativus*. This change was attributed to the amount of food consumed, amount of faeces produced and finally the amount of food assimilated in the body. Assimilation was found to be more on *C. melo*. The differences in the development on different parts in the present investigation could also be due to similar reasons.

5.5.2 **Comparative biology on different cucurbits**

Results of the investigation indicated that larvae developed faster on gherkin followed by cucumber, chow-chow and coccinea. However, all the larvae that survived, pupated on cucumber as compared to other hosts. However, there was no change in pupal duration. This clearly shows that gherkin is an important host plant and is more susceptible than cucumber. However, same sex ratio on both gherkin and cucumber suggest that both gherkin and cucumber are equally susceptible to *D. indica*. However, all pupae, the larval stage of which was reared on coccinea, eclosed to adults while the least percent moth emergence observed on cucumber indicate to the possibility on the impact of nutritional variation between the crops on the emergence behaviour of the moths. Based on this, it is easy to classify gherkin and cucumber as most preferred and coccinea and chow-chow as less preferred hosts.

The respective male and female biased sex ratio on coccinea and chow-chow would only indicate to the physiological changes in the plant species and the differential bearing they have on the sex ratio.

Several workers have conducted studies on the biology and host preference of *D. indica* on different cucurbitaceous plants and no common consensus has been arrived especially regarding the preferred host. Pandey (1975) showed *Citrulus vulgaris* to be the most preferred. Similarly, cucumber (Tripathi and Pandey, 1976), ridge gourd (Krishnaprasad and Rai, 1978), *Cucumis melo* (Ba-Angood, 1979), *Benincasa hispida* (Ke *et al.*, 1988) and musk melon, long melon, water melon, pumpkin, squash and ivy gourd (Peter and David, 1990c) have been reported as the preferred hosts. Majority of the workers have attributed preference to the presence of nutrients. On the contrary, Ba-Angood (1979), attributed faster development of the larvae on *C. melo* to greater assimilation of food. Peter and David (1991c) did not find any significant difference in the development of larvae.

5.6 Nature of damage

Observations made on nature of damage by the larvae, larval behaviour, adult behaviour etc., on gherkins are in conformity with the observations made by several workers on different cucurbits (Patel and Kulkarni, 1956; Butani, 1975; Ke *et al.*, 1986 and Ba-Angood, 1979) where the larvae were generally feeding on leaves and they occasionally attacked fruits and flowers. However, Ba-Angood (1979) has observed this pest feeding largely on pumpkin fruits. The damage done by *D. hyalinata* and *D. nitidalis* is similar to that made by *D. indica* (Reid and Cuthbert, 1956 and Pena *et al.*, 1987a).

5.7 Gherkin fruit portion preferred by *D. indica*

Results did not show any significant preference of the larvae to the fruit portion. This suggests that the larvae donot discriminate the portion of the fruit. As and when it encounters the fruits, it starts feeding. This information would come handy while sorting out the damaged fruits in the processing unit during which time the entire fruit should by meticulously examined for damage.

5.8 Management of gherkin pests

5.8.1 *Diaphania indica*

Results clearly indicated that commercial and crude preparations of neem and honge proved ineffective against *D. indica* on gherkin. These have not been tried against this pest prior to this study. However, Dreyer and Hellpap (1991) reported that crude water extracts of neem had effectively controlled *D. hyalinata* on cucumber.

Phosalone was moderate in action whenever it was used except in one occasion where its effect was on par with carbaryl. Peter and David (1989) rated phosalone ahead of carbaryl against *D. indica*.

Dichlorvos and *Bacillus turingiensis* were moderately effective in curbing the pest population levels. Although these chemicals were moderately effective they are generally considered to be safe due to their action. On the contrary to the present investigation, Schreiner (1991) obtained effective control of *D. indica* by using *B. turingiensis*.

Bacillus turingiensis has also been widely used for the control of *D. hyalinata* and *D. nitidalis* (Delphanque and Greener, 1974 and 1975 and Webb, 1994).

Of the twelve chemicals tested, carbaryl (0.1%) and methomyl (0.05%) was a significant reduction in the larval population of *D. indica* in experiments wherever these two chemicals were used. The effect of these chemicals could be observed even on the next day after spray. In one of the experiments, it was found that when these chemicals were used, there was no significant build up of the larval population even at 17 days after spray. However, though not significant, there was slight buildup of the larval numbers from 13 days after spray. This suggests that spraying of these chemicals once every 15 days would provide an effective control of the pest.

It is evident from the present investigation that, the pest population is less on 0-15 day old crop and increases thereafter. Hence, spraying of recommended dose of carbaryl (0.1%) and methomyl (0.05%) once in 15 days from 15 days after sowing would be beneficial. This recommendation should be followed when the population is moderate and when the pest population is very high, insecticidal spraying should be commenced on a week old crop and later continued with an interval of 15 days.

Carbaryl and methomyl were effective only at recommended concentrations of 0.1% and 0.05% respectively. The same chemicals were effective for a short duration at lower concentrations (0.06% and 0.03% respectively). Later on the larval population increased. Several workers have obtained effective control of *D. indica* on cucumber and other related cucurbits by using carbaryl (Butani, 1975; Ito, 1984; Peter and David, 1989; Sorenson, 1993) and methomyl (Peter and David, 1989). Peter and David (1989) have found carbaryl to be more persistent than methomyl.

The same chemicals viz., methomyl, carbaryl and *B. turingiensis* have also been widely used for the control of *D.* hyalinata and *D. nitidalis* across the globe (Sarmiento and Zarate, 1973; Delphanque and Greener, 1974 and 1975; Perez *et al.*, 1982; Acosta *et al*, 1986; Lorini and Foerster, 1987).

Sorenson (1993) found residues of carbaryl on summer squash for just a day. Ahmed and Ismail (1995) concluded that residues of methomyl in cucumber remain for shorter period and have recommended an interval of 14 days between two sprays. Madan *et al* (1996) found methomyl in below detectable form after three days in bitter and smooth gourds. These studies suggest that both carbaryl and methomyl can be used on gherkin to effectively manage the pest. However, Bangerth (1990) reported that use of carbaryl, neem and ethephon affected polar transport system in cucumber fruits.

The method of spraying is an important aspect that should be borne in mind before tackling this pest using insecticides. As the pest resides on the under surface of the leaves, within bud cluster inside flowers often within the folds formed by webbing, should be targeted to these parts. The under surface of the leaf should be completely drenched and so also buds which harbour young larvae. Since this crop is highly cross pollinated spraying of insecticides should be done during late evening hours.

As gherkin is trailed vertically, the crop appears like a mat due to overlapping of leaves. Sufficient care should hence be taken while spraying to see that all the parts receive the chemicals spray.

5.8.2 **Leafminer, *Liriomyza trifolii***

Deltamethrin and NSKE in one experiment and deltamethrin and triazophos in another were the most effective chemicals against the serpentine leafminer. Infact in these treatments, there was very less build up of the miners when compared to other treatments. Lyra *et al* (1989) also reported deltamethrin to be effective chemical for the control of *L. trifolii.* Further, Richter and Tsegaye (1988) reported that deltamethrin was highly toxic to the larvae of *L. trifolii.* All these three chemicals were highly effective in reducing the populations of leafminers (Jagannatha, 1994). Various extracts of neem were fairly effective in controlling *L. trifolii* (Larew *et al.*, 1986; 1988; Lindquist, *et al,* 1986; Meisner, *et al,* 1986; Parkman and Peinkowskwi, 1990; Jagannatha, 1994). However, its commercial formulation nimbicidine was ineffective during the study period which did not agree with Stein and Parrella (1985).

Carbaryl and methomyl were ineffective against leafminers which was in agreement with the results obtained by Lyra *et al,* (1989).

Based on the results, it can be recommended that, fresh preparations of NSKE can be used and its usage should be encouraged. Triazophos and deltamethrin can also be used to control the leafminers but their use should be minimised on gherkins.

5.8.3 **Thrips, *Thrips palmi***

Results showed that dimethoate was superior to other chemicals tested against *T. palmi* on gherkin. However, cypermethrin and deltamethrin were also equally effective in reducing thrips

population. Honge Seed Kernel Extract (HSKE) and water sprays failed to control the pest. The population was less even in untreated check during second spray which was attributed to heavy rains that occurred two days before second spray. This suggests that heavy rains can control the pest effectively.

The results are in agreement with those of Morishita (1993) who obtained effective control of *T. palmi* on cucumber by using cypermethrin, fenourb and methidathion. Whereas, on the contrary, Stenseth (1986) reported that cypermethrin, fenvalarate, permethrin and deltamethrin did not give expected control of *T. palmi.*

5.8.4 **Aphids, *Aphis gossypii***

Phosalone and deltamethrin effectively reduced aphid population. There was no population throughout the cropping period in phosalone and deltamethrin treated plots. This indicates that these chemicals are highly effective in containing aphid populations. Dichlorvos was also effective in curbing the aphids. Carbaryl and nimbicidine were moderately effective. Results showed that phosalone and dichlorvos can be effectively used to control aphids. Further, these chemicals can also take care of *D. indica* when its population is at lower levels. Ohsawa and Watanabe (1987) and Kasem and Yakob (1985) have observed effective control of *A. gossypii* by using DDVP and phosalone respectively on cucumber.

5.9 Monitoring fruit fly, *Bactrocera cucurbitae* populations

Results clearly indicated that cue-lure in combination with dichlorvos was significantly superior over other traps in trapping fruit

flies. Similar results were obtained by several other workers who have been able to trap fruit flies in cucumber and other cucurbits using cue-lure (Batra, 1959; Steiner and Lee, 1954; Lall and Singh, 1965; Chu *et al*, 1994; Shelly and Villalobos, 1995: Liu and Chen, 1995).

Further, in the same experiment, traps placed in South-West (SW) and North-East (NE) direction trapped more number of flies than those placed in NW and SE. The difference among the two sets was significant. Further, interaction between the traps and the position was found to be significant. Cue-lure and dichlorvos placed in SW direction significantly trapped the largest number of flies. This shows that there is a positional effect. This effect could have been largely due to the direction of wind which predominantly blew from SW to NE during the study period. Thus, it can be hypothesised that fruitflies move upwind i.e., against the direction of dispersal of cuelure, and get trapped. Hence, to increase the effectiveness of trapping, traps should be placed in the direction of the wind flow at the course of the field. By increasing the number of traps in this direction, more number of flies can expected to be trapped.

Cuelure in combination with dichlorvos was the most effective in trapping large number of flies in all the experiments. Effectiveness of the attractant remained for two days, although trapping in low numbers was observed even after the fourth day. Replenishing or dispensing the attractant everyday trapped significantly high number of flies.

Yeast, molasses, fishmeal and fruit pulps and juices failed to attract fruitflies significantly, albeit a few flies, were trapped. Interestingly, some females were trapped by them (females were not

trapped by cue-lure). The consequence of this could be overwhelming as females can reduce the subsequent buildup of the population quite substantially.

There was no difference in the mortality of fruit flies when dichlorvos and methomyl were used with cue-lure suggesting that both are equally effective.

Cue-lure pellets was not as effective in trapping flies as liquid suggesting that liquid formulation could be releasing chemicals, to the atmosphere more easily than pellets.

Steiner and Lee (1954) reported 68-100% control of *B. cucurbitae* in Hawai in 28 months. Catches of *B. frauenfeldi*, as high as 99.9% was observed with cue-lure and the attraction significantly decreased after two months (Chu *et al*, 1994). Besides cuelure, other attractants like yeast hydrolysate, molasses, methyl eugenol, 4-(-p-hydroxyphenyl)-2-butanone have been used to attract fruit flies either solely or in combinations or with cue-lure (Steiner and Lee, 1954; Nishida, 1958; Beroza, *et al*, 1960; Doolittle, *et al*, 1970, Chu *et al*, 1994).

SUMMARY

VI. SUMMARY

The present investigation was carried out to study the incidence of insect pests on gherkin (*Cucumis anguria*), their seasonal incidence, distribution pattern of *Diaphania indica*, its biology on gherkin and other hosts, management strategies for the major pests and the loss caused by *D. indica*. The salient features of the investigation are listed hereunder :

Results of the study related to the distribution pattern of plant parts clearly indicated that leaves are more abundant followed by buds, flowers and fruits. Buds and flowers have very short life span while fruits are harvested every day when they are of 3-4 days old after fruit set when they are approximately 2-3 cm long. This would make the counts of these plant parts appear much lower at any given point of time, when compared with leaves that stay for a relatively longer time once they are put forth. In general, all the plant parts showed aggregated ($s^2/x > 1$) distribution pattern barring a few excepations. The trend was similar at both Hansbhavi and Lingapura.

Likewise, more number of larvae were observed on leaves when compared with buds, flowers and fruits (in descending order of infestation). Comparable with that of plant parts, larval distribution also showed aggregation ($s^2/x > 1$) pattern. This is attributed largely to the differences in the abundance of plant parts.

The number of larvae were comparitively more abundant in the top rather than the bottom subquadrat. Once again, the trends were similar at both the locations.

Although numerically, leaves supported maximum number of larvae , the number of larvae per unit plant part was altogether different. It was found that buds were proportionately most infested. This was followed by flowers, fruits and leaves in the same order, thus indicationg the larval preference.

The relationship between the abundance of larvae of *D. indica* in the bottom and top subquadrats showed a strong positive correlation. The number of larvae in the bottom subquadrats were more in the bottom subquadrats were more when compared with the top. This relationship was consistant at both the localities indicating that either of the subquadrats could be used for sampling of *D. indica* larvae of gherkins.

Results of nested Anova conducted to study the relative distribution showed that buds supported more number of larvae followed by flowers, fruits and leaves. The difference in the distribution of larvae between bottom and top subquadrats which were prominent at Lingapura and less so at Hansbhavi can be attributed to the crop age. At Hansbhavi, the crop was in its vegetative phase and hence contained more plant parts suitable for larval growth unlike at Lingapura where it was nearing senesence. Hence at Lingapura, the larvae present started clustering around the few suitable parts made available by the plants.

Results on evaluation of sampling plan by using mean number of larvae per subquadrat within a transect indicated that a sample size of 3-4 subquadrats (either bottom or top subquadrat) would be ideal for sampling *D.* indica larvae on gherkins.

Systematic and random sampling considering five quadrats (one transact) as one unit showed marginal variations in the mean

number of larvae per transect. The best-eye-fit curves showed that three transects would be an ideal sample size for an area of 0.2 hactres. The results were similar at both the localities. Finally, it is concluded that 3-4 subquadrats in a transect at random and three transects sampled systematically in an area of 0.2 ha gherkin field would be sufficient for sampling *D. indica* larvae on gherkins. Similar sampling procedures can be extended for other caterpillar pests as well.

Among the different pests observed on gherkins, *D. indica, Liriomyza trifolii, Bactrocera cucurbitae* were the most serious. The other pests observed were *Helicoverpa armigera, Chrysodeixis chlcitis, Aphis gossypii, Thrips palmi, Aspangopus janus, Spilothelus spondurus, Cletus sp., Geocoris sp., Nazara viridula,* and *Hypocitrus allata.*

Diaphania indica occurred in all the areas where gherkin was grown throughout the year. Its population varied with season and age of the crop. It reached its highest in number during June-October while peaking at August. The lowest population for the same was recorded during February. Population fluctuation was similar during both the years. During 1996, incidence in the population was observed during October and in contrary to the previous year, it reached its maximum during January. This change in population was attributed to weather parameters. Pest incidence showed negatively correlated with temperature but was non-significant and positively correlated with relative humidity which was found significant.

When considering the age of age crop it was found that the pest population was less on 0-15 day old crop while it was highest

on 16-30 day old crop. Thereafter, the population tended to decline. Increase in incidence was mainly due to profuse growth of the plant which provided enough food for the pest. Decrease in the population after 30 days was mainly due to the spraying of the insecticides. The pest population varied with locations but it was apparent that localities did not have any influence on the pest incidence.

The population of *Helicoverpa armigera* maintained a general low level in all the location observed during the study. This indicated that the pest is not serious on gherkins. However, the pest occurred throughout the year, maximising in number during March in 1996. Its incidence was negatively correlated with mean relative humidity.

The serpentine leafminer, *Liriomyza trifolii*, was one of the serious pests of gherkin recorded during the study. Highest proportions of its population was observed during February - March maximising during March. Minimal numbers was recorded during July. The population again tended to incline late in the season during July. This was because the pest preferred higher temperatures and lower relative humidity which was evident.

The incidence of leafminers was severe during 1996 particularly during March. However, during January 1997 highest ever population was recorded which precariously dropped during February which was due to higher temperatures prevailed during those periods.

The pest population increased as the age of the crop progressed. The lowest population was recorded on 0-15 day old

crop which generally increased with the age of the crop which increased thereafter. However, in some of the localities, the population decreased even in older crop. Increased population level was mainly due to the availability of the food and its decline in older crop was due to spraying of insecticides.

Locality did not have any impact on the population incidence. The highest ever record of population at Mundwad during January was due to higher temperatures whereas subsequent decrease in the next month was due to the removal and burning of the affected leaves.

The semilooper, *Chrysedeixis chalcitis* population was not of any serious consequence. However, the population attained its maximum during October. It was absent during February, April and June.

The population score of aphids *Aphis gossypii*, was highest during March which gradually declined till January. Lowest population was recorded during April and August. The population incidence was high whenever there was decrease in humidity indicating its preference to dry conditions.

Population of the spider mite, *Tetranychuis* sp was high during February-May. It attained its maximum level during April. Population of mites also showed significant negative correlation with the relative humidity which indicated that these also prefer dry conditions.

Caterpillars of *D. indica* attacked almost all parts of the vine. They usually remained on the undersurface of the leaves. Feeding

led to skelitanisation which imparted a papery appearance to the leaves. often, caterpillars folded the leaves and remained inside.

Caterpillars devoured the fruits either completely or partly. Early instars occasionally attacked very young fruits of one day old. Flowers and buds also did not escape the attack of caterpillars. Early instar caterpillars were observed to attack buds in large numbers.

All the larval instars produced silk. However, late instar larvae used it for webbing the part of the vine on which they attacked.

Larvae of *H. armigera* attacked both fruits and flowers and ate them either partially or completely.

All the larval instars of *C. chalcitis* attacked only leaves.

The maggots of *L. trifolii* made extensive mines in the leaf feeding upon the mesophyll tissues. The mines were irregularly curved and appeared contorted.

Feeding by aphids led to curling and crumpling of leaves. Feeding by mites led to the formation of yellow specks on the upper surface of the leaves.

The study on biology of *D. indica* on gherkin leaves revealed that egg, larval and pupal periods were 3, 14.5 and 11.6 days respectively. All the larvae pupated and eclosed to give male biased sex. Adults survived for 7.5 days. This clearly indicated that gherkin is also one of its important host.

Each female laid 28.5 eggs per day either singly or in groups of two or more.

There was no significant difference in the total larval duration and percent pupation on different parts of gherkin. This was attributed to nutritional status of the plant which could be equal in all the parts. However, minute change could have affected the sex ratio on flowers and fruits. In general, leaves proved to be the best part for the larvae.

Study on comparative biology of *D. indica* on different cucurbits showed significant difference in the larval duration among different cucurbitaceous fruits considered for the study. The larval duration was significantly high on coccinea followed by chow-chow, cucumber and gherkin. All the larvae survived on cucumber when compared with other hosts. There was no significant difference in the pupal duration. All pupae eclosed to adults when reared on cocinea. Male to female adult emergence ratio was equal when larvae were reared either on gherkin and cucumber. However, it was respectively male and female biased on coccinea and chow-chow.

Both gherkin and cucumber are equally preferred by the larvae than the other two which may be because of their equal nutritional status.

There was no significant difference in the larval numbers/m2 between calypso and nun varieties of gherkin crop suggesting larvae does not distinguish the varieties.

The population of larvae significantly increased with the crop age in both the localities. Its highest population was recorded on 60 days old crop which indicated that the crop provides more and more food for the larvae as it grows old.

Portion of the fruit did not seen to have a significant bearing on the larval preference. This suggested that the larvae donot discriminate the portion of the fruit.

Percent fruit damage was significantly reduced in carbaryl and methomyl treated plots followed by dichlorvos, phosalone, NSKE and *Bacillus thuringiensis*. Percent fruit damage was reduced three days spray. Carbaryl and/or methomyl can be used to reduced the percent fruit damage.

In all the experiments conducted, carbaryl (0.1%) and methomyl (0.05%) were highly efficient in reducing the population of *D. indica* when compared to other chemicals that were tested. There was no significant buildup of the pest population even at 17th day after spray. However, the same chemicals at lower concentrations were effective only for a shorter period.

Phosalone, dichlorvos and *B. thuringiensis* controlled the population moderately. The plant products were not very effective in curbing the pest population.

Triazophos (0.05%), deltamtethrin and NSKE (4%) significantly effective in controlling the leafminer population.

Phosalone and deltamethrin effectively controlled aphid population.

Population of thrips was significantly reduced by dimethoate and cypermethrin.

Experiments involving fruit flies revealed that cue-lure was the most efficient attractant, with water and chemical insecticide, which trapped them in large numbers. Traps placed at SW and NE position trapped more number of firuit flies as fruit flies moved against wind and got trapped. Fruit pulps and juices though were successful in trapping fruit flies, the numbers was meager. Fish meal and molasses failed to attract flies.

Both dichlotvos and methomyl killed the fruit flies when used with cuelure.

Daily replacement of cuelure increased efficiency of trapping fruit flies. Hence, for monitoring purpose cue-lure should be replenished every day.

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* original not seen

APPENDIX

APPENDIX-1

Months	Mean Max. Temp. (c)		Mean Min. Temp. (c)		Total Rain Fall (mm)		Mean Relative Humidity (%) at 0830 hrs	
	1995	1996	1995	1996	1995	1996	1995	1996
Bangalore								
January	26.8	28.5	16.2	15.5	18.5	0	87	79
February	30.5	30.4	18.1	16.4	0	0	84	82
March	32.3	33.8	19.4	19.5	16.5	0	69	67
April	33.6	33.5	22.0	21.8	33.8	90.8	77	79
May	31.4	35.2	21.3	21.7	147.7	117.6	82	78
June	30.5	29.4	20.8	20.4	95.6	228.2	86	87
July	27.7	28.8	20.1	20.1	107.7	51.0	89	86
August	28.1	27.5	20.3	19.7	237.1	302.9	90	89
September	28.2	27.9	19.9	19.9	251.6	275.8	88	90
October	28.0	27.7	19.8	19.3	155.1	83.8	87	86
November	28.6	27.8	18.6	17.9	13.1	1.4	78	79
December	27.7	25.8	14.8	16.0	0	2.8	77	82
K.G.F.								
January	25.7	27.3	15.5	14.0	6.2	0	81	75
February	30.0	29.3	16.6	15.2	0	0	74	71
March	32.3	33.5	18.2	17.3	22.2	0	58	47
April	34.1	33.4	20.7	20.5	25.6	108.4	67	71
May	31.6	36.0	21.0	21.6	239.8	75.2	74	62
June	31.6	30.2	21.0	20.1	33.8	210.4	74	76
July	29.6	29.8	20.0	19.8	39.0	25.2	77	76
August	29.6	28.7	19.9	19.3	205.6	197.2	81	80
September	29.4	27.8	19.5	19.2	97.6	395.4	81	87
October	28.3	27.2	19.2	18.1	117.2	65.6	82	83
November	27.5	26.3	17.6	16.9	122.2	23.6	80	77
December	26.0	23.9	14.1	14.9	0	116.4	79	82
Gadag	1997							
January	28.8		16.2		0		69	
February	32.6		16.1		0		43	