DEVELOPMENT OF INTEGRATED PEST MANAGEMENT ON BHENDI

Thesis submitted in partial fulfillment of the requirements for the award of the Degree of **DOCTOR OF PHILOSOPHY in AGRICULTURAL ENTOMOLOGY** to the Tamil Nadu Agricultural University, Coimbatore.

By

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CERTIFICATE

This is to certify that the thesis entitled **"Development of Integrated Pest Management on Bhendi"** submitted in partial fulfillment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURAL ENTOMOLOGY)** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Mr. M. CHANDRASEKARAN** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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Abstract

ABSTRACT

DEVELOPMENT OF INTEGRATED PEST MANAGEMENT ON BHENDI

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Detailed investigations on the ovicidal action and ovipositional deterrent effects of neem products against the fruitborer, *Earias vittella* Fabricius, effects of *B.t* products on the mortality of larvae of *E. vittella*, mechanism of resistance/ susceptibility of bhendi entries, persistent toxicity of certain insecticides, evaluation of neem products, *B. t.* formulations, insecticides, different levels of N, P and K fertilizers and development of an IPM for the management of major pests of bhendi were carried out in the Department of Agricultural Entomology. Tamil Nadu Agricultural University, Coimbatore.

Ovicidal action and ovipositional deterrent effects of neem products against *E. vittella* showed that Neemazal - F (1 ml/lit) and TNAU NO 60 EC (c) (30 ml/lit) were highly effective in causing higher mortality of eggs (44 to 54%), deterring the egg laying (< 25 eggs / fruit) and reducing the hatchability of eggs (< 65%).

B.t. products Delfin and Biobit @ 2 g lit^{-1} registered more than 95 per cent mortality of larvae of *E.vittella* within four days after treatment when compared to Spicturin.

Out of six bhendi entries screened, OHD-1, COOH-1, Varsha Uphar and Arka Anamika recorded less population of aphid, leafhopper and whitefly, less fruitborer damage, higher trichome density per sq. cm., greater plant height, higher fruit yield per plant, more length, girth and weight of individual fruit conferring their resistant / moderately resistant status when compared to the susceptible entries MDU-1 and Pusa Sawani against major pests of bhendi.

Experiment conducted on persistent toxicity of insecticides against sucking pests of bhendi revealed that imidacloprid 200 SL (0.004%) and acephate 75 SP (0.11%) were found to persist 19 and 21 days, 19 and 17 days and also 17 and 19 days for aphid, leafhopper and whitefly respectively.

The results obtained from the field experiment on evaluation of neem products and insecticides against sucking pests showed that the neem products Neemazal-F (1ml/lit) and TNAU NO 60 EC (c) (20 ml/lit) and the insecticides imidacloprid 200 SL (0.004%) and acephate 75 SP (0.11%) gave higher per cent reduction in population of aphid, leafhopper and whitefly with increased fruit yield and high CBR.

With reference to the evaluation of different *B.t.* formulations and insecticides against *E. vittella,* the results indicated that the *B. t.* products *viz.,* Delfin and Biobit @ 2g lit^{-1} and the insecticides, endosulfan 35 EC (0.07%) and triazophos 40 EC (0.08%) were found to be highly effective in reducing the fruitborer damage and realising increased fruit yield with high CBR.

The most effective neem products, *B.t.* formulations and insecticides against major pests of bhendi mentionted above were also found to be safe to predators like coccinellids, spiders and chrysopid as evidenced by the highest survival rate after these products were used under field conditions.

Experiment conducted on impact of different levels of N, P and K fertilizers revealed that the treatment with increased dose of 'K' application along with recommended dose of 'N' and 'P' (40 : 50 : 45 kg ha^{-1}) registered lesser population of aphid, leafhopper, whitefly and less fruitborer damage with maximum fruit yield and high CBR proving its supremacy over other treatments.

Based on the yield, CBR and per cent reduction of sucking pests and fruitborer damage, the suitable IPM package developed out of eight different combination of treatments consisted of the following practices *viz.,* basal application of high dose of 'K' (45 kg ha^{-1}) with recommended 'N' (40 kg ha^{-1}) and 'P' (50 kg ha^{-1}), spraying of Neemazal-F (1ml/ lit) / TNAU NO 60 EC (c) (20 ml/lit) at 50 per cent ETL and imidacloprid 200 SL (0.004%) / acephate (0.11%) at 100 per cent ETL against sucking pests, release of egg parasitoid *Trichogramma chilonis* Ishii @ 50,000 ha^{-1} at flowering stage and spraying of Delfin / Biobit @ 2g lit^{-1} and triazophos (0.08%)/endosulfan (0.07%) at 5 and 10 per cent fruit damage respectively against the fruitborers.

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(M. CHANDRASEKARAN)

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Introduction

1. INTRODUCTION

Bhendi, *Abelmoschus esculentus* (L.) Moench, which belongs to the family Malvaceae is one of the world's oldest cultivated crops. The first record was made by the Egyptians in 1216 A.D., although the plant explorer Vavilov indicated that the crop flourished even before that date in the tropical climate of Ethiopia, while others had identified it's origin as India.

In India, bhendi is cultivated in almost all the states and its largest producers are Bihar, Orissa, West Bengal, Assam, Andra Pradesh and Karnataka. The area under bhendi cultivation in India is 4.31 lakh hectares and its' production is 40.33 lakh tonnes with an average yield of 9.36 tonnes ha^{-1}. In Tamil Nadu, it occupies an area of 4335 hectares with production of fruits upto 38,020 tonnes (Anon., 1999).

Bhendi is ravaged by many insect pests right from germination of seeds to harvest of fruits. In the early stage, sucking pests like the aphid, *Aphis gossypii* Glover, the leafhopper, *Amrasca biguttula biguttula* Ishida and the whitefly *Bemisia tabaci* Gennadius desap the leaves and in later stage, the fruitborers, *Earias vittella* Fabricius and *Earias insulana* Boisduval cause extensive damage to fruits, resulting in 69 per cent reduction in yield (Rawat and Sahu, 1973). Farmers rely solely on the chemical insecticides for the management of pests of bhendi because of easy adaptability, immediate and spectacular knockdown effects of pesticides on insects (Pawar *et al.,* 1988; Verma, 1989). Despite these credentials, continuous use of chemical insecticides has been found to be ecologically unsafe and indiscriminate use of insecticides has resulted in development of resistance by insects to insecticides, resurgence of primary pests, upsurgence of secondary pests, inimical to predators and parasitoids, accumulation of pesticides residues in fruits (Mitra *et al,* 1999), break-down of food web in natural ecosystem (Krishnamurthi, 1999) and environmental pollution (Mahapatro and Gupta, 1998).

The problems of pest control, concern on over-reliance and unilateral use of pesticides in our environment have been the subject of intense debate during these days. Agenda 21 of the United Nations Conference of Environment and Development (UNCED) at Rio de Janeiro in June, 1992 pinpointed the Integrated Pest Management (IPM) as one of the requirements for promoting sustainable agriculture and rural development. The basic concept of IPM is to make need based use of pesticides instead of indiscriminate use of chemicals (Mahapatro, 1999). Bio-rational pesticides encompassing the botanicals and microbials have been identified as ideal components of IPM (Singh, 1996; Ramarethinam, 1998; Kumbhar *et al.,* 2000).

Realising the gaining importance of IPM for sustainable development of crops, the following investigations were under taken on bhendi to develop an IPM package for adoption by the farmers.

- To study the ovicidal action and ovipositional deterrent effect of neem products against *E. vittella.*
- To study the effect of *B. t.* products on mortality of larvae of *E. vittella.*

- To study the mechanisms of resistance / susceptibility of selected bhendi entries to major pests of bhendi.
- To study the persistent toxicity of insecticides against sucking pests of bhendi.
- To study the efficacy of different neem products, *B.t.* formulations and insecticides against major pests of bhendi.
- To study the impact of N, P and K fertilizers on major pests of bhendi and
- To develop an IPM model/package on bhendi for its sustainable production and productivity.

Review of Literature

2. REVIEW OF LITERATURE

The literature pertaining to the management aspects of bhendi insect pests reviewed in relation to the present investigation *viz.*, "Development of Integrated Pest Management on Bhendi" has been presented here under.

2.1. Ovicidal action of neem products

Saxena *et al.* (1981) reported that dipping the eggs of rice leaf folder, *Cnaphalocrosis medinalis* Guenee in to neem oil prevented hatching to an extent of 30-50 per cent. Koul (1984) and Dorn (1986) found that azadirachtin, an isolate of neem seed had ovicidal activity against the eggs of *Dysdercus koenigii* F.

Venkateswarulu (1988) found that neem oil had ovicidal action on *Spodoptera litura* Fab. and *Pericallia ricini* F. on blackgram. Mallikarjunappa (1989) reported that Neemark had high ovicidal activity against the eggs of *Adisura atkinsoni* Moorei on field bean.

Schmutterer (1990) found that extracts from seeds of neem tree, *Azadirachta indica,* A. Juss possessed toxic, antifeedant, repellant, growth regulating and fecundity reducing properties for various insects. The fly species (Stark, 1990) and *Plutella xylostella* L. (Friend, 1998) were failed to enclose after the larvae treated with ten per cent neem seed kernel extracts.

2.2. Ovipositional deterrent effect of neem products

Two per cent neem seed kernel suspension in water, proved as an effective repellant and ovipositional deterrent to the moths of tobacco caterpillar, *S. litura*

(Joshi and Sitaramaiah, 1979). Fagoonee (1981) found that oviposition by gravid female of cabbage leaf webber, *Crocidolomia binotalis* Zeller was deterred by NSKE at two per cent both in the laboratory and field experiments.

Saxena and Rembold (1984) reported that neem seed oil acted as a contact ovipositional deterrant but not as a repellant to *Heliothis armigera* Hubner females.

According to Sharma *et al.* (1984) neem had high ovipositional deterrent activity against the adults of potato tuber moth, *Phthorimoea operculella* Zeller. Hellpap and Mercado (1986) found that oviposition by females of *Spodoptera frugiperda* Hb. was fifty per cent lower on neem treated cloth under normal conditions.

Ayyangar and Rao (1989) reported that both methanol and hexane extracts of neem seed kernels exhibited ovipositional deterrency against *S.litura*, the former being more deterrent at a lower concentration when compared to the latter.

Chandramohan and Nanjan (1992) found that a neem oil product 'Biosol' (0.4%) was 3 to 4 times more efficacious in oviposition deterrency against *P. xylostella* compared to garlic sprays at 2.5 per cent. The ovipositional deterrency effect of neem seed kernel solution and Neemark on *Earias vittella* Fabricius and *S. litura* was experimentally proved by Sojitra and Patel (1992) and Patel and Patel (1998) respectively.

The azadirachtin enriched neem oil formulation Neemolin (1%) treated groundnut leaves were less preferred by *S. litura*. The percentage of larval settlement, subsequent feeding and number of eggs laid by *S. litura* were more on untreated control when compared to Neemolin sprayed plants (Singh, 1996).

Oviposition by citrus leafminer, *Phyllocnistis citrella* Stainton moths was the least on Kagzi lime seedlings when treated with Achook (0.4%) compared to neem seed kernel extract (Patel and Patel, 2000).

2.3. Resistance of bhendi varieties/cultivars to major pests

The cultivars Sel 6-2 and Pusa Sawani, recorded less reduction in yield due to fruitborer incidence (Raut and Somone, 1979 and Mote, 1982). Uthamasamy and Subramanian (1985) reported that the okra variety AE 22 found resistant to the leafhopper, *Amrasca devastans* Distant was crossed with the susceptible variety Pusa Sawani. The F_1 plants were highly susceptible and F_2 plants were segregated in a 3:1 ratio of susceptible to resistant plants. Single gene was involved in the inheritance of resistance.

Among the 33 okra genotypes screened, the least affected by fruitborer (on number basis) was Sel.1 (3.8%) and Sel.10 exhibited higher infestation (38.7%) (Sardana and Dutta, 1989).

Vyas and Patel (1990) reported that among the six bhendi varieties screened, maximum larval mortality of *Earias vittella* (78%) was recorded in Gujarat Okra.1 and minimum (46%) on Pusa Sawani.

Mahal *et al.* (1991 and 1993) reported that the development of leafhopper took longer time and survival was reduced on the resistant okra varieties IC 7194 and New selection as compared to Pusa Sawani.

Mazumdar *et al.* (1996) found that overall preference of whitefly was less and its population was comparatively low on Parbhani Kranti and M-31 than on Pusa Sawani.

2.4. Persistent toxicity of insecticides

Sandhu and Harcharan (1975) reported that dimethoate 30 EC at 0.187 kg a.i/ha was the most persistent against the cotton aphid followed by malathion 50EC at 0.5 kg a.i./ha.

Subbaratnam and Butani (1984) found that fenvalerate (0.04%) had high initial and prolonged persistent toxicity, followed by fenvalerate (0.02%), phenthoate (0.1%), quinalphos (0.1%) and fenitrothion (0.1%) against jassid *Amrasca biguttula biguttula* Ishida on brinjal.

Investigations by Bohade *et al.* (1987) revealed that monocrotophos 36 WSC (0.05%), dimethoate (0.05%) and formothion (0.05%) persisted for a longer duration when compared to endosulfan (0.05%) against cotton aphid, *Aphis gossypii* Glover. On bhendi, monocrotophos 36 WSC (0.06%) exhibited excellent results and was highly persistent followed by phosphamidon (0.03%) and dimethoate (0.03%) against the aphid.

Kumar and Santharam (1999) observed that the persistence of imidacloprid 200SL at 100 ml ha^{-1} was 30 and 22 days and that of methyl-o-demeton at 500 ml ha^{-1} was 18 and 14 days against leafhoppers and aphids on cotton respectively.

Ramesh Babu and Santharam (2000) studied the persistent toxicity of imidacloprid 200 SL foliar spray against aphids and leafhoppers on groundnut in comparison with methyl-o-demeton. They reported that imidacloprid spray both at 100 and 150 ml ha^{-1} persisted for 23 days against aphids and for leafhoppers it was 29 and 31 days at 100 and 150 ml/ha respectively while methyl-o-demeton at 500 ml ha^{-1} persisted for 15 days against aphids and 17 days against leafhoppers.

Vijayalakshmi *et al.* (2000) found that triazophos 40 EC @ 350 g a.i. ha^{-1} and 700 g a.i. ha^{-1} persisted upto 5 and 10 days respectively on bhendi fruits.

2.5. Efficacy of neem and neem based products against certain pests

2.5.1. Aphid, *Aphis gossypii* Glover

According to Jotwani and Srivastava (1981), neem oil one per cent was quite effective against *A. gossypii* on bhendi. Neem oil at 0.05 per cent effectively reduced the population of *A. gossypii* on cotton (Natarajan *et al.*, 1991). Neemrich 80 EC at 0.8 per cent resulted in 84 per cent mortality of *A. gossypii* on cotton (Bhatnagar and Kandasamy, 1993).

Nimbalkar *et al.* (1994) found that combination spray of Neemax and monocrotophos 36 SL was quite effective against *A. gossypii* on okra.

Peter (1994) reported that, Neemazal - F containing five per cent azadirachtin was compatible with endosulfan 35 EC which were effective against aphids on cotton. Spraying of neem oil at one per cent followed by neem seed kernel powder 10 per cent treatment offered best control of aphids on tea (Bisen and Goshhajra, 1995).

Kulat *et al.* (1997) reported that seed extracts of *Azadirachta indica* (5%) gave similar level of control as compared to endosulfan (0.07%) against *A. gossypii* on okra.

2.5.2. Leafhopper, *Amrasca biguttula biguttula* Distant

Jayashree (1984) reported that the leafhopper population was effectively controlled by spraying with neem oil + karanji oil at three per cent followed by neem oil at three per cent concentration. Mohan (1988) found that spraying of NSKE at five per cent, resulted in maximum reduction in population of brinjal aphid and leafhopper.

Sardana and Krishnakumar (1989) and Rao *et al.* (1993) opined that spraying of Neemark, Repelin and neem oil, all at one per cent concentration failed to provide any significant control of leafhopper population on okra when compared to endosulfan 35 EC (0.07 %) spray under field condition.

Kumar (1996) reported that though the population of brinjal leafhopper was reduced immediately after spraying Neemazal-F (0.1%), the population shot up again within a week. NSKE (5%) and neem oil (3%) were found to be quite effective in controlling bhendi leafhopper (Vidya *et al.*, 1993). Neem oil at two per cent was also effective against the okra leafhopper (Brar *et al.*, 1994).

According to Udaiyan and Ramarathinam (1994), formulated products of neem derivatives could control the leafhopper on bhendi, as effectively as chemical pesticides *viz.*, monocrotophos (0.02%) dichlorvos (0.02%) and phosalone (0.02%) through frequent sprays, but neem extract as oil, did not have much efficacy as that of formulated neem derived products. The growth inhibitory effect of NSKE on okra leafhopper was also proved by Patel and Patel (1996).

2.5.3. Whitefly, *Bemisia tabaci* Gennadius

NSKE at 5 per cent reduced the whitefly egg viability, oviposition, prolonged larval period and increased larval mortality on cotton (Coudriet *et al.* 1985) and on bhendi (Kathirvel, 1988).

Flint and Parks (1989) reported sixty per cent reduction in population of whiteflies on cotton after the application of aqueous sprays containing 160 ppm of azadirachtin. Considerable reduction in nymphal and adult population of *B. tabaci* on cotton was effected by neem oil 0.5 per cent and NSKE 5 per cent and were as effective as endosulfan 35 EC (0.07%) (Nimbalkar *et al.*, 1990a).

Neem oil and NSKE each at three per cent concentration were found to be successful in controlling the adult whitefly population on tapioca (Kirubavathy *et al.*, 1999) and on cotton (Hadimani and Sannarveerappanavar, 1999).

2.5.4. Fruitborer, *Earias* spp.

According to Pathak and Krishna (1986) copulation between normal females and males exposed to neem oil vapour resulted in a relatively greater decline in the deposition of fertile eggs. Samuthiravelu and David (1987) found that neem oil 0.30 and 0.50 per cent reduced the survival and fecundity of *E. vittella* adults respectivley. Neem oil at 0.5 per cent alone and combination of neem oil (0.5%) with deltamethrin (0.09%) were effective in minimizing the shoot, square and boll infestation due to *E. vittella* (Samuthiravelu and David, 1990). Neem and karanji seed extracts (5%) and neem oil (3%) treatments recorded lower infestation by bollworms on cotton (Nimbalkar *et al.*, 1990b).

Samuthiravelu and David (1991) proved that neem oil at 2 per cent alone or at 0.5 per cent with endosulfan 0.035 per cent was quite effective against *Earias* spp. on okra.

Patel and Sojitra (1993) reported that three sprays of Repelin at ten per cent effected upto 73.26 per cent reduction in shoot and fruit damage by *E. vittella*. Sharma and Singh (1993) found that Achook, Neemguard and Neemark at 5 kg/ha were effective in controlling *E. vittella*.. NSKE 5 per cent alone and its combination with either malathion (0.025%) or endosulfan (0.035%) exhibited significantly reduced fruitborer damage on okra (Sarode and Gabhane, 1994).

Ganesan *et al.* (1995) found that seed extracts of custard apple, mahua and jatropha (each at one per cent concentration) alone and in combination with neem affected the *E. vittella* larvae either by direct kill or interference with its metamorphosis.

Shukla *et al.* (1996) recorded 64.43 and 64.04 quintals of healthy okra fruits per hectare in malathion (0.05%) and neem oil (1%) treated plots respectively as against 51.12 q/ha in untreated check.

According to Kumar and Sundarababu (1999) Neemazal-F (5%) @ 1 ml/lit was the most potent antifeedant against sphingid, *Acherontia styx* W. larvae with 97.40 per cent protection on brinjal. In the field experiment conducted against *H.armigera* on pigeonpea, neem oil based EC formulation (1500 ppm), neem oil (300 ppm) and solvent based NSKE EC (1500 ppm) showed 16.67, 19.67 and 21.33 per cent mortality of *H. armigera* on 72 hours after treatment (Rao *et al.*, 1999).

Singh and Varatharajan (2000) recorded varying degrees of malformations in Bihar hairy caterpillar *Spilosoma obliqua* Wlk. when treated with Neemazal - T/S (azadirachtin -1% EC) at the concentrations of 0.25 per cent to 0.4 per cent. Feeding inhibition and deterrency effect of neem oil based EC formulations containing 0.03 per cent azadirachtin against *H. armigera* was experimentally proved by Ramerethinam *et al.* (2000).

2.6. Microbial control of pests with *Bacillus thuringiensis* Berliner

The world market for biopesticides is dominated by *B. thuringiensis* (*B.t.*) (80%) followed by entomophilic nematodes (13.3%) and others (6.7%) (Easwaramoorthy, 2000). *B.t.* with its different varieties were tested for their pathogenicity against more than 137 species of insects belonging the orders Lepidoptera, Hymenoptera, Diptera and Coleoptera (Heimpel, 1967; Feitelson *et al.*, 1992).

Weekly sprays of Dipel (*B.t.* var *kurstaki*) at 0.5 kg/ha reduced the fruit infestations by *E. vittella* on okra (Taylor, 1974; Krishnaiah *et al.*, 1981).

Panchabhavi and Sudhindra (1994) reported that a *B.t.* based formulation Halt (*B.t.* var k*urstaki*) significantly reduced the damage to fruiting bodies by *Earias* spp. to an extent of 50-60 per cent on cotton when applied @ 1.5 kg/ha.

The granular feeding baits containing a combination of *B.t.* var. k*urstaki* and *B.t.* var *aizawai*, when applied on cotton was more effective than *B.t.* var k*urstaki* (Dipel) spray against *E. insulana* (Navon *et al.*, 1997).

Satapathy and Panda (1997) reported that Biolep (*B.t.* var k*urstaki*) was more effective than Bioasp (*B.t.* var k*urstaki*), when applied both @ 1 kg/ha against *Earias* spp. Kharbade *et al.* (1998a & b) found that the *B.t.* based insecticides Dipel, Delfin and Halt, all @ 2 g lit^{-1} proved to be highly pathogenic to *E. vittella.*

Delfin 50 WG @ 0.5 kg/ha and 1 kg/ha was found to be superior in controlling the larvae of diamond back moth *P. xylostella* L. on cabbage (Tambe *et al.*, 1997; Kulkarni *et al.,* 1999) and *E. vittella* on bhendi (Kharbade *et al.*, 1999) by recording lesser damage and higher yield.

According to Mahpatro and Gupta (1999 a and b) spraying of Biobit (*B.t.* var k*urstaki*) @ 1.5 kg ha^{-1} at evening hours (6 pm) resulted in very effective control of *E. vittella* on okra and avoidance to the *B.t.* treated okra fruits by the fruitborer was also increased with an increase in the *B.t.* concentration. Chandra *et al.* (1999) observed that the higher concentration of Biobit was found to be associated with reduced population, higher pupal mortality and lower emergence of normal adults in *H. armigera.*

Patel and Vyas (1999) reported that *B.t.k.* was compatible with cypermethrin and spraying of this combined products enhanced the mortality of *E. vittella*.

2.7. Role of entomophages in suppression of bhendi pests

2.7.1. Aphid, *A. gossypii*

The predator, *Coccinella transversalis* Fab. has been reported to feed on 15 different aphid species in India and considered as an important natural biocontrol agent on aphids (Rao, 1969; Tao and Chiu, 1971; Singh and Singh, 1985; Ghosh and Chakrabarti, 1986). The number of aphids consumed by the coccinellid is dependent on size and species of aphids and on the stage of the coccinellid. The third and fourth instar grubs of coccinellids consumed more number of aphids on bhendi (Olszak, 1988). The green lacewing *Chrysoperla carnea* Stephen consumed aphids of different species ranging from 374 to 419 in its life period of 12-15 days (Balasubramani, 1991). *C. carnea* was known to consume about 400 aphids at a temperature of 20 - 25°C during its life span of 12-15 days (Javansteenis, 1992). The population of *Coccinella septumpunctata* Linn. and *C.carnea* was increased with the increased aphid population (Atakan and Ozgur, 1996).

2.7.2. Leafhopper, *A. biguttula biguttula*

Chrysopa spp. were reported to feed on *A. biguttula biguttula* (Singh *et al.*, 1993; Balasubramanian and Swamiappan, 1994). Vennila (1998) reported the relationship between sucking pests (*A. biguttula biguttula*; *A. gossypii*) and their predators (*Cheilomenus sexmaculata* Fabricius; *C. carnea*) on cotton.

2.7.3. Whitefly, *B. tabaci*

B. tabaci, has been preyed upon by many species of chrysopids *viz.*, *Chrysopa cymbele* Stephen, *Chrysopa flavifrons* Brauer, *C. carnea* and *Nineta (Chrysopa) flava* (Scap.) on cotton (Or and Gerling, 1985; Gerling, 1986).

Abdel-Gawaad *et al.* (1990) recorded *Coccinella undecimpunctata* L. and *C. carnea* as natural enemies of *B. tabaci* on various host plants. The larvae of *Mallada boninensis* Okamato, a chrysopid predator consumed 453 nymphs of whiteflies (Joshi and Yadav, 1990).

Rodriquez - Rodrigez *et al.* (1994) reported that in fields where IPM was practiced, *Eretmocerus mundus* (Mercet) and *Encarcia lutea* (Masi) were recorded but *E. mundus* was the predominant species,. and wherever chemical control methods were adopted, no parasitoids could be observed on vegetable crops.

2.7.4. Fruitborers, *Earias* spp.

Hanumamna *et al.* (1984) reported that eggs of *E. vittella* were parasitized by *Trichogramma chilonis* Ishii, in the laboratory and the percentage of parasitism was 89.39. Naganagoud and Thontadarya (1984) found that *Trichogramma achaeae* Nagaraja and Nagarkatti and *T. chilonis* parasitized the eggs of *Earias* spp. on cotton and okra, to an extent of 23.44 and 14.87 per cent respectively.

According to Pawar and Prasad (1985), parasitism by *Bracon kirkpatricki* (Wilk.) and *Chelonus blackburnii* Cam. was 15.0 and 5.6 per cent respectively while the egg parasitism by *Trichogramma brasiliensis* (Ashmead) was 25 per cent.

Prasad *et al.* (1985) stated that *T. brasiliensis*, *Trichogramma pretiosum* Riley, *T. achaeae* and the *C. blackburnii* and *B. kirkpatricki* effectively controlled the fruit borers, *E. vittella, E. insulana* on bhendi and concluded that the use of natural enemies could be incorporated in the integrated control programme.

The predatory spiders *Erigonidium graminiculatum* (Walker), *Theridon octomaculatum* (L.) and *Misumenops* sp. constituted 92.4 per cent of their community during June - September. There were four peaks in their population dynamics between June and September, coinciding with those of *Earias* spp. and their populations were closely correlated with weather factors (Qu *et al.*, 1986).

Tuhan *et al.* (1987) found that release of *T. brasiliensis* @ 50,000/ha/week followed by sprays of carbaryl, dimethoate and monocrotophos significantly reduced the damage by *Earias* spp. on cotton. According to Verma and Shenhmar (1988) *T. chilonis* was the most common egg parasitoid of *Earias* spp. with 30 per cent parasitism during September - October and 35 per cent during October - November, while the chalcid, *Brachymeria lasus* (Walker) recorded upto 40 per cent parasitism in October. Inundative releases of *C. blackburnii* and *B. kirkpatricki* had the recovery of 11.5 per cent parasitoids from the parasitised larvae of *E. vittella* (Surulivelu, 1989).

Brar *et al.* (1991a) reported that during October and November, the eggs of *Earias* spp. were parasitised by *T. achaeae* to an extent of 19.7 per cent in cotton. Patil *et al.* (1991) found that spraying of phosalone and cypermethrin in combination with release of egg parasitoid, *T. achaeae* resulted in significant reduction in number of insecticidal sprays with a cost benefit ratio of 1:4.2.

In the field trials conducted by Raja *et al.* (1998) to manage *E. vittella* the results revealed that release of *T. chilonis* at fortnightly interval reduced the fruit damage by 49.22 per cent and the cost : benefit ratio was 1: 2.74. Release of *T. chilonis* @ 50,000/ha based on the 100, 75, 50 and 25 per cent ETL (i.e., 10.0, 7.5, 5.0 and 2.5 per cent fruit damage) recorded the fruit damage by *E. vittella* in okra as 6.47, 6.96, 7.33 and 7.82 per cent respectively (Sumathi, 1999).

2.8. Chemical control of major pests of bhendi

2.8.1. Aphid, *A. gossypii*

Mohan (1985) investigated that the insecticides methomyl, profenofos, bromophos and endosulfan at 0.5 kg a.i. ha^{-1} were effective against okra aphid. Acephate (0.1%) and triazophos (0.1%) were equally effective against the bhendi aphid (Prasad *et al.*, 1993).

Imidacloprid 200 SL at 1.5 ppm to 2.5 ppm when applied to the petioles of excised potato leaves, more aphids walked off from the treated leaves when compared to the untreated leaves (Woodford, 1992).

Treverrow (1996) reported that, when imidacloprid 200 SL injected into pseudostem against banana aphid, *Pentalonia nigronervosa* Coq., even 40 days after treatment no aphids were detected on the plants.

Imidacloprid 200 SL (Confidor) at 50 ml/hl was highly effective against grey aphids in apple and persisted upto 80 days (Barbieri and Covallini, 1997; Pollini and Bariselli, 1997). Imidacloprid 200 SL as foliar spray @ 50 g a.i ha^{-1} effectively controlled the tobacco aphid, *Myzus nicotianae* Blackman throughout the season (Ramaprasad *et al.*, 1998).

2.8.2 Leaf hopper, *A.biguttula biguttula*

Dimethoate @ 200 g a.i./ha was the most toxic compound to *A. biguttula biguttula and A. devastans* as reported by Rajendra Singh and Teotia (1978), El-Shahwy *et al.* (1991), Bhalla *et al.* (1994), Borah (1994) and Dhawan *et al.* (1979). Malathion (0.1%) and leptophos (0.05%) were effective against leafhoppers on okra upto 12 days (Gulab Singh and Chopra, 1979; Jat, 1981 and Darshan Singh *et al.*, 1982).

Darshan Singh *et al.* (1982) reported that higher bhendi yield was obtained when the crop was sprayed with endosulfan @ 350 g.a.i. ha^{-1} when the threshold of leafhopper population was 5 nymphs/leaf. Quinalphos and methamidophos both at 0.05 per cent were very effective causing 90 per cent reduction in leafhopper population (Sosamma Jacob and Sashi Verma, 1985).

Malathion (0.05%) when applied at 15 DAG followed by 0.03 per cent dimethoate at 30 DAG resulted in effective control of leafhopper population and higher yield of okra (Waryam Singh *et al.*, 1991; Borah, 1994).

Bhendi fruit yield was found to be higher as a result of scheduled application of 0.05 per cent monocrotophos, 0.2 per cent carbaryl, 0.07 per cent endosulfan and 0.03 per cent dimethoate against *A. biguttula biguttula* at 45, 60, 75, 90 and 105 days after sowing (Patel and Bhalani, 1988).

The efficacy of different treatments resulting higher mortality of leafhopper was in the order of 0.05 per cent endosulfan (95.57%) > 0.05 per cent malathion (91.61%) > 0.05 per cent quinalphos (91.05%) > 0.025 per cent phosalone (88.86%) (Yadav *et al.*, 1988).

Ali and Karim (1990) reported that application of dimethoate @ 1.2 lit ha^{-1} at a threshold level of one hopper/leaf resulted in 1.5 to 2.0 times more profit per hectare in cotton.

According to Dahiya *et al.* (1990) endosulfan (0.07%) spray was highly persistent and controlled the leafhopper population upto 15 days on bhendi. Attique and Ghaffer (1996) reported that foliar application of imidacloprid 200 SL (Confidor) effectively controlled the early season attack of *A. devastans* on cotton.

Patel *et al.* (1997) found that endosulfan (0.035%) was very effective in controlling okra leafhopper population when compared to sprays of chlorpyriphos (0.04%), quinalphos (0.025%) and triazophos (0.04%).

Gupta *et al.* (1998) found that application of imidacloprid @ 3 g/kg of seed as well as foliar spray at 0.05 per cent was very effective against cotton leafhoppers.

Girraddi *et al.* (1998) reported that spraying of acephate 600 g a.i/ha was effective, resulting good control of leafhoppers with higher fruit yield of 7.1 t/ha of bhendi. Carbosulfan 25 EC at 0.075% when sprayed twice at 15 days interval, commencing from 40 DAS significantly reduced the population of aphid (97.5%) and leafhopper (84.5%) on bhendi (Asafali and Chinniah, 1999).

2.8.3. Whitefly, *B.tabaci*

The spread of Yellow Vein Mosaic Virus Disease (YVMD) in okra was restricted by four sprays of dimethoate (0.05%) (Sastry and Singh, 1973 a & b) or fortnightly treatment with a 1:1 mixture of dimethoate (0.05%) and endosulfan

(0.07%) combined with regular removal of infected plants upto 55 days from sowing (Sinha and Chakrabarti, 1982) gave good control of the vector, *B. tabaci* and YVMD. Dimethoate 0.03 per cent and acephate 75 WSP @ 1.0 kg a.i/ha sprays were very effective, resulting in 90 per cent reduction in whitefly population on cotton (Singh *et al*., 1973; Sidhu and Dhawan, 1977).

Singh and Mahant Singh (1989) reported that three sprays of phosphamidon (0.02%) or methyl demeton 25 EC (0.025%) reduced the population of *B. tabaci* and YVMD and thereby increased the yields. Monocrotophos 36 WSC @ 500 g a.i. ha^{-1} and dimethoate @ 225 g a.i. ha^{-1} were highly effective and gave satisfactory control of whitefly when sprayed at 20 days interval (EI-Shahwy *et al.*, 1991).

According to Borah and Nath (1995), spraying of dimethoate (0.03%) at 15 and 30 days after germination significantly reduced the whitefly population. Walnuj and Mote (1995) found that the treatment with imidacloprid 70 WS 10 g kg^{-1} seed treatment plus 0.04 per cent root dip gave the highest protection from whitefly infestation and increased yield of tomato.

2.8.4. Fruitborers, *Earias* spp.

According to Parkash *et al.* (1980), application of dimethoate at 0.03 per cent at 25 days after sowing followed by spraying of phosalone (0.10%) on 45, 60, 75 and 90 days after sowing gave the best control of *Earias vittella* on okra. Jadhav and Nawale (1984) reported that spraying of endosulfan 35 EC (0.05%) four times at 10 days interval from the time of flowering gave effective control of *E. vittella* and resulted higher fruit yield of bhendi.

In the trials conducted by Dhandapani (1985) to evaluate the need based (ETL of 5% fruit damage) Vs. scheduled application of endosulfan (0.07%) given at 10 days interval (5 sprays) commencing from 45 days after sowing, the results revealed that need based application of treatments resulted in high CBR when compared to scheduled application.

Acephate at 750 g a.i. ha^{-1} and quinalphos at 250 g a.i ha^{-1} when applied on 35th day after sowing significantly reduced the *Earias* spp. infestation (Chari *et al.*, 1987).

Two applications of malathion 50 EC @ 1 lit ha^{-1} and carbaryl 50 WP @ 1 kg ha^{-1} gave significant control of fruitborer infestation (Konar and Rai, 1990). Combination of malathion 0.05 per cent and dimethoate 0.03 per cent spray when applied on 25 and 35 days after germination, they were quite effective against *E. vittella* (Borah, 1995).

Foliar sprays of malathion 50 EC @ 1 lit. ha^{-1} at vegetative stage followed by carbaryl 50 WP @ 1 kg ha^{-1} at fruiting stage of the crop at 15 days interval resulted in effective control of okra fruitborer infestation (Rishikumar *et al.*, 1996). Among the 13 insecticidal treatments tested, endosulfan 35 EC (0.07%) was highly effective in controlling *E. vittella* (Sarode and Gabhane, 1998).

Tomar (1998) reported that combination of Dipel (*B.t. kurstaki*) 0.01 per cent and endosulfan 0.035 per cent was found to be effective in reducing the shoot and fruitborer infestation on okra.

2.9. Influence of NPK fertilizers on pest incidence

Rippa and George (1965) reported that the rate of whitefly breeding was increased in proportion to the nitrogen content of leaves of cotton.

Agarwal *et al.* (1979) studied that the late sown cotton crop with higher dose of nitrogen suffered more from the attack of leafhopper than early sown crop with low dose of nitrogen. The use of fertilizers greatly influenced the whitefly population and the plants, which received more nitrogenous fertilizers became more vulnerable to whitefly attack as reported by Reddy and Rao (1982).

Moawad and Nasr (1984) found that the number of egg masses of *Spodoptera littoralis* Boisd was increased as the amount of nitrogenous fertilizer increased. Natarajan *et al.* (1986) suggested that the use of fertilizer and irrigation should be limited to arrest excessive vegetative growth of the crop and to control whitefly, *B. tabaci* on cotton. Illango and Uthamasamy (1989) reported that increased nitrogen resulted in corresponding increase in bollworm incidence in cotton.

The excessive use of nitrogenous fertilizers resulted in bushy growth of plant and attracted whiteflies in large number (Purohit and Deshpande, 1991; Balaji and Veeravel, 1995).

According to Surekha and Arjuna Rao (2000) Vermicompost and FYM caused non-succulent growth of plants and clearly exhibited superiority in minimizing the fruitborer population on bhendi over straight fertilizers, which allowed luxuriant plant growth, attracting higher infestation.

2.10. Safety of neem products, *B.t.* formulations and insecticides to natural enemies

2.10.1. Neem products

Extracts from the seeds of neem have shown excellent insecticidal properties but safety to human beings and the environment with only slight or no deleterious effects on beneficial insects (Schmutterer *et al.*, 1981; Schmutterer and Ascher, 1984). The wolf spider, *Lycosa pseudoannulata* Boeshirger, an important predator of planthoppers and leafhoppers in rice was not sensitive to neem oil or alcoholic and aqueous NSKE (Saxena *et al.*, 1984). Predaceous coccinellids survived the application of a formulation with high neem oil content, whereas the target pest, the sorghum aphid, *Melanaphis sacchari* (Zchnt) was successfully controlled (Srivastava and Parmer, 1985). NSKE five per cent and neem cake extract 10 per cent as high volume sprays had been found to record better recolonization of wolf spider, *L. pseudoannulata* at 7 and 21 days after application (Mohan, 1988).

Neem product application was reported to be safer to predatory mirid, *Cyrtorrhinus lividipennis* (Reuter) and *L. pseudoannulata* (Saxena, 1989; Jayaraj *et al.*, 1993).

Azadirachtin was found to be non-toxic to *Delphastus pusillus* Leconte, a coccinellid predator on whitefly when either the plant or *B. tabaci* eggs were treated (Hoelmer *et al.*, 1990).

Yadav and Patel (1990) reported the repellent effect of neem compounds against the egg laying by *Chrysopa sclestes* Banks, but showed no effect on the hatching of eggs. Price and Schuster (1991) reported the NSKE application reduced the number of *Encarsia* spp. and *Aleurodiphiulus* spp., the parasitoids of sweet potato whitefly, *B. tabaci*.

Schmutterer (1992) reported that the hymenopteran parasitoid, *Apanteles glomeratus* L. was not harmed at low doses of azadirachtin (10 and 20 ppm).

Feldhege and Schmutterer (1993) found that the application of 10 ppm azadirachtin was relatively non-toxic, whereas concentration of 20 ppm led to slight but significant reduction of fitness of *Encarsia formosa* Gah, a parasitoid of the green house whitefly, *Trialeurodes vaporariorum* (Westwood). Hymenopteran endolarval parasitoid of *P. xylostella*, *Diadegma semiclausum* (Hellen) was not affected by AZT (containing 30 mg azadirachtin ml^{-1}) (Verkerk and Wright, 1993).

Lowry and Isman (1995) reported that Neem Seed Oil (NSO) prevented adult eclosion of syrphids *Eupeodes fumipennis* (Thompson), larval coccinellids, *C. undecimpunctata* to 7 and 11 per cent respectively. NSO had not reduced the rate of parasitism of *Myzus persicae* (Sulzer) by *Diaeretiella rapae* (McIntosh).

Justin (1996) observed the safetiness of Nimbecidine to *Cotesia plutellae* (Kurd). Jhansilakshmi *et al.* (1997a) observed that Neemark (2 and 4%) and Rakshak (0.2 and 0.5%) were the safest neem formulations to *Microvelia douglasi atrolineata* Bergroth. Econeem and Neemazal-T/S (0.1 - 1.0%) were found to be safer to *T.chilonis* (Jhansilakshmi *et al.*, 1997b).

2.10.2. *Bacillus thuringiensis*

The extent of parasitism by the late instar larvae of *C. plutellae* (Kurd) were not affected when the *P. xylostella* larvae treated with *B.t.* + insecticide combination (Yen and Hsiao, 1977). Safety of *B.t.* to *C. plutellae* was also reported by Chiu *et al.* (1974). Hamed (1979) found that *B.t.k.* had no deleterious effect on the predatory bug *Picromerus bidens* L. The lacewing predator, *C. carnea* was affected in terms of larval duration and rate of food consumption, when the larvae were fed on a host treated with *B.t.* and similar effects were pronounced with *C. undecimpunctata* also (Salama *et al.*, 1982).

The egg parasitoid, *Trichogramma evanescens* Westwood was not affected when fed directly on a diet infected with *B.t.* or allowed to parasitise the host eggs sprayed with *B.t.* var *entomocidus* at 500 $\mu g\ ml^{-1}$ diet (Salama and Zaki, 1983). *B.t.* was reported to be safer to *T. chilonis* (Brunner and Stevens, 1986) and *C. plutellae* (Lim *et al.*, 1986; Talekar and Yang, 1991) but found to be toxic to adult parasitic insects at high oral dosages under laboratory conditions (Hamed, 1979). In field studies, *B.t.* sprays were reported to have no adverse effect on the populations of *Apanteles fumiferanae* Vier., a parasitoid of *Choristoneura fumiferana* (Chem.) (Niwa *et al.*, 1987).

Bellows *et al.* (1993) found that *B.t.* formulations was the least harmful to *Aphytis melinus* Debach, a parasitoid of citrus diaspidid scale. Giroux *et al.* (1994) studied the effect of bacterial insecticides M-one (*B.t.* product) on predation efficiency and mortality of adult *Coleomegilla maculata lengi* Timberlake used to control the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). The results indicated the consumption of pollen contaminated with M-one had no lethal effect on adults of *C. maculata*.

Castelo Branco and Franco (1995) reported the safetiness of *B.t.* to the adults of *T. pretiosum*. Hassan and Graham Smith (1995) reported that *B.t.* had no lethal effect on *Microplitis demolitor* Wilkinson and *Trichogrammatoidea bactrae* Nagaraja. Sims (1995) evaluated purified preparations of a *B.t.k.* CryIAc protein equivalent to the insecticidal protein produced by transgenic cotton against *C.carnea* and reported that risks to beneficial non-lepidopteran insect species were negligible.

2.10.3. Insecticides

The pesticides are rated as having high, medium, low or zero toxicity to eggs, larvae and adults of the green lacewing, *C. carnea*. Eggs were highly susceptible. Larvae and adults were killed by the residues of most of the organo phosphates and chlorinated hydrocarbons tested (Bartlett, 1964). Populations of *C.carnea* have shown tolerance to pyrethroids (Plapp and Bull, 1978; Grafton-Cardwell and Hoy, 1985) and resistance to some type of organophosphorus and carbamate insecticides (Plapp and Bull, 1978).

Varma *et al.* (1988) found that fenvalerate, permethrin, oxydemeton methyl, DDT, dimethoate, deltamethrin and phosphamidon were safe to the parasitoid, *T. achaeae*.

Among the 15 insecticides tested against *T. chilonis*, oxydemeton-methyl at 0.06 per cent recorded the lowest mortality, maximum parasitism and emergence from the parasitized host (Brar *et al.*, 1991b). Narayana and Ramesh Babu (1992) observed that the development of the immature stages of *T. chilonis* was affected when exposed to growth regulator, Triflumuron. Pyrethroids were the most toxic to *A. melinus* and *Rhizobius lophanthae* (Blaisd), followed by carbamates and organophosphates (Bellows and Morse, 1993). Mani (1993) evaluated the toxicity of different pesticides to the green lace wing, *Mallada boninensis* (Okamoto), an important predator of sucking insects. Larvae were less susceptible than the adults. Fenvalerate, endosulfan, methyl demeton and synthetic pyrethroids were less toxic to the larvae.

Biddinger and Hull (1995) evaluated abamectin, methomyl, several types of Insect Growth Regulators (IGR), and several organophosphate insecticides for toxicity to the egg, larval, pupal and adult stages of the coccinellid mite predator, *Stethorus punctum* (Leconte). Abamectin was toxic to *S. punctum* larvae and adults in the laboratory and methomyl was toxic to adults. Tebufenozide and all organophosphate insecticides were tolerated by *S. punctum*.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on "Development of Integrated Pest Management on Bhendi" was carried out during the period 1998-2001. The materials utilized and methods adopted are described in this chapter.

3.1. Study area

The laboratory experiments were carried out at the insectary in the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore. The field trials were conducted in the farmers' fields of different locations in Coimbatore region.

3.2. Maintenance of test insects

3.2.1. Sucking pests

The bhendi plants were raised periodically in earthern pots filled with pot mixture. Thirty day old plants were used for culturing the test insects. The test insects *viz.*, aphid, *Aphis gossypii* Glover, leafhopper, *Amrasca biguttula biguttula* Ishida and whitefly, *Bemisia tabaci* Genn. collected from the fields were inoculated on the potted plants for culturing them. The pots were then covered with mylar film cage. The cultured insects were used for laboratory experiments.

3.2.2. Fruitborer *Earias* spp.

Field collected larvae were inoculated on the fruits of okra for mass culturing of them, pupae were collected and kept in a 30 x 30 x 30 cm cage for emergence. Ten pairs of adults were transferred to plastic bucket (7 litre capacity) for mating and oviposition, fresh bhendi fruits were kept inside as ovipositional substrate and ten per cent sugar solution enriched with ABDEC vitamin solution was provided as food for the adults and covered with sterile muslin cloth. The eggs laid on the fruits were removed with camel hairbrush, sterilized by using ten per cent formaldehyde followed by water and kept for hatching. Immediately after hatching, the larvae were transferred to fresh bhendi fruits after making slight incision with the help of a knife, kept in a rearing tray (30 x 15 x 5 cm). The top of the tray was covered with a sterile muslin cloth. The rearing of fruitborer was carried out at room temperature (26 $\pm$ 4°C). Fresh food was provided to the larvae in fresh rearing containers on alternate days (Plate 1).

3.3. Laboratory experiment

3.3.1. Studies on ovicidal action of neem products

To study the ovicidal action of neem products against the eggs of bhendi fruitborer, *E. vittella*, laboratory experiment was conducted with the following treatments.

S.No.	Treatments	Source	Dose/lit
1.	Neemazal - (T/S) (Azadirachtin – 1%)	EID Parry (India) Ltd.	3.0 ml
2.	Neemazal - F (Azadirachtin – 5%)	EID Parry (India) Ltd.	1.0 ml
3.	Econeem (Azadirachtin – 0.3%)	PJ Margo Pvt. Ltd.	3.0 ml
4.	TNAU NO (0.03%)	Tamil Nadu Agricultural University	1.0 ml
5.	TNAU NO 60 EC (c)	Tamil Nadu Agricultural University	30.0 ml
6.	NSKE	Retail outlet	100 g
7.	Endosulfan	Retail outlet	2.0 ml
8.	Control	-	-

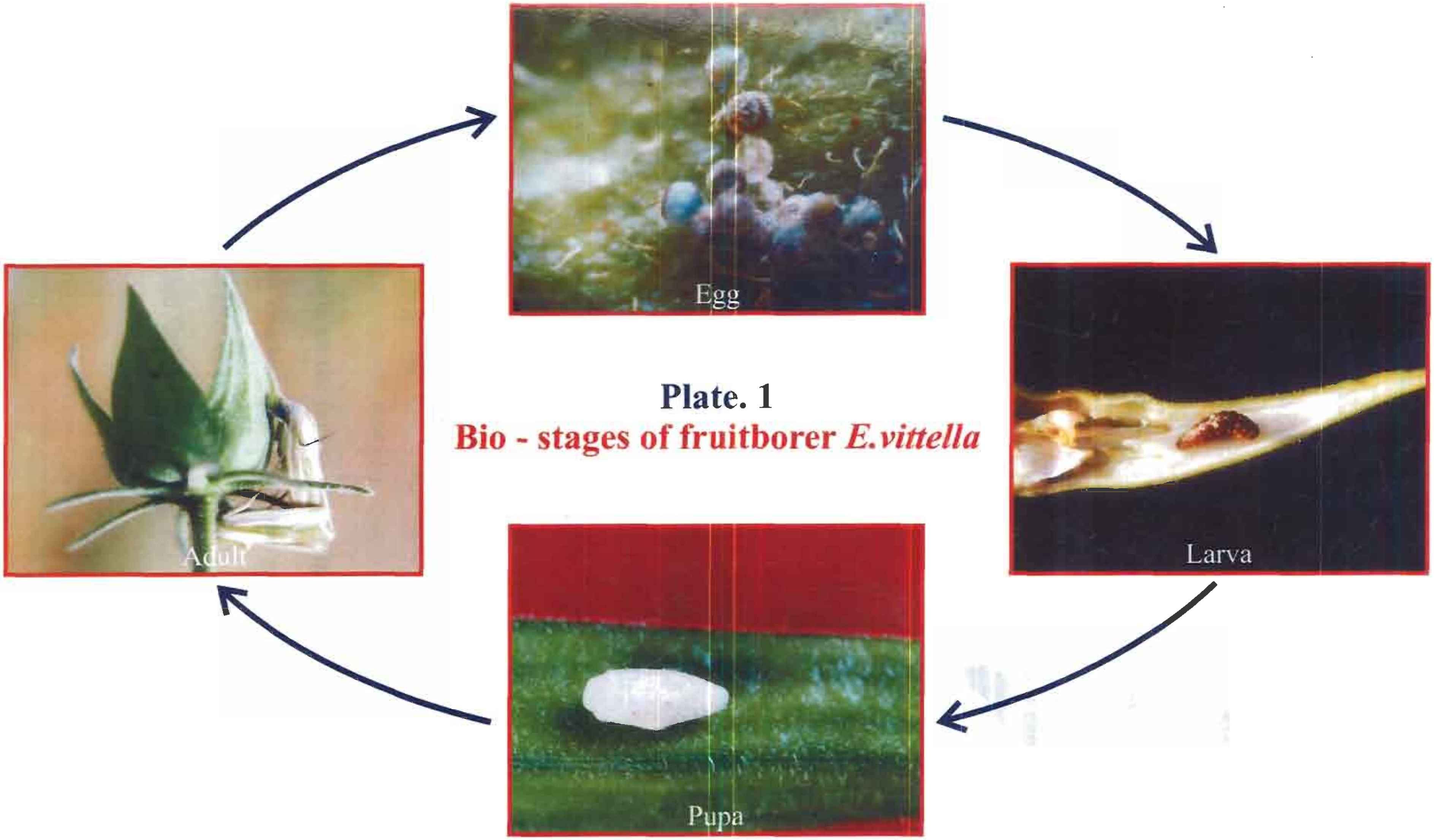


Plate. 1

Bio - stages of fruitborer *E.vittella*

The experiment was conducted in a Randomized Block Design (RBD) with eight treatments, replicated thrice with 25 eggs per replication. The eggs were placed on filter paper within petriplates and were treated with sprays of respective treatments, whereas the eggs treated with distilled water served as control. The sprayed eggs were kept as such for about ten minutes till the spray was completely dry and then transferred carefully to untreated petridishes. The number of larvae hatched out of 25 eggs in each replication was recorded and per cent hatchability of eggs was worked out.

3.3.2. Ovipositional deterrent effect of neem products

A free choice test was conducted to assess the ovipositional deterrent effect of neem products listed out in section 3.3.1. against fruitborer moths. Bhendi fruits with petiole kept in water in glass vials were treated with neem products individually and placed inside the ovipositional cage of size 30 x 30 x 30 cm. Each treatment was replicated three times. Fruits treated with distilled water served as control. Five pairs of moths were released into each cage. Cotton swab soaked in ten per cent sugar solution was provided in a pencillin vial to serve as adult feed. The number of eggs laid in each treatment was recorded daily till the death of the moths. Per cent hatchability of eggs was also recorded.

3.3.3. Effect of *B.t.* products on the larvae of *E. vittella*

An experiment was conducted to study the effect of different commercial *B.t.* formulations against the bhendi fruitborer, *E. vittella* as per the method suggested by Mahapatro and Gupta (1999a). The *B.t.* products tested were,

S.No.	Treatment	Species	Source	Concentration /lit
1.	Spicturin FC	*B. t.* var. *gallariae*	SPIC Ltd.	2.0 ml
2.	Spicturin FC	*B. t.* var. *gallariae*	SPIC Ltd.	3.0 ml
3.	Spicturin FC	*B. t.* var. *gallariae*	SPIC Ltd.	4.0 ml
4.	Delfin WG	*B. t.* var. *kurstaki*	PJ Margo Pvt. Ltd.	1.0 g
5.	Delfin WG	*B. t.* var. *kurstaki*	PJ Margo Pvt. Ltd.	1.5 g
6.	Delfin WG	*B. t.* var. *kurstaki*	PJ Margo Pvt. Ltd.	2.0 g
7.	Biobit HPWP	*B. t.* var. *kurstaki*	Rallis India Ltd.	1.0 g
8.	Biobit HPWP	*B. t.* var. *kurstaki*	Rallis India Ltd.	1.5 g
9.	Biobit HPWP	*B. t.* var. *kurstaki*	Rallis India Ltd.	2.0 g
10.	Endosulfan	-	Retail outlet	2.0 ml
11.	Control	-	-	-

The *B.t.* suspensions were prepared in distilled water. Bhendi fruits were dipped in different concentrations of above commercial *B.t.* formulations. After proper drying in shade for ten minutes, the bhendi fruits were taken in plastic tray (20 x 15 x 5 cm) and six days old, third instar larvae of test insect was released @ 5 larvae fruit^{-1} tray^{-1} replication^{-1} and this experiment was replicated six times. Thus, thirty insects were tested for each concentration and data on mortality of larvae were recorded on 24 and 48 hours after treatment. Then fresh fruits were replenished as food to the larvae on alternate days. Subsequently the data on mortality of larvae were recorded for the post exposure period upto pupation. Mortality data was corrected using Abbott's formula (Abbott, 1925).

Abbott's formula

$$\text{Corrected per cent mortality} = \frac{P_o - P_c}{100 - P_c} \times 100$$

where

P_o = Observed per cent mortality in treatment

P_c = Observed per cent mortality in control.

3.3.4. Studies on mechanism of resistance/susceptibility of bhendi entries to major pests

Moderately resistant pre-release cultures (2), released cultivars (3) and one susceptible check were chosen to study their mechanism of resistance/ susceptibility to major pests of bhendi. Five replications per entry were maintained. Five plants per replication were observed for the incidence of sucking pests and fruitborers.

3.3.4.1. Assessment of pest population

The observations on the population of sucking pests *viz.*, aphid, leafhopper and whitefly were recorded at ten days interval, commencing from 30^{th} day and continued upto 90^{th} day after sowing. Hopperburn due to leafhopper and yellow vein mosaic disease incidence due to whitefly were also recorded at 25, 45, 65 and 85 days after sowing.

a. Aphid, *A. gossypii*

The total population of aphid (nymphs and adults) on six leaves per plant representing two leaves from top, middle and bottom of five tagged plants per replication and the mean population of aphid per plant was worked out (Plate 2). Based on the mean population of aphid per plant recorded on the last count, the entries were classified as detailed below.

Mean population/plant	Category
1-5	Resistant
6-25	Moderately Resistant
26-100	Susceptible
>100	Highly susceptible

(Sumathi, 1999)

b. Leafhopper, *A. biguttula biguttula*

The leafhopper population was recorded from six leaves per plant representing two from top, middle and bottom portion of five tagged plants in each replication (Plate 3). Based on the mean leafhopper population the entries were categorised as under,

No. of nymphs/leaf	Category
<1	Highly Resistant
1.1 - 3.0	Resistant
3.1 - 5.0	Moderately Resistant
5.1 - 7.0	Susceptible
>7.1	Highly susceptible

(Brar *et al.*, 1995).

Hopperburn symptoms due to leafhopper attack (Plate 3) was also evaluated in the same lines and graded as detailed below.

Grade	Symptom
1.	**No damage:** entire leaf green, showing no hopperburn
2.	**Low damage:** about 1-25% leaf area showing hopperburn, yellowing at the leaf margins,
3.	**Medium damage:** about 26-50% leaf area showing hopperburn, slight cupping and yellowing of leaf margins
4.	**High damage:** about 51-75% leaf area showing hopperburn, severe cupping and bronzing of leaves
5.	**Severe damage:** entire leaf area (almost 100%) showing hopperburn, petiole and leaf drying up.

$$\text{Leaf hopper Injury Index} = \frac{(P_1xG_1) + (P_2xG_2) + (P_3xG_3) + (P_4xG_4) + (P_5xG_5)}{(P_1 + P_2 + P_3 + P_4 + P_5)}$$

P_1 to P_5 - number of plants falling in each category (G_1 to G_5).

Based on the Injury Index, the entries were classified as detailed below.

Leafhopper Injury Index	Rating
1.0 - 1.80	Highly Resistant
1.81 - 2.60	Resistant
2.61 - 3.40	Moderately Resistant
3.41 - 4.20	Susceptible
>4.21	Highly susceptible

(Hooda *et al.*, 1997)

As suggested by Uthamasamy *et al.* (1973), visual rating of plants was taken into consideration in evaluating the resistance of bhendi entries/accessions to the leafhopper infestation.

c. Whitefly, *B. tabaci*

The population of nymphs from six leaves per plant representing two leaves from top, middle and bottom of each plant and from five tagged such plants was recorded per replication. The mean population of whiteflies per plant was worked out and based on the mean population the entries were classified as detailed below.

Mean population per plant	Category
1 - 2	Resistant
3 - 10	Tolerant
11 – 50	Susceptible
> 50	Highly susceptible

(Sumathi, 1999)

d. Yellow Vein Mosaic Disease (YVMD)

The total number of plants and the number of plants exhibiting yellow vein mosaic symptoms (Plate 4) per replication were recorded and the per cent YVMD incidence was worked out. The test entries were graded based on the observations made as detailed below.

Percent YVMD incidence	Category
< 10	Highly Resistant
10 – 20	Resistant
20 – 40	Moderately Resistant
40 - 60	Susceptible
> 60	Highly susceptible

(Bora *et al.*, 1992)

Plate. 2

Aphid (nymphs and adults)

Aphid infested leaf

Plate. 3

Leafhopper (adult)

Different grades of hopperburn

1 - no damage 2 - low damage (1 - 25%)
3 - medium damage (26 - 50%)
4 - high damage (51 - 75%)
5 - severe damage (100%)

Plate. 4

Whitefly (adults)

Yellow Vein Mosaic Disease

e. Fruitborers, *Earias* spp.

The total and affected fruits from five plants per replication were counted from each harvest and per cent damage was worked out. Based on the mean per cent damage of ten harvests the entries were classified as detailed below.

Scale	Percentage Infestation of fruits	Rating
1	1-10	Highly Resistant
3	11-20	Resistant
5	21-40	Moderately Resistant
7	41-60	Susceptible
9	> 60	Highly susceptible

(Mote, 1982)

3.3.4.2. Trichome density

The density of trichomes on mid-vein of leaves of bhendi were recorded 45 and 65 days after sowing from five tagged plants in each replication. In each plant, three leaves (one at top, one middle and one at bottom) were chosen for the study. Leaf samples were cut into one sq. cm, taken in a glass test tube and heated in 20 ml water for 15 minutes at 85°C. Leaves were again boiled in 20 ml of 90 per cent ethanol until the chlorophyll content was entirely removed. Then the leafbits were boiled in 90 per cent lactic acid at 85°C until the leafbits became transparent. The content in test tubes were cooled and the leaf samples were mounted on clean glass slides, using a drop of lactic acid. The density of trichomes (Plate 5) present in one sq. cm area of each leaf bit was estimated and expressed as number of trichomes per sq. cm area following the method of Kannan (1995).

3.3.4.3. Fruit parameters

The length and girth from each harvested bhendi fruit were recorded at each harvest from five tagged plants in each replication and the mean fruit length (cm) and girth (cm) of individual entry were worked out.

3.3.4.4. Plant height

The plant height in each entry was recorded from five plants tagged at random per replication at 10 days interval upto the last harvest and the average plant height (cm) of individual entry was worked out.

3.3.5. Studies on persistent toxicity of insecticides on bhendi to sucking pests

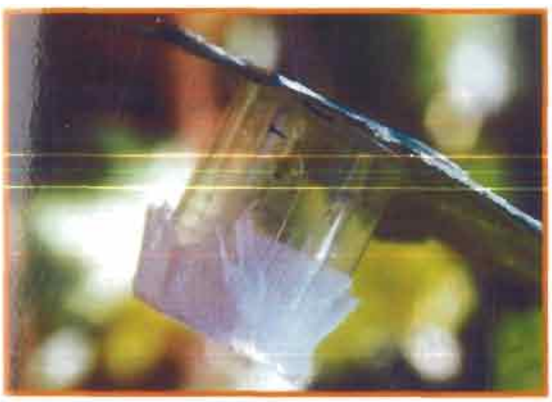
The persistent toxicity of the following treatments were studied in green house condition at 29 – 33°C and the method of assessment is described below.

S.No.	Treatment	Concentration (%)
1.	Methyl demeton 25 EC	0.05
2.	Imidacloprid 200 SL	0.004
3.	Dimethoate 30 EC	0.06
4.	Carbosulfan 25 EC	0.05
5.	Profenofos 50 EC	0.075
6.	Acephate 75 SP	0.11
7.	Control	-

Plate. 5

Trichome density

Plate. 6



Clip-on cage

Plate. 7

Micro cage

Plate. 8

Field experiment

a. Whitefly and leafhopper

The clip - on micro cages of 3-4 cm dia. made out of transparent mylar film sheets were used for confining the test insects on leaves after imposing them with treatments (Plate 6). The number of surviving insects in each cage was counted daily and fresh set of 10 individuals were released on each day of count after removing the insects released on the previous day. The procedure was followed till no mortality of pests in the treated plants was observed.

b. Aphid

The clip-on blister pack tablet covers of one cm dia. were used for confining the aphids on leaves after treating them with insecticides (Plate 7). Mortality observations were taken as per the procedure discussed under section 3.3.5.a.

The persistent toxicity index was worked out following the method as described by Pradhan (1967).

3.4. Field experiments

3.4.1. Evaluation of neem products, *Bacillus thuringiensis (B.t.)* formulations and insecticides

The efficacy of recommended neem products, *B.t.* formulations and insecticides was evaluated under field condition. The experiments were conducted in a randomized block design and the treatments were replicated three times with a plot size of 20 m^2 (4 x 5 m) per replication. The variety grown was Parbhani Kranti (Plate 8).

3.4.1.1. Evaluation of neem products for their efficacy against sucking pests of bhendi

S.No.	Treatment	Dose/lit
1.	TNAU NO 60 EC (c)	20.0 ml
2.	TNAU NO 60 EC (c)	30.0 ml
3.	NSKE	50 g
4.	NSKE	100 g
5.	Neem oil	20.0 ml
6.	Neem oil	30.0 ml
7.	Neemazal - F (Azadirachtin - 5%)	1.0 ml
8.	Neemazal - F (Azadirachtin - 5%)	1.5 ml
9.	Methyl demeton 25 EC	2.0 ml
10.	Control	-

In this experiment, three rounds of sprays of above treatments were given against sucking pests *viz.*, the aphid, the leafhopper and the whitefly when their damage exceeded the 50 per cent ETL.

ETL for sucking pests

Leafhopper : 2 number/leaf

Aphid : 10 per cent infested plants

Whitefly : 5 nymphs/leaf

For the management of fruitborers, *Earias insulana* and *E.vittella*, as a general treatment with endosulfan 0.07 per cent was given, when their damage exceeded 100 per cent ETL (10 per cent fruit damage).

a. Assessment of sucking pests population

Observations were made on the population of sucking pests from five tagged plants at random per plot, before spraying and one, three seven and fourteen days after each round of sprays, by counting the total number of nymphs/adults of sucking pests from three leaves per plant representing one top, one middle and one bottom leaf of each of five tagged plants. The mean population of above sucking pests after each observation was worked out per plant and per cent reduction of population in each treatment over untreated check was worked out following the method of Henderson and Tilton (1955).

$$\text{Per cent reduction} = 100\left\{1 - \frac{T_a \times C_b}{T_b \times C_a}\right\}$$

Where,

T_b = Population in treated plot before spraying

T_a = Population in treated plot after spraying

C_b = Population in check plot before spraying

C_a = Population in check plot after spraying.

b. Assessment of population of natural enemies

The population of predators *viz.*, the coccinellid beetles (*Menochilus sexmaculatus* Fabricius, *Micraspis crocea* Mulsant), the spiders (*Oxyopes* sp., *Clubiona* sp.) and the green lace wing (*Chrysoperla carnea* Stephen) were recorded from ten plants selected at random per plot on seven days after each round of sprays and the mean population per ten plants was worked out (Plate 9).

Plate. 9 Natural Enemies

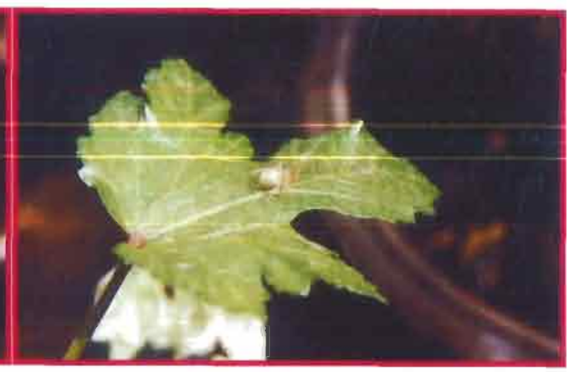
Coccinellids

Menochilus sexmaculatus

Micraspis crocea

Spiders

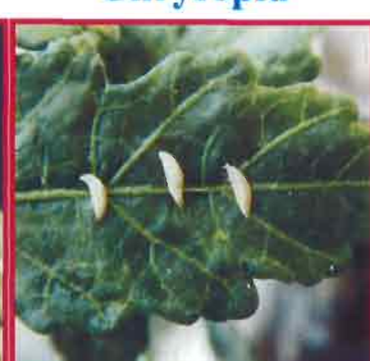
Oxyopes sp.



Clubiona sp.

Chrysopid

Eggs



Larvae

Adults

3.4.1.2. Evaluation of different *B.t.* formulations for their efficacy against fruitborer, *Earias* spp.

S. No.	Treatment	Species	Source	Concentration/lit
1.	Spicturin FC	*B. t.* var *gallariae*	SPIC Ltd.	3.0 ml
2.	Spicturin FC	*B. t.* var *gallariae*	SPIC Ltd.	4.0 ml
3.	Delfin WG	*B. t.* var. *kurstaki*	PJ Margo Pvt. Ltd.	1.5 g
4.	Delfin WG	*B. t.* var. *kurstaki*	PJ Margo Pvt. Ltd.	2.0 g
5.	Biobit HPWP	*B. t.* var. *kurstaki*	Rallis India Ltd.	1.5 g
6.	Biobit HPWP	*B. t.* var. *kurstaki*	Rallis India Ltd.	2.0 g
7.	Endosulfan 35 EC	-	-	2.0 ml
8.	Control	-	-	-

As a general treatment, for the management of sucking pests two rounds of sprays of methyl demeton 0.05 per cent was given when their damage exceeded 100 per cent ETL as given under 3.4.1.1.

In this experiment, two rounds of sprays of above treatments were given against fruitborers *Earias* spp. when their damage exceeded the 50 per cent ETL (5 per cent fruit damage).

a. Assessment of fruitborer damage

The total number of fruits and the number of affected fruits (fruit showing exit holes plugged with excreta) per plot (20 m^2) were recorded at each picking. The weights of healthy and affected fruits were also recorded for each plot. The per cent damaged to fruits by the borers was worked out both on number and weight basis. The data on mean weight of healthy fruits for each treatment were worked out and converted into hectare basis.

b. Assessment of population of natural enemies

The assessment of natural enemies population was similar to that described under the section 3.4.1.1.

3.4.1.3. Evaluation of different insecticides for their efficacy against sucking pests

S.No.	Treatments	Concentration (%)
1.	Methyl demeton 25 EC	0.05
2.	Imidacloprid 200 SL	0.004
3.	Dimethoate 30 EC	0.06
4.	Carbosulfan 25 EC	0.05
5.	Profenofos 50 EC	0.075
6.	Acephate 75 SP	0.11
7.	Control	-

In this experiment three rounds of sprays of above treatments were given against sucking pests *viz.*, the aphid, the leafhopper and the whitefly when their damage exceeded ETL as given under 3.4.1.1.

a. Method of assessment

The assessment of pest and predators population is similar to that described under the section 3.4.1.1.

3.4.1.4. Evaluation of different insecticides for their efficacy against fruitborer, *Earias* spp.

S.No.	Treatments	Concentration (%)
1.	Endosulfan 35 EC	0.07
2.	Malathion 50 EC	0.10
3.	Triazophos 40 EC	0.08
4.	Phosalone 35 EC	0.07
5.	Quinalphos 25 EC	0.05
6.	Profenofos 50 EC	0.075
7.	Control	-

For the management of sucking pests, as a general treatment, one round of spray with methyl demeton @ 0.05 per cent was given, when their damage exceeded ETL as described under 3.4.1.1

In this experiment, two rounds of spray of treatments were given against fruitborer, *Earias* spp. when their damage exceeded the ETL (10 per cent fruit damage).

a. Method of assessment

The assessment of fruitborer damage is similar to that described under the section 3.4.1.2 and the assessment of population of natural enemies is similar to that described under the section 3.4.1.1.

3.4.2. Impact of N, P and K fertilizers

The experiment was conducted in a Randomized Block Design (RBD), replicated thrice with seven treatments with the plot size of 20 m^2. The variety Parbani Kranti was sown with a spacing of 45 x 30 cm. "P" and "K" as super phosphate and muriate of potash fertilizers were applied as basal doses while "N" as urea was applied in two split doses *viz.*, basal and top dressing at 30 days after sowing. The treatments and levels used are mentioned below.

S.NO.	N		P		K (kg/ha)
1.	40	:	50	:	30
2.	40	:	50	:	0
3.	40	:	50	:	45
4.	40	:	50	:	60
5.	0	:	50	:	30
6.	60	:	50	:	30
7.	80	:	50	:	30

Method of assessment

a. Sucking pests

Observations on the population of sucking pests *viz.*, the aphid, the leaf hopper and whitefly were recorded at weekly intervals, commencing from 15th day and continued upto 92nd day after sowing. Assessment was made by counting total number of nymphs/adults of sucking pests from three leaves per plant selecting one top, one middle and one bottom leaf of each of five tagged plants. The mean population of above sucking pests after each observation was worked out per plant and subjected to corresponding square root ($\sqrt{x + 0.5}$) transformation before statistical analysis.

b. Fruitborer

The fruitborer damage was assessed similar to the method described under the section 3.4.1.2.

3.5. Cost : Benefit Ratio (CBR)

Cost : Benefit Ratios were worked out for all the field experiments, using the following formula as recommended by Akila Selvaraj and Sundara Babu (1994).

$$\text{Cost benefit ratio} = \frac{\text{Cost of produce}}{\text{Cost of cultivation} + \text{Cost of plant protection}}$$

3.6. Development of IPM on bhendi

The treatments which were found to be effective in different experiments conducted against sucking pests and fruitborers were selected and experimented in the IPM field trial.

Treatment details

S. No.	Treatments	Dose/lit
1.	Neemazal – F	1.0 ml
2.	TNAU NO (c) 60 EC	20 ml
3.	Imidacloprid 200 SL	0.2 ml
4.	Acephate 75 SP	1.5 g
5.	Biobit HPWP	2.0 g
6.	Delfin WG	2.0 g
7.	Endosulfan 35 EC	2.0 ml
8.	Triazophos 40 EC	2.0 ml
9.	Control	-

TREATMENT STRUCTURE FOR IPM TRIAL

T. No.	NPK/ha	Sucking pests (Aphid, Leaf hopper and Whitefly)		Fruitborer (*Earias* spp.)		
		At 50% ETL	At 100% ETL	Release	At 50% ETL	At 100% ETL
T_1	40:50:30	Neemazal - F	Acephate	Release of *Trichogramma chilonis* Ishii @ 50,000/ha only once at flowering	Biobit	Endosulfan
T_2	40:50:45	Neemazal - F	Acephate		Biobit	Endosulfan
T_3	40:50:30	Neemazal - F	Imidacloprid		Delfin	Triazophos
T_4	40:50:45	Neemazal - F	Imidacloprid		Delfin	Triazophos
T_5	40:50:30	TNAU NO 60 EC (c)	Acephate		Delfin	Triazophos
T_6	40:50:45	TNAU NO 60 EC (c)	Acephate		Delfin	Triazophos
T_7	40:50:30	TNAU NO 60 EC (c)	Imidacloprid		Biobit	Endosulfan
T_8	40:50:45	TNAU NO 60 EC (c)	Imidacloprid		Biobit	Endosulfan
T_9	40:50:30	-	-	-	-	-

Method of assessment

The assessment of population of sucking pests and predators was similar to that described under the section 3.4.1.1 and the assessment of fruitborer damage was similar to that described under the section 3.4.1.2.

3.7. Statistical analysis

The data obtained on percentage of reduction in population of sucking pests and fruit damage in different experiments were transformed into corresponding arcsin values (Snedecor and Cochran, 1967) and analysed statistically as per the method of Goulden (1952) and the mean values were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1976).

Results

4. RESULTS

The results obtained from various experiments are presented under the following heads.

1. Ovicidal action of neem products against *Earias vittella* Fabricius.
2. Ovipositional deterrent effect of neem products against *E. vittella*
3. Effect of *B.t.* products on mortality of larvae of *E. vittella*
4. Mechanism of resistance/susceptibility of bhendi entries to major pests
5. Persistent toxicity of insecticides against sucking pests on bhendi
6. Evaluation of neem products, *B.t.* formulations and insecticides on major pests of bhendi
7. Impact of N, P and K fertilizers on major pests of bhendi
8. Development of IPM on bhendi

4.1. Laboratory experiments

4.1.1. Ovicidal action of neem products against *E. vittella*

Studies conducted to evaluate the ovicidal action of neem products on the eggs of *E. vittella* showed (Table 1) that endosulfan (2 ml/lit) treatment effected higher mortality of eggs to an extent of 64 per cent. Among the neem products evaluated, Neemazal-F (1 ml/lit) resulted in maximum mortality of eggs (53.33%) followed by TNAU NO 60 EC (c) (30 ml/lit) and TNAU NO (1 ml/lit) by recording 44.00 and 32.00 per cent mortality of eggs respectively. The order of efficacy of other treatments in recording high mortality of eggs was Econeem 3 ml/lit (28.00%) > Neemazal - T/S 3 ml/lit (25.33%) > NSKE 100 g/lit (21.67%) and these were all on par. All the above treatments were superior to untreated check which also recorded 6.67 per cent mortality of eggs of *E. vittella*.

Table 1. Ovicidal action of neem products against *E. vittella*

Treatments	Dose/lit	Ovicidal action	
		Mortality of eggs (%)	**Hatchability of eggs (%)**
Neemazal - T/S (Azadirachtin-1%)	3 ml	25.33 (30.20)[e]	74.67 (59.79)[cd]
Neemazal-F (Azadirachtin-5%)	1 ml	53.33 (46.91)[b]	46.67 (53.09)[b]
Econeem (Azadirachtin - 0.3%)	3 ml	28.00 (31.91)[de]	72.00 (58.08)[c]
TNAU NO (0.03%)	1 ml	32.00 (34.42)[d]	68.00 (55.58)[c]
TNAU NO 60 EC (c)	30 ml	44.00 (41.55)[c]	56.00 (48.45)[b]
NSKE	100 g	21.67 (27.72)[e]	78.33 (62.26)[d]
Endosulfan 35 EC	2 ml	64.00 (53.14)[a]	36.00 (36.85)[a]
Control	-	6.67 (14.80)[f]	93.33 (75.20)[e]

Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P = 0.05) by DMRT.

The per cent hatchability of *E. vittella* eggs was the highest (93.33) in control. Among the other treatments, NSKE (100 g/lit), Neemazal - T/S (3 ml/lit), Econeem (3 ml/lit) and TNAU NO (1 ml/lit) effected the hatchability of eggs to the tune of 78.33, 74.67, 72.00 and 68.00 per cent respectively which were all on par with each other. The hatchability of eggs of *E. vittella* was less in Neemazal-F 1 ml/lit (46.67%) and TNAU NO 60 EC (c) 30 ml/lit (56.00%) treatments as against the treated check endosulfan 2 ml/lit (36.00%).

4.1.2. Ovipositional deterrent effect of neem products against *E. vittella*

In an experiment conducted on ovipositional deterrent effect of neem products to moths of *E. vittella*, the results revealed that TNAU NO 60 EC (c) (30 ml/lit) was the most effective treatment in deterring egg laying recording 20.00 eggs per fruit, followed by Neemazal-F (1 ml/lit) and TNAU NO (1 ml/lit), which recorded 24.00 and 30.00 eggs per fruit respectively as against 53.00 eggs per fruit in untreated control (Table 2). The treatments Econeem (3 ml/lit) and Neemazal - T/S (3 ml/lit) were on par. The number of eggs laid per fruit was 44.67 in NSKE (100 g/lit) revealing the lowest ovipositional deterrent action among the neem products tested.

Regarding the egg hatchability, the lowest hatchability of 43.56 per cent was recorded in endosulfan (2 ml/lit) followed by TNAU NO 60 EC (c) (30 ml/lit), Neemazal-F (1 ml/lit), TNAU NO (1 ml/lit) and Econeem (3 ml/lit) which resulted 58.61, 63.84, 68.01 and 71.47 per cent hatchability of eggs and these were all on par statistically. Maximum egg hatchability of 79.80 per cent was recorded in NSKE (100 g/lit) as against 94.96 per cent in untreated check (Table 2).

Table 2. **Ovipositional deterrent action of neem products against *E. vittella***

Treatments	Dose/lit	Ovipositional deterrent action	
		Number of eggs laid	Hatchability of eggs (%)
Neemazal - T/S (Azadirachtin-1%)	3 ml	39.00 (6.25)^{e}	78.63 (62.46)^{e}
Neemazal-F (Azadirachtin-5%)	1 ml	24.00 (4.90)^{c}	63.84 (53.04)^{bc}
Econeem (Azadirachtin - 0.03%)	3 ml	35.00 (5.92)^{e}	71.47 (57.72)^{d}
TNAU NO (0.03%)	1 ml	30.00 (5.47)^{d}	68.01 (55.56)^{cd}
TNAU NO 60 EC (c)	30 ml	20.00 (4.46)^{b}	58.61 (49.96)^{b}
NSKE	100 g	44.67 (6.68)^{f}	79.80 (63.52)^{e}
Endosulfan 35 EC	2 ml	15.33 (3.91)^{a}	43.56 (41.30)^{a}
Control	-	53.00 (7.28)^{g}	94.96 (77.08)^{f}

Figures within parentheses are $\sqrt{x + 0.5}$ and arcsin transformed values.
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

4.1.3. Effect of different *B.t.* products on mortality of larvae of *E. vittella*

The larval mortality data (Table 3) showed an increasing trend during exposure and post-exposure periods in all treatments. However, the mortality data recorded on each observation day showed that the larval mortality was increased with increased dosage of individual treatments. Among the *B.t.* products tested, Biobit and Delfin at its increased dosages (2.0 g/lit) caused maximum larval mortality of 98.89 and 96.67 per cent respectively within four days. The next in order were Biobit (1.5 g/lit), Delfin (1.5 g/lit) and Spicturin (4 ml/lit) which recorded 93.33, 90.00 and 74.44 per cent larval mortality respectively on 5th day after treatment. The least larval mortality of 48.89 per cent was observed in Spicturin (2.0 ml/lit) treatment only six days after treatment when compared to endosulfan treatment at 2.0 ml per litre, which brought cent per cent mortality of larvae within three days after treatment.

4.1.4. Mechanism of resistance/susceptibility of bhendi entries to major pests

4.1.4.1. Screening of bhendi entries for their relative resistance and susceptibility to major pests

a) Aphid *Aphis gossypii* Glover

The differential susceptibility/resistance of entries of bhendi was assessed to the aphid *A. gossypii*. The data on mean population of aphid per plant are presented in Table 4.

The population of aphid on 30 DAS was minimum on OHD-1 (1.20 number per plant) followed by COOH-1, Arka Anamika, Varsha Uphar and Pusa Sawani recording 2.00, 3.40, 4.00 and 5.00 aphids per plant respectively. The maximum aphid population was observed on MDU-1 (5.20 number per plant).

Table 3. Effect of different *B.t.* products on mortality of larvae of *E. vittella*

Treatments	Dose/lit	Per cent larval mortality						
		Exposure period (d)			Post exposure period (d)			
		1	2	3	4	5	6	7
Spicturin (*B.t.g*)	2.0 ml	11.11 (19.42)^{f}	37.78 (37.92)^{i}	45.56 (42.45)^{h}	46.67 (43.09)^{h}	47.78 (43.72)^{f}	48.89 (44.36)^{b}	-
Spicturin (*B.t.g*)	3.0 ml	13.22 (21.32)^{f}	44.44 (41.81)^{h}	63.33 (52.75)^{g}	64.44 (53.40)^{g}	65.56 (54.07)^{e}	67.78 (55.42)^{a}	-
Spicturin (*B.t.g*)	4.0 ml	24.67 (29.77)^{e}	62.22 (52.08)^{g}	70.00 (56.81)^{f}	73.33 (58.94)^{f}	74.44 (59.64)^{d}	-	-
Delfin (*B.t.k.*)	1.0 g	30.78 (33.68)^{d}	71.11 (57.49)^{f}	78.89 (62.66)^{e}	80.00 (63.43)^{e}	81.11 (64.26)^{c}	-	-
Delfin (*B.t.k.*)	1.5 g	42.22 (40.52)^{c}	80.00 (63.48)^{d}	85.56 (67.69)^{d}	88.89 (70.57)^{d}	90.00 (71.56)^{b}	-	-
Delfin (*B.t.k.*)	2.0 g	54.44 (47.55)^{b}	84.44 (66.80)^{c}	94.44 (76.51)^{bc}	96.67 (79.49)^{b}	-	-	-
Biobit (*B.t.k.*)	1.0 g	34.44 (35.93)^{d}	75.56 (60.38)^{e}	86.67 (68.59)^{d}	87.78 (69.58)^{d}	88.89 (70.73)^{b}	-	-
Biobit (*B.t.k.*)	1.5 g	45.56 (42.44)^{c}	82.22 (65.08)^{cd}	93.33 (75.36)^{c}	92.22 (73.88)^{c}	93.33 (75.03)^{a}	-	-
Biobit (*B.t.k.*)	2.0 g	57.89 (47.54)^{b}	87.78 (69.58)^{b}	95.56 (78.00)^{b}	98.89 (86.50)^{a}	-	-	-
Endosulfan 35 EC	2.0 ml	64.44 (53.40)^{a}	93.33 (75.36)^{a}	100.00 (90.00)^{a}	-	-	-	-

Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

Table 4. Screening of entries of bhendi for their relative resistance/susceptibility to aphid, *A. gossypii*

Entries	Population of aphid per plant*						
	Days after sowing (DAS)						
	30	40	50	60	70	80	90
OHD-1	1.20 (1.31)^{a}	3.00 (1.87)^{a}	3.00 (1.87)^{a}	5.00 (2.34)^{a}	5.20 (2.38)^{a}	6.00 (2.54)^{a}	7.00 (2.73)^{a}
COOH-1	2.00 (1.58)^{b}	3.00 (1.81)^{a}	5.00 (2.35)^{b}	7.20 (2.77)^{b}	7.80 (2.88)^{b}	9.00 (3.08)^{b}	10.00 (3.24)^{b}
Arka Anamika	3.40 (1.97)^{c}	4.80 (2.30)^{b}	6.00 (2.55)^{c}	8.80 (3.05)^{c}	10.20 (3.27)^{d}	13.60 (3.75)^{c}	15.00 (3.94)^{c}
Varsha Uphar	4.00 (2.12)^{c}	4.80 (2.30)^{b}	6.20 (2.59)^{c}	9.00 (3.08)^{c}	9.00 (3.08)^{c}	14.20 (3.83)^{c}	15.60 (4.01)^{d}
MDU-1	5.20 (2.39)^{d}	6.00 (2.55)^{b}	8.00 (2.91)^{d}	9.80 (3.21)^{d}	16.00 (4.06)^{d}	26.00 (5.14)^{d}	29.80 (5.95)^{d}
Pusa Sawani	5.00 (2.41)^{d}	7.80 (2.88)^{c}	12.80 (3.64)^{e}	13.00 (3.67)^{e}	19.00 (4.42)^{e}	27.80 (5.77)^{d}	36.00 (6.04)^{e}

* Mean of 5 replications

Figures within parentheses are $\sqrt{x + 0.5}$ transformed values.

Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

The order of minimum population of aphid recorded on 60 DAS was on OHD-1 (5.00) < COOH-1 (7.20) < Arka Anamika (8.80) < Varsha Uphar (9.00) < MDU-1 (9.80) < Pusa Sawani (13.00).

The population of aphid on 90 DAS was minimum on OHD-1 recording 7.00 number/plant followed by COOH-1, Arka Anamika, Varsha Uphar and MDU-1 recorded 10.00, 15.00, 15.60 and 29.80 aphids per plant respectively. The maximum aphid population was observed on Pusa Sawani (36.00 number/plant) exhibiting its susceptibility to aphid damage.

Based on the mean population of aphid per plant recorded on the last count (90 DAS) the entries were categorised as detailed below.

Mean population/plant	Category	Entries
1-5	Resistant	-
6-25	Moderately Resistant	OHD-1, COOH-1, Arka Anamika, Varsha Uphar
26-100	Susceptible	Pusa Sawani , MDU-1
> 100	Highly Susceptible	-

b. Leafhopper, *Amrasca biguttula biguttula* Ishida

The mean population of leafhopper recorded on bhendi entries were presented in Table 5. From the table, it is evident that population of leafhopper per plant was increased with increase in crop age from 30 to 90 DAS. The population of leafhopper on 30 DAS was minimum on OHD-1 and COOH-1 (both recorded 0.80 hopper/plant) followed by Arka Anamika, Varsha Uphar and MDU-1, which were on par by recording 1.60, 2.00 and 2.80 hoppers per plant respectively. The maximum leafhopper population was observed on Pusa Sawani (3.0 hoppers/plant).

Table 5. **Screening of entries of bhendi for their relative resistance/susceptibility to leafhopper, *A. biguttula biguttula***

Entries	Population of leafhopper per plant*						
	Days after sowing (DAS)						
	30	40	50	60	70	80	90
OHD-1	0.80 (1.13)^{a}	1.60 (1.44)^{a}	2.40 (1.70)^{a}	2.60 (1.76)^{a}	3.80 (2.07)^{a}	4.00 (2.12)^{a}	4.60 (2.26)^{a}
COOH-1	0.80 (1.13)^{a}	2.00 (1.57)^{a}	2.80 (1.81)^{a}	3.00 (1.87)^{a}	4.00 (2.12)^{a}	4.20 (2.17)^{a}	5.00 (2.33)^{a}
Arka Anamika	1.60 (1.44)^{ab}	1.80 (1.52)^{a}	2.60 (1.76)^{a}	3.00 (1.87)^{a}	3.80 (2.07)^{a}	4.60 (2.26)^{a}	5.00 (2.33)^{a}
Varsha Uphar	2.00 (1.58)^{ab}	2.20 (1.58)^{a}	3.00 (1.87)^{a}	3.60 (2.39)^{b}	4.00 (2.11)^{a}	4.60 (2.26)^{a}	4.60 (2.25)^{a}
MDU-1	2.80 (1.81)^{b}	3.00 (1.81)^{ab}	4.80 (2.30)^{c}	5.80 (2.50)^{c}	6.00 (2.55)^{b}	6.80 (2.70)^{b}	7.20 (2.77)^{b}
Pusa Sawani	3.00 (1.87)^{c}	4.20 (2.16)^{b}	3.80 (2.07)^{b}	5.20 (2.39)^{c}	5.80 (2.50)^{b}	7.80 (2.88)^{c}	8.00 (2.91)^{c}

* Mean of 5 replications

Figures within parentheses are $\sqrt{x + 0.5}$ transformed values.

Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

The order of maximum population of leafhopper recorded on 60 DAS was on MDU-1 (5.80) > Pusa Sawani (5.20) > Varsha Uphar (3.60) > Arka Anamika and COOH-1 (3.00) > OHD-1 (2.60).

The population of leafhopper on 90 DAS showed that there was no significant difference between OHD-1, Varsha Uphar, COOH-1 and Arka Anamika recording 4.60 to 5.00 hoppers per plant followed by MDU-1 (7.20 hoppers/plant). The maximum leafhopper population was observed on the susceptible check, Pusa Sawani (8.00 hoppers/plant).

Based on the mean leafhopper population recorded on the last count, the entries were categorised as under.

No. of nymphs/leaf	Category	Entries
< 1	Highly Resistant	-
1.1 - 3.0	Resistant	-
3.1 - 5.0	Moderately Resistant	OHD-1, COOH-1, Arka Anamika, Varsha Uphar
5.1 - 7.0	Susceptible	-
> 7.1	Highly Susceptible	MDU-1, Pusa Sawani

c. Leafhopper Injury Index

The leafhopper injury grades assessed during different periods of crop growth on different entries were subjected to calculation of leafhopper injury indices. The leafhopper injury index values (Table 6) obtained on 25 DAS was minimum on OHD-1 (1.40) followed by COOH-1 (1.60), Arka Anamika (1.60), Varsha Uphar (1.80) and MDU-1 (2.00), which were on par with each other. Maximum leafhopper injury index of 2.20 was recorded on Pusa Sawani.

Table 6. **Screening of bhendi entries for their resistance/susceptibility on the basis of Leafhopper Injury Index**

Entries	Leafhopper Injury Index*			
	Days after sowing (DAS)			
	25	45	65	85
OHD-1	1.40[a]	2.00[a]	2.80[a]	3.00[a]
COOH-1	1.60[ab]	2.20[ab]	2.60[a]	3.20[a]
Arka Anamika	1.60[ab]	2.40[ab]	2.80[a]	3.40[a]
Varsha Uphar	1.80[ab]	2.80[b]	3.20[ab]	3.40[a]
MDU-1	2.00[ab]	2.80[b]	3.60[b]	4.00[b]
Pusa Sawani	2.20[b]	3.80[c]	3.80[b]	4.26[b]

*Mean of 5 replications
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

The order of leafhopper injury index values obtained on 45 DAS were Pusa Sawani (3.80) > MDU-1 (2.80) = Varsha Uphar (2.80) > Arka Anamika (2.40) > COOH-1 (2.20) > OHD-1 (2.00).

The leafhopper injury index values worked out on 65 DAS was minimum on COOH-1 (2.60) which was in tune with OHD-1 (2.80) and Arka Anamika (2.80), followed by Varsha Uphar (3.20) and MDU-1 (3.60) as against leafhopper injury index of 3.80 recorded on the susceptible check, Pusa Sawani.

The leafhopper injury index values obtained on 85 DAS in different entries were in the order of OHD-1 (3.00) < COOH-1 (3.20) < Arka Anamika (3.40) = Varsha Uphar (3.40) < MDU-1 (4.00) < Pusa Sawani (4.26).

Based on the leafhopper injury index, the entries were further classified as detailed below.

Leafhopper Injury Index	Rating	Entries
1.0 - 1.80	Highly Resistant	-
1.81 - 2.60	Resistant	-
2.61 - 3.40	Moderately Resistant	OHD-1, COOH-1, Arka Anamika, Varsha Uphar
3.41 - 4.20	Susceptible	MDU-1
> 4.21	Highly Susceptible	Pusa Sawani

d. Whitefly, *Bemisia tabaci* Gennadius

The results obtained on population of whitefly on different entries of bhendi showed (Table 7) that the order of recording high population of whitefly on 30

Table 7. Screening of entries of bhendi for their relative resistance/susceptibility to whitefly, *B. tabaci*

Entries	Population of whitefly per plant*						
	Days after sowing (DAS)						
	30	40	50	60	70	80	90
OHD-1	1.00 (1.22)^{a}	1.60 (1.44)^{a}	2.00 (1.57)^{a}	2.80 (1.81)^{a}	3.60 (2.02)^{a}	4.80 (2.30)^{a}	5.20 (2.39)^{a}
COOH-1	3.00 (1.87)^{c}	3.60 (1.91)^{b}	3.80 (2.07)^{b}	5.00 (2.34)^{b}	5.00 (2.35)^{b}	5.20 (2.38)^{b}	5.80 (2.50)^{b}
Arka Anamika	1.80 (1.52)^{b}	2.60 (1.76)^{b}	3.80 (2.07)^{b}	5.20 (2.38)^{b}	6.20 (2.58)^{c}	7.00 (2.73)^{b}	7.80 (2.88)^{c}
Varsha Uphar	1.20 (1.30)^{a}	2.80 (1.81)^{b}	4.00 (2.11)^{b}	4.00 (2.11)^{b}	6.00 (2.55)^{c}	7.80 (2.88)^{c}	8.60 (3.01)^{d}
MDU-1	3.60 (2.02)^{d}	4.80 (2.30)^{c}	6.00 (2.54)^{c}	6.80 (2.70)^{c}	8.40 (2.98)^{d}	8.80 (3.05)^{d}	10.20 (3.27)^{e}
Pusa Sawani	3.80 (2.07)^{d}	5.00 (2.35)^{c}	7.00 (2.74)^{c}	9.60 (3.18)^{d}	10.80 (3.36)^{e}	11.40 (3.45)^{e}	13.20 (3.70)^{f}

* Mean of 5 replications
Figures within parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

DAS was in Pusa Sawani (3.80) > MDU-1 (3.60) > COOH-1 (3.00) > Arka Anamika (1.80) > Varsha Uphar (1.20) > OHD-1 (1.00).

The population of whitefly on 60 DAS was minimum on OHD-1 (2.80 number/plant). Varsha Uphar, COOH-1 and Arka Anamika recording 4.00, 5.00 and 5.20 number of whiteflies per plant, which were on par with each other while MDU-1 recorded the whitefly population of 6.80 per plant. Maximum population of whitefly was on the susceptible check Pusa Sawani (9.60/plant).

The order of minimum population of whitefly recorded on 90 DAS was on OHD-1 (5.20) < COOH-1 (5.80) < Arka Anamika (7.80) < Varsha Uphar (8.60) < MDU-1 (10.20) < Pusa Sawani (13.20).

Based on the mean whitefly population per plant recorded on 90 DAS the entries were categorised as detailed below.

Mean population per plant	Category	Entries
1 - 2	Resistant	-
3 - 10	Moderately Resistant	OHD-1, COOH-1, Arka Anamika, Varsha Uphar
11 - 50	Susceptible	MDU-1, Pusa Sawani
> 50	Highly susceptible	-

e. Yellow Vein Mosaic Disease (YVMD)

The relative resistance/susceptibility of bhendi entries to the incidence of Yellow Vein Mosaic Disease (YVMD) are presented in Table 8. In all the entries the per cent incidence of YVMD was gradually increased as the age of the crop

Table 8. **Reaction of bhendi entries against YVMD disease**

Entries	Per cent Yellow Vein Mosaic Disease (YVMD) incidence*			
	Days after sowing (DAS)			
	25	45	65	85
OHD-1	6.67 (14.96)[a]	6.67 (14.96)[a]	13.33 (21.41)[a]	26.68 (31.09)[a]
COOH-1	6.67 (14.96)[a]	13.33 (21.41)[b]	26.67 (31.09)[b]	33.33 (35.26)[b]
Arka Anamika	13.33 (21.41)[b]	20.00 (26.56)[c]	33.33 (35.26)[c]	40.00 (39.23)[c]
Varsha Uphar	13.33 (21.41)[b]	20.00 (26.56)[c]	26.67 (31.09)[b]	33.33 (35.26)[b]
MDU-1	20.00 (26.56)[c]	33.33 (35.26)[d]	46.67 (43.09)[d]	53.33 (46.90)[d]
Pusa Sawani	26.67 (31.09)[d]	40.00 (39.23)[e]	53.33 (49.90)[e]	66.67 (54.73)[e]

* Mean of 5 replications
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

increased from 25 to 85 DAS. The minimum YVMD incidence of 6.67 per cent was recorded on 25 DAS on OHD-1 and COOH-1, followed by Arka Anamika and Varsha Uphar each with 13.33 per cent YVMD incidence, as against 20.00 per cent incidence on MDU-1. The susceptible check Pusa Sawani recorded 26.67 per cent incidence of YVMD.

The relative incidence of YVMD on different entries recorded on 45 DAS was in the order of Pusa Sawani (40.00%) > MDU-1 (33.33%) > Varsha Uphar (20.00%) = Arka Anamika (20.00%) > COOH-1 (13.33%) > OHD-1 (6.67%).

The incidence of YVMD recorded on 65 DAS showed that less incidence of YVMD (13.33%) was recorded on the entry OHD-1 when compared to the susceptible check Pusa Sawani with 53.33 per cent. Among the other entries COOH-1 and Varsha Uphar were on par with each other recording 26.67 per cent YVMD incidence followed by Arka Anamika (33.33%) and MDU-1 (46.67%).

The reaction of the entries in recording less per cent incidence of YVMD on 85 DAS was in the order of OHD-1 (26.68) < COOH-1 (33.33) = Varsha Uphar (33.33) < Arka Anamika (40.00) < MDU-1 (53.33) < Pusa Sawani (66.67). The entries were classified based on the intensity of per cent incidence of YVMD as detailed below.

Per cent YVMD incidence	Category	Entries
< 10	Highly Resistant	-
11 - 20	Resistant	-
21 - 40	Moderately Resistant	OHD-1, COOH-1, Varsha Uphar, Arka Anamika
41 - 60	Susceptible	MDU-1
> 61	Highly Susceptible	Pusa Sawani

f. Fruit damage

The data obtained on per cent fruit damage, recorded at each picking on different entries of bhendi are presented in Table 9. The trend of per cent fruit damage by the borer observed among the entries from 1st picking to 10th picking was found to be same and uniform. The lesser incidence of fruitborer damage on different entries was in the order of OHD-1 (24.17%) < COOH-1 (25.09%) < Arka Anamika (27.13%) < Varsha Uphar (27.19), but the latter two entries were on par with each other. MDU-1 and Pusa Sawani recorded the fruit damage upto 43.11 and 61.82 per cent respectively exhibiting their susceptibility to the fruitborer *Earias* spp.

Based on the mean per cent fruit damage of ten harvests, the entries were categorised as detailed below.

Infestation percentage of fruits	Rating	Entries
1 – 10	Highly Resistant	-
11 – 20	Resistant	-
21 – 40	Moderately Resistant	OHD-1, COOH-1, Arka Anamika, Varsha Uphar
41 – 60	Susceptible	MDU-1
> 60	Highly Susceptible	Pusa Sawani

4.1.4.2. Trichome density

The influence of trichome density in conferring resistance/susceptibility of different entries of bhendi are given in Table 10.

Table 9. **Reaction of bhendi entries for their relative resistance/susceptibility to fruitborer damage**

Entries	Per cent fruit damage (in each picking)*										
	1	2	3	4	5	6	7	8	9	10	Mean
OHD-1	23.30 (28.86)^{a}	24.06 (29.37)^{a}	24.48 (29.65)^{a}	23.72 (29.14)^{a}	24.71 (29.81)^{a}	24.46 (29.64)^{a}	24.51 (29.67)^{a}	24.33 (29.55)^{a}	24.00 (29.33)^{a}	24.20 (29.47)^{a}	24.17 (29.45)^{a}
COOH-1	24.74 (29.83)^{b}	24.24 (29.49)^{a}	25.75 (30.49)^{b}	25.00 (30.00)^{b}	24.54 (29.70)^{a}	24.23 (29.49)^{a}	26.43 (30.94)^{b}	25.60 (30.39)^{b}	25.57 (30.37)^{b}	24.80 (29.87)^{a}	25.09 (30.06)^{b}
Arka Anamika	26.44 (30.94)^{c}	25.70 (30.46)^{b}	27.61 (31.70)^{c}	26.60 (31.05)^{c}	29.01 (32.59)^{c}	28.43 (32.22)^{c}	27.74 (31.78)^{c}	26.80 (31.17)^{c}	26.36 (30.89)^{c}	26.59 (31.04)^{c}	27.13 (31.39)^{c}
Varsha Uphar	27.25 (31.47)^{d}	26.10 (30.72)^{b}	28.85 (32.49)^{d}	27.63 (31.71)^{d}	27.78 (31.81)^{d}	27.56 (31.67)^{b}	26.20 (30.79)^{b}	25.10 (30.06)^{b}	26.70 (31.11)^{c}	28.74 (32.42)^{c}	27.19 (31.43)^{c}
MDU-1	37.20 (37.58)^{e}	47.25 (43.42)^{c}	36.50 (37.17)^{e}	39.97 (39.21)^{e}	49.02 (44.44)^{d}	48.22 (43.98)^{d}	48.20 (43.97)^{d}	46.50 (42.99)^{d}	39.22 (38.77)^{d}	39.04 (38.67)^{d}	43.11 (41.04)^{d}
Pusa Sawani	68.76 (56.02)^{f}	61.32 (51.54)^{d}	56.82 (48.92)^{f}	45.50 (42.42)^{f}	68.40 (55.80)^{e}	69.09 (56.22)^{e}	60.00 (50.77)^{e}	59.21 (50.31)^{e}	63.10 (52.59)^{e}	66.00 (54.33)^{e}	61.82 (51.84)^{e}

* Mean of 5 replications
Figures within parentheses are arcsin transformed values.
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

The trichome density recorded on leaves of bhendi on 25 DAS was maximum on OHD-1 (37.60 per sq. cm) and minimum on Pusa Sawani (19.00 per sq. cm). The remaining bhendi entries *viz.*, Arka Anamika, COOH-1, MDU-1 and Varsha Uphar recorded 33.60, 28.20, 26.40 and 26.20 trichomes per sq. cm. respectively.

The density of trichomes per sq. cm. recorded on 45 DAS on different entries was in the order of OHD-1 (46.20) > Arka Anamika (38.40) > COOH-1 (36.00) > MDU-1 (28.60) > Varsha Uphar (28.00) > Pusa Sawani (19.20).

The trichome density was less (19.80 trichomes per sq. cm.) on Pusa Sawani when recorded on 65 DAS when compared to other entries. Among the other entries, OHD-1, Arka Anamika, COOH-1, Varsha Uphar and MDU-1 recorded 43.00, 37.20, 32.80, 31.60 and 27.20 trichomes per sq. cm. respectively.

Considering the density of trichomes per sq. cm. of all the three periods of observations, higher density of trichomes recorded in different entries were in the order of OHD-1 (42.27) > Arka Anamika (36.40) > COOH-1 (32.33) > Varsha Uphar (28.60) > MDU-1 (27.40) > Pusa Sawani (19.33).

The test entries were further graded based on the mean trichome density per sq. cm. as detailed below.

Trichome density per sq. cm.	Category	Entries
> 30	Resistant	OHD-1, Arka Anamika, COOH-1
21 – 30	Moderately Resistant	Varsha Uphar, MDU-1
< 20	Highly Susceptible	Pusa Sawani

Table 10. Evaluation of bhendi entries for resistance on the basis of trichome density

Entries	Trichome density (per sq.cm)*			
	25 DAS	45 DAS	65 DAS	Mean
OHD-1	37.60 (6.17)[a]	46.20 (6.83)[a]	43.00 (6.60)[a]	42.27 (6.53)[a]
COOH-1	28.20 (5.36)[c]	36.00 (6.04)[c]	32.80 (5.77)[c]	32.33 (5.72)[c]
Arka Anamika	33.60 (5.84)[b]	38.40 (6.24)[b]	37.20 (6.14)[b]	36.40 (6.07)[b]
Varsha Uphar	26.20 (5.17)[d]	28.00 (5.34)[e]	31.60 (5.66)[d]	28.60 (5.39)[d]
MDU-1	26.40 (5.19)[d]	28.60 (5.40)[d]	27.20 (5.26)[e]	27.40 (5.28)[e]
Pusa Sawani	19.00 (4.36)[e]	19.20 (4.88)[f]	19.80 (4.94)[f]	19.33 (4.90)[f]

DAS-Days after sowing
* Mean of 5 replications
Figures within parentheses are $\sqrt{x + 0.5}$ transformed values.
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

4.1.4.3. Plant height

The data gathered on plant height (cm) in each entry at ten days interval from 20 days to 90 DAS are given in Table 11. Maximum height of 89.80 cm was recorded in the entry OHD-1 when compared to Pusa Sawani with 80.26 cm height. The remaining entries *viz.*, Arka Anamika, COOH-1, Varsha Uphar and MDU-1 differed significantly with each other by recording the plant height of 88.00, 86.28, 83.00 and 81.66 cm respectively.

4.1.4.4. Fruit parameters

The data gathered on influence of fruit parameters of bhendi entries on yield are furnished in Table 12.

a. Fruits per plant

The highest number of 23.60 fruits per plant was recorded on OHD-1, followed by COOH-1, Arka Anamika, Varsha Uphar and MDU-1 with 21.80, 20.00, 18.20 and 16.40 fruits per plant respectively. The lowest number of fruits per plant (15.00) was recorded on Pusa Sawani.

b. Fruit length

In COOH-1, OHD-1 and Arka Anamika entries, the mean length of fruit was 15.12, 15.10 and 14.58 cm respectively, while it was 13.81, 13.25 and 12.91 cm on Varsha Uphar, MDU-1 and Pusa Sawani respectively and they were on par with each other.

c. Fruit girth

The order of girth of the fruit (cm) recorded from different entries was COOH-1 (5.46) > OHD-1 (5.27) > Arka Anamika (5.25) > Varsha Uphar (5.21) > MDU-1 (4.91) > Pusa Sawani (4.63).

Table 11. Screening of bhendi entries for their resistance/susceptibility on the basis of plant height

Entries	Plant height (in cm)*							
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
OHD-1	14.60^{a}	21.58^{a}	30.66^{a}	39.58^{a}	47.23^{a}	60.26^{a}	76.28^{a}	89.80^{a}
COOH-1	13.05^{b}	19.80^{b}	28.92^{b}	35.25^{b}	40.08^{c}	52.00^{c}	69.80^{b}	86.28^{c}
Arka Anamika	12.95^{b}	20.25^{b}	29.25^{b}	35.41^{b}	42.83^{b}	55.80^{b}	68.10^{c}	88.00^{b}
Varsha Uphar	10.78^{c}	16.66^{c}	25.33^{c}	31.58^{c}	36.83^{d}	50.00^{d}	66.00^{d}	83.00^{d}
MDU-1	11.00^{c}	16.60^{c}	24.50^{cd}	31.00^{c}	35.00^{e}	48.20^{e}	64.00^{f}	81.66^{e}
Pusa Sawani	11.25^{c}	16.80^{c}	24.33^{d}	31.20^{c}	35.80^{e}	50.00^{d}	65.00^{e}	80.26^{d}

*Mean of 5 replications
DAS - Days after sowing
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

Table 12. **Influence of fruit parameters of bhendi entries on yield**

Entries	Fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Yield per plant (g)
OHD-1	23.60[a]	15.10[a]	5.27[a]	16.80[a]	386.43[a]
COOH-1	21.80[b]	15.12[a]	5.46[a]	16.00[ab]	338.67[b]
Arka Anamika	20.00[c]	14.58[a]	5.25[a]	15.66[b]	301.62[c]
Varsha Uphar	18.20[d]	13.81[b]	5.21[a]	15.40[bc]	280.30[d]
MDU-1	16.40[e]	13.25[bc]	4.91[b]	14.66[c]	240.81[e]
Pusa Sawani	15.00[f]	12.91[c]	4.63[b]	13.20[d]	200.33[f]

Values are mean of 5 replications
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

d. Fruit weight

The mean weight per fruit was minimum in Pusa Sawani 13.20 g and maximum in OHD-1 with 16.80 g while the weight of individual fruit in other entries was in the order of COOH-1, Arka Anamika, Varsha Uphar and MDU-1 recording 16.00, 15.66, 15.40 and 14.66 respectively.

e. Yield per plant

The innate capacity of bhendi entries in producing higher fruit yield per plant was in the order of OHD-1 (386.43 g) > COOH-1 (338.67 g) > Arka Anamika (301.62 g) > Varsha Uphar (280.30 g) > MDU-1 (240.81 g) > Pusa Sawani (200.33 g).

4.1.5. Persistent toxicity of selected insecticides against sucking pests of bhendi

a. Leafhopper

The persistent toxicity of certain insecticides against leafhopper was assessed using clip-on micro cage method and the results are furnished in Table 13. The results of the study indicated that the treatments methyl demeton 25 EC (0.05%), imidacloprid 200 SL (0.004%), dimethoate 30 EC (0.06%), carbosulfan 25 EC (0.05%), profenofos 50 EC (0.075%) and acephate 75 SP (0.11%) effected cent per cent mortality of leafhopper population on 1 DAT and recorded the mortality of 82.25 - 94.28 per cent on 3 DAT, 75.71 - 88.57 per cent on 5 DAT, 51.43 - 68.57 per cent on 7 DAT, 25.71 -52.85 per cent on 9 DAT, 14.28 - 28.57 per cent on 11 DAT and 8.57 - 20.00 per cent on 13 DAT. The per cent mortality of leafhopper population was progressively decreased in all the treatments as the days advanced.

Table 13. **Persistent toxicity of certain insecticides against bhendi leafhopper, *A. biguttula biguttula***

Treatments	Conc. (%)	Mortality (%) Days after treatment (DAT)										T	P	PTI	ORE
		1	3	5	7	9	11	13	15	17	19				
Methyldemeton 25 EC	0.05	100.00	85.71	75.71	55.71	25.71	15.71	11.43	4.29	0.00	0.00	46.78	15	701.70	6
Imidacloprid 200 SL	0.004	100.00	94.28	82.85	68.57	52.85	28.57	20.00	14.28	7.14	2.86	47.14	19	895.66	1
Dimethoate 30 EC	0.06	100.00	82.85	78.57	65.71	41.42	17.14	8.57	0.00	0.00	0.00	56.33	13	732.20	4
Carbosulfan 25 EC	0.05	100.00	87.14	75.71	58.57	35.71	21.42	15.43	8.57	2.86	0.00	45.05	17	765.77	3
Profenofos 50 EC	0.075	100.00	82.25	88.57	51.43	25.71	14.28	11.43	2.86	0.00	0.00	47.14	15	707.10	5
Acephate 75 SP	0.11	100.00	90.00	77.14	62.86	35.71	21.42	17.14	11.43	4.29	0.00	46.67	17	793.39	2

T =Mean per cent mortality
P = Period (in days)
PTI = Persistent Toxicity Index
ORE = Order of Relative Efficacy

Based on the lowest per cent mortality of leafhopper with reference to the persistent toxicity of insecticides, dimethoate 30 EC (0.06%) persisted only upto 13 DAT while methyl demeton 25 EC (0.05%) and profenofos 50 EC (0.075%) had the persistent toxicity upto 15 DAT. Acephate 75 SP (0.11%) and carbosulfan 25 EC (0.05%) had the persistent toxicity upto 17 DAT, while imidacloprid (0.004%) had the persistent toxicity upto 19 DAT.

The order of relative efficacy (ORE) of insecticides in terms of mortality of leafhopper due to cumulative exposure (PT value) was with imidacloprid 200 SL (0.004%) > acephate 75 SP (0.11%) > carbosulfan 25 EC (0.05%) > dimethoate 30 EC (0.06%) > profenofos 50 EC (0.075%) > methyl demeton 25 EC (0.05 %).

b. Whitefly

The results of the study showed (Table 14) that the treatments effected cent per cent mortality of whiteflies on 1 DAT, 88.57 - 97.14 per cent on 3 DAT, 74.28 - 87.14 per cent on 5 DAT, 47.14 - 74.28 per cent on 7 DAT, 30.00 - 61.43 per cent on 9 DAT, 20.00 - 45.71 an 11 DAT, 12.86 - 31.42 per cent on 13 DAT and 2.86 - 18.57 on 15 DAT. The per cent mortality of whiteflies was gradually decreased as the days advanced in all the treatments tested.

The persistence of acephate 75 SP (0.11%) lasted for 19 days, followed by imidacloprid 200 SL (0.004%) and carbosulfan 25 EC (0.05%) both persisted upto 17 DAT. In case of dimethoate 30 EC (0.06%), methyl demeton 25 EC (0.05%) and profenofos 50 EC (0.075%), the chemicals persisted only upto 15 DAT. The order of relative efficacy (ORE) of the insecticides based on the persistent toxicity index is as follows.

Table 14. Persistent toxicity of certain insecticides against bhendi whitefly, *B. tabaci*

Treatments	Conc. (%)	Mortality (%) Days after treatment (DAT)										T	P	PTI	ORE
		1	3	5	7	9	11	13	15	17	19				
Methyldemeton 25 EC	0.05	100.00	90.00	75.71	47.14	32.85	20.00	12.86	5.71	0.00	0.00	48.03	15	720.45	5
Imidacloprid 200 SL	0.004	100.00	95.71	84.28	62.86	52.85	32.85	25.71	14.28	5.71	0.00	52.69	17	895.73	2
Dimethoate 30 EC	0.06	100.00	92.86	78.57	58.57	37.14	20.00	12.86	4.29	0.00	0.00	50.54	15	758.10	4
Carbosulfan 25 EC	0.05	100.00	90.00	85.71	64.28	48.57	28.57	14.28	8.57	2.86	0.00	49.20	17	836.40	3
Profenofos 50 EC	0.075	100.00	88.57	74.28	47.14	30.00	21.42	15.71	2.86	0.00	0.00	47.50	15	712.50	6
Acephate 75 SP	0.11	100.00	97.14	87.14	74.28	61.43	45.71	31.42	18.57	8.57	2.86	52.71	19	1001.49	1

T =Mean per cent mortality
P = Period (in days)
PT I = Persistent Toxicity Index
ORE = Order of Relative Efficacy

Acephate 75 SP (0.11%) > imidacloprid 200 SL (0.004%) > carbosulfan 25 EC (0.05%) > dimethoate 30 EC (0.06%) > methyl demeton 25 EC (0.05%) > profenofos 50 EC (0.075%).

c. Aphid

The persistent toxicity of certain insecticides against aphid was assessed using clip-on blister package and the results (Table 15) indicated that the treatments recorded cent per cent mortality of aphid on 1 DAT, 87.14 - 95.71 per cent on 3 DAT, 80.00 - 88.57 per cent on 5 DAT, 56.57 - 78.57 per cent on 7 DAT, 40.00 - 65.71 per cent on 9 DAT, 14.28 - 50.00 per cent on 11 DAT, 11.43 - 34.28 per cent on 13 DAT and 2.86 - 21.42 per cent on 15 DAT. As the days advanced the mortality decreased progressively in all the treatments.

The persistence of the chemical acephate 75 SP (0.11%) was observed for 21 DAT, followed by imidacloprid 200 SL (0.004%) persisting upto 19 days, while it was 17 days in methyl demeton 25 EC (0.05%), carbosulfan 25 EC (0.05%) and profenofos 50 EC (0.075%). The least persistence (upto 15 DAT) was observed on dimethoate 30 EC (0.06%) treated plants. The order of relative efficacy (ORE) interms of mortality due to cumulative exposure (PT value) is as follows.

Acephate 75 SP (0.11%) > imidacloprid 200 SL (0.004%) > methyl demeton 25 EC (0.05%) > carbosulfan 25 EC (0:05%) > profenofos 50 EC (0.075%) > dimethoate 30 EC (0.06%).

Table 15. Persistent toxicity of certain insecticides against bhendi aphid, *A. gossypii*

Treatments	Conc. (%)	Mortality (%) Days after treatment (DAT)											T	P	PTI	ORE
		1	3	5	7	9	11	13	15	17	19	21				
Methyldemeton 25 EC	0.05	100.00	92.86	81.43	70.00	52.85	30.00	14.28	7.14	2.86	0.00	0.00	50.16	17	852.72	3
Imidacloprid 200 SL	0.004	100.00	95.71	85.71	75.71	60.00	45.71	28.86	15.71	7.14	2.86	0.00	51.74	19	983.06	2
Dimethoate 30 EC	0.06	100.00	88.57	97.14	56.57	40.00	14.28	11.43	2.86	0.00	0.00	0.00	51.36	15	770.40	6
Carbosulfan 25 EC	0.05	100.00	94.29	80.00	72.85	55.71	18.57	14.00	10.00	4.59	0.00	0.00	50.00	17	850.00	4
Profenofos 50 EC	0.075	100.00	87.14	80.00	64.85	45.71	18.57	15.71	5.71	2.86	0.00	0.00	46.73	17	794.41	5
Acephate 75 SP	0.11	100.00	95.71	88.57	78.57	65.71	50.00	34.28	21.42	10.00	5.71	1.42	50.13	21	1052.73	1

T =Mean per cent mortality
P = Period (in days)
PT I = Persistent Toxicity Index
ORE = Order of Relative Efficacy

4.2. Field experiments

4.2.1. Evaluation of neem products, *B.t.* formulations and insecticides against major pests of bhendi

4.2.1.1. Evaluation of neem products for their efficacy against sucking pests of bhendi

a. Aphid

The results obtained on the relative efficacy of different neem products against aphid are furnished in Table 16.

I Spray

Observations made on the population of aphid before treatment and per cent reduction in population different days after treatment over untreated check indicated that the pre-treatment population of aphid in different treatments ranged from 16.13 to 21.73 per plant.

The per cent reduction in population of aphid on one Day After First Spray (DAFS) ranged from 28.56 to 83.94. High per cent mortality of aphid to an extent of 83.94, 76.85 and 67.81 were recorded in the treatments methyl demeton (2 ml/lit), Neemazal-F (1.5 ml/lit) and TNAU NO 60 EC (c) (30 ml/lit) respectively, while the treatments Neemazal - F (1 ml/lit), Neem oil (30 ml/lit), TNAU 60 EC (c) (20 ml/lit), neem oil (20 ml/lit), NSKE (100 g/lit) and NSKE (50 g/lit) recorded 58.96, 50.84, 48.04, 38.43, 37.46 and 28.56 per cent reduction of aphid respectively

The order of efficacy of treatments in recording high per cent reduction in population of aphid on 3 DAFS was with methyl demeton (2 ml/lit) (92.59)>

Neemazal-F (1.5 ml/lit) (76.85) > TNAU NO 60 EC (c) (30 ml/lit) (73.15) > Neemazal-F (1 ml/lit) (65.98) > neem oil (30 ml/lit) (57.98) > TNAU NO 60 EC (c) (20 ml/lit) (54.91) > neem oil (20 ml/lit) (50.00) > NSKE (100 g/lit) (44.54) > NSKE (50 g/lit) (35.14)

The per cent reduction of aphid was significantly reduced in all treatments on 7 DAFS. The maximum per cent reduction of 65.58 was recorded in methyl demeton (2 ml/lit) followed by Neemazal -F (1.5 ml/lit), TNAU NO 60 EC (c) (30 ml/lit) and Neemazal - F (1 ml/lit) recording 58.17, 54.51 and 50.13 per cent reduction of aphid respectively, while neem oil (30 ml/lit), TNAU NO 60 EC (c) (20 ml/lit), neem oil (20 ml/lit), NSKE (100 g/lit) and NSKE (50 g/lit) recorded 45.14, 36.88, 31.73, 28.94 and 20.86 per cent reduction in aphid population respectively.

II Spray

The results obtained after the second spray revealed that per cent reduction in aphid population on one Day After Second Spray (DASS) was maximum (86.43) in the plot treated with methyl demeton (2 ml/lit), whereas Neemazal - F (1.5 ml/lit), TNAU NO 60EC (c) (30 ml/lit), Neemazal - F (1 ml/lit), neem oil (30 ml/lit) and TNAU NO 60 EC (c) (20 ml/lit) recorded 76.06, 69.16, 59.26, 55.92 and 55.46 per cent reduction of aphid respectively, followed by neem oil (20 ml/lit) (42.56%), NSKE (100 g/lit) (39.96%) and NSKE (50 g/lit) (31.97%).

Among the eight neem products tested, Neemazal - F (1.5 ml/lit) had brought 77.03 per cent reduction in population of aphid, while TNAU NO 60 EC (c) (30 ml/lit), Neemazal - F (1 ml/lit) and neem oil (30 ml/lit) with 72.99, 65.78, and 58.78 per cent reduction respectively on 3 DASS. The remaining treatments were on par in their efficacy.

The order of efficacy of treatments in reducing the population of aphid on 7 DASS was with methyl demeton 2 ml/lit (70.17%) > Neemazal - F 1.5 ml/lit (64.47%) > TNAU NO 60 EC (c) 30 ml/lit (60.43%) > Neemazal - F 1 ml/lit (50.21%) > neem oil 30 ml/lit (45.57) > TNAU NO 60 EC (c) 20 ml/lit (39.97%) > neem oil 20 ml/lit (31.61) > NSKE 100 g/lit (27.79) > NSKE 50 g/lit (21.52).

III Spray

On one Day After Third Spray (DATS), Neemazal - F (1.5 ml/lit) recorded 70.87 per cent reduction in population of aphid as against 85.73 per cent by methyl demeton (2 ml/lit). The treatments next in order were TNAU NO 60 EC (c) (30 ml/lit) and Neemazal-F (1 ml/lit) which recorded 64.69 and 56.83 per cent reduction of aphid respectively. The moderate per cent reduction of aphid to an extent of 49.14 and 45.22 were recorded in neem oil (30 ml/lit) and TNAU NO 60 EC (c) (20 ml/lit) treatments respectively and less than forty per cent reduction in aphid population was recorded in neem oil (20 ml/lit) and NSKE (50 and 100 g/lit) treated plots.

Similarly on 3 DATS, methyl demeton (2 ml/lit) and Neemazal-F (1.5 ml/lit) recorded 90.17 and 75.79 per cent reduction in population of aphid respectively, while Neemazal - F (1 ml/lit) TNAU NO 60 EC (c) (30 ml/lit), neem oil (30 ml/lit) TNAU NO 60 EC (c) (20 ml/lit), NSKE (100 g/lit), neem oil (20 ml/lit) and NSKE (50 g/lit) recorded 61.24, 60.83, 56.56, 55.38, 46.14, 45.11 and 39.39 per cent reduction respectively.

Table 16. Evaluation of certain neem products against bhendi aphid, *A. gossypii*

Treatments	Dose/ lit	Per cent reduction of aphid over control (mean of 3 replications)											
		I Spray				II Spray				III Spray			
		Pre-count*	1 DAFS	3 DAFS	7 DAFS	Pre-count*	1 DASS	3 DASS	7 DASS	Pre-count*	1 DATS	3 DATS	7 DATS
TNAU NO 60EC (c)	20 ml	20.00	48.04 (43.88)^{f}	54.91 (47.82)^{f}	36.88 (37.39)^{f}	24.60	55.46 (48.13)^{e}	57.24 (49.16)^{e}	39.97 (39.21)^{f}	19.06	45.22 (42.25)^{f}	55.38 (48.09)^{d}	39.31 (38.82)^{e}
TNAU NO 60 EC(c)	30 ml	21.73	67.81 (55.44)^{c}	73.15 (58.80)^{c}	54.51 (47.57)^{c}	20.73	69.16 (56.27)^{c}	72.99 (58.69)^{c}	60.43 (51.02)^{c}	17.93	64.69 (53.54)^{c}	60.83 (51.25)^{c}	54.55 (47.61)^{c}
NSKE	50 g	20.00	28.56 (32.80)^{h}	35.14 (36.36)^{i}	20.86 (27.17)^{i}	24.20	31.97 (34.43)^{h}	35.64 (36.65)^{g}	21.52 (27.63)^{i}	22.06	32.80 (35.93)^{h}	39.39 (38.87)^{f}	22.52 (28.32)^{h}
NSKE	100 g	20.60	37.46 (37.74)^{g}	44.54 (41.87)^{h}	28.94 (32.54)^{h}	22.60	39.96 (39.19)^{g}	41.98 (40.38)^{f}	27.79 (31.81)^{h}	19.80	34.35 (35.87)^{h}	46.14 (42.78)^{e}	27.77 (31.79)^{g}
Neem oil	20 ml	18.93	38.43 (38.31)^{g}	50.00 (45.00)^{g}	31.73 (34.28)^{g}	24.13	42.56 (40.72)^{f}	44.04 (41.57)^{f}	31.61 (34.21)^{g}	21.60	38.59 (38.40)^{g}	45.11 (42.19)^{e}	30.86 (33.74)^{f}
Neem oil	30 ml	16.13	50.84 (45.49)^{e}	57.98 (49.60)^{e}	45.14 (42.21)^{e}	24.86	55.92 (48.40)^{e}	58.78 (50.05)^{e}	45.57 (42.46)^{e}	19.66	49.14 (44.51)^{e}	56.56 (48.77)^{d}	40.57 (39.56)^{e}
Neemazal-F	1 ml	16.93	58.96 (50.16)^{d}	65.98 (54.08)^{d}	50.13 (45.07)^{d}	19.00	59.26 (50.32)^{d}	65.78 (54.19)^{d}	50.21 (45.12)^{d}	16.20	56.83 (48.93)^{d}	61.24 (51.50)^{c}	48.61 (44.20)^{d}
Neemazal-F	1.5 ml	19.46	76.85 (61.25)^{b}	76.85 (61.25)^{b}	58.17 (49.70)^{b}	14.06	76.06 (60.71)^{b}	77.03 (61.37)^{b}	64.47 (53.41)^{b}	14.20	70.87 (57.34)^{b}	75.59 (60.39)^{b}	62.59 (52.29)^{b}
Methyl demeton 25 EC	2 ml	17.53	83.94 (66.38)^{a}	92.59 (74.24)^{a}	65.58 (54.08)^{a}	12.46	86.43 (68.40)^{a}	90.42 (71.99)^{a}	70.17 (56.90)^{a}	12.06	85.73 (67.82)^{a}	90.17 (71.75)^{a}	73.02 (58.71)^{a}

* No. of aphids per plant
DAFS = Days After First Spray ; DASS = Days After Second Spray ; DATS = Days After Third Spray
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

The order of efficacy of treatments in recording high mortality of aphid on 7 DATS was methyl demeton (2 ml/lit) (73.02%) > Neemazal - F (1.5 ml/lit) (62.59%) > TNAU NO 60 EC (c) (30 ml/lit) (54.55%) > Neemazal - F (1 ml/lit) (48.61%) > neem oil (30 ml/lit) (40.57%) = TNAU NO 60 EC (c) (20 ml/lit) (39.31%) > neem oil (20 ml/lit) (30.86%) > NSKE (100 g/lit) (27.77%) > NSKE (50 g/lit) (22.52%).

b. Leafhopper

The results obtained on per cent reduction in population of leafhopper one, three and seven days after each round of spray are presented in Table 17.

I Spray

The per cent reduction in leafhopper population was higher in all the treatments on 1 DAFS when compared to 3 and 7 DAFS. In general, the order of efficacy of different treatments in recording maximum per cent reduction of leafhopper was with methyl demeton (2 ml/lit) (96.48, 89.84 and 70.29) > Neemazal - F (1.5 ml/lit) > (81.65, 74.59 and 62.72) > TNAU NO 60 EC (c) (30 ml/lit) (76.52, 65.73 and 52.17) > Neemazal - F (1 ml/lit) (67.58, 60.78 and 48.75) > neem oil (30 ml/lit) (60.53, 50.24 and 43.17) > TNAU NO 60 EC (c) (20 ml/lit) (58.93, 51.21 and 40.34) > neem oil (20 ml/lit) (47.38, 40.96 and 33.75) > NSKE (100 g/lit) (47.30, 38.87 and 30.17) > NSKE (50 g/lit) (33.99, 29.17 and 22.23) after 1,3 and 7 DAFS respectively.

II Spray

The per cent reduction of leafhopper on 1 DASS was less than 50 in NSKE at its both doses when compared to Neemazal - F (1.5 ml/lit) and TNAU NO 60

Table 17. **Evaluation of certain neem products against bhendi leafhopper, *A. biguttula biguttula***

Treatments	Dose/ lit	Per cent reduction of leafhopper over control (mean of 3 replications)											
		I Spray				II Spray				III Spray			
		Pre-count*	1 DAFS	3 DAFS	7 DAFS	Pre-count*	1 DASS	3 DASS	7 DASS	Pre-count*	1 DATS	3 DATS	7 DATS
TNAU NO 60EC (c)	20 ml	8.60	58.93 (50.14)^e	51.21 (45.69)^e	40.34 (39.43)^f	20.00	50.15 (45.08)^f	47.69 (43.67)^f	32.10 (34.51)^f	20.00	51.47 (45.84)^f	48.61 (44.21)^e	35.89 (36.80)^f
TNAU NO 60 EC(c)	30 ml	9.20	76.52 (61.02)^c	65.73 (54.17)^c	52.17 (46.24)^c	16.80	72.38 (58.30)^c	65.62 (54.10)^c	52.26 (46.29)^c	14.20	67.46 (55.22)^c	63.53 (52.85)^c	50.20 (45.11)^c
NSKE	50 g	10.80	33.99 (36.26)^g	29.17 (32.68)^g	22.23 (28.12)^i	17.40	38.53 (38.37)^h	35.43 (36.53)^g	21.96 (27.94)^g	19.13	35.79 (36.74)^h	30.21 (33.34)^g	23.45 (28.96)^h
NSKE	100 g	8.73	47.30 (43.45)^f	38.87 (38.57)^f	30.17 (33.31)^h	19.40	45.95 (42.67)^g	33.70 (37.88)^g	30.14 (33.29)^f	21.00	40.98 (39.80)^g	36.75 (37.31)^f	28.44 (32.22)^g
Neem oil	20 ml	10.73	47.38 (43.49)^f	40.96 (39.79)^f	33.75 (35.51)^g	20.80	50.15 (45.08)^f	47.69 (43.67)^f	32.09 (34.51)^f	20.53	41.30 (39.99)^g	39.02 (38.65)^f	30.28 (33.58)^g
Neem oil	30 ml	10.00	60.53 (51.08)^e	50.24 (45.14)^e	43.17 (41.07)^e	14.60	61.60 (51.71)^e	54.21 (47.41)^e	40.97 (39.79)^e	18.13	54.49 (47.57)^e	49.64 (44.79)^e	38.72 (38.48)^e
Neemazal-F	1 ml	10.86	67.58 (55.29)^d	60.78 (51.22)^d	48.75 (44.28)^d	18.80	65.88 (54.25)^d	60.22 (50.89)^d	44.89 (42.07)^d	17.93	62.07 (51.98)^d	53.74 (47.14)^d	42.37 (40.61)^d
Neemazal-F	1.5 ml	8.00	81.65 (64.64)^b	74.59 (59.73)^b	62.72 (52.37)^b	14.20	80.64 (63.90)^b	70.93 (57.37)^b	61.27 (51.51)^b	10.80	75.86 (60.57)^b	70.29 (56.97)^b	58.90 (50.13)^b
Methyl demeton 25 EC	2 ml	9.80	96.48 (79.30)^a	89.84 (71.43)^a	70.29 (56.97)^a	12.00	79.69 (69.91)^a	79.69 (63.22)^a	67.65 (55.34)^a	9.20	89.31 (70.93)^a	75.79 (60.52)^a	63.74 (52.98)^a

* No. of leafhopper per plant
DAFS = Days After First Spray ; DASS = Days After Second Spray ; DATS = Days After Third Spray
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

EC (c) (30 ml/lit) recording 80.64 and 72.38 respectively, followed by Neemazal-F (1 ml/lit) and neem oil (30 ml/lit) with 65.88 and 61.60 per cent reduction respectively. Neem oil (20 ml/lit) and TNAU NO 60 EC (c) (20 ml/lit) were on par by recording 50.15 per cent reduction of leafhopper. The per cent reduction of leafhopper was gradually decreased on 3 and 7 DASS when compared to 1 DASS, and the efficacy of treatments on 3 and 7 DASS followed the same trend as that of 1 DASS.

III Spray

The general order of high per cent reduction of leafhopper on 1,3 and 7 DATS was recorded in methyl demeton (2 ml/lit) (89.31, 75.79 and 63.74) > Neemazal - F (1.5 ml/lit) (75.86, 70.29 and 58.90) > TNAU NO 60 EC (c) (30 ml/lit) (67.46, 63.33 and 50.20) > Neemazal - F (1 ml/lit) (62.07, 53.74 and 42.37) > neem oil (30 ml/lit) (54.49, 49.64 and 38.72) > TNAU NO 60 EC (c) (20 ml/lit). (51.47, 48.61 and 35.89) > neem oil (20 ml/lit) (41.30, 39.02 and 30.28) > NSKE (100 g/lit) (40.98, 36.75 and 28.44) > NSKE (50 g/lit) (35.79, 30.21 and 23.45).

c. Whitefly

The results obtained on per cent reduction in population of whitefly are given in the Table 18.

I Spray

It is quite evident that the overall performance among the neem products was excellant in Neemazal -F (1.5 ml/lit) and TNAU NO 60 EC (c) (30 ml/lit) in reducing the whitefly population to an extent of 78.16 and 73.16 per cent respectively on 1 DAFS as against 41.19 per cent with NSKE (50 g/lit). The moderate level of per cent reduction in population ranging from 65.58 to 59.55 was observed in Neemazal - F (1 ml/lit), neem oil (30 ml/lit) and TNAU NO 60 EC (c) (20 ml/lit). Neem oil (20 ml/lit) and NSKE (100 g/lit) treatments were on par in their efficacy.

The reduction in population of whitefly was gradually reduced in all treatments on 7 DAFS when compared to 1 and 3 DAFS. The treatments methyl demeton (2 ml/lit) and Neemazal -F (1.5 ml/lit) effected more than 50 per cent reduction in population even 7 DAFS but the remaining treatments could reduce the population less than 40 per cent and the least effective treatment was NSKE (50 g/lit) (25.00%).

II Spray

The general effectiveness of different treatments in reducing the whitefly population was found to be gradually reduced from 1 to 7 DASS. The order of efficacy of treatments in increasing the per cent reduction of whitefly in the ascending order was with NSKE (50 g/lit) (43.03 to 22.85) < NSKE (100 g/lit) (49.68 to 25.41) < neem oil (20 ml/lit) (51.74 to 30.30) < TNAU NO 60 EC (c) (20 ml/lit) (60.66 to 32.71) < neem oil (30 ml/lit) (64.42 to 37.31) < Neemazal - F (1 ml/lit) (69.54 to 46.56) < TNAU NO 60 EC (c) (30 ml/lit) (76.65 to 50.51) < Neemazal - F (0.15%) (83.79 to 56.99) < methyl demeton (2 ml/lit) (95.55 to 72.17).

III Spray

The efficacy of different neem products on 1,3 and 7 DATS was more or less equal in recording uniform reduction in population of whitefly. In general,

Table 18. Evaluation of certain neem products against bhendi whitefly, *B. tabaci*

Treatments	Dose/ lit	Per cent reduction of whitefly over control (mean of 3 replications)											
		I Spray				II Spray				III Spray			
		Pre-count*	1 DAFS	3 DAFS	7 DAFS	Pre-count*	1 DASS	3 DASS	7 DASS	Pre-count*	1 DATS	3 DATS	7 DATS
TNAU NO 60EC (c)	20 ml	9.20	59.55 (50.50)^{e}	51.91 (46.09)^{f}	32.46 (34.73)^{f}	21.33	60.66 (51.15)^{f}	55.72 (48.28)^{f}	32.71 (34.88)^{f}	20.60	58.58 (49.94)^{f}	52.03 (46.16)^{e}	42.44 (40.65)^{e}
TNAU NO 60 EC(c)	30 ml	5.00	73.16 (58.80)^{c}	64.90 (53.67)^{c}	49.66 (44.80)^{c}	15.40	76.65 (61.11)^{c}	66.84 (54.84)^{c}	50.51 (45.29)^{c}	16.66	70.49 (57.09)^{c}	64.82 (53.62)^{c}	54.84 (47.78)^{c}
NSKE	50 g	10.00	41.19 (39.92)^{g}	35.35 (36.48)^{i}	25.00 (29.99)^{h}	23.00	43.03 (40.99)^{h}	37.98 (38.04)^{i}	22.85 (28.55)^{i}	21.93	46.06 (39.26)^{h}	29.20 (32.71)^{h}	19.12 (25.92)^{h}
NSKE	100 g	8.46	48.40 (44.08)^{f}	41.07 (39.85)^{h}	27.33 (31.52)^{g}	21.33	49.68 (44.81)^{g}	43.21 (41.09)^{h}	25.41 (30.26)^{h}	24.00	42.00 (40.39)^{h}	35.40 (36.51)^{g}	23.21 (29.99)^{g}
Neem oil	20 ml	4.23	50.50 (45.28)^{f}	45.41 (42.36)^{g}	27.81 (31.82)^{g}	25.06	51.74 (45.99)^{g}	48.18 (43.95)^{g}	30.30 (33.39)^{g}	23.80	48.07 (43.89)^{g}	40.28 (39.39)^{f}	26.41 (30.91)^{f}
Neem oil	30 ml	9.80	61.53 (51.67)^{e}	55.98 (48.43)^{e}	36.10 (36.93)^{e}	18.40	64.42 (53.38)^{e}	60.42 (51.01)^{e}	37.31 (37.64)^{e}	24.13	61.68 (51.75)^{e}	52.10 (46.20)^{e}	42.45 (40.65)^{e}
Neemazal-F	1 ml	7.53	65.58 (54.08)^{d}	60.65 (51.15)^{d}	45.08 (42.17)^{d}	17.06	69.54 (56.50)^{d}	64.42 (53.38)^{d}	46.56 (43.03)^{d}	18.53	65.45 (54.00)^{d}	58.63 (49.97)^{d}	50.99 (45.56)^{d}
Neemazal-F	1.5 ml	7.93	78.16 (62.14)^{b}	69.16 (56.26)^{b}	58.17 (49.70)^{b}	15.40	83.79 (66.26)^{b}	70.96 (57.39)^{b}	56.99 (49.02)^{b}	13.00	75.50 (60.33)^{b}	69.70 (56.60)^{b}	59.79 (50.64)^{b}
Methyl demeton 25 EC	2 ml	6.06	90.26 (71.86)^{a}	86.79 (68.70)^{a}	78.17 (62.15)^{a}	12.46	95.55 (77.90)^{a}	83.28 (65.87)^{a}	72.17 (58.16)^{a}	10.53	87.42 (69.24)^{a}	77.45 (61.65)^{a}	64.41 (53.37)^{a}

* No. of whitefly per plant
DAFS = Days After First Spray ; DASS = Days After Second Spray ; DATS = Days After Third Spray
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

NSKE (50 g/lit) recorded the lowest per cent reduction in population ranging from 46.06 to 19.12. Methyl demeton (2 ml/lit) resulted more than 60 per cent reduction even on 7 DATS. In case of neem products, Neemazal - F and TNAU NO 60 EC (c) proved their efficacy by recording more than 50 per cent reduction on 7 DATS. All other treatments differed significantly but effected less than 40 per cent reduction in population of whitefly.

d. Yield and Cost Benefit Ratio (CBR)

The data on healthy fruit yield of bhendi for different neem products treatments and its CBRs are furnished in Table 19. The plots treated with methyl demeton recorded maximum yield of 6150 kg ha^{-1}. Among the neem products Neemazal-F (1.5 ml/lit) and TNAU NO 60 EC (c) (30 ml/lit) registered maximum fruit yield of 6060 and 5860 kg ha^{-1} respectively. The minimum yield (< 4000 kg ha^{-1}) was recorded in NSKE treated plots as against untreated check which registered only 2540 kg ha^{-1}.

Considering the cost of production, gross returns and net returns from this experiment, the maximum Cost Benefit Ratio (CBR) was obtained in methyl demeton (2 ml/lit) (1: 3.09) and the order of neem treatments in securing high CBR was Neemazal-F (1 ml/lit) (1: 2.45) > Neemazal - F (1.5 ml/lit) (1: 2.30) > TNAU NO 60 EC (c) (20 ml/lit) (1: 2.20) > TNAU NO 60 EC (c) (30 ml/lit) (1: 1.94) > neem oil (20 ml/lit) (1: 2.12) > neem oil (30 ml/lit) (1: 1.94) > NSKE (50 g/lit) (1: 1.71) > NSKE (100 g/lit) (1: 1.53) > Untreated check (1: 1.44).

Table 19. Effect of certain neem products against sucking pests of bhendi - Yield and Cost Benefit Ratio (CBR)

Treatments	Dose/ lit	Yield of healthy fruits (in kgs)		Cost of yield/ha @ Rs.5/kg (Gross return)	Cost of cultivation Rs/ha	Cost of treatment Rs/ha	Total cost Rs/ha	Net return Rs/ha	Cost Benefit Ratio
		Per plot	Per ha						
TNAU NO 60EC (c)	20 ml	11.14 [b]	5580 [e]	27900	8658	3985	12643	15247	1:2.20
TNAU NO 60 EC(c)	30 ml	11.72 [ab]	5860 [c]	28300	8658	5860	14158	13782	1:1.94
NSKE	50 g	7.36 [d]	3680 [i]	18400	8658	2110	10768	7632	1:1.71
NSKE	100 g	7.76 [d]	3880 [h]	19400	8658	3985	12643	6757	1:1.53
Neem oil	20 ml	10.20 [c]	5100 [g]	25500	8658	3385	12043	13457	1:2.12
Neem oil	30 ml	11.00 [b]	5500 [f]	27500	8658	5485	14143	13357	1:1.94
Neemazal-F	1 ml	11.50 [b]	5750 [d]	28750	8658	3085	11743	17007	1:2.45
Neemazal -F	1.5 ml	12.22 [a]	6060 [b]	30300	8658	4510	13168	17132	1:2.30
Methyl demeton	2 ml	12.28 [a]	6150 [a]	30750	8658	1297	9955	20795	1:3.09
Control	-	5.07 [e]	2540 [j]	12500	8658	-	8658	3842	1:1.44

Table 20. **Effect of neem products on population of natural enemies**

Treatments	Dose/lit	Population of natural enemies per ten plants*		
		Coccinellids	Spiders	Chrysopids
TNAU NO 60 EC (c)	20.0 ml	12.33 (3.58) [b]	11.28 (3.43) [b]	5.88 (2.52) [ab]
TNAU NO 60 EC (c)	30.0 ml	9.50 (3.16) [d]	7.60 (2.84) [f]	3.96 (2.11) [d]
NSKE	50 g	12.75 (3.64) [b]	11.23 (3.42) [b]	5.92 (2.53) [ab]
NSKE	100 g	10.00 (3.24) [d]	9.58 (3.17) [d]	4.68 (2.27) [cd]
Neem oil	20.0 ml	11.08 (3.40) [c]	10.83 (3.36) [bc]	5.75 (2.50) [ab]
Neem oil	30.0 ml	9.75 (3.20) [d]	8.66 (3.03) [e]	4.08 (2.14) [d]
Neemazal-F	1.0 ml	11.00 (3.39) [c]	10.58 (3.33) [c]	5.33 (2.41) [bc]
Neemazal-F	1.5 ml	9.67 (3.19) [d]	8.00 (2.91) [f]	4.00 (2.12) [d]
Methyl demeton	2.0 ml	5.80 (2.51) [e]	4.28 (2.18) [g]	2.83 (1.82) [e]
Control	-	13.92 (3.80) [a]	12.66 (3.63) [a]	6.66 (1.67) [a]

* Mean of four observations of 3 replications
Figures within parentheses are $\sqrt{x + 0.5}$ transformed values
Means followed by the same letter(s) in a column are not significantly different (P = 0.05) by DMRT.

e. Effect of neem products on population of natural enemies

The overall safety of different neem treatments by recording higher population of natural enemies *viz.*, coccinellids (*Menochilus sexmaculatus* Fabricius and *Micraspis crocea* Mulsant), spiders (*Oxyopes* sp. and *Clubiona* sp.) and chrysopid (*Chrysoperla carnea* Stephen) respectively was in the order of untreated check (13.92, 12.66 and 6.66) > NSKE 50 g/lit (12.75, 11.23 and 5.92) > TNAU NO 60 EC (c) 20 ml/lit (12.33, 11.28 and 5.88) > Neem oil (20 ml/lit) (11.08, 10.83 and 5.75) > Neemazal-F 1 ml/lit (11.00, 10.58 and 5.33) > NSKE 100 g/lit (10.00, 9.58 and 4.68) > neem oil 30 ml/lit (9.75, 8.66 and 4.08) Neemazal-F 1.5 ml/lit (9.67, 8.00 and 4.00) > TNAU NO 60 EC (c) 30 ml/lit (9.50, 7.60 and 3.96) > methyl demeton (5.80, 4.28 and 2.83) (Table 20).

4.2.1.2. Evaluation of *B.t.* formulations for their efficacy against bhendi fruitborer, *Earias* spp.

a. Fruitborer damage

The results obtained on per cent fruit damage both on number and weight bases in different *B.t.* treatments are presented in Table 21. The efficacy of *B.t.* products in reducing the fruitborer damage on number and weight bases was more or less uniform. Among the *B.t.* treatments, Biobit 2 g/lit recorded less per cent fruit damage of 5.59 and 5.56 in comparison with endosulfan 35EC 2ml/lit which recorded 4.26 and 4.18 per cent both on number and weight bases respectively, followed by Biobit 1.5 g/lit (6.56 and 6.62%), Delfin 2.0 g/lit (7.69 and 7.37%) and Delfin 1.5 g/lit (8.73 and 8.21%), which were on par with each other. Spicturin 3.0 ml/lit recorded 10.99 and 13.33 per cent fruit damage when compared to 19.33 and 21.01 per cent in untreated check respectively both on number and weight bases.

Table 21. Efficacy of different *B.t.* formulations on the fruit damage by *Earias* spp.

Treatments	Dose/ litre	Number basis		Weight basis	
		Per cent fruit damage*	Per cent reduction over control	Per cent fruit damage*	Per cent reduction over control
Spicturin FC	3.0 ml	10.99 (19.36)[e]	43.15	13.33 (21.41)[f]	31.04
Spicturin FC	4.0 ml	10.64 (19.02)[e]	44.95	12.55 (20.75)[f]	40.27
Delfin WG	1.5 g	8.73 (17.19)[d]	54.83	8.21 (16.65)[e]	60.92
Delfin WG	2.0 g	7.69 (16.08)[cd]	60.21	7.37 (15.75)[d]	64.92
Biobit HPWP	1.5 g	6.56 (14.84)[bc]	66.06	6.62 (14.91)[c]	68.49
Biobit HPWP	2.0 g	5.59 (13.66)[ab]	71.08	5.56 (13.63)[b]	73.54
Endosulfan 35 EC	2.0 ml	4.26 (11.91)[a]	77.96	4.18 (11.79)[a]	80.10
Control	-	19.33 (26.00)[f]		21.01 (27.28)[g]	

*Mean of 3 replications

Figures within parentheses are arcsin transformed values

Means followed by the same letter(s) in a column are not significantly different (P = 0.05) by DMRT.

The overall performance of different treatments in reducing fruitborer damage over untreated check respectively in number and weight bases was in the order of endosulfan 2.0 ml/lit (77.96 and 80.10%) > Biobit 2g/lit (71.08 and 73.54%) > Biobit 1.5 g./lit (66.06 and 68.49%) > Delfin 2.0 g/lit (60.21 and 64.92%) > Delfin 1.5 g/lit (54.83 and 60.92%) > Spicturin 4.0 ml/lit (44.95 and 40.27%) > Spicturin 3.0 ml/lit (43.15 and 31.04%).

b. Yield and Cost Benefit Ratio (CBR)

The statistical analysis of the data on plot yield computed for hectare basis in different *B.t.* treatments indicated that the efficacy of treatments in recording higher fruit yield (kg/ha) was in the order of endosulfan 2.0 ml/lit (6930) > Biobit 2.0 g/lit (5330) > Delfin 2 g/lit (5280) > Biobit 1.5 g/lit (5220)> Delfin 1.5 g/lit (5200) > Spicturin 4.0 ml/lit (4100) > Spicturin 3.0 ml/lit (3900) > Untreated check (2900).

The efficacy of treatments in securing high CBR was in the order of endosulfan 2.0 ml/lit (1: 3.52) > Delfin 2.0 g/lit (1: 2.35) > Biobit 2.0 g/lit (1: 1.97) > Biobit 1.5 g/lit (1: 1.92) > Delfin 1.5 g/lit (1: 1.90) > Spicturin 3 ml/lit (1: 1.75) > Spicturin 4 ml/lit (1: 1.74) > control (1: 1.67) (Table 22).

c. Effect of *B.t.* formulations on population of natural enemies

The results obtained from this experiment showed (Table 23) that the order of safety of treatments in recording higher population of coccinellids (*M. sexmaculatus* and *M. crocea*), spiders (*Oxyopes* sp. and *Clubiona* sp.) and chrysopid (*C. carnea*) per ten plants was respectively in untreated control (13.66,

Table 22. **Effect of different *B.t.* formulations on the incidence of *Earias* spp. - Yield and Cost Benefit Ratio (CBR)**

Treatments	Dose/ litre	Yield of healthy fruit (in kgs)		Cost of yield/ha @ Rs.5/kg (Gross return)	Cost of cultivation Rs/ha	Cost of treatment Rs/ha	Total cost Rs/ha	Net return Rs/ha	Cost Benefit Ratio
		Per plot	Per ha						
Spicturin FC	3.0 ml	7.80 ^{c}	3900 ^{e}	19500	8658	2508	11166	8334	1:1.75
Spicturin FC	4.0 ml	8.20 ^{c}	4100 ^{d}	20500	8658	3108	11766	8734	1:1.74
Delfin WG	1.5 g	10.40 ^{b}	5200 ^{c}	26000	8658	5058	13716	12284	1:1.90
Delfin WG	2.0 g	10.56 ^{b}	5280 ^{bc}	26400	8658	6508	15166	11234	1:2.35
Biobit HDWP	1.5 g	10.44 ^{b}	5220 ^{c}	26100	8658	3828	12486	13614	1:1.92
Biobit HDWP	2.0 g	10.66 ^{b}	5330 ^{b}	26650	8658	4828	13526	13124	1:1.97
Endosulfan 35 EC	2.0 ml	13.86 ^{a}	6930 ^{a}	34650	8658	1178	9836	24814	1:3.52
Control		5.80 ^{d}	2900 ^{f}	14500	8658	-	8658	5842	1:1.67

Table 23. **Effect of *B.t.* formulations on population of natural enemies**

Treatments	Dose/lit	Population of natural enemies per ten plants*		
		Coccinellids	Spiders	Chrysopids
Spicturin	3.0 ml	12.36 (3.59) bc	6.00 (2.55) c	4.83 (2.31) b
Spicturin	4.0 ml	11.92 (3.52) c	4.92 (2.33) de	3.97 (2.11) c
Delfin	1.5 g	12.67 (3.63) b	6.88 (2.71) b	4.91 (2.33) b
Delfin	2.0 g	11.86 (3.52) c	4.80 (2.30) e	3.62 (2.03) c
Biobit	1.5 g	12.25 (3.57) bc	5.56 (2.46) cd	4.00 (2.12) c
Biobit	2.0 g	10.62 (3.33) d	3.36 (2.04) f	3.50 (2.00) c
Endosulfan	2.0 ml	4.88 (2.32) e	2.62 (1.77) g	1.96 (1.57) d
Control	-	13.66 (3.76) a	10.83 (3.37) a	8.08 (2.93) a

* Mean of four observations of 3 replications
Figures within parentheses are $\sqrt{x + 0.5}$ transformed values
Means followed by the same letter(s) in a column are not significantly different (P = 0.05) by DMRT.

10.83 and 8.08) > Delfin 1.5 g/lit (12.67, 6.88 and 4.91) > Spicturin 3 ml/lit (12.36, 6.00 and 4.83) > Biobit 1.5 g/lit (12.25, 5.56 and 4.00) > Spicturin 4 ml/lit (11.92, 4.92 and 3.97) > Delfin 2.0 g/lit (11.86, 4.80 and 3.62) > Biobit 2.0 g/lit (10.62, 3.36 and 3.50) > endosulfan 2 ml/lit (4.88, 2.62 and 1.96).

4.2.1.3. Evaluation of certain insecticides for their efficacy against sucking pests of bhendi

a. Aphid

The results obtained on the relative efficacy of certain insecticides against aphid are given in Table 24.

I Spray

On 1 DAFS, profenofos was found to be significantly superior in reducing the aphid population to an extent of 70.96 per cent, followed by imidacloprid (63.24%). Methyl demeton and carbosulfan were on par with each other by recording 61.04 and 60.38 per cent reduction in population of aphid, while less than 60 per cent reduction was recorded in acephate and dimethoate treatments.

The order of efficacy of treatments in recording high per cent reduction in population of aphid on 3 DAFS was imidacloprid (80.69) > methyl demeton (78.07) > acephate (71.14) > dimethoate (67.48) > profenofos (53.10) > carbosulfan (52.21).

On 7 DAFS, acephate was significantly superior in resulting 77.53 per cent reduction in population of aphid, followed by imidacloprid, methyl demeton and dimethoate with 68.42, 63.19 and 58.69 per cent reduction of aphid, while profenofos and carbosulfan were with less than 50 per cent reduction only.

II Spray

On 1 DASS, imidacloprid and methyl demeton treatments recorded 66.04 and 64.37 per cent reduction in population of aphid, followed by profenofos, acephate, carbosulfan and dimethoate with 57.83, 57.76, 56.30 and 55.07 per cent reduction respectively, which were on par with each other.

On 3 DASS, the per cent reduction of aphid was higher in imidacloprid and acephate with 82.79 and 80.56 respectively, followed by 77.20 per cent in methyl demeton, 67.16 per cent in dimethoate, 51.94 per cent in carbosulfan and 50.52 per cent reduction of aphid in profenofos.

On 7 DASS, higher per cent reduction in population of aphid was recorded in acephate (75.27%) followed by imidacloprid (68.38%), methyl demeton (64.71%), dimethoate (58.65%), profenofos (42.94%) and carbosulfan (40.63%) treatments.

III Spray

On 1 DATS, high per cent reduction in population of aphid was recorded with imidacloprid (81.25) followed by methyl demeton (67.19). Dimethoate and acephate, profenofos and carbosulfan recording 64.86 and 61.66, 57.85 and 57.62 per cent reduction in population of aphid respectively were on par with each other.

The order of efficacy of treatments in bringing high reduction in population of aphid was more or less uniform on 3 and 7 DATS. Among the treatments acephate was significantly superior resulting in high mortality of aphid (78.98 and

Table 24. Evaluation of certain insecticides against bhendi aphid, *A. gossypii*

Treatments	Conc. (%)	Per cent reduction of aphids over control (mean of 3 replications)											
		I Spray				II Spray				III Spray			
		Pre-count*	1 DAFS	3 DAFS	7 DAFS	Pre-count*	1 DASS	3 DASS	7 DASS	Pre-count*	1 DATS	3 DATS	7 DATS
Methyl demeton 25 EC	0.05	15.00	61.04 (51.38)[c]	78.07 (62.08)[b]	63.19 (52.65)[c]	12.00	64.39 (56.36)[a]	77.20 (61.48)[c]	64.71 (53.55)[c]	14.00	67.19 (55.05)[b]	73.67 (59.12)[c]	60.23 (50.90)[c]
Imidacloprid 200 SL	0.004	13.66	63.24 (52.68)[b]	80.69 (63.94)[a]	68.42 (55.81)[b]	10.66	66.04 (54.36)[a]	82.79 (65.49)[a]	68.38 (55.78)[b]	12.00	81.25 (64.34)[a]	75.75 (60.50)[b]	64.92 (53.68)[b]
Dimethoate 30 EC	0.06	15.00	54.66 (47.67)[d]	67.48 (55.23)[d]	58.69 (50.00)[d]	15.00	55.07 (47.91)[c]	67.16 (55.03)[d]	58.65 (49.98)[d]	14.66	64.86 (53.64)[c]	68.54 (55.88)[d]	51.46 (45.84)[d]
Carbosulfan 25 EC	0.05	10.66	60.38 (50.99)[c]	52.21 (46.27)[e]	42.47 (40.69)[f]	18.60	56.30 (48.62)[bc]	51.94 (46.11)[e]	40.63 (39.59)[f]	23.66	57.62 (49.38)[d]	63.00 (52.54)[e]	48.77 (44.30)[e]
Profenofos 50 EC	0.075	12.00	70.96 (57.39)[a]	53.10 (46.78)[e]	46.55 (43.21)[e]	18.66	57.83 (49.50)[b]	50.52 (45.30)[e]	42.94 (40.94)[e]	24.00	57.85 (49.52)[d]	64.73 (53.57)[e]	48.79 (44.31)[e]
Acephate 75 SP	0.11	13.00	59.92 (50.72)[c]	71.14 (57.50)[c]	77.53 (61.71)[a]	12.00	57.76 (49.46)[b]	80.56 (63.84)[b]	75.27 (60.18)[a]	12.00	61.66 (51.74)[c]	78.98 (62.71)[a]	67.07 (51.98)[a]

* No. of aphids per plant
DAFS = Days After First Spray ; DASS = Days After Second Spray ; DATS = Days After Third Spray
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

67.07%) followed by imidacloprid (75.75 and 64.92%) methyl demeton (73.67 and 60.23%) dimethoate (68.54 and 51.46%), profenofos (64.73 and 48.79%) and carbosulfan (63.00 and 48.77%). Profenofos and carbosulfan treatments recorded only 48.79 and 48.77 per cent reduction of aphid on 7 DATS respectively, which were on par with each other.

b. Leafhopper

I Spray

On 1 DAFS, imidacloprid and acephate recorded high per cent reduction in population of leafhopper to an extent of 88.74 and 83.31 respectively, followed by profenofos and dimethoate with 79.81 and 78.17 per cent respectively. Carbosulfan and methyl demeton were equally effective resulting in 81.49 ad 80.69 per cent reduction of leafhopper respectively.

The order of efficacy of different treatments in recording higher per cent reduction in population of leafhopper on 3 and 7 DAFS respectively was with acephate (78.86 and 59.81) > imidacloprid (77.48 and 55.27) carbosulfan (70.52 and 51.73) > methyl demeton (67.01 and 49.45) > dimethoate (63.16 and 38.68) > profenofos (62.28 and 47.05).

II Spray

On 1 DASS, imidacloprid and acephate recorded 80.05 and 78.63 per cent reduction in population of leafhopper, which were on par followed by carbosulfan (75.13%) and methyl demeton (74.46%), which were also in accordance with each other. Profenofos and dimethoate recorded only 69.02 and 66.06 per cent reduction in population of leafhopper respectively.

Table 25. Evaluation of certain insecticides against bhendi leafhopper, *A. biguttula biguttula*

Treatments	Conc. (%)	Per cent reduction of leafhopper over control (mean of 3 replications)											
		I Spray				II Spray				III Spray			
		Pre-count*	1 DAFS	3 DAFS	7 DAFS	Pre-count*	1 DASS	3 DASS	7 DASS	Pre-count*	1 DATS	3 DATS	7 DATS
Methyl demeton 25 EC	0.05	9.00	80.69 $(63.94)^{cd}$	67.01 $(54.94)^{c}$	49.45 $(44.68)^{d}$	13.66	74.46 $(59.65)^{b}$	63.83 $(53.03)^{d}$	54.47 $(47.56)^{c}$	15.00	72.00 $(58.05)^{c}$	64.68 $(53.54)^{d}$	51.90 $(46.09)^{bc}$
Imidacloprid 200 SL	0.004	8.00	88.74 $(70.40)^{a}$	77.48 $(61.67)^{a}$	55.27 $(48.92)^{b}$	10.00	80.05 $(63.47)^{a}$	76.88 $(61.26)^{b}$	57.55 $(49.34)^{b}$	12.00	80.64 $(63.90)^{a}$	72.54 $(58.40)^{b}$	56.73 $(48.87)^{a}$
Dimethoate 30 EC	0.06	7.00	78.17 $(62.15)^{e}$	63.16 $(52.63)^{d}$	38.68 $(38.45)^{f}$	15.66	66.06 $(54.36)^{d}$	56.48 $(48.72)^{f}$	50.19 $(45.10)^{e}$	17.00	67.05 $(54.97)^{e}$	58.82 $(50.08)^{f}$	45.58 $(42.46)^{e}$
Carbosulfan 25 EC	0.05	9.00	81.49 $(64.52)^{bc}$	70.52 $(57.11)^{b}$	51.73 $(45.99)^{c}$	12.33	75.13 $(60.09)^{b}$	66.48 $(54.62)^{c}$	52.83 $(46.62)^{d}$	14.66	75.34 $(60.23)^{b}$	67.60 $(55.31)^{c}$	50.58 $(45.33)^{cd}$
Profenofos 50 EC	0.075	10.00	79.18 $(62.85)^{de}$	62.28 $(52.11)^{d}$	47.05 $(45.30)^{e}$	15.00	69.02 $(56.18)^{c}$	59.00 $(50.18)^{e}$	51.64 $(45.94)^{d}$	16.66	69.88 $(56.72)^{d}$	60.11 $(50.83)^{e}$	48.73 $(44.27)^{d}$
Acephatse 75 SP	0.11	10.33	83.31 $(65.89)^{b}$	78.86 $(62.62)^{a}$	59.81 $(50.66)^{a}$	10.00	78.63 $(62.47)^{a}$	80.80 $(64.02)^{a}$	60.95 $(51.33)^{a}$	11.00	76.78 $(61.19)^{b}$	72.97 $(58.68)^{a}$	53.75 $(47.15)^{b}$

* No. of leafhopper per plant

DAFS = Days After First Spray ; DASS = Days After Second Spray ; DATS = Days After Third Spray

Figures within parentheses are arcsin transformed values

Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

On 3 and 7 DASS, the per cent reduction of leafhopper population respectively was higher in acephate (80.80 and 60.95) followed by imidacloprid (76.88 and 57.55), carbosulfan (66.48 and 52.83), methyl demeton (63.83 and 54.47), profenofos (59.00 and 51.64) and dimethoate (56.48 and 50.19).

III Spray

The efficacy of different treatments in reducing leafhopper population over untreated check respectively on 1,3 and 7 DATS was in the order of imidacloprid (80.64, 72.54 and 56.73%) > acephate (76.78, 72.97 and 53.75%) > carbosulfan (75.34, 67.60 and 50.58) > methyl demeton (72.00, 64.68 and 51.90%) > profenofos (69.88, 60.11 and 48.73%) > dimethoate (67.05, 58.82 and 45.58%) (Table 25).

c. Whitefly

The results obtained on the relative efficacy of certain insecticides on the control of whitefly are furnished in Table 26.

I Spray

The order of efficacy of different treatments in reducing whitefly population on 1 and 3 DAFS was imidacloprid (82.21 and 57.64%) > carbosulfan (57.89 and 54.32%) > acephate (76.93 and 51.22%) = methyl demeton (67.48 and 50.97%) > dimethoate (62.68 and 48.04%) > profenofos (72.14 and 36.24%). On 7 DAFS, all the above treatments were able to bring down the whitefly population ranging from 17.11 to 28.55 per cent.

Table 26. Evaluation of certain insecticides against bhendi whitefly, *B. tabaci*

Treatments	Conc. (%)	Per cent reduction of whitefly over control (mean of 3 replications)											
		I Spray				II Spray				III Spray			
		Pre-count*	1 DAFS	3 DAFS	7 DAFS	Pre-count*	1 DASS	3 DASS	7 DASS	Pre-count*	1 DATS	3 DATS	7 DATS
Methyl demeton 25 EC	0.05	11.66	67.48 (55.23)[d]	50.97 (45.55)[c]	27.01 (31.31)[ab]	5.66	77.75 (61.72)[b]	63.62 (52.90)[d]	84.50 (66.82)[a]	7.66	50.00 (45.00)[c]	46.58 (43.04)[c]	58.70 (50.01)[c]
Imidacloprid 200 SL	0.004	10.66	82.21 (65.06)[a]	57.64 (49.39)[a]	25.62 (30.41)[bc]	6.33	64.85 (53.63)[e]	95.22 (77.41)[a]	81.36 (64.43)[b]	6.33	68.40 (55.80)[a]	53.84 (47.20)[a]	72.83 (58.58)[a]
Dimethoate 30 EC	0.06	11.00	62.68 (52.35)[e]	48.04 (43.88)[d]	24.44 (29.63)[c]	7.66	62.59 (52.29)[f]	80.41 (63.75)[c]	35.20 (36.39)[d]	8.33	32.52 (36.58)[d]	31.45 (34.11)[d]	55.63 (48.23)[d]
Carbosulfan 25 EC	0.05	12.00	57.89 (49.54)[f]	54.32 (47.59)[b]	24.61 (29.74)[c]	7.66	70.95 (57.39)[d]	56.28 (48.61)[e]	11.30 (19.63)[f]	10.33	32.03 (34.47)[e]	24.37 (29.58)[e]	51.39 (45.80)[e]
Profenofos 50 EC	0.075	11.33	72.14 (58.14)[c]	36.24 (37.01)[e]	17.11 (24.43)[d]	7.33	73.94 (59.30)[c]	20.98 (27.26)[f]	15.29 (23.01)[e]	13.66	29.28 (32.76)[f]	15.00 (22.79)[f]	38.68 (38.45)[f]
Acephate 75 SP	0.11	12.33	76.93 (61.30)[b]	51.22 (45.70)[c]	28.85 (32.30)[a]	8.33	80.96 (64.13)[a]	85.39 (67.53)[b]	61.47 (51.63)[c]	12.66	60.82 (51.25)[b]	49.18 (44.53)[b]	70.58 (57.15)[b]

* No. of whitefly per plant
DAFS = Days After First Spray ; DASS = Days After Second Spray ; DATS = Days After Third Spray
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

II Spray

The efficacy of different treatments in recording high mortality of whiteflies from 1 to 7 DASS was found to range from 80.96 to 61.47 in acephate, from 77.55 to 84.50 in methyl demeton, from 73.94 to 15.29 in profenofos, from 70.95 to 11.30 in carbosulfan, from 64.85 to 81.36 in imidacloprid and from 62.59 to 35.20 in dimethoate.

III Spray

The performance of different treatments resulting in high per cent reduction in population of whiteflies on 1,3 and 7 DATS was with imidacloprid (68.40, 53.84 and 72.83) followed by acephate (60.82, 49.18 and 70.58), methyl demeton (50.00, 46.58 and 58.70), dimethoate (32.52, 31.45 and 55.63), carbosulfan (32.03, 24.37 and 51.39) and profenofos (29.28, 15.00 and 36.68) respectively.

d. Yield and Cost Benefit Ratio (CBR)

The treatments registering maximum healthy fruit yield (kg ha^{-1}) was in the order of imidacloprid (6300) > acephate (6140) > profenofos (6000) > carbosulfan (5940) > methyl demeton and dimethoate (5660) > control (3995).

Maximum CBR was obtained from imidacloprid treatment (1:3.27) followed by acephate (1:2.97), dimethoate (1:2.96), profenofos (1:2.93), methyl demeton (1:2.91) and carbosulfan (1:2.77) as against untreated check, which recorded only 1:2.30 (Table 27).

e. Effect of certain insecticides on population of natural enemies

In the experiment conducted with different insecticides for the control of sucking pests, the population of natural enemies coccinellids (*M. sexmaculatus* and

Table 27. **Evaluation of certain insecticides against sucking pests of bhendi - Yield and Cost Benefit Ratio (CBR)**

Treatments	Conc. (%)	Yield of healthy fruits (in kgs)		Cost of yield/ha @Rs.5/kg (Gross return)	Cost of cultivation Rs/ha	Cost of treatment Rs/ha	Total cost Rs/ha	Net return Rs/ha	Cost Benefit Ratio
		Per plot	Per ha						
Methyl demeton 25 EC	0.05	11.32 d	5660 a	28300	8638	1062	9720	18580	1:2.91
Imidacloprid 200 SL	0.004	12.56 a	6300 a	31500	8658	972	9630	21870	1:3.27
Dimethoate 30 EC	0.06	11.32 d	5660 a	28300	8658	873	9531	18769	1:2.96
Carbosulfan 25 EC	0.05	11.88 c	5940 a	29700	8658	2076	10734	18966	1:2.77
Profenofos 50 EC	0.075	12.00 bc	6000 a	30000	8658	1554	10212	19788	1:2.93
Acephate 75 SP	0.11	12.28 ab	6140 a	30700	8658	1687	10345	20355	1:2.97
Control	-	7.99 e	3995 b	19975	8658	-	8658	11317	1:2.30

Table 28. Effect of certain insecticides on population of natural enemies

Treatments	Conc. (%)	Population of natural enemies per ten plants*		
		Coccinellids	Spiders	Chrysopids
Methyl demeton 25 EC	0.05	5.33 (2.41) [b]	3.66 (2.04) [bc]	2.00 (1.57) [b]
Imidacloprid 200 SL	0.004	4.66 (2.26)	3.66 (2.04) [bc]	1.67 (1.46) [bc]
Dimethoate 30 EC	0.06	4.50 (2.23) [bc]	3.25 (1.93) [c]	1.33 (1.34) [c]
Carbosulfan 25 EC	0.05	3.58 (2.02) [c]	2.97 (1.86) [c]	0.83 (1.15) [d]
Profenofos 50 EC	0.075	3.83 (2.08) [c]	3.00 (1.87) [c]	0.92 (1.19) [d]
Acephate 75 SP	0.11	4.17 (2.16) [c]	3.17 (1.91) [c]	1.33 (1.34) [c]
Control	-	9.92 (3.23) [a]	11.08 (3.40) [a]	4.86 (2.31) [a]

* Mean of four observations of 3 replications
Figures within parentheses are $\sqrt{x + 0.5}$ transformed values
Means followed by the same letter(s) in a column are not significantly different (P = 0.05) by DMRT.

M. crocea), spiders (*Oxyopes* sp. and *Clubiona* sp.) and chrysopid (*C. carnea*) per ten plants were respectively higher in untreated check (9.92, 11.08 and 4.86) and next in order was methyl demeton (5.33, 3.66 and 2.00) followed by imidacloprid (4.66, 3.66 and 1.67) > dimethoate (4.50, 3.25 and 1.33) > acephate (4.17, 3.17 and 1.33) > profenofos (3.83, 3.00 and 0.92) > carbosulfan (3.58, 2.97 and 0.83) (Table 28).

4.2.1.4. Evaluation of certain insecticides for their efficacy against bhendi fruitborer, *Earias* spp.

a. Fruitborer damage

Number basis

The results obtained on effectiveness of two rounds of sprays with different insecticidal treatments are presented in Table 29. The fruitborer damage was less in endosulfan (4.00%) followed by quinalphos (5.24%), profenofos (5.86%), triazophos (6.79%), malathion (8.16%) and phosalone (8.72%) as against 19.85 per cent fruit damage in untreated control.

The order of efficacy of treatments in reducing the fruit damage was endosulfan (79.84%) > quinalphos (73.60%) > profenofos (70.48%) > triazophos (65.79%) > malathion (58.89%) > phosalone (56.07%).

Weight basis

The results obtained on per cent fruit damage (Table 29) of different treatments on weight basis indicated that the order of efficacy of treatments in bringing less per cent fruit damage was with endosulfan (3.56) < quinalphos (4.79) < profenofos (5.34) < triazophos (6.80) < malathion (8.07) < phosalone (8.49) <

Table 29. **Efficacy of certain insecticides on the fruit damage by *Earias* spp.**

Treatments	Conc. (%)	Number basis		Weight basis	
		Per cent fruit damage*	Per cent reduction over control	Per cent fruit damage*	Per cent reduction over control
Endosulfan 35 EC	0.07	4.00 (11.51)[a]	79.84	3.56 (10.86)[a]	82.24
Malathion 50 EC	0.10	8.16 (16.52)[bc]	58.89	8.07 (16.50)[d]	59.73
Triazophos 40 EC	0.08	6.79 (15.01)[bc]	65.79	6.80 (15.03)[cd]	66.07
Phosalone 35 EC	0.07	8.72 (11.03)[c]	56.07	8.49 (16.83)[d]	57.63
Quinalphos 25 EC	0.05	5.24 (13.17)[ab]	73.60	4.79 (12.60)[ab]	76.10
Profenofos 50 EC	0.075	5.86 (13.87)[abc]	70.48	5.34 (13.61)[bc]	73.35
Control	-	19.85 (26.42)[d]		20.04 (26.54)[e]	

* Mean of 3 replications
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

untreated check (20.04), with the resultant reduction in fruit damage upto 82.24, 76.10, 73.35, 66.07, 59.73 and 57.63 per cent in the treatments endosulfan, quinalphos, profenofos, triazophos, malathion and phosalone respectively.

b. Yield and Cost Benefit Ratio (CBR)

The data on fruit yield of bhendi and CBRs for different treatments are furnished in Table 30. In general, all the insecticidal treatments enhanced the bhendi fruit yield when compared to untreated check. The order of performance of treatments in recording high bhendi fruit yield (kg/ha) was endosulfan (7710) > profenofos (6910) > triazophos (6790) > quinalphos (6490) > malathion (6090) > phosalone (5720) while untreated check recorded 3500 kg/ha only.

The cost benefit ratio obtained in different treatments were 1: 4.06 in endosulfan followed by 1: 3.45 in triazophos, 1: 3.44 in profenofos, 1: 3.41 in quinalphos, 1: 3.22 in malathion, 1: 2.95 in phosalone as against only 1: 2.02 in untreated check.

c. Effect of certain insecticides on population of natural enemies

In the experiment conducted with different insecticides against fruitborer, *Earias* spp. the order of effect of insecticides in recording higher population of natural enemies coccinellids (*M. sexmaculatus* and *M. crocea*), spiders (*Oxyopes* sp. and *Clubiona* sp.) and chrysopid (*C. carnea*) per ten plants was respectively in untreated check (11.33, 8.75 and 5.92) > endosulfan (5.83, 3.92 and 3.33) > malathion (5.00, 3.83 and 300) > triazophos (4.88, 3.25 and 2.92) > phosalone (4.67, 3.00 and 2.58) > profenofos (4.25, 2.92 and 2.08) > quinalphos (3.92, 2.83 and 1.67) (Table 31).

Table 30. Evaluation of certain insecticides against *Earias* spp. - Yield and Cost Benefit Ratio (CBR)

Treatments	Conc. (%)	Yield of healthy fruits (in kgs)		Cost of yield/ha @Rs.5/kg (Gross return)	Cost of cultivation Rs/ha	Cost of treatment Rs/ha	Total cost Rs/ha	Net return Rs/ha	Cost Benefit Ratio
		Per plot	Per ha						
Endosulfan 35 EC	0.07	15.42^{a}	7710^{a}	38550	8658	824	9482	29068	1:4.06
Malathion 50 EC	0.10	12.18^{d}	6090^{e}	30450	8658	804	9462	20988	1:3.22
Triazophos 40 EC	0.08	13.58^{b}	6790^{c}	33950	8658	1198	9856	24094	1:3.45
Phosalone 35 EC	0.07	11.44^{e}	5720^{f}	28600	8658	1034	9692	18908	1:2.95
Quinalphos 25 EC	0.05	12.98^{c}	6490^{d}	32450	8658	858	9516	22934	1:3.41
Profenofos 50 EC	0.075	13.82^{b}	6910^{b}	34550	8658	1390	10048	24502	1:3.44
Control	-	7.00^{f}	3500^{g}	17500	8658	-	8658	8842	1:2.02

Table 31. Effect of certain insecticides on population of natural enemies

Treatments	Conc. (%)	Population of natural enemies per ten plants*		
		Coccinellids	Spiders	Chrysopids
Endosulfan 35 EC	0.07	5.83 (2.51) [b]	3.92 (2.09) [b]	3.33 (1.95) [b]
Malathion 50 EC	0.10	5.00 (2.34) [c]	3.83 (2.08) [bc]	3.00 (1.87) [c]
Triazophos 40 EC	0.08	4.88 (2.32) [c]	3.25 (1.93) [cd]	2.92 (1.84) [c]
Phosalone 35 EC	0.07	4.67 (2.27) [cd]	3.00 (1.87) [d]	2.58 (1.75) [d]
Quinalphos 25 EC	0.05	3.92 (2.10) [e]	2.83 (1.82) [d]	1.67 (1.47) [f]
Profenofos 50 EC	0.075	4.25 (2.18) [de]	2.92 (1.84) [d]	2.08 (1.60) [e]
Control	-	11.33 (3.44) [a]	8.75 (3.04) [a]	5.92 (2.53) [a]

* Mean of four observations of 3 replications

Figures within parentheses are $\sqrt{x + 0.5}$ transformed values

Means followed by the same letter(s) in a column are not significantly different (P = 0.05) by DMRT.

4.2.2. Impact of N, P and K fertilizers on the incidence of major pests of bhendi

a. Aphid

Population of aphid was found to be increased as the age of the crop advanced from 15 to 92 Days After Treatment (DAT), irrespective of the NPK fertilizers. However, the impact of NPK application was well pronounced from 15 to 92 DAT regarding the population ranging from 0.00 to 6.83 in 40:50:60 kg/ha, from 0.00 to 8.00 in 40:50:45 kg/ha, from 1.33 to 13.66 in 40:50:30 kg/ha, from 1.99 to 16.50 in 0:50:30 kg/ha, from 2.66 to 17.43 in 60:50:30 kg/ha, from 3.98 to 20.66 in 80:50:30 kg/ha and from 5.00 to 21.33 in 40:50:0 kg/ha. It is evident that NPK at 40:50:60 kg/ha and 40:50:45 kg/ha able to record less population of aphid when compared to the recommended dose of 40:50:30 kg/ha. As the dose of N was increased from 0 to 80 kg/ha, the aphid population also was found to increase from 16.50 to 20.66 per plant (Table 32).

b. Leafhopper

From the table 33, it is quite evident that the population level of leafhopper per plant in all the treatments were in an increasing trend with the increase in crop age. Double the dose of 'K' (40:50:60 kg/ha) and 1½ dose of 'K' (40:50:45 kg/ha) treatments recorded less population of leafhopper to an extent of 4.00 and 5.66 per plant respectively, while the recommended dose of NPK @ 40:50:30 kg/ha, 'N' untreated (0:50:30 kg/ha) and 1½ dose of 'N' (60:50:30 kg/ha) registered leafhopper population of 10.66, 12.33 and 15.33 per plant respectively on 92 DAT. Higher population of 17.66 and 18.99 leafhoppers per plant was recorded on 92 DAT in double the dose of 'N' (80:50:30 kg/ha) and 'K' untreated (40:50:0 kg/ha) plots respectively, which were on par.

Table 32. **Impact of N, P and K fertilizers against bhendi aphid, *A. gossypii***

Treatments NPK (kg/ha)	Population of aphid per plant* – Days after treatment (DAT)											
	15	22	29	36	43	50	57	64	71	78	85	92
40 : 50 : 30	1.33 (1.34)^{b}	2.67 (1.78)^{c}	3.00 (1.87)^{b}	3.00 (1.86)^{b}	3.67 (2.04)^{b}	5.00 (2.35)^{b}	9.00 (3.08)^{c}	10.66 (3.34)^{d}	9.87 (3.22)^{b}	12.00 (3.53)^{c}	12.33 (3.58)^{b}	13.66 (3.76)^{c}
40 : 50 : 0	5.00 (2.34)^{e}	6.66 (20.67)^{e}	7.33 (2.80)^{d}	9.00 (3.08)^{f}	9.66 (3.19)^{d}	10.99 (3.39)^{d}	13.31 (3.72)^{e}	15.00 (3.94)^{f}	16.33 (4.10)^{d}	17.98 (4.30)^{e}	19.00 (4.42)^{d}	21.33 (4.67)^{e}
40 : 50 : 45	0.00 (0.71)^{a}	1.00 (1.19)^{b}	2.33 (1.68)^{b}	3.00 (1.86)^{b}	3.66 (2.04)^{b}	5.00 (2.34)^{b}	7.00 (2.74)^{b}	7.33 (2.80)^{b}	5.66 (2.47)^{a}	7.67 (2.85)^{b}	6.33 (2.61)^{a}	8.00 (2.91)^{b}
40 : 50 : 60	0.00 (0.71)^{a}	0.00 (0.71)^{a}	1.00 (1.22)^{a}	1.33 (1.32)^{a}	2.66 (1.78)^{a}	3.00 (1.86)^{a}	3.66 (2.04)^{a}	4.00 (2.12)^{a}	4.99 (2.34)^{a}	4.99 (2.34)^{a}	6.00 (2.54)^{a}	6.83 (2.61)^{a}
0 : 50 : 30	1.99 (1.57)^{c}	2.33 (1.67)^{c}	2.66 (1.77)^{b}	4.00 (2.11)^{c}	4.33 (2.20)^{b}	6.00 (2.54)^{b}	7.66 (2.85)^{b}	9.00 (3.08)^{c}	12.33 (3.58)^{c}	14.99 (3.94)^{d}	15.33 (3.97)^{c}	16.50 (4.12)^{d}
60 : 50 : 30	2.66 (1.77)^{c}	3.00 (1.86)^{c}	5.00 (2.34)^{c}	6.33 (2.61)^{d}	5.66 (2.48)^{c}	9.00 (3.08)^{c}	9.66 (3.19)^{cd}	11.00 (3.39)^{c}	12.33 (3.58)^{c}	14.66 (3.89)^{d}	16.00 (4.06)^{c}	17.43 (4.23)^{d}
80 : 50 : 30	3.98 (2.11)^{d}	4.66 (2.27)^{d}	5.00 (2.34)^{c}	7.66 (2.85)^{e}	8.66 (3.03)^{d}	8.66 (3.03)^{c}	11.00 (3.39)^{d}	12.33 (3.58)^{e}	15.67 (4.02)^{d}	17.43 (4.23)^{e}	20.00 (4.53)^{d}	20.66 (4.60)^{e}

*Mean of 3 replications

Figures within parentheses are $\sqrt{x + 0.5}$ transformed values.

Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

Table 33. **Impact of N, P and K fertilizers against bhendi leafhopper, *A. biguttula biguttula***

Treatments	Population of leafhopper per plant*											
	Days after treatment (DAT)											
N P K (kg/ha)	15	22	29	36	43	50	57	64	71	78	85	92
40 : 50 : 30	0.00 $(0.71)^{a}$	1.33 $(1.34)^{ab}$	2.66 $(1.78)^{bc}$	4.00 $(2.12)^{cd}$	5.33 $(2.41)^{c}$	5.99 $(2.55)^{c}$	5.66 $(2.48)^{c}$	6.33 $(2.61)^{c}$	7.00 $(2.74)^{c}$	7.00 $(2.74)^{c}$	9.33 $(3.14)^{c}$	10.66 $(3.34)^{c}$
40 : 50 : 0	2.33 $(1.68)^{c}$	4.00 $(2.12)^{d}$	5.33 $(2.41)^{e}$	6.00 $(2.55)^{ef}$	7.99 $(2.91)^{de}$	8.33 $(2.97)^{de}$	9.99 $(3.10)^{c}$	15.00 $(3.93)^{e}$	15.66 $(4.02)^{f}$	17.00 $(4.18)^{f}$	17.66 $(4.26)^{e}$	18.99 $(4.41)^{e}$
40 : 50 : 45	0.00 $(0.71)^{a}$	1.00 $(1.19)^{a}$	2.33 $(1.68)^{b}$	2.66 $(1.78)^{b}$	4.00 $(2.12)^{b}$	4.33 $(2.19)^{b}$	5.00 $(2.34)^{b}$	5.33 $(2.41)^{c}$	4.00 $(2.12)^{b}$	5.00 $(2.34)^{b}$	5.33 $(2.41)^{b}$	5.66 $(2.48)^{b}$
40 : 50 : 60	0.00 $(0.71)^{a}$	1.00 $(1.22)^{a}$	1.33 $(1.35)^{a}$	0.00 $(0.71)^{a}$	0.00 $(0.71)^{a}$	1.33 $(1.35)^{a}$	0.00 $(0.71)^{a}$	2.00 $(1.58)^{a}$	2.00 $(1.56)^{a}$	2.33 $(1.68)^{a}$	3.00 $(1.87)^{a}$	4.00 $(2.12)^{a}$
0 : 50 : 30	1.66 $(1.47)^{c}$	2.00 $(1.58)^{bc}$	2.33 $(1.68)^{b}$	3.00 $(1.87)^{bc}$	5.00 $(2.34)^{bc}$	7.33 $(2.80)^{cd}$	7.66 $(2.85)^{c}$	9.00 $(3.08)^{d}$	9.33 $(3.13)^{d}$	11.00 $(3.39)^{d}$	11.00 $(3.39)^{c}$	12.33 $(3.58)^{c}$
60 : 50 : 30	0.85 $(1.13)^{b}$	2.66 $(1.78)^{c}$	3.66 $(2.04)^{cd}$	5.01 $(2.35)^{de}$	6.99 $(2.73)^{d}$	7.66 $(2.86)^{de}$	9.00 $(3.08)^{c}$	11.00 $(3.39)^{e}$	12.66 $(3.63)^{e}$	13.00 $(3.67)^{e}$	15.00 $(3.94)^{d}$	15.33 $(3.98)^{d}$
80 : 50 : 30	1.66 $(1.46)^{c}$	3.00 $(1.84)^{c}$	4.00 $(2.12)^{d}$	7.33 $(2.80)^{f}$	9.00 $(3.08)^{e}$	9.33 $(3.14)^{e}$	9.00 $(3.08)^{c}$	12.00 $(3.54)^{e}$	12.66 $(3.63)^{e}$	15.33 $(3.99)^{f}$	17.00 $(4.18)^{de}$	17.66 $(4.26)^{e}$

*Mean of 3 replications

Figures within parentheses are $\sqrt{x + 0.5}$ transformed values.

Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

c. Whitefly

The whitefly population was not observed upto 29 DAT in double dose of 'K' (40:50:60 kg/ha) and it recorded a minimum population of 3.00 per plant, but the population ranged from 4.00 to 18.00 per plant from 15 to 92 DAT in 0 'K'. The order of effect of treatments in recording less population of whitefly per plant from 15 DAT to 92 DAT was with 40:50:45 (0.00 to 5.66) < 0:50:30 (2.00 to 9.00) < 40:50:30 (1.00 to 9.33) < 60:50:30 (2.00 to 11.00) < 80:50:30 kg/ha (3.00 to 13.00) (Table 34).

d. Fruitborer damage

The results of fruit damage both on number and weight bases recorded in different levels of NPK treatments are presented in Table 35. The order of effect of treatments in recording less per cent fruit damage respectively in number and weight bases was with 40:50:60 (15.72 and 14.85) < 40:50:45 (16.99 and 16.52) < 40:50:30 (17.96 and 17.84) < 0:50:30 (20.38 and 19.29) < 60:50:30 (22.17 and 21.33) < 40:50:0 (23.00 and 22.26) < 80:50:30 kg/ha (23.56 and 22.29).

e. Yield and Cost Benefit Ratio (CBR)

The statistical analysis of the data recorded from individual plot computed to hectare basis for different levels of NPK treatments, indicated that the plots treated with double the dose of 'K' (40:50:60) recorded high fruit yield of 4070 kg/ha, followed by 1 ½ dose of 'K' (40:50:45) recording 3875 kg/ha. Recommended dose of NPK (40:50:30) stood next and brought fruit yield of 3345 kg/ha. The treatments next in order were with 0:50:30 (2920 kg/ha) > 60:50:30 (2500 kg/ha) > 80:50:30 (2410 kg/ha). The minimum yield of 2180 kg/ha was recorded in the 'K' untreated (40:50:0 kg/ha) plots.

Table 34. Impact of N, P and K fertilizers against bhendi whitefly, *B. tabaci*

Treatments N P K (kg/ha)	Population of whitefly per plant* – Days after treatment (DAT)											
	15	22	29	36	43	50	57	64	71	78	85	92
40 : 50 : 30	1.00 (1.22)[b]	1.66 (1.46)[c]	2.00 (1.58)[b]	2.66 (1.78)[c]	3.00 (1.87)[b]	5.01 (2.35)[c]	5.33 (2.41)[b]	6.00 (2.54)[b]	8.00 (2.91)[d]	8.65 (3.03)[d]	9.00 (3.08)[c]	9.33 (3.14)[c]
40 : 50 : 0	4.00 (2.12)[e]	5.01 (2.34)[f]	6.29 (2.61)[f]	7.00 (2.74)[f]	8.66 (3.03)[e]	9.66 (3.19)[e]	10.00 (3.24)[d]	12.00 (3.53)[e]	13.33 (3.72)[f]	15.00 (3.94)[f]	17.66 (4.26)[f]	18.00 (4.30)[f]
40 : 50 : 45	0.00 (0.71)[a]	1.00 (1.21)[b]	1.66 (1.46)[b]	2.00 (1.58)[b]	2.55 (1.74)[b]	2.00 (1.58)[b]	3.00 (1.87)[a]	3.66 (1.97)[a]	4.00 (2.12)[b]	5.00 (2.35)[b]	5.33 (2.41)[b]	5.66 (2.48)[b]
40 : 50 : 60	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	1.00 (1.22)[a]	1.00 (1.22)[a]	1.33 (1.34)[a]	2.66 (1.77)[a]	2.99 (1.87)[a]	2.33 (1.68)[a]	2.66 (1.78)[a]	3.00 (1.87)[a]	3.00 (1.86)[a]
0 : 50 : 30	2.00 (1.58)[c]	2.66 (1.78)[d]	3.00 (1.87)[c]	4.00 (2.12)[d]	4.33 (2.20)[c]	5.00 (2.34)[c]	5.66 (2.48)[b]	6.33 (2.61)[b]	7.00 (2.74)[c]	7.33 (2.80)[c]	8.33 (2.97)[c]	9.00 (3.08)[c]
60 : 50 : 30	2.00 (1.58)[c]	3.79 (2.07)[e]	4.00 (2.12)[b]	5.66 (2.48)[e]	7.00 (2.74)[d]	7.00 (2.73)[d]	7.66 (2.85)[c]	8.00 (2.91)[c]	8.33 (2.97)[d]	9.00 (3.80)[d]	10.66 (3.34)[d]	11.00 (3.40)[d]
80 : 50 : 30	3.00 (1.84)[d]	4.66 (2.27)[f]	5.33 (2.41)[e]	6.99 (2.74)[f]	7.33 (2.80)[d]	9.00 (3.08)[e]	9.66 (3.19)[d]	10.00 (3.24)[d]	11.00 (3.39)[e]	11.33 (3.44)[e]	12.66 (3.63)[e]	13.00 (3.67)[e]

*Mean of 3 replications

Figures within parentheses are $\sqrt{x + 0.5}$ transformed values.

Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

Table 35. **Impact of N, P and K fertilizers on fruit damage by *Earias* spp.**

Treatments N P K (kg ha^{-1})	Per cent fruit damage*	
	Number basis	Weight basis
40 : 50 : 30	17.96 (25.07)^{c}	17.84 (24.98)^{c}
40 : 50 : 0	23.00 (28.66)^{ef}	22.26 (28.15)^{e}
40 : 50 : 45	16.99 (24.34)^{b}	16.52 (23.98)^{b}
40 : 50 : 60	15.72 (23.36)^{a}	14.85 (22.66)^{a}
0 : 50 : 30	20.38 (26.83)^{d}	19.29 (26.05)^{d}
60 : 50 : 30	22.17 (28.09)^{e}	21.33 (27.51)^{e}
80 : 50 : 30	23.56 (29.04)^{f}	22.29 (28.17)^{e}

* Mean of 3 replications
Figures within parentheses are arcsin transformed values
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT.

Table 36. Impact of N, P and K fertilizers on the incidence of major pests of bhendi - Yield and Cost Benefit Ratio (CBR)

Treatments N P K (kg/ha)	Yield of healthy fruits (in kgs)		Cost of yield/ha @Rs.5/kg (Gross return)	Cost of cultivation Rs/ha	Cost of treatment Rs/ha	Total cost Rs/ha	Net return Rs/ha	Cost Benefit Ratio
	Per plot	Per ha						
40 : 50 : 30	6.69 [b]	3345 [c]	16725	8658	1528	10186	6539	1:1.64
40 : 50 : 0	4.36 [d]	2180 [g]	10900	8658	1400	10058	842	1:1.08
40 : 50 : 45	7.75 [a]	3875 [b]	19225	8658	1591	10249	8976	1:1.87
40 : 50 : 60	8.14 [a]	4070 [a]	20350	8658	1655	10313	10037	1:1.97
0 : 50 : 30	5.84 [bc]	2920 [d]	14600	8658	1128	9786	4814	1:1.49
60 : 50 : 30	5.00 [cd]	2500 [e]	12500	8658	1726	10384	2116	1:1.20
80 : 50 : 30	4.82 [d]	2410 [f]	12050	8658	1928	10586	1464	1:1.14

The effect of NPK treatments in securing high CBR was well pronounced in 40:50:60 kg/ha NPK level (1:1.97) followed by 40:50:45 (1:1.87), 40:50:30 (1:1.64), 0:50:30 (1:1.49), 60:50:30 (1:1.20), 80:50:30 (1:1.14) and 40:50:0 kg/ha (1:1.08) (Table 36).

4.2.3. Development of IPM on bhendi

4.2.3.1. Effect of NPK fertilizers, botanicals and insecticides against major pests of bhendi

The results obtained from the IPM experiment on the above aspects with special reference to per cent reduction in population of aphid, leafhopper and whitefly are presented in the Table 37-39.

a. Aphid

Significant reduction in aphid population was registered at 3 DAFS, with more than 75 per cent reduction in T_2, T_4, T_6 and T_8 indicating their superior effectiveness over other treatments. At 7 DAFS, T_2 and T_4 were found to be the best treatments with 60 per cent reduction in population of aphid. The general trend in the order of their efficacy in recording higher reduction in population of aphid was $(T_2 = T_4) > (T_6 = T_8) > (T_1 = T_3) > T_7 > T_5$.

The per cent reduction in population of aphid on 3 and 7 DASS was comparatively higher in T_2 and T_4 treatments recording 88.84 and 66.34, 86.42 and 64.00 respectively followed by T_6 (82.34 and 54.12 %) and T_8 (79.68 and 52.27%), while T_5 and T_7 recorded less than 50 per cent reduction. In general the order of relative efficacy of treatments followed the trend of $T_2 > T_4 > T_6 > T_8 > T_1 > T_3 > T_5 > T_7$ based on the level of mortality of aphid (Table 37).

Table 37. **Effect of N, P and K fertilizers, biocides and insecticides against bhendi aphid, *A. gossypii***

T. No.	Treatments		Dose (ml/lit)	Pre-count**	Per cent reduction over control*		Treatments	Dose (ml (or) g/lit)	Pre-count**	Per cent reduction over control*	
	NPK (kg/ha)	I Spray			3 DAFS	7 DAFS	II Spray			3 DASS	7 DASS
T_1	40 : 50 : 30	Neemazal-F	1.0	19.73	67.66 $(55.34)^d$	42.98 $(40.96)^d$	Acephate	1.5	14.52	75.57 $(60.38)^e$	48.92 $(44.38)^e$
T_2	40 : 50 : 45	Neemazal-F	1.0	14.52	82.34 $(65.15)^a$	60.00 $(50.76)^b$	Acephate	1.5	10.68	88.84 $(70.48)^a$	66.34 $(54.53)^a$
T_3	40 : 50 : 30	Neemazal-F	1.0	18.64	66.80 $(54.82)^d$	43.18 $(41.08)^d$	Imidacloprid	0.2	13.90	72.38 $(58.30)^f$	46.46 $(42.97)^f$
T_4	40 : 50 : 45	Neemazal-F	1.0	13.42	81.88 $(64.81)^a$	60.60 $(51.12)^a$	Imidacloprid	0.2	9.66	86.42 $(68.38)^b$	64.00 $(53.13)^b$
T_5	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	17.00	62.49 $(52.33)^f$	38.08 $(38.10)^f$	Acephate	1.5	14.86	68.60 $(55.91)^g$	44.10 $(41.61)^g$
T_6	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	12.84	76.34 $(60.90)^{bc}$	52.21 $(46.27)^c$	Acephate	1.5	11.12	82.34 $(65.15)^c$	54.12 $(47.36)^c$
T_7	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	19.00	63.86 $(53.04)^e$	38.63 $(38.43)^e$	Imidacloprid	0.2	13.24	62.16 $(52.04)^h$	40.07 $(39.27)^h$
T_8	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	12.66	76.62 $(61.08)^b$	51.98 $(46.12)^c$	Imidacloprid	0.2	10.00	79.68 $(63.21)^d$	52.27 $(46.30)^d$

*Mean of 3 replications

** No. of aphids per plant

Figures within parentheses are arcsin transformed values.

Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

b. Leafhopper

The treatments T_2 and T_4 registered a remarkable reduction in population of leafhopper i.e., 73.80 and 74.60 on 3 DAFS, 57.32 and 56.84 per cent on 7 DAFS respectively, while T_6 and T_8 resulted the per cent reduction in population of leafhopper ranging from 67.75 to 50.59 followed by T_1 and T_3 when compared to T_5 and T_7 which brought only less than 50 per cent reduction.

The order of efficacy of different treatments in bringing higher per cent reduction in population of leafhoppers on 3 and 7 DASS respectively was with T_4 (90.00 and 66.52) > T_6 (83.67 and 60.00) > T_3 (80.81 and 56.78) > T_1 (77.33 and 54.80) > T_7 (75.78 and 52.32) > T_5 (74.65 and 50.10), but T_2, T_4, T_6 and T_8 proved its superiority over other treatments (Table 38).

c. Whitefly

On 3 DAFS, significant reduction in population of whiteflies to an extent of 66.66 and 66.04 per cent was brought out by T_2 and T_4 respectively. The treatments with moderate level of per cent reduction was achieved by T_6 (64.00), T_8 (63.87), T_3 (59.86) and T_1 (58.98), while the treatments T_7 and T_5 recorded 49.96 and 49.11 per cent respectively. At 7 DAFS, all the treatments effected less than 50 per cent reduction in population but the order of efficacy was same as observed on 3 DAFS.

The order of performance of different combinations of treatments resulting in higher per cent reduction in population of whitefly on 3 and 7 DASS was with T_4 (94.22 and 66.18) = T_2 (93.86 and 64.63) > T_8 (85.96 and 54.44) = T_6 (83.72 and 51.26) > T_3 (79.97 and 42.74) > T_1 (76.62 and 40.86) > T_5 (72.22 and 36.50) > T_7 (72.10 and 41.22) (Table 39).

Table 38. **Effect of N, P and K fertilizers, biocides and insecticides against bhendi leafhopper, *A. biguttula biguttula***

T. No.	Treatments		Dose (ml/lit)	Pre-count**	Per cent reduction over control*		Treatments	Dose (ml (or) g/lit)	Pre-count**	Per cent reduction over control*	
	NPK (kg/ha)	I Spray			3 DAFS	7 DAFS	II Spray			3 DASS	7 DASS
T_1	40 : 50 : 30	Neemazal-F	1.0	9.80	57.98 (49.59)^{de}	40.00 (39.23)^{e}	Acephate	1.5	13.66	77.33 (61.57)^{f}	54.80 (47.75)^{e}
T_2	40 : 50 : 45	Neemazal-F	1.0	6.80	73.80 (59.21)^{ab}	57.32 (49.21)^{a}	Acephate	1.5	11.86	88.25 (69.96)^{b}	65.96 (54.31)^{a}
T_3	40 : 50 : 30	Neemazal-F	1.0	9.33	58.87 (50.11)^{d}	41.32 (40.00)^{d}	Imidacloprid	0.2	14.60	80.81 (64.02)^{e}	56.78 (48.90)^{d}
T_4	40 : 50 : 45	Neemazal-F	1.0	7.60	74.60 (59.74)^{a}	56.84 (48.93)^{a}	Imidacloprid	0.2	12.33	90.00 (71.57)^{a}	66.52 (54.65)^{d}
T_5	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	10.33	44.63 (41.92)^{f}	33.92 (35.62)^{h}	Acephate	1.5	15.38	74.65 (59.77)^{h}	50.10 (45.06)^{g}
T_6	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	7.33	67.75 (55.40)^{c}	50.59 (45.34)^{b}	Acephate	1.5	11.80	83.67 (66.16)^{d}	60.00 (50.77)^{c}
T_7	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	9.20	43.82 (41.45)^{g}	32.98 (35.05)^{g}	Imidacloprid	0.2	16.33	75.78 (60.52)^{g}	52.32 (46.33)^{f}
T_8	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	6.73	67.42 (55.19)^{c}	49.99 (44.99)^{c}	Imidacloprid	0.2	12.00	84.41 (66.74)^{c}	61.08 (51.40)^{b}

*Mean of 3 replications
** No. of leafhopper per plant
Figures within parentheses are arcsin transformed values.
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

Table 39. **Effect of N, P and K fertilizers, biocides and insecticides against bhendi whitefly, *B. tabaci***

T. No.	Treatments		Dose (ml/lit)	Pre-count**	Per cent reduction over control*		Treatments	Dose (ml (or) g/lit)	Pre-count**	Per cent reduction over control*	
	NPK (kg/ha)	I Spray			3 DAFS	7 DAFS	II Spray			3 DASS	7 DASS
T_1	40 : 50 : 30	Neemazal-F	1.0	7.33	58.98 (50.17)^{e}	39.66 (39.03)^{d}	Acephate	1.5	13.68	76.62 (61.08)^{e}	40.86 (39.73)^{d}
T_2	40 : 50 : 45	Neemazal-F	1.0	6.66	66.66 (54.73)^{a}	45.38 (42.35)^{b}	Acephate	1.5	10.68	93.86 (75.65)^{a}	64.63 (53.51)^{a}
T_3	40 : 50 : 30	Neemazal-F	1.0	8.00	59.86 (50.69)^{d}	40.00 (39.23)^{d}	Imidacloprid	0.2	12.66	79.97 (63.42)^{d}	42.74 (40.82)^{d}
T_4	40 : 50 : 45	Neemazal-F	1.0	5.33	66.04 (54.35)^{ab}	46.12 (42.77)^{a}	Imidacloprid	0.2	10.00	94.22 (76.09)^{a}	66.18 (54.44)^{a}
T_5	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	7.66	49.11 (44.49)^{g}	35.68 (36.68)^{e}	Acephate	1.5	13.33	72.22 (58.19)^{f}	36.50 (37.16)^{e}
T_6	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	6.33	64.00 (53.13)^{c}	42.84 (40.88)^{c}	Acephate	1.5	11.80	83.72 (66.20)^{c}	51.26 (45.72)^{c}
T_7	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	8.33	49.96 (44.97)^{f}	34.99 (36.26)^{f}	Imidacloprid	0.2	14.58	72.10 (58.11)^{f}	41.22 (39.94)^{d}
T_8	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	5.00	63.87 (53.05)^{c}	42.96 (40.95)^{c}	Imidacloprid	0.2	10.66	85.96 (67.99)^{b}	54.44 (47.55)^{b}

*Mean of 3 replications
** No. of whitefly per plant
Figures within parentheses are arcsin transformed values.
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

d. Fruitborer damage

The efficacy of different combinations of treatments in bringing less percentage of damage to the bhendi fruits by *Earias* spp. both on number and weight bases was found to range from 4.12 to 4.78 in T_4 and T_6, from 5.38 to 7.07 in T_2 and T_8 and from 7.66 to 8.39 in T_1 and T_7. Considering the overall performance of treatments in reducing per cent fruitborer damage over untreated control, the relative efficacy of treatments followed the order of $T_4 > T_6 > T_8 = T_2 > T_3 = T_5 = T_7 = T_1$ (Table 40).

e. Yield and Cost Benefit Ratio (CBR)

The impact of different combinations of treatments in IPM experiment on the yield of bhendi fruits and CBRs are furnished in Table 41. In general all the treatments enhanced the bhendi fruit yield when compared to untreated check. The order of performance of treatments in recording higher bhendi fruit yield (kg/ha) was with T_4 (6880) > T_6 (6780) > T_2 (6720) = T_8 (6700) > T_3 (6250) > T_5 (6090) > T_7 (5840) > T_1 (5740) > T_9 (3250).

Considering the cost of cultivation, gross return and net return from this IPM experiment, the maximum CBR was obtained in T_2 (1:2.77) and T_8 (1:2.75) followed by the order of treatments securing high CBR was T_4 (1:2.71) > T_6 (1:2.57) > T_3 (1:2.47) > T_7 (1:2.41) > T_1 (1:2.38) > T_5 (1:2.32) while the untreated check (T_9) recorded only 1:1.88.

Table 40. **Effect of NPK fertilizers, biocides and insecticides on the incidence of fruitborer *Earias* spp.**

T. No.	Treatment structure for IPM								Number basis*		Weight basis*	
	NPK (kg/ha)	I Spray	Dose (ml/lit)	II Spray	Dose (ml (or) g/lit)	Release	III Spray (Dose: 2.0 g/lit)	IV Spray (Dose: 2.0 ml/lit)	Per cent fruit damage	Per cent reduction over control	Per cent fruit damage	Per cent reduction over control
T_1	40 : 50 : 30	Neemazal-F	1.0	Acephate	1.5	Release of *T. chilonis* @ 50,000/ha at flowering	Biobit	Endosulfan	8.39 (16.83)^{e}	61.26	7.86 (16.28)^{c}	64.04
T_2	40 : 50 : 45	Neemazal-F	1.0	Acephate	1.5		Biobit	Endosulfan	7.07 (15.42)^{c}	67.36	5.56 (13.64)^{b}	74.56
T_3	40 : 50 : 30	Neemazal-F	1.0	Imidacloprid	0.2		Delfin	Triazophos	7.23 (15.60)^{d}	66.62	6.82 (15.14)^{c}	68.80
T_4	40 : 50 : 45	Neemazal-F	1.0	Imidacloprid	0.2		Delfin	Triazophos	4.12 (11.71)^{a}	80.97	4.26 (11.91)^{a}	80.51
T_5	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	Acephate	1.5		Delfin	Triazophos	7.36 (15.74)^{de}	66.02	7.36 (15.74)^{c}	66.33
T_6	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	Acephate	1.5		Delfin	Triazophos	4.78 (12.63)^{ab}	77.93	4.66 (12.47)^{ab}	78.68
T_7	40 : 50 : 30	TNAU NO 60 EC (c)	20.0	Imidacloprid	0.2		Biobit	Endosulfan	7.86 (16.28)^{de}	63.71	7.66 (16.07)^{c}	64.96
T_8	40 : 50 : 45	TNAU NO 60 EC (c)	20.0	Imidacloprid	0.2		Biobit	Endosulfan	5.87 (14.02)^{bc}	72.89	5.38 (13.41)^{b}	75.39
T_9	40 : 50 : 30	-	-	-	-	-	-	-	21.66 (27.74)^{f}	-	21.86 (27.87)^{d}	-

*Mean of 3 replications
Figures within parentheses are arcsin transformed values.
Means followed by the same letter(s) in a column are not significantly different (P=0.05) by DMRT

Table 41. Impact of IPM on bhendi : Cost Benefit Ratio (CBR)

T. No.	Yield of healthy fruits (in kgs)		Cost of yield/ha @Rs.5/kg (Gross return)	Cost of cultivation Rs/ha	Cost of treatment Rs/ha	Total cost Rs/ha	Net return Rs/ha	Cost Benefit Ratio
	Per plot	Per ha						
T_1	11.48^{d}	5740^{g}	28700	8658	3387	12045	16655	1:2.38
T_2	13.44^{a}	6720^{c}	33600	8658	3450	12108	21492	1:2.77
T_3	12.50^{b}	6250^{d}	31250	8658	3951	12609	18641	1:2.47
T_4	13.76^{a}	6880^{a}	34400	8658	4014	12672	21728	1:2.71
T_5	12.18^{bc}	6090^{e}	30450	8658	4489	13147	17303	1:2.32
T_6	13.56^{a}	6780^{b}	3390 0	'8658	4552	13210	20690	1:2.57
T_7	11.68^{c}	5840^{f}	29200	8658	3449	12107	17093	1:2.41
T_8	13.40^{a}	6700^{c}	33500	8658	3512	12170	21330	1:2.75
T_9	6.50^{e}	3250^{h}	16250	8658	-	8658	7592	1:1.88

Table 42. **Effect of IPM practices on population of natural enemies**

Treatment No.	Population of natural enemies per ten plants*		
	Coccinellids	Spiders	Chrysopids
T_1	8.08 (3.93) [d]	6.67 (2.67) [d]	3.08 (1.89) [e]
T_2	8.92 (3.06) [c]	7.50 (2.83) [c]	3.58 (2.02) [cd]
T_3	7.25 (2.78) [ef]	5.33 (2.41) [e]	2.00 (1.57) [f]
T_4	6.83 (2.71) [f]	5.75 (2.50) [e]	2.25 (1.65) [f]
T_5	8.50 (3.00) [c]	7.53 (2.83) [c]	3.56 (2.01) [cd]
T_6	7.50 (2.83) [e]	6.66 (2.67) [d]	3.25 (1.93) [de]
T_7	10.58 (3.33) [b]	8.92 (3.07) [b]	4.00 (2.12) [c]
T_8	10.83 (3.36) [b]	9.00 (3.08) [b]	4.83 (2.30) [b]
T_9	16.92 (4.17) [a]	14.33 (3.85) [a]	6.67 (2.67) [a]

* Mean of four observations of 3 replications
Figures within parentheses are $\sqrt{x + 0.5}$ transformed values
Means followed by the same letter(s) in a column are not significantly different (P = 0.05) by DMRT.

4.2.3.2. Impact of IPM practices on population of natural enemies

The impact of different combinations of treatments as evidenced based on the presence of higher population of natural enemies *viz.*, coccinellids (*M.sexmaculatus* and *M. crocea*), spiders (*Oxyopes* sp. and *Clubiona* sp.) and chrysopid (*C. carnea*) was respectively in untreated check (16.92, 14.33 and 6.67) > T_8 (10.83, 9.00 and 4.83) > T_7 (10.58, 8.92 and 4.00) > T_2 (8.92, 7.50 and 3.58) > T_5 (8.50, 7.53 and 3.56) > T_1 (8.08, 6.67 and 3.08) > T_6 (7.50, 6.66 and 3.25) > T_3 (7.25, 5.33 and 2.00) > T_4 (6.83, 5.75 and 2.25) (Table 42).

Discussion

5. DISCUSSION

The results obtained from the studies made on the management of major pests of bhendi are discussed in this chapter.

5.1. Lab experiments

5.1.1. Ovicidal action of neem products against *Earias vittella* Fabricius

The antifeedant, repellant, growth regulatory, ovicidal, ovipositional deterrent, fecundity reduction and toxic properties of seed extracts of neem, *Azadirachta indica* A. Juss was documented by Schmutterer (1990) on various insect pests.

The present investigation revealed that among the treatments tested, endosulfan, Neemazal-F and TNAU NO 60 EC (c) resulted higher per cent mortality and less per cent hatching of eggs of *E. vittella* based on the effectiveness of treatments (Fig. 1). These results are in consonance with the following findings. Verkerk and Wright (1993) reported that azadirachtin at 100 μg concentration effected 48 per cent mortality of *Plutella xylostella* L. eggs and the ovicidal effect of neem products *viz.*, neem oil, NSKE at different concentrations on *Heliothis armigera* Hubner and *Spodoptera litura* Fab. was also proved by Mehta *et al.* (1994) and Suryakala *et al.* (1995) respectively. Similarly the hatchability of eggs of rice leaf folder, *Cnaphalocrosis medinalis* Guenee and *S. litura* was strongly inhibited when dipped into neem oil (Saxena *et al.*, 1981; Ramachandra Rao *et al.*, 1990) revealing the effectiveness of azadirachtin content in different neem formulations against many pests.

Fig 1. Ovicidal action of neem products against *E. vittella*

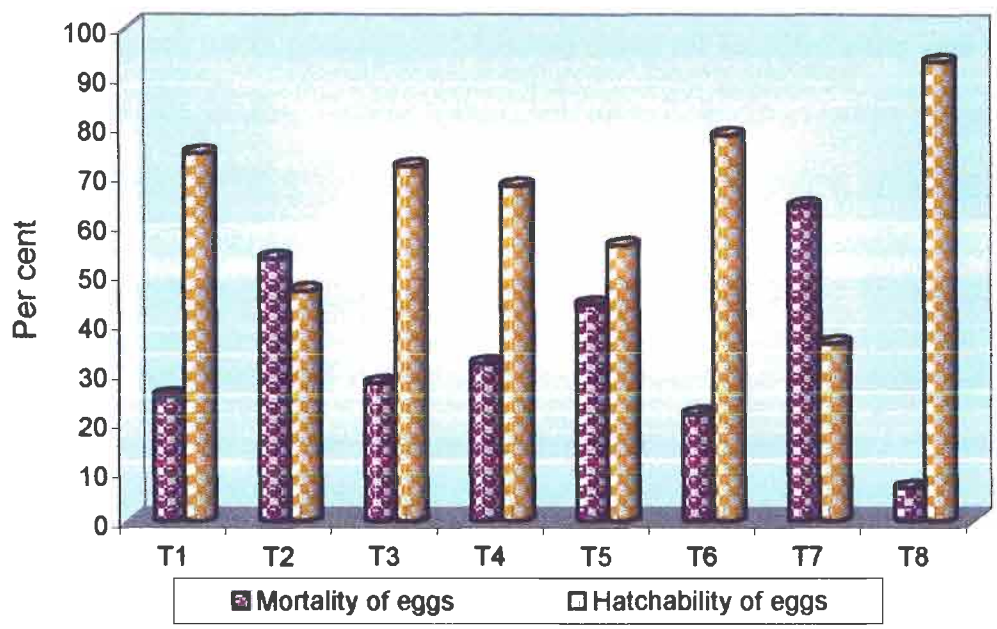
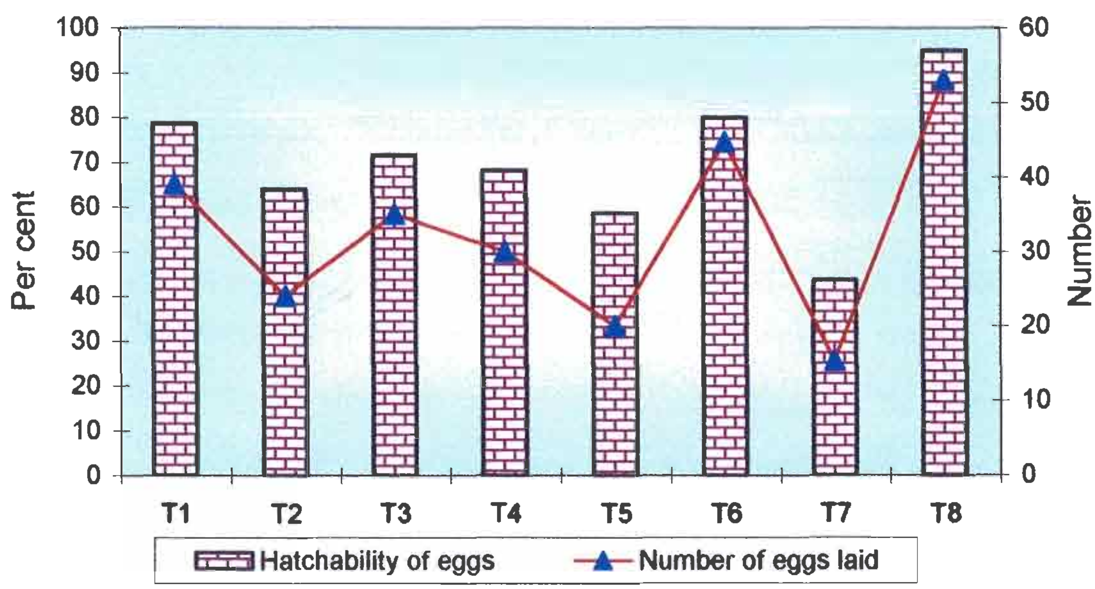


Fig 2. Ovipositional deterrent action of neem products against *E. vittella*



T1 - Neemazal-T/S	T2 - Neemazal-F	T3 - Econeem	T4 - TNAU NO
T5 - TNAU NO 60 EC (c)	T6 - NSKE	T7 - Endosulfan	T8 - Control

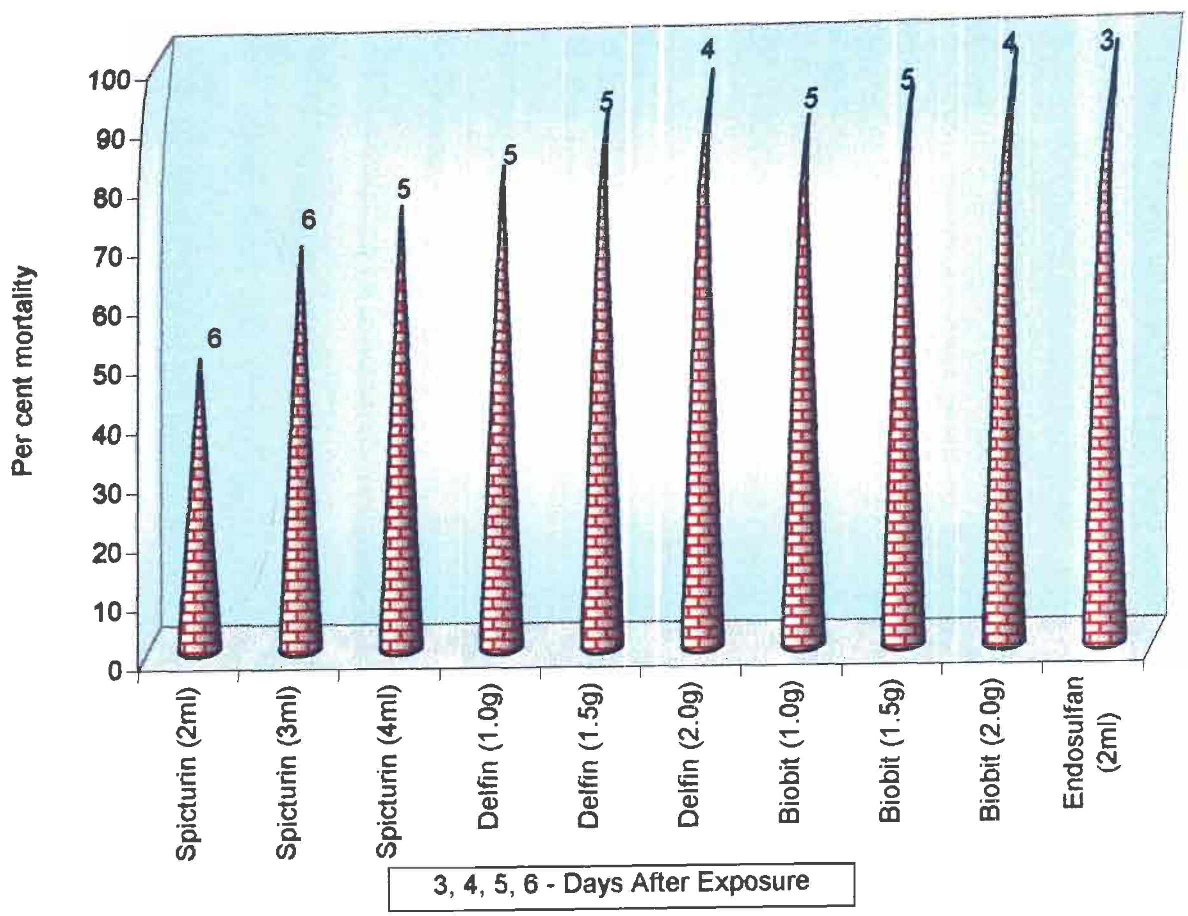
5.1.2. Ovipositional deterrent effect of neem products against *E. vittella*

Schmutterer (1990) and Mehta *et al.* (1994) observed that application of formulated neem products, NSKE and neem oil on plant parts was known to repel the female moths, *Crocidolomia binotalis* Zell, *Spodoptera furgiperda* Hb. and *H. armigera* for oviposition. In the present investigation, spraying of endosulfan, TNAU NO 60 EC (c) and Neemazal-F deterred oviposition by *E. vittella* and recorded significantly less number of eggs per fruit when compared to rest of the neem treatments and untreated fruits. The per cent hatchability of eggs laid was also considerably less on fruits treated with endosulfan, TNAU NO 60 EC (c) and Neemazal-F ranging from 43.56 to 63.84 per cent and from 68.01 to 79.80 per cent in other neem based products as against 94.96 per cent in untreated check (Fig. 2). The results of this investigation is in agreement with the findings of earlier researchers on the ovipositional deterrent effect of Neemark on bhendi fruit borer, *E. vittella* (Sojitra and Patel, 1992; Patel *et al.*, 1994) of Neemazal-F (0.1%) on brinjal fruitborer *Leucinodes orbonalis* Guen. (Kumar, 1996) and of Achook, Granim, Neemark, Nimbecidine, Neemol and NSKS on citrus leaf miner, *Phyllocnistis citrella* Stainton (Patel and Patel, 2000).

5.1.3. Effect of *B.t.* products on mortality of larvae of *E. vittella*

The larval mortality of *E. vittella* was found to be increased when the concentrations of *B.t.* were increased from 2 to 4 ml in case of Spicturin and from 1 to 2 g in case of Delfin and Biobit during exposure period of three days and post-exposure period of another three days. However, fourth day after the treatments the per cent mortality of larvae found to range from 46.67 to 73.33 in Spicturin, from 80.00 to 96.67 in Delfin and from 87.78 to 98.89 per cent in Biobit treatments

Fig 3. Effect of different *B.t.* products against larvae of *Earias vittella*



clearly exhibiting the effect of different *B.t.* products in bringing higher mortality of larvae. When the larvae were treated with lower doses of *B.t. viz.,* Spicturin @ 2 and 3 ml, it took six days to bring 48.89 and 67.78 per cent mortality and of Delfin @ 1.0 and 1.5 g resulted 81.11 and 90.00 per cent mortality and Biobit at 1.0 and 1.5 g brought 88.89 and 93.33 per cent mortality on five days after treatment respectively. These results clearly indicated the effectiveness of different doses of *B.t.* products and length of exposure period to effect higher mortality of larvae (Fig. 3). The present findings were in tune with earlier reports of Asano and Suzuki (1973) and Yendol *et al.* (1975) on larvae of *Trichoplusia ni* (Hubner), Hornby and Gardner (1987) on *S. frugiperda,* Gould *et al.* (1991) on *Heliothis virescens* (Fabricius) and Mahapatro and Gupta (1999 a&b) on *E. vittella.*

5.1.4. Resistance/susceptibility of bhendi entries to major pests of bhendi

In the present investigation, based on the population of sucking pests *viz.*, aphid, leafhopper and whitefly, leafhopper injury index, YVMD incidence, fruit damage, trichome density, plant height, fruit parameters and yield, the six bhendi entries were classified as moderately resistant, susceptible and highly susceptible. It is evident from the results obtained that the population of sucking pests, leafhopper injury index and YVMD incidence were found to increase when the age of crop advanced. Out of six bhendi entries, OHD-1, COOH-1, Arka Anamika and Varsha Uphar exhibited its moderate level of resistance against aphid, leafhopper, whitefly and fruitborer. The entries MDU-1 and Pusa Sawani were found to be susceptible to aphid and whitefly but were highly susceptible to leafhopper (Fig. 4). Considering the leafhopper injury index, YVMD incidence and fruitborer damage, MDU-1 was susceptible and Pusa Sawani was highly susceptible (Table 43).

Table 43. Resistance/susceptibility of bhendi entries to major pests

Entries \ Test insects	Aphid	Leafhopper	LII*	Whitefly	YVMD	Fruitborer
OHD-1	MR	MR	MR	MR	MR	MR
COOH-1	MR	MR	MR	MR	MR	MR
Arka Anamika	MR	MR	MR	MR	MR	MR
Varsha Uphar	MR	MR	MR	MR	MR	MR
MDU-1	S	HS	S	S	S	S
Pusa Sawani	S	HS	HS	S	HS	HS

* LII - Leafhopper Injury Index

The present findings of progressive increase in vector population of whitefly Vs YVMD incidence with the increase in age of crop (Fig. 5) is in agreement with the results of Borad *et al.* (1993) who reported that the intensity of YVMD incidence was directly related with the population level of *Bemisia tabaci* Gennadius. The moderate resistant nature of the entry Arka Anamika to *B. tabaci* and YVMD incidence in the present investigation is also in consonance with the results of Bora *et al.* (1992), Mathew *et al.* (1993) and Sannigrahi and Choudhury (1998). Srivastava *et al.* (1995) and Dhankar (1996) reported that the variety Varsha Uphar was resistant to YVMD incidence, however the same variety exhibited its moderate level of resistance to YVMD incidence in the present studies. The susceptible nature of the entry Pusa Sawani observed in the screening experiments is also documented by Uthamasamy and Subramanian (1985) and Uthamasamy (1986) to the leafhopper, by Mathew *et al.* (1993) and Sannigrahi and Choudhury (1998) to the whitefly and by Madav and Dumbre (1985) and Ghai *et al.* (1990) to the fruitborer.

Fig 4. Reaction of bhendi entries against major pests

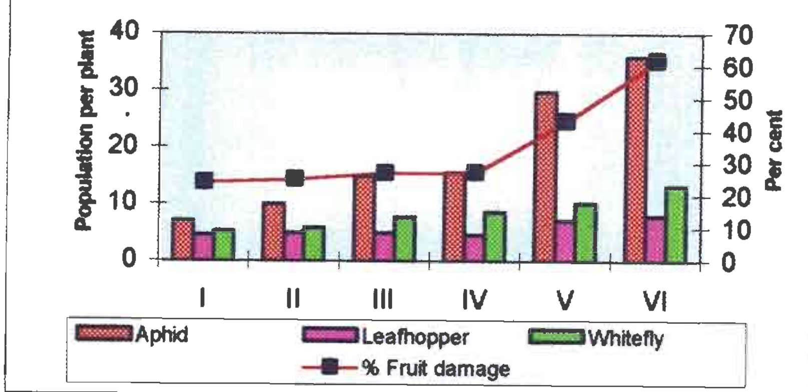


Fig 5. Screening of bhendi entries for resistance to whitefly

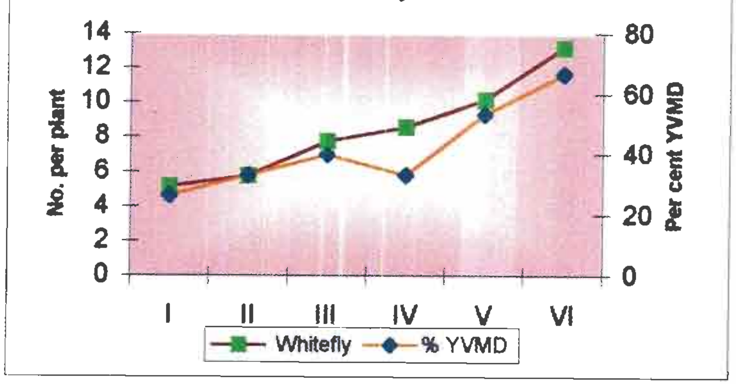


Fig 6. Screening of bhendi entries against leafhopper

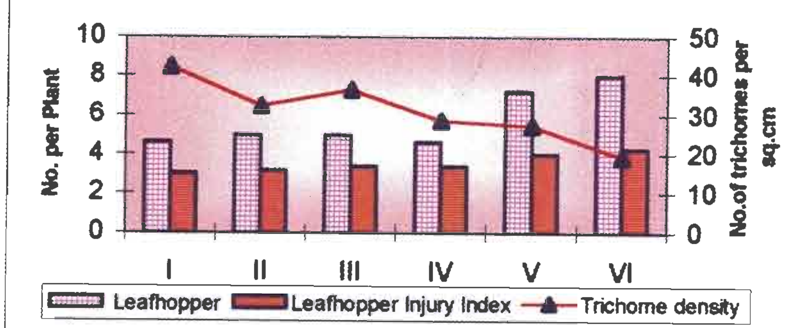
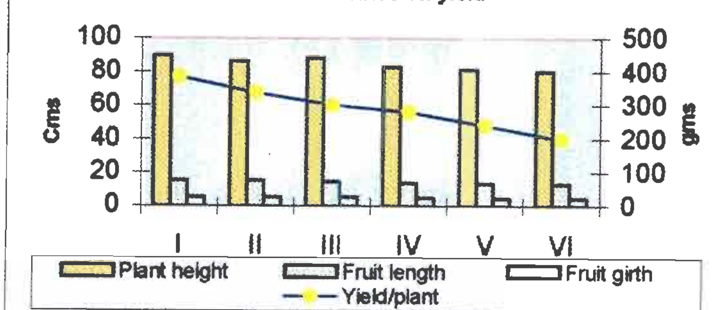


Fig 7. Influence of plant height and fruit parameters of bhendi entries on yield



I - OHD-1	II - COOH-1	III - Arka Anamika	IV - Varsa Uphar	V - MDU-1	VI - Pusa Sawani

Considering the mean trichome density per sq. cm., the entries OHD-1, COOH-1 and Arka Anamika may be regarded as resistant to the leafhopper which recorded more than 30 trichomes, while tolerant entries Varsha Uphar and MDU-1 recorded 21-30 trichomes as against Pusa Sawani with less than 20 trichomes (Fig.6). These results are in agreement with the work of Uthamasamy (1985) who opined that the number, length and density of the trichomes could influence the leafhopper resistance. Taylo and Bernardo (1996) observed the negative correlation between trichome length/density and number of leafhopper eggs deposited, nymphs emerged, attraction of adults to the host plant and amount of the sap ingested.

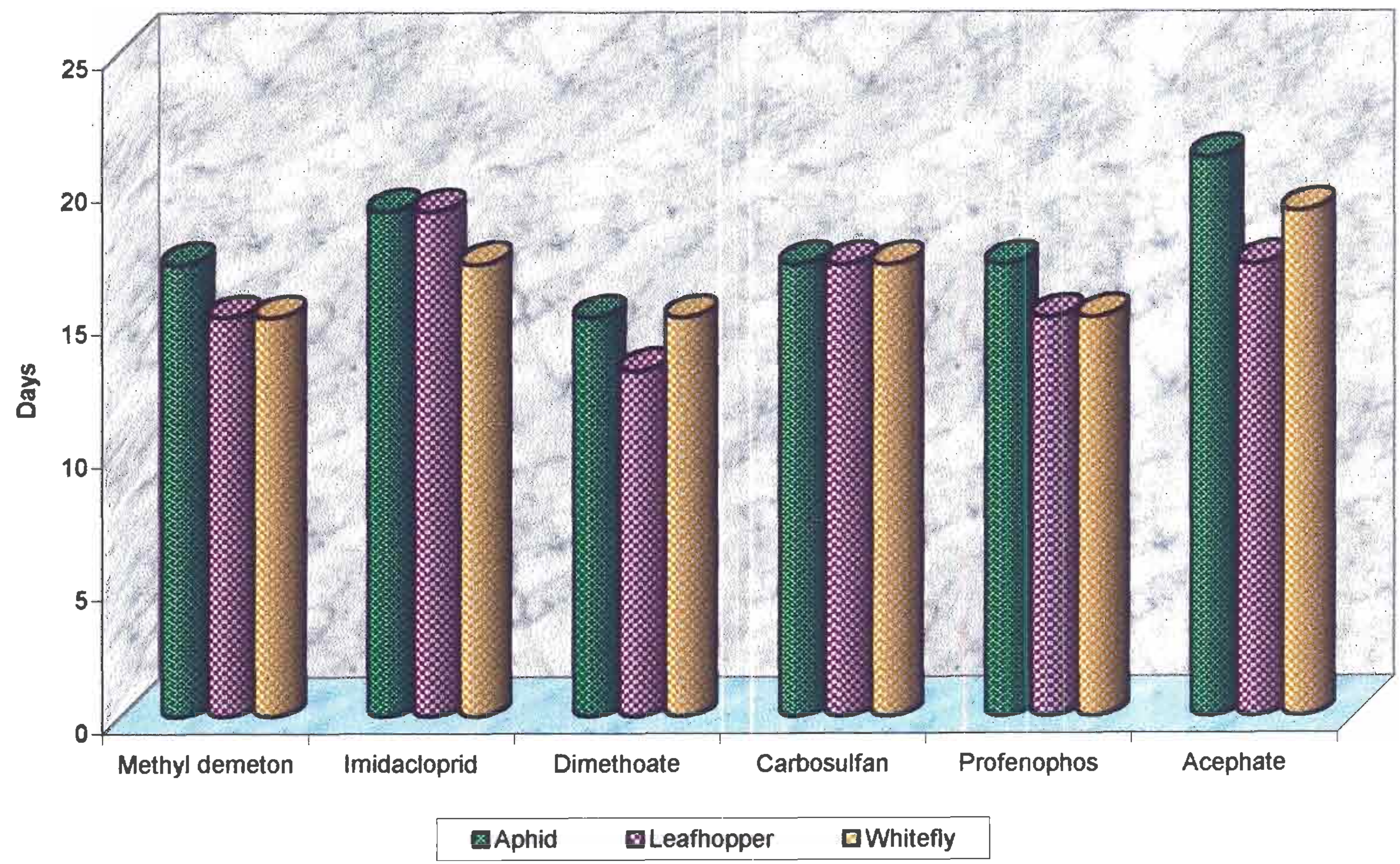
Among the six bhendi entries, OHD-1 recorded the maximum plant height of 89.80 cm as against the susceptible Pusa Sawani with 80.26 cm height. This result exhibits the moderate level of resistance of OHD-1 to major pests of bhendi in relation with plant height. However, Uthamasamy *et al.* (1972) reported that the incidence of leafhopper on okra was positively correlated with plant height and stem thickness. In addition to the above, the moderately resistant entries OHD-1, COOH-1, Arka Anamika and Varsha Uphar recorded more number of fruits per plant, increased fruit length, girth and weight of individual fruit and yield per plant when compared to MDU-1 and Pusa Sawani (Fig. 7).

5.1.5. Persistent toxicity of insecticides against sucking pests of bhendi

The results obtained on persistent toxicity of insecticides against the sucking pests *viz.*, aphid, leafhopper and whitefly clearly showed that imidacloprid 200 SL (0.004%) and acephate 75 SP (0.11%) were found to be the best insecticides and proved their efficacies by retaining their toxicity more than 17 days when compared to other insecticides tested to the sucking pests. The persistence of imidacloprid was 19 and 17 days against leafhopper and whitefly, which was 17 and 19 days for leafhopper and whitefly in acephate respectively, whereas profenofos and methyl demeton were persistent only upto 15 days against the above pests. With regard to aphid, acephate and imidacloprid persisted for 21 and 19 days respectively followed by methyl demeton, carbosulfan and profenofos with 17 days. The least persistence of 15 days was observed in dimethoate (Fig. 8).

The persistent toxicity of imidacloprid and acephate against sucking pests is in agreement with the findings of Shantappanavar *et al.* (1995) who reported that the persistent toxicity of imidacloprid 70 WS at 75 g a.i/ha and acephate 75 SP at 900 g a.i/ha lasted for 29 and 24 days respectively against tobacco aphid, *Myzus persicae* (Sulzer). The longer persistence in this case may be due to the application of higher dose of insecticides. Similar earlier results revealed that imidacloprid 200 SL as foliar spray at 100 ml/ha persisted for 22 days against the aphid, *Aphis gossypii* Glover and 30 days against leafhopper, *Amrasca devastans* (Distant) on cotton (Kumar, 1998), for 23 days against the aphid, *Aphis craccivora* Koch. and 29 days against the leafhopper *Empoasca kerri* Pruthi on groundnut (Ramesh Babu, 1999), for 23 and 29 days against the aphid and leafhopper on bhendi respectively (Sivaveerapandian, 2000). Analysing the overall persistence of different insecticides, it may be concluded that imidacloprid 200 SL (0.004%) and acephate 75 SP (0.11%) can be recommended to obtain better and longer control of sucking pests of bhendi.

Fig 8. Persistent toxicity of certain insecticides against sucking pests of bhendi



5.2. Field experiments

5.2.1. Evaluation of neem products, *B.t.* formulations and insecticides against major pests of bhendi

a. Sucking pests

Neem products:

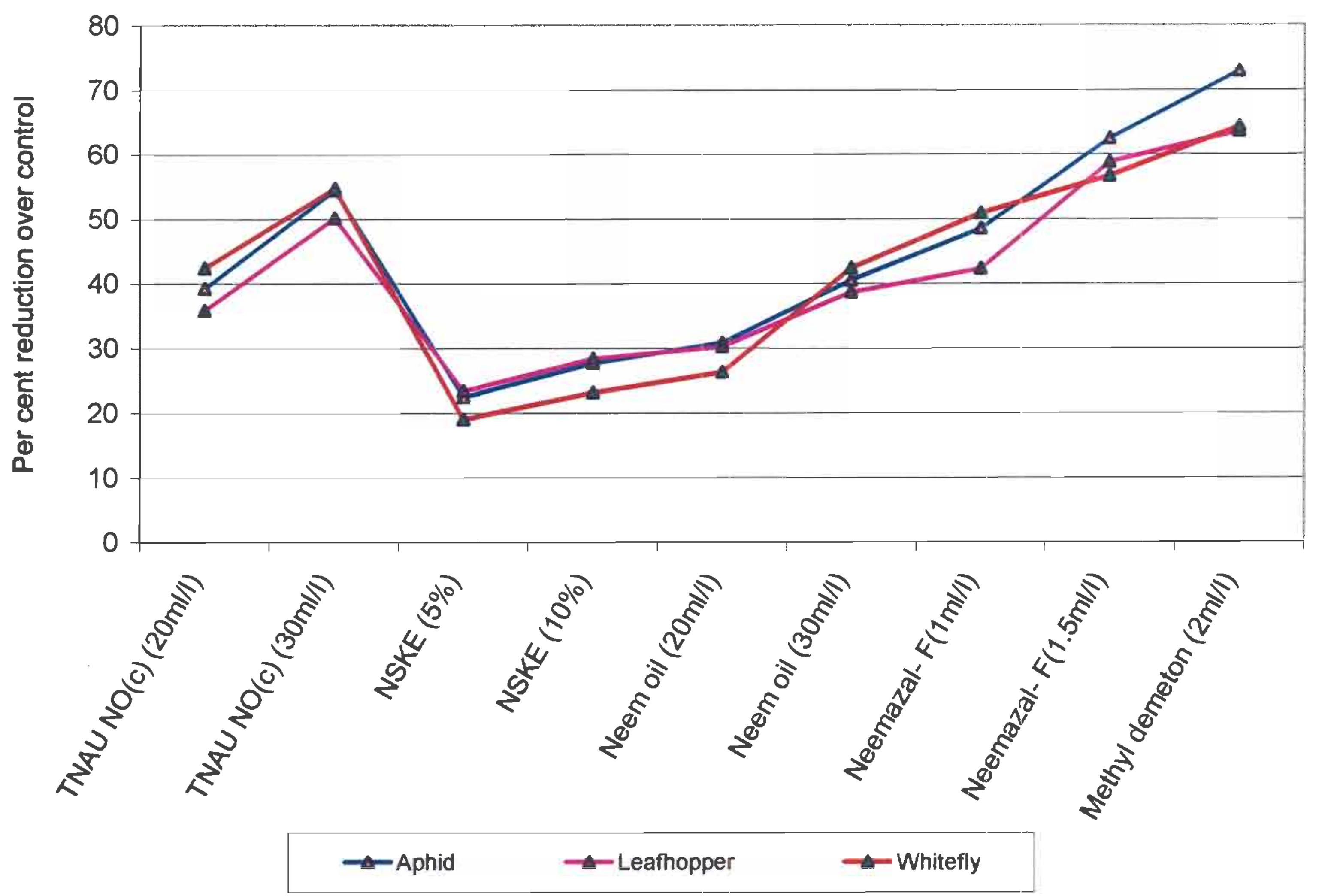
The results obtained from the experiment on evaluation of neem products in comparison with methyl demeton against sucking pests of bhendi (Fig. 9) revealed that all the treatments resulted in higher per cent reduction in population of aphid, leafhopper and whitefly one day after treatment when compared to third and seventh day after each round of spray. Based on the overall performance of the neem products, Neemazal-F (1.5 ml/lit) and TNAU NO 60 EC (c) (30 ml/lit) were found to be excellent in reducing the population of sucking pests from 70 to 80 per cent after each round of spray, while moderate level of 50 to 70 per cent reduction in population of sucking pests was achieved in the treatments Neemazal-F (1 ml/lit), neem oil (30 ml/lit) and TNAU NO 60 EC (c) (20 ml/lit). The treatments neem oil (20 ml/lit) and NSKE (50 and 100 g/lit) were able to reduce the population of sucking pests to less than 40 per cent only. In general, the effectiveness of neem products stood next to the standard check methyl demeton (2 ml/lit), which recorded more than 90 per cent reduction in population.

Considering the order of effectiveness, treatments resulting in high per cent reduction in population of sucking pests was with methyl demeton > Neemazal-F > TNAU NO 60 EC (c) compared to other treatments. The effectiveness of Neemazal-F against sucking pests in the present study is in accordance with the findings of Peter (1994) against cotton aphid and Kumar (1996) and Srinivasan

(1997) on sucking pests of brinjal. Earlier scientists also proved the effectiveness of some of the neem formulations against various crop pests *viz.*, Neemark (1.0%) against cotton aphid (Puri *et al.* 1991) and bhendi aphid (Nimbalkar *et al.*, 1994). Achook (1%) against chilli thrips (Raman *et al.*, 1993; Keisa and Varatharajan, 1996; Chandrasekaran, 1996). Neem oil (3%) against rice leafhopper (Mariappan and Saxena., 1983), rice thrips (Madhusudhan and Gopalan, 1988), chilli thrips (Chandrasekaran and Veeravel, 1997), cotton whitefly (Puri *et al.,* 1994), citrus blackfly (Katole and Mahajan, 1994) and citrus psyllid (Katole *et al.*, 1994). In these experiments high per cent reduction in population of sucking pests was achieved with higher doses of neem formulations. These results are in agreement with the findings of Singh (1993) and Jayaraj (1993) who stated that survival of sucking pest population was decreased progressively with increased concentration of neem oil. The least effectiveness of NSKE (50 g/lit) in the present study against sucking pests was also earlier reported by Pillai and Ponniah (1988) and Raghuraman and Saxena (1994).

According to Udaiyan and Ramarathinam (1994), formulated products of neem derivatives could control the sucking pests of bhendi as effectively as chemical pesticides through frequent sprays, but neem oil and NSKE did not have much efficacy as that of formulated neem derived products. It may be concluded that the formulated neem products owe their toxic attributes by possession of large number of bitter compounds *viz.*, azadirachtin, azadiradion, nimbocinal, epinimbocinal, gedunin and salanin among which azadirachtin is considered to be the most potent alkaloid, acting as an antifeedant to major pests. The factor which was found to be responsible to exhibit antifeedant and deterrant actions on different pest species.

Fig 9. Evaluation of certain neem products against sucking pests of bhendi



Insecticides:

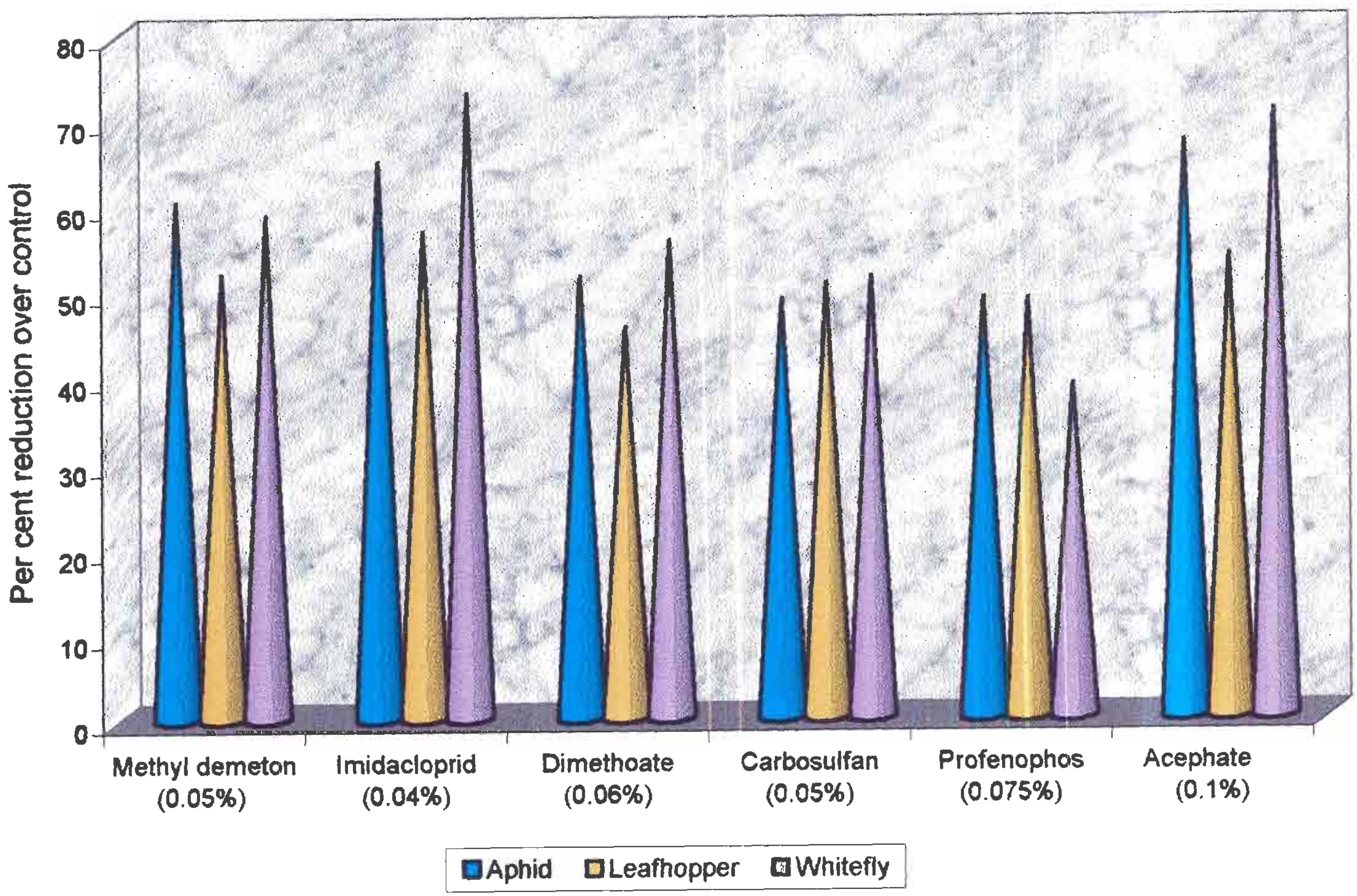
The results obtained on the relative efficacy of certain insecticides against sucking pests of bhendi (Fig. 10) are discussed below.

In case of aphid, the order of efficacy of treatments as a whole in reducing its population was 3 DAS > 7 DAS > 1 DAS, except in carbosulfan and profenofos treatments. Considering the overall performance, imidacloprid and acephate exhibited their superiority by recording more than 80 per cent reduction while methyl demeton and dimethoate recorded 70-80 per cent reduction as against less than 70 per cent reduction in carbosulfan and profenofos. Bio-efficacy of imidacloprid against different aphids as foliar treatment was reported by several workers against damson hop aphid, *Phorodon humuli* (Martin *et al.*, 1992), against potato aphid, *Myzus persicae* Sulzer (Woodford, 1992), against cotton aphid, *A. gossypii* (Mc Nally and Mullins, 1996), against banana aphid, *Pentalonia nigronervosa* Coq. (Treverrow, 1996), against tobacco aphid, *Myzus nicotionae* Blackman (Ramaprasad *et al.*, 1998), against groundnut aphid, *A. craccivora* (Ramesh Babu, 1999) and also against bhendi aphid, *A. gossypii* (Sivaveerapandian, 2000). The effectiveness of acephate (0.1%) observed in the present study against okra aphid is in accordance with findings of Prasad *et al.* (1993).

With regard to control of leafhopper, there was significant reduction in the population one day after treatment ranging from 66.06 to 88.74 per cent followed by on 3rd day after treatment, which ranged from 56.48 to 80.80 per cent and from 38.68 to 60.95 per cent on 7th day after each round of spray. Among the treatments, imidacloprid and acephate resulted high per cent reduction in population of leafhopper which was in the order of 1 DAT > 3 DAT > 7 DAT in the first, second and third round of sprays. The significant efficacy of imidacloprid and acephate obtained in the present study is in consonance with the results of earlier scientists. Sivaveerapandian (2000) found that application of imidacloprid @ 100ml/ha significantly reduced the bhendi leafhopper *Amrasca biguttula biguttula* Ishida. Similar results were reported by Kumar (1998) and Gupta *et al.* (1998) on cotton leafhopper, *A. devastans* and Ramesh Babu (1999) on groundnut leafhopper, *E. kerri*. Iwaya and Tsubio (1992) reported that spraying of imidacloprid at 0.01 per cent significantly reduced the population of leafhopper and planthopper in rice. Spraying of acephate @ 600 g ai ha^{-1} was quite effective, resulting good control of leafhoppers with higher fruit yield of 7.1 t/ha on bhendi (Giraddi *et al.*, 1998).

In case of whitefly, the maximum per cent reduction in whitefly population was observed in imidacloprid (upto 95 per cent) followed by acephate with 70-90 per cent reduction and both the chemicals pronounced their efficacy even 7 days after treatment, while the remaining insecticides recorded maximum per cent reduction on first day but there was a gradual decline in percent reduction after 3^{rd} and 7^{th} day of each spray. The present findings on the superior efficacy of imidacloprid and acephate is in consonance with earlier reports of Walnuj and Mote (1995) who found that imidacloprid 70 WS @ 10g kg^{-1} as seed treatment plus 0.04 per cent root dip gave the highest protection from whitefly infestation and increased yield of tomato. While acephate 75 SP @ 1.0 kg/ha sprays were found to be very effective resulting in 90 per cent reduction in whitefly population on cotton (Sidhu and Dhawan, 1977).

Fig 10. Evaluation of certain insecticides against sucking pests of bhendi



Analysing the performance of both synthetic insecticides and neem products as evidenced in the present investigation Rajashri *et al.* (1991) and Mohapatra *et al.*(1991) were of the opinion that insecticides had shown superior performance on the reduction of sucking pests population when compared to neem products. The plausible reasons might be their systemic action and their active ingredients, which have positioned well in the plant system. In conclusion, though the neem products are in possession of high antifeedant and repellant properties to insects, synthetic inorganic pesticides have a score over plant derived organic products because of their greater knockdown effects.

b. Fruitborer *E. vittella*

The efficacy of *B.t.* products in comparison with insecticides on per cent reduction in fruit damage over control based on both number and weight bases was in the order of the standard check endosulfan (2ml/lit) > Biobit (2g/lit) > Biobit (1.5 g/lit) > Delfin (2g/lit) > Delfin (1.5 g/lit) > Spicturin (4 ml/lit) > Spicturin (3 ml/lit). Among the bases of damage, fruitborer damage was invariably higher on weight basis when compared to number basis. On considering the yield, the same above trend was observed with *B.t.* products (Fig. 11). The present results on the effectiveness of Biobit is in confirmity with the findings of Chandra *et al.* (1999), Mahapatro and Gupta (1999a) and Shankar *et al.* (1992) who reported that Biobit @ 1.5 kg ha^{-1} was quite effective in controlling *E. vittella* and *H. armigera* on bhendi and pigeon pea respectively. The effectiveness of Delfin observed in the present study is also in agreement with the reports of Kharbade *et al.* (1998 a&b) and Kharbade *et al.* (1999), on *E. vittella.* Tambe *et al.*, (1997) and Kulkarni *et al.* (1999) also reported that Delfin was able to control larvae of *P. xylostella*

Fig 11. Efficacy of different *B.t.* formulations on the fruit damage by *Earias* spp.

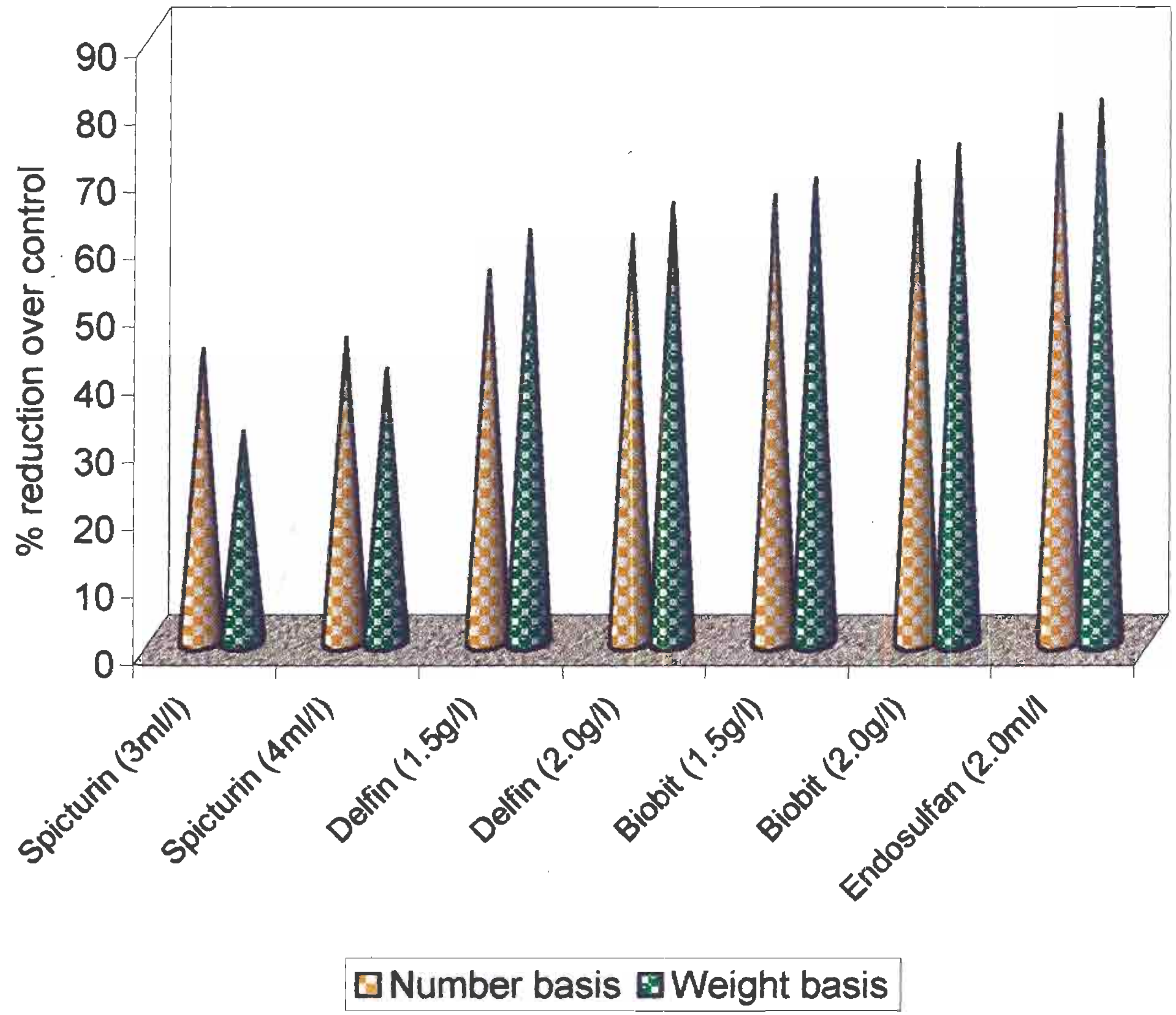
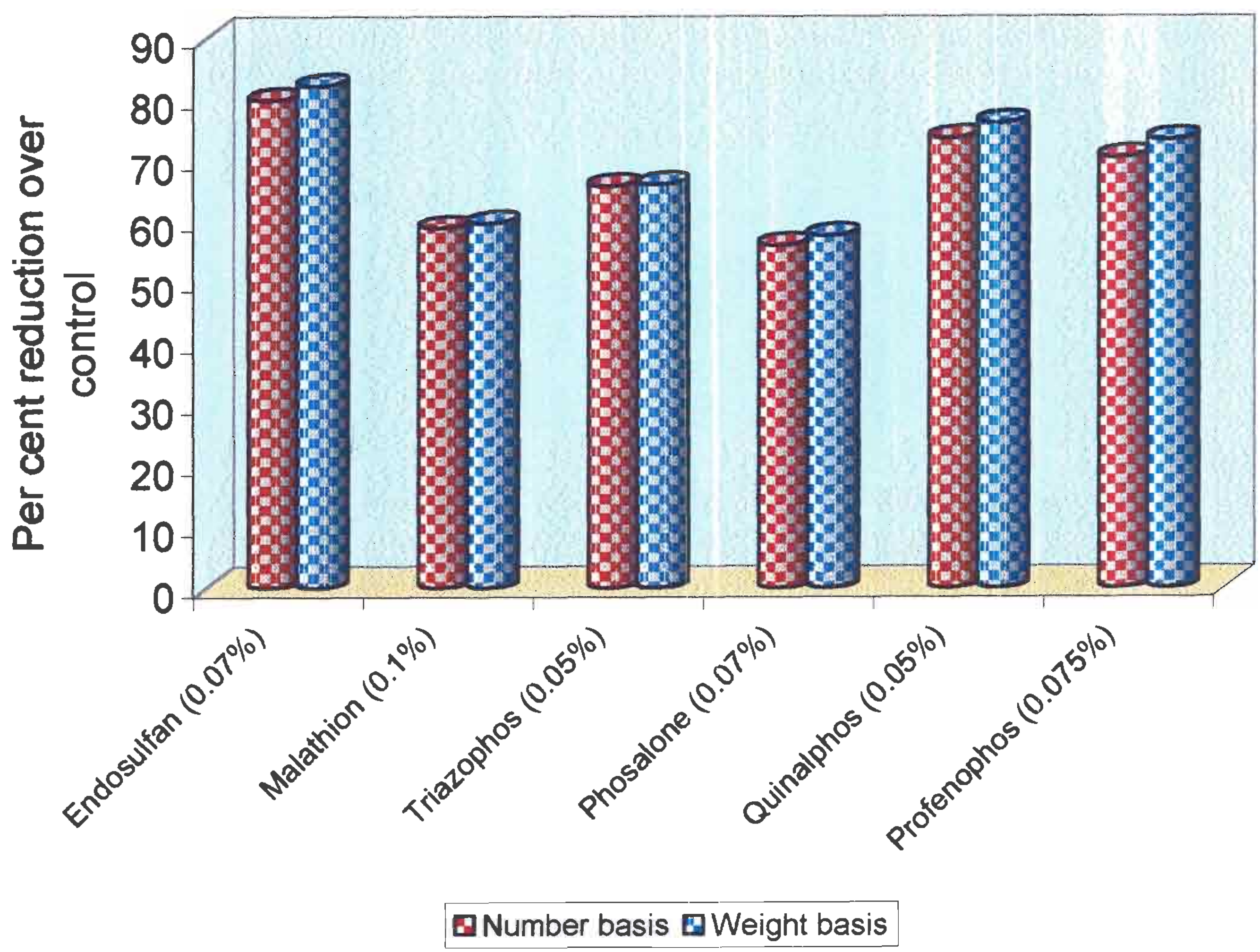


Fig 12. Efficacy of certain insecticides on the fruit damage by *Earias* spp.



recording less damage and higher yield of cabbage. The less effectiveness of Spicturin as observed in the present study is also in consonance with the results of Srinivasan (1997) against the shoot and fruitborer of brinjal.

The results obtained on per cent fruit damage and yield indicated that the order of efficacy of insecticides in bringing less per cent fruit damage and maximum yield was with endosulfan < triazophos < profenofos < quinalphos < malathion < phosalone < untreated check (Fig. 12). The superior efficacy of endosulfan recorded in the present investigation is in agreement with the results of Jadhav and Nawale (1984), Dhandapani (1985), Samuthiravelu and David (1991), Patel *et al.* (1997), Sarode and Gabhane (1994 and 1998), Tomar (1998) and Sumathi (1999) on bhendi. Similarly the efficacy of other treatments in reducing the fruitborer damage which is in tune with the present findings was observed with quinalphos (Chari *et al.* (1987), with malathion (Konar and Rai, 1990; Borah, 1995 and Rishikumar *et al.*, 1996), with Phosalone (Parkash *et al.*, 1980) and with profenofos (Surekha and Arjuna Rao, 2000).

5.2.1.1. Effect of neem products, *B.t.* formulations and insecticides on population of natural enemies

The relative safety of different neem products in recording higher population of natural enemies *viz.*, coccinellids (*Menochilus sexmaculatus* Fabricius and *Micraspis crocea* Mulsant), spiders (*Oxyopes* sp. and *Clubiona* sp.) and chrysopid (*Chrysoperla carnea* Stephen) was in the order of untreated check > NSKE (50 g/lit) > TNAU NO 60 EC (c) (20 ml/lit) > neem oil (20 ml/lit) > Neemazal-F (1 ml/lit) > NSKE (100 g/lit). This investigation is in agreement with the earlier reports of Srivastava and Parmer (1985) that predatory coccinellids survived the application of neem oil formulated products and that of Saxena *et al.* (1984) who reported that the wolf spider, *Lycosa pseudoannulata* (Bosenberg and Strand) was insensitive to neem oil and aqueous NSKE. Mohan (1988), Saxena (1989) and Jayaraj *et al.* (1993) also found that neem product application was highly safer to predators. Bhuvaneshwari *et al.* (1993) reported nil mortality of second instar grubs of *C. carnea* treated with neem oil and NSKE at different concentrations.

Among the *B.t.* formulations tested in comparison with untreated check, the above predator populations were relatively high in untreated check followed by Delfin (1.5 g/lit), Spicturin (3 ml/lit), Biobit (1.5 g/lit), Spicturin (4 ml/lit) and Delfin (2 g/lit). According to Burges (1981) *B.t.* is absolutely safe to human beings and other non-target organisms including parasites and predators. The safety of *B.t.* formulations to predators was also reported by Babrikova *et al.* (1982), who found that the *B.t.* subsp. *thuringiensis* (Bactospeine), *B.t.* subsp k*urstaki* (Dipel) were safe to *Chrysopa* grubs under field conditions. The *B.t.* products, Biobit and Delfin (2 g/lit) were comparatively harmless to the eggs of *C. carnea* (Srinivasan, 1997; Praveen, 2000).

The experiments conducted with different insecticides against sucking pests revealed that the highest population of above mentioned predators was recorded in untreated check followed by methyl demeton, imidacloprid, dimethoate and acephate. As in case of insecticides against fruitborer, endosulfan, malathion and triazophos found to be comparatively safer to predators. Lesser population of above predators was recorded in carbosulfan, profenopbhos phosalone and quinalphos. Safety and toxicity of insecticides to predators was reported by several earlier workers Krishnamoorthy (1985) reported that *Chrysopa* eggs were totally unaffected by pesticides. The grubs and adults were killed (70 - 100%) by insecticides like quinalphos chlorpyriphos, malathion and dichlorvos. Pree and Hagley (1985) reported the susceptibility of grubs and adults of *Chrysopa oculata* (Say) to organo phosphorous and synthetic pyrethroids. Mani (1993) reported that none of the insecticides was safe to the chrysopids, where as endosulfan 0.07 percent was moderately toxic to the larvae and highly toxic intially to the adults. The lesser population of natural enemies in insecticidal treatments indicated the detrimental effect of insecticides on the natural enemies complex on bhendi. Hence it is imperative to develop an IPM programme using bio-control agents which would maintain the biotic balance of pests in any cropping system.

5.2.2. Impact of N, P and K fertilizers on the incidence of major pests of bhendi

The results obtained on impact of N, P and K fertilizers on the incidence of major pests of bhendi (Fig. 13 & 14) clearly exhibited that the population of sucking pests *viz.,* aphid, leafhopper and whitefly was found to be increased as the age of the crop advanced and the plots treated with double the dose of 'K' (60 kg ha^{-1}) and 1 ½ dose of 'K' (45 kg ha^{-1}) were found to be the superior treatments in recording less population of sucking pests and fruitborer damage when compared to the recommended dose of NPK @ 40 : 50 : 30 kg ha^{-1}. These findings are in confirmity with the results of Mary and Balakrishnan (1990) and Chandrasekaran (1996). As the dose of 'N' is increased from 40 to 80 kg ha^{-1} population of sucking

Fig 13. Impact of NPK fertilizers against sucking pests of bhendi

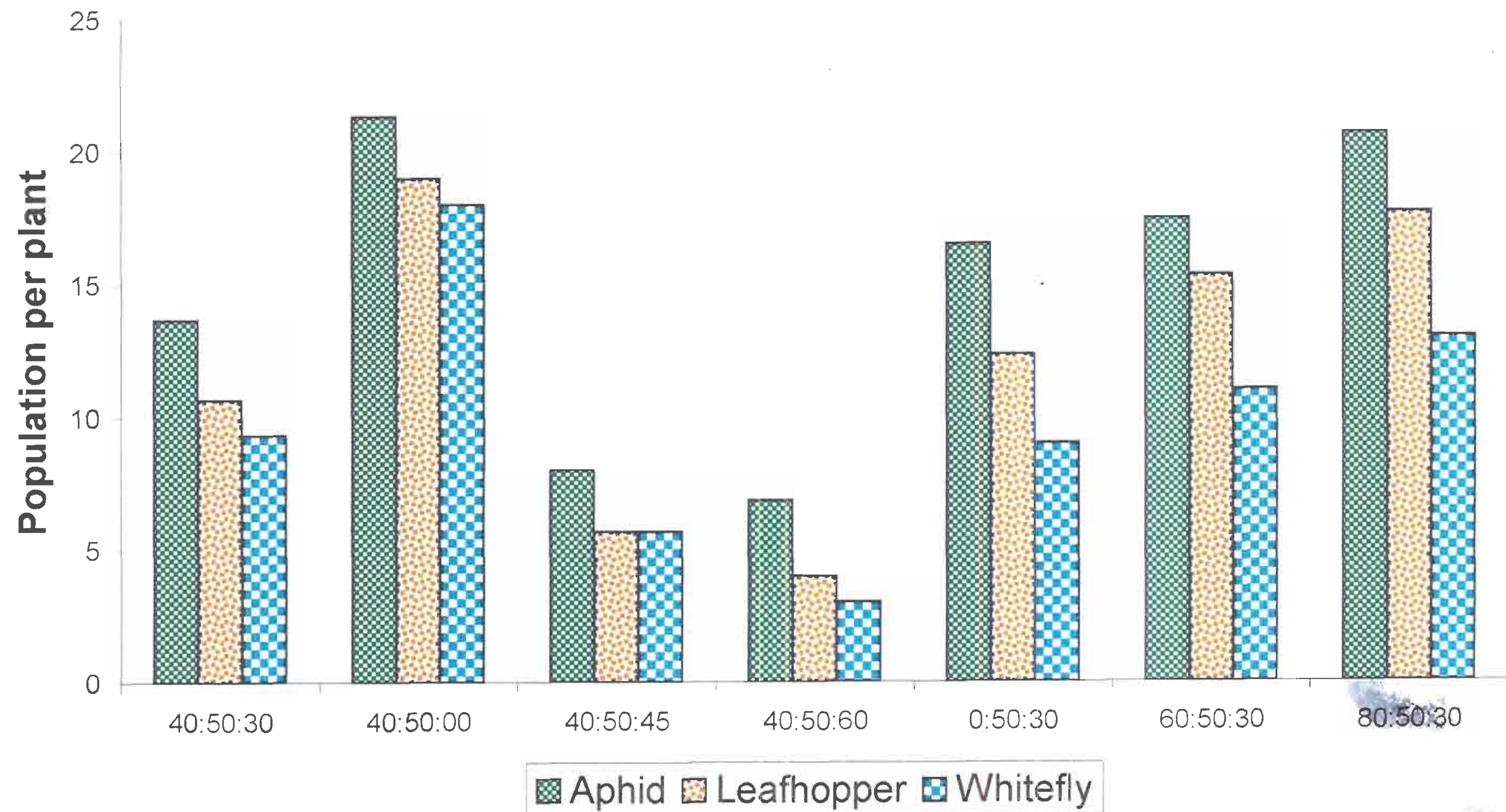
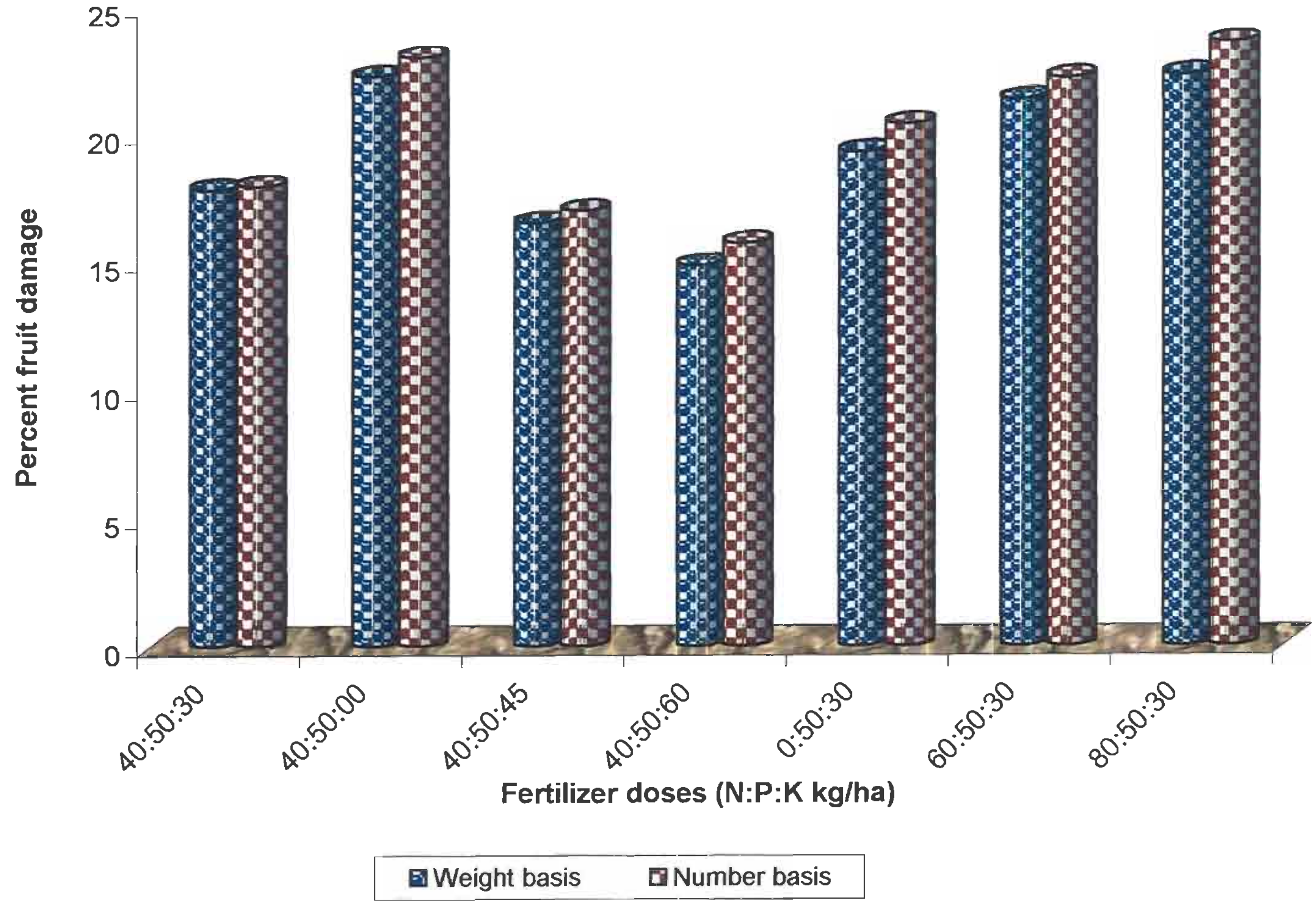


Fig. 14. Impact of N, P and K fertilizers on fruit damage by *Earias* spp.

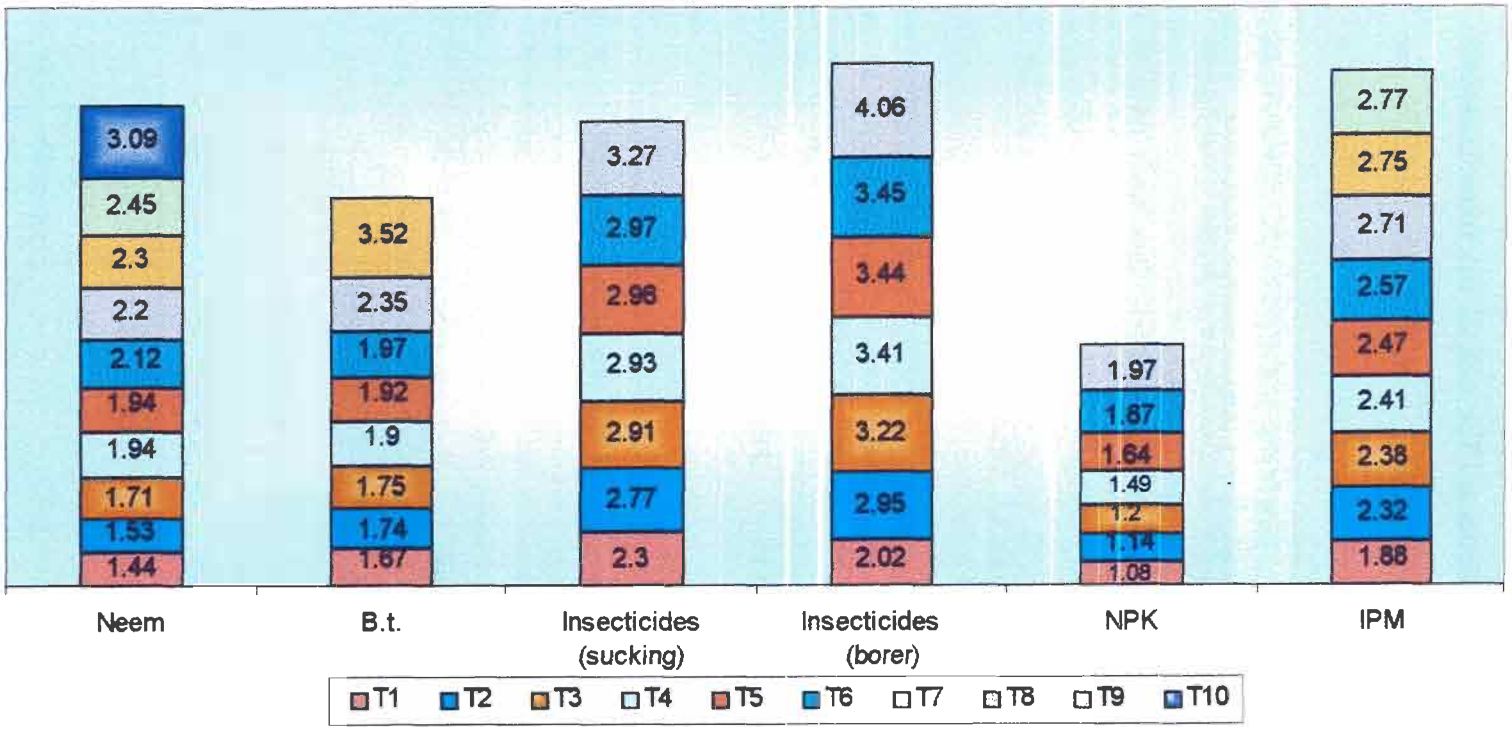


pests and fruitborers damage were found to be increased when compared to the recommended and also the increased doses of 'K' treatments. However, the impact of application of increased doses of 'N' in enhancing the population/damage of pests was reported in case of chilli thrips by Paul and Fernando (1939); cotton whitefly by Rippa and George (1965), Agarwal *et al.* (1979), Reddy and Rao (1982), Natarajan (1986), Natarajan *et al.* (1986), Purohit and Deshpande (1991) and Balaji and Veeravel (1995); cotton boll worm by Moawad and Nasr (1984) and Illango and Uthamasamy (1989) and bhendi fruitborer by Surekha and Arjuna Rao (2000). Considering the healthy fruit yield ha^{-1}, the plots treated with increased doses of 'K' @ 45 and 60 kg ha^{-1} registered higher yield when compared to recommended dose of 'K' (30 kg ha^{-1}). The yield was significantly decreased when the 'N' level was increased from 40 to 80 kg/ha.

5.2.3. Cost Benefit Ratio (CBR)

The performance of different treatments in several experiments based on CBRs revealed that in case of neem products, high CBRs were recorded in Neemazal-F @ 1ml /lit (1:2.45) and TNAU NO 60 EC @ 20 ml/lit (1:2.20). With regard to *B.t.* formulations, Delfin and Biobit @ 2.0 g/lit registered the maximum CBRs of 1: 2.35 and 1: 1.97 respectively. In case of experiments conducted with several insecticides against the sucking pests and fruitborer, high CBRs obtained were with the treatments imidacloprid (1:3.27), acephate (1:2.97), endosulfan (1: 4.06) and triazophos (1:3.45). Regarding the fertilizer experiment with varying levels of NPK, the treatments with 40: 50: 60 kg ha^{-1} and 40 : 50 : 45 kg ha^{-1} resulted high CBRs of 1 : 1.97 and 1 : 1.87 respectively (Fig. 15).

Fig 15. Cost Benefit Ratio (CBR)



	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Neem	C	NSKE (10%)	NSKE (5%)	NO (c) (30ml)	NO (30ml)	NO (20ml)	NO (c) (20ml)	Na (1.5ml)	Na (1ml)	Md (2ml)
B.t.	C	Spic (4ml)	Spic (3ml)	Delfin (1.5g)	Biobit (1.5g)	Biobit (2g)	Delfin (2g)	Endo (2ml)	-	-
Insecticides(s)	C	C. sulfan	M. demeton	Profenophos	Dimethoate	Acephate	Imidacloprid	-	-	-
Insecticides(b)	C	Phosalone	Malathion	Quinalphos	Profenophos	Triazophos	Endosulfan	-	-	-
NPK	40:50:0	80:50:30	60:50:30	0:50:30	40:50:30	40:50:45	40:50:60	-	-	-
IPM	T9	T5	T1	T7	T3	T6	T4	T8	T2	-

NO(c)- TNAU NO (c) Na- Neemazal F Md- Methyl demeton Spic- Spicturin Endo- Endosulfan C.sulfan- Carbosulfan C- Control

5.2.4. Development of IPM on bhendi

With a view to evolve a suitable IPM package against major pests of bhendi, based on higher CBRs obtained from different experiments, the most significant treatments were selected from each experiment and were included as treatments in the IPM experiment to confirm their impact. The combined effects of application of fertilizers, botanicals, biocides, insecticides and release of egg parasitoids which not only reduce the incidence/damage of the pests but also result in high yield and CBRs were also considered.

TREATMENT STRUCTURE FOR IPM TRIAL

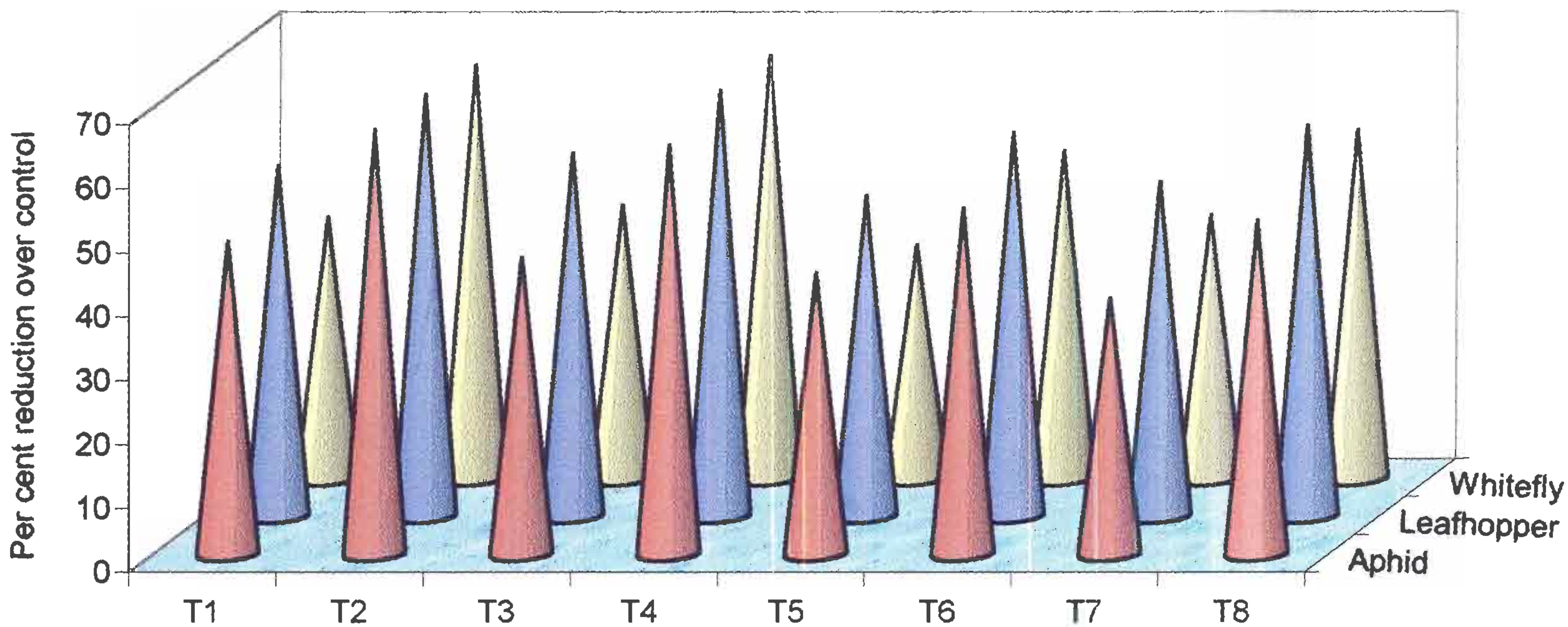
<table>
<tr><th rowspan="2">T. No.</th><th rowspan="2">NPK/ha</th><th colspan="2">Sucking pests
(Aphid, Leaf hopper and Whitefly)</th><th colspan="3">Fruit borer
(Earias spp.)</th></tr>
<tr><th>At 50% ETL</th><th>At 100% ETL</th><th>Release</th><th>At 50% ETL</th><th>At 100% ETL</th></tr>
<tr><td>T1</td><td>40:50:30</td><td>Neemazal - F</td><td>Acephate</td><td rowspan="8">Release of Trichogramma chilonis Ishii @ 50,000/ha only once at flowering</td><td>Biobit</td><td>Endosulfan</td></tr>
<tr><td>T2</td><td>40:50:45</td><td>Neemazal - F</td><td>Acephate</td><td>Biobit</td><td>Endosulfan</td></tr>
<tr><td>T3</td><td>40:50:30</td><td>Neemazal - F</td><td>Imidacloprid</td><td>Delfin</td><td>Triazophos</td></tr>
<tr><td>T4</td><td>40:50:45</td><td>Neemazal - F</td><td>Imidacloprid</td><td>Delfin</td><td>Triazophos</td></tr>
<tr><td>T5</td><td>40:50:30</td><td>TNAU NO 60 EC (c)</td><td>Acephate</td><td>Delfin</td><td>Triazophos</td></tr>
<tr><td>T6</td><td>40:50:45</td><td>TNAU NO 60 EC (c)</td><td>Acephate</td><td>Delfin</td><td>Triazophos</td></tr>
<tr><td>T7</td><td>40:50:30</td><td>TNAU NO 60 EC (c)</td><td>Imidacloprid</td><td>Biobit</td><td>Endosulfan</td></tr>
<tr><td>T8</td><td>40:50:45</td><td>TNAU NO 60 EC (c)</td><td>Imidacloprid</td><td>Biobit</td><td>Endosulfan</td></tr>
<tr><td>T9</td><td>40:50:30</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

IPM for sucking pests of bhendi

Considering the eight different combination of treatments against sucking pests *viz.*, aphid, leafhopper and whitefly (Fig. 16), the effect of fertilizers, botanical and chemical insecticides were taken in to account. In general, application of higher dose of potash @ 45 kg ha $^{-1}$ than the recommended dose of 30 kg ha $^{-1}$ in combination with botanical and chemical insecticides had resulted in significant reduction in population of aphid, leafhopper and whitefly, as evidenced with high per cent reduction in treatments T_2, T_4, T_6, and T_8 on both 3rd and 7th day after spraying. The normal dose of potash (30 kg ha^{-1}) however, recorded less per cent reduction of sucking pests population in combination with botanical and chemical insecticides (T_1, T_3, T_5 and T_7). The effect of potash felt at higher doses in reducing the population of sucking pests might be attributed to the induction of resistance to the bhendi plants.

From the above experiment, it is obvious that alternating sprays of chemical insecticides with botanicals has become ideal in bringing down the sucking pest populations on bhendi. The above sprays in combination with higher doses of potash fertilizers had resulted in significant reduction in population of aphids, leafhopper and whitefly. Among the treatments, the combination of Neemazal-F, imidacloprid with high dose of potash was found to be highly effective than that of combination of TNAU NO 60 EC (c) + acephate, TNAU NO 60 EC (c) + imidacloprid and Neemazal-F + acephate along with high dose of potash. Hence, basal application of high dose of potash (45 kg ha^{-1}) followed by first spray with Neemazal-F (1ml/lit) / TNAU NO 60 EC (c) (20 ml/lit) at 50 per cent ETL followed by second spray with imidacloprid (0.004%) / acephate (0.11%) at 100 per cent ETL were found to be the best treatment combinations for IPM strategy against sucking pests of bhendi.

Fig 16. Effect of NPK, biocides and insecticides against sucking pests of bhendi



IPM for fruitborer, *Earias* spp.

Combination of treatments included were application of fertilizers, biocides, chemical insecticides and release of *T. chilonis*. The per cent fruit damage both on number and weight bases were considered for evolving a suitable IPM strategies.

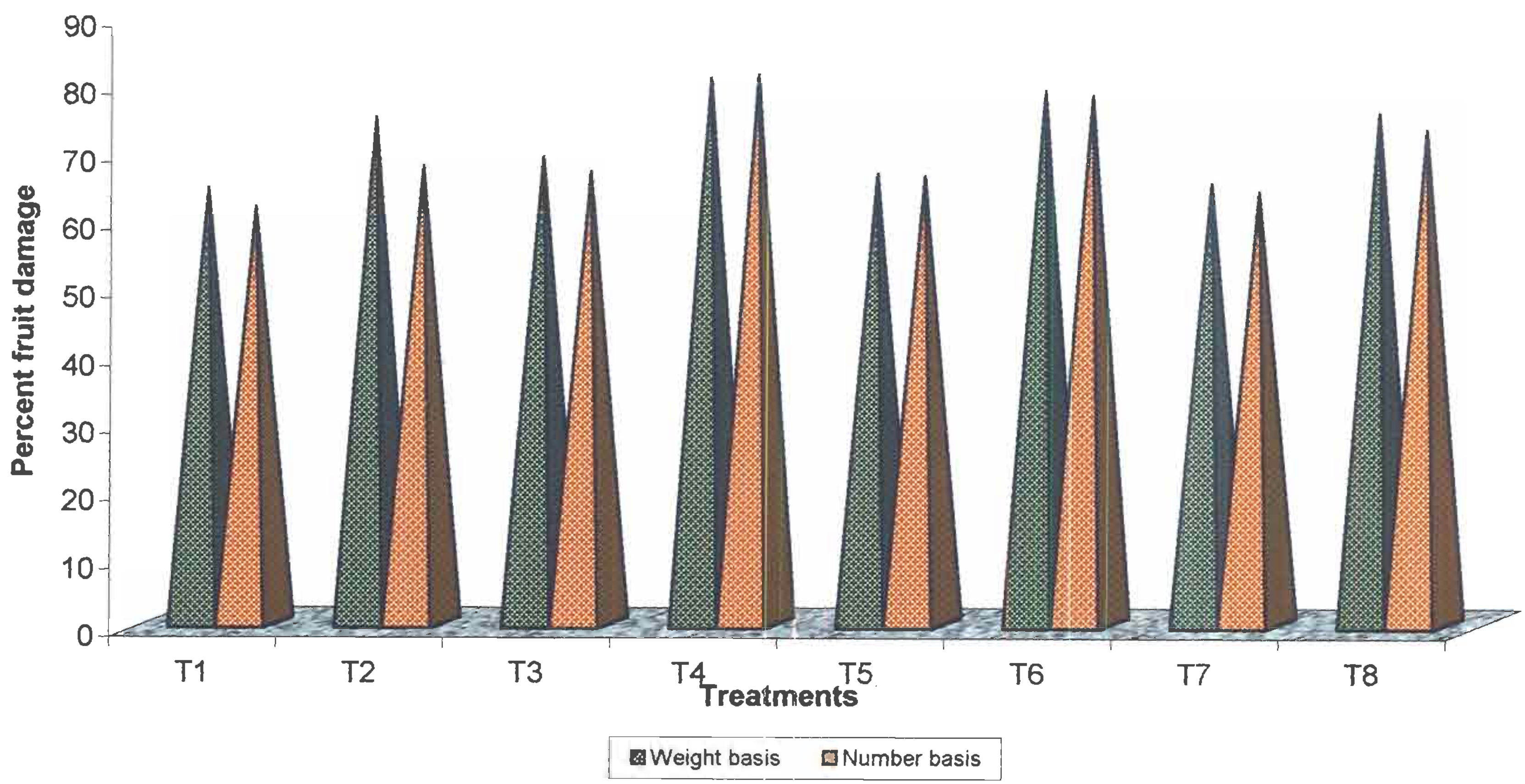
The indirect effects of sprays of neem products (I spray) and chemical insecticides (II spray) were also taken into account. Plots treated with higher dose of potash (45 kg ha^{-1}) followed by release of *T. chilonis* and spraying of *B.t* formulations and insecticides recorded less fruit damage by *Earias* spp. on bhendi. It is obvious that higher dose of potash indirectly has triggered the resistance mechanisms of plants against insect pests.

On evaluating the effect of different combination of treatments against *Earias spp.*, the plots in which the application of higher dose of 'K' (45 kg ha^{-1}) followed by spraying of Neemazal-F (1ml /lit) and imidacloprid (0.004%), release of *T. chilonis* and spraying of Delfin (2g/lit) and triazophos (0.08%) (T4) recorded less fruit damage with high healthy fruit yield ha^{-1} (Fig. 17).

Calculating the CBR as evidenced by the impact of different treatments against sucking pests and fruitborer, revealed the cost effective treatment combinations *viz.*, T_2 and T_4 which gave the highest net return and CBR. Treatment combinations T_6 and T_8 also be considered as they stood next (Fig. 15). Highest net return and CBR obtained in the above mentioned treatments were due to low cost of treatment and high yield of fruits. It is concluded that the treatment combinations T_4 and T_8 were found to be quite promising for adoption.

Though there are ample number of reports on the individual use of botanicals, chemical insecticides and *B. t.* products for the management of insect

Fig. 17. Effect of NPK, biocides and insecticides on the incidence of fruitborer, *Earias* spp



pests of bhendi, no records are available on the IPM packages for bhendi pests. Application of potassium fertilizers at higher doses was found to increase the fibre content of okra fruits which could minimize the borer infestation as suggested by Arora *et al.* (1996). In the present investigation also, the treatment combinations with high doses of potash recorded minimum incidence of sucking pests and less damage to fruits by fruitborer, *Earias* spp.

Neem leaves, neem oil, NSKE and neem cake are known to be promising for insect pest management of both agricultural and horticultural crops. Neem formulations are found to be best suited for IPM as reported by Ramarethinam (1998). In the present study, the use of neem formulations (Neemazal-F and TNAU NO 60 EC (c)) in combination with *B.t.* products (Delfin and Biobit) and chemical insecticides (imidacloprid, acephate, endosulfan and triazophos) along with egg parasitoid (*T.chilonis*) significantly reduced the population of sucking pests and fruitborer. The neem formulations, though they have toxic principal alkaloid 'azadirachtin' they do possess repellant, deterrent and antifeedant properties against the sucking pests of bhendi. Release of *T. chilonis* followed by spraying of *B t.* products like Biobit and Delfin were found to be effective against fruitborer. Praveen (2000) also obtained good results in reducing the *Earias* spp damage after the release of *T. chilonis* @ 50,000 ha^{-1} followed by spraying of *B.t.* @ 1.0 kg ha^{-1}. The effectiveness of *B. t.* products observed in the present study is in confirmity with the findings of Srinivasan (1997) who reported effectiveness of above products against brinjal shoot and fruitborer.

In the present investigation, release of *T. chilonis* @ 50,000 ha^{-1} once at flowering followed by spraying of *B. t.* products once at 5 per cent fruit damage (50% ETL) and of insecticides at 10 per cent fruit damage (100 % ETL) significantly reduced the fruit damage by the fruitborers. Earlier studies conducted by Sumathi (1999), who also recommended the release of *T. chilonis* @ 50,000 ha^{-1} at flowering followed by spraying of neem oil (3%) at 5 per cent fruit damage and endosulfan (0.07%) at 10 per cent fruit damage for the management of bhendi fruitborer *Earias* spp..

Considering the overall scenario emerging from the discussion on research carried out in the present investigation, the following IPM package is evolved for the management of major pests of bhendi.

(i) Application of increased dose of 'K' (45 kg ha^{-1}) with recommended dose of 'N' (40 kg ha^{-1}) and 'P' (30 kg ha^{-1}).

(ii) **Against sucking pests**

Spraying of Neemazal-F (1 ml/lit) (or) TNAU NO 60 EC (c) (20 ml/lit) at 50 per cent ETL —followed by→ spraying of imidacloprid 200 SL (0.004%) (or) acephate 75 SP (0.11%) at 100 per cent ETL

(iii) **Against fruitborer, *Earias* spp.**

Release of *T. chilonis* @ 50,000 parasitoids ha^{-1} at flowering stage

↓ followed by

spraying of Biobit (or) Delfin (2 g/lit) at 5 per cent fruit damage (50% ETL) —followed by→ spraying of endosulfan (0.07%) (or) triazophos (0.08%) at 10 per cent fruit damage (100% ETL)

It is obvious that by following the IPM practices developed as an outcome of present investigation, the emergence of crisis and disaster phases in the insect pest management of bhendi would be avoided.

Summary

6. SUMMARY

The following are the salient findings obtained from the investigations made with special reference to the management of major pests of bhendi.

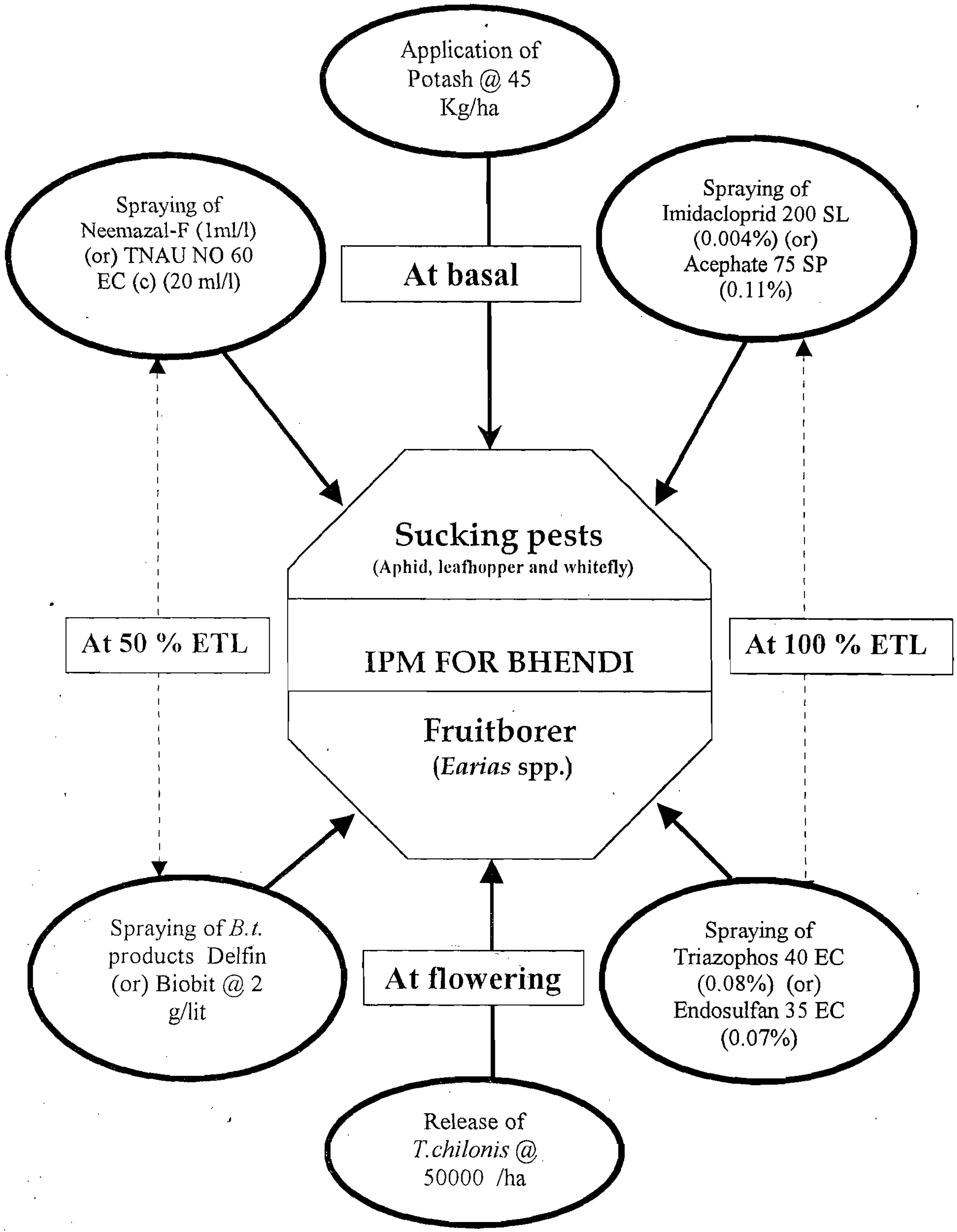
- Among the neem products evaluated for their ovicidal action and ovipositional deterrency, Neemazal-F (1ml/lit) and TNAU NO 60 EC (c) (30 ml/lit) were highly effective against fruitborers causing maximum mortality of eggs, reducing the per cent hatchability of eggs and deterring their oviposition when compared to other neem products *viz.*, Neemazal-T/S, Econeem, TNAU NO and NSKE.
- *B.t.* products *viz.*, Delfin and Biobit @ 2g lit^{-1} effected higher mortality of *E. vittella* larvae within a short period of four days as against seven days in Spicturin.
- Among the bhendi entries evaluated for their relative resistance / susceptibility to major pests, it was found that the entries OHD-1, COOH-1, Varsha Uphar and Arka Anamika were moderately resistant, whereas MDU-1 and Pusa Sawani were susceptible/highly susceptible to aphid, leafhopper, whitefly and fruitborers.
- Studies made on the mechanism of resistance against leafhopper indicated that the resistant entries OHD-1, COOH-1 and Arka Anamika possessed high density of trichomes per sq. cm, while moderately resistant entries (Varsha Uphar, MDU-1) and susceptible entry (Pusa Sawani) had less number of trichomes per sq. cm.
- Out of six bhendi entries tested, COOH-1, OHD-1, Arka Anamika, Varsha Uphar had greater plant height, higher fruit yield per plant and more length,

girth and weight of fruits proving their moderate level of resistance when compared to MDU-1 and Pusa Sawani against major pests of bhendi.

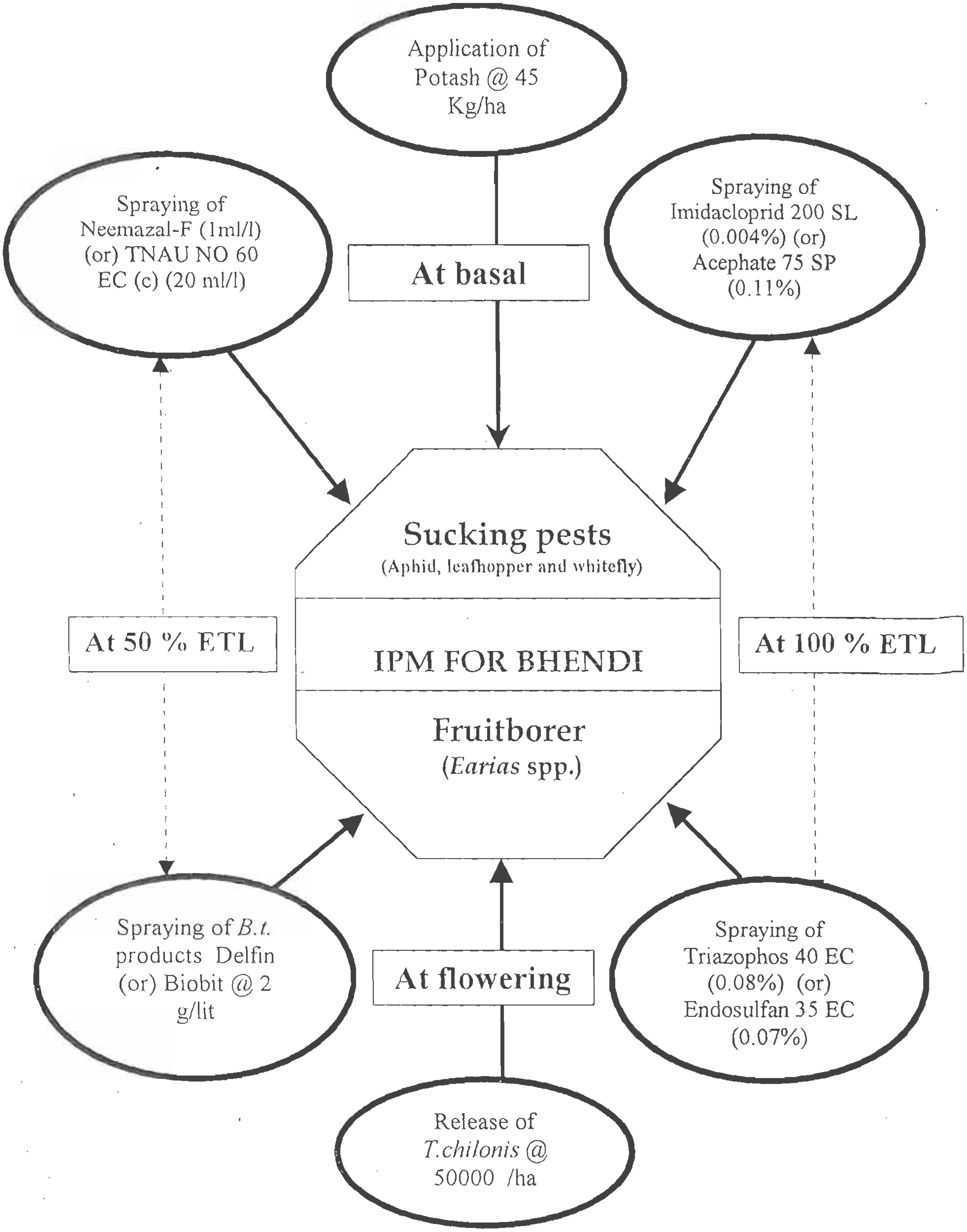
- Experiment conducted on persistent toxicity of insecticides against sucking pests of bhendi revealed that imidacloprid 200 SL (0.004%) and acephate 75 SP (0.11%) were found to persist 19 and 21 days, 19 and 17 days and also 17 and 19 days for aphid, leafhopper and whitefly respectively.
- Among the neem products tested for their efficacy against sucking pests of bhendi at 50 per cent ETL, Neemazal-F (1ml/ lit) and TNAU NO 60 EC (c) (20ml/lit) were found to be superior to other treatments resulting in higher fruit yield and high CBRs of 1: 2.45 and 1: 2.20 respectively, but their efficacies were only next to standard check, methyl demeton (0.05%) under field condition.
- Field evaluation of insecticides for their efficacies against sucking pests at 100 per cent ETL, showed that spraying of imidacloprid 200 SL (0.004%) and acephate 75 SP (0.11%) were highly effective against the aphid, leafhopper and whitefly with higher per cent reduction in above pest populations and recording higher fruit yield with high CBRs of 1: 3.27 and 1: 2.97 respectively.
- Among the *B.t* formulations when experimented at 5 per cent fruit damage Delfin and Biobit @ 2g lit^{-1} significantly reduced the fruit damage by the borers and recorded the higher fruit yield with high CBRs of 1: 2.35 and 1: 1.97 respectively. But their efficacies were found to be second in ranking when compared with standard check endosulfan (0.07%).
- Among the insecticides evaluated at 10 per cent fruit damage against the bhendi fruitborer, *Earias vittella* Fabricius and *E. insulana* Boisduval, endosulfan 35 EC (0.07%) and triazophos 40 EC (0.08%) were superior to

other treatments and resulted in higher per cent reduction in fruitborer damage, higher fruit yield and high CBRs of 1: 4.06 and 1: 3.45 respectively.

- Investigations made on the effect of different levels of 'N' and 'K' with recommended 'P' fertilizers revealed that basal application of increased level of potash (45 kg ha^{-1}) registered less population of aphid, leafhopper and whitefly and less fruit damage by the fruitborers with higher fruit yield and high CBR of 1: 1.87.
- Individual experiments with different insecticides against major pests of bhendi clearly indicated the supremacy of Neemazal-F and TNAU NO 60 EC (c) (neem products), Biobit and Delfin (*B.t* products), imidacloprid and endosulfan (chemical insecticides) over their counterpart. When these products were evaluated for safety against natural enemy complex in bhendi, higher survival rate of predators like coccinellids, spiders and chrysopids were observed in the above mentioned treatment plots than that of the other treatments, confirming their suitability for IPM in bhendi.
- In the IPM experiment, conducted with different combinations of treatments, the results revealed that the treatment combinations T_4 and T_8 which consisted of the following practices *viz.*, basal application of high dose of 'K' (45 kg ha^{-1}) with recommended 'N' (40 kg ha^{-1}) and 'P' (50 kg ha^{-1}), spraying of Neemazal - F (1ml/lit) / TNAU NO 60 EC (c) (20 ml/lit) at 50 per cent ETL and imidacloprid 200 SL (0.004%) / acephate 75 SP (0.11%) at 100 per cent ETL against sucking pests, release of egg parasitoid *Trichogramma chilonis* Ishii @ 50,000 ha^{-1} at flowering stage and spraying of Delfin / Biobit @ 2g lit^{-1} and triazophos (0.08%) / endosulfan (0.07%) at 5 and 10 per cent fruit damage respectively against the fruitborers were found to be the best and ideal IPM package for major pests of bhendi in realising higher fruit yield ha^{-1} and maximum CBR.



INTEGRATED PEST MANAGEMENT MODEL FOR BHENDI



INTEGRATED PEST MANAGEMENT MODEL FOR BHENDI

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