MANAGEMENT OF OKRA PESTS WITH NEEM FORMULATIONS IN ALTERNATION WITH SYNTHETIC INSECTICIDES

By

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B.Sc.(Agri) First Class
[Regd.No. 99196]

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH ,
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MAHARASHTRA (INDIA)

in partial fulfillment of the requirements for the Degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY.

MAHATMA PHULE KRISHI VIDYAPEETH
DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
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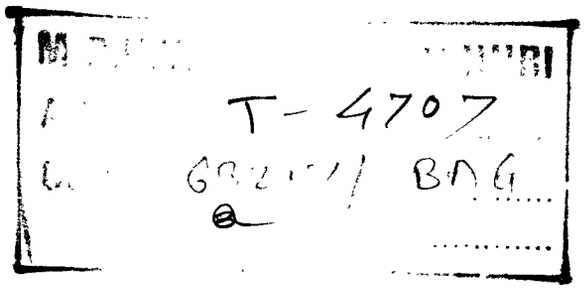

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CANDIDATE'S DECLARATION

I here by declare that this thesis entitled " **MANAGEMENT OF OKRA PESTS WITH NEEM FORMULATIONS IN ALTERNATION WITH SYNTHETIC INSECTICIDES** " or part there of has not been submitted by me or any other person to any other University or Institute for Degree or Diploma

Place :Pune
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(A.S. Jadhav)

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19 OCT 2001

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place : Pune
Date : 15/10/2001

(Abhaykumar S. Bagde)

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ABBREVATIONS

a.i.	active ingredient
C. D.	Critical Difference
Cv	co.variety
E.C.	Emulsifiable Concentrate
et al.	et alii (and others)
Fig.	Figure
G	Granules
g	gram (S)
ha	hectare
i.e.	that is
kg	kilo gram
lit.	Litre
ml	milli litre
mm	milli metre
No.	Number
pp	page (S)
q	quintal
S.C.	Soluble concentrate
S.E.	Standard error
t	tonne
viz.,	videlicet (Namely)
%	Per cent
@	at the rate of
/	per
NSKE	Neem Seed Kernal Extract
>	Greater than
WS	Water soluble

ABSTRACT

"MANAGEMENT OF OKRA PESTS WITH NEEM FORMULATIONS IN ALTERNATION WITH SYNTHETIC INSECTICIDES"

By

BAGADE ABHAYKUMAR SADASHIVRAO

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

2001

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Two field experiments were conducted on the experimental farm of Entomology section, College of Agriculture, Pune in summer 2001 to evaluate the promising neem formulations in alternation with synthetic insecticides against okra pests *viz.*, shoot and fruit borer, jassids and aphids. The effects of number and application interval of neem formulation in alternation with synthetic insecticides were also studied to find out the possibility of reducing one spray of insecticide by increasing the spray interval from 15 to 21 days.

The studies carried out revealed that all the insecticidal treatments significantly reduced the aphid and jassid population and fruit borer infestation on okra. The treatment with cypermethrin 0.01% was found to be the most superior, which registered the lowest fruit borer infestation both on number and

Contd.

weight basis. The neem formulation treatment *viz.*, Achook 0.5 %, ZA – 199 0.5% and NSKE 5% when alternated with cypermethrin 0.01% comprising total 4 sprays and imidacloprid 0.004% 4 sprays alone were found to be the next effective treatments against fruit borer.

Three sprays of imidacloprid 0.004% were found to be the most effective inchecking the population of aphids and jassids. The cypermethrin 0.01% alone and Achook 0.5% and NSKE 5% both alternated with Imidacloprid 0.004% comprising 4 sprays were found to be next best treatments in reducing jassid population.

Cypermethrin 0.01% and neem formulations *viz.*, Achook 0.5%,ZA-199 0.5% and NSKE 5% all alternated with synthetic comprising insecticides *viz.*, cypermethrin 0.01% and imidacloprid 0.04% comprising 4 sprays were found to be next effective treatments against aphids.

It is concluded that 4 sprays of cypermethrin and 3 sprays of imidacloprid were found to be most effective in reducing the fruit borer infestation and population of aphids and jassids, respectively. The neem formulations when alternated with cypermethrin were found promising in controlling fruit borer. The neem formulations when alternated with imidacloprid controlled the jassids effectively while neem formulataions when alternated with both synthetic insecticides were found effective in checking the population of aphids. Thus, spraying of neem formulation in alternation with synthetic insecticide could be exploited in IPM strategies against okra pests to overcome the problems associated with the repeated uses of synthetic insecticides.

Abstract contd..... A.S.Bagde

The population build up of mites was found to be higher in the plots treated with cypermethrin 0.01% and neem formulations alternated with cypermethrin 0.01%. The least population was observed in untreated control. Thus, it was observed that the repeated use of synthetic insecticides particularly pyrethroids increase the mite population.

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INTRODUCTION

1. INTRODUCTION

Okra, *Abelmoschus esculantus* Linn. (Moench) is commonly known as Lady's finger in western style and "bhendi" in Indian language. It is of African origin. It is grown extensively in all the tropical and sub tropical parts of the world. It is cultivated throughout India, in states of Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Maharashtra. In Maharashtra, it is grown all the year round providing continuous and good source of income to the farmers. It was cultivated on an area of 6993 ha. with productivity of 40854 M.T. during the year 1996-97 (Anonymous, 1998). It is extensively grown in Ahmednagar, Amaravati, Aurangabad, Dhule, Jalgoan, Nagpur, Nashik, Osmanabad, Parbhani and Pune districts in the state of Maharashtra.

Okra is commonly grown for its unripe fruits which are consumed as vegetable in daily diet. The tender green fruits are of high nutritive value, being rich in pectin and mucilage and good source of iron, calcium and potassium, besides they are rich source of vitamin A, B and C. In addition, mucilagenous extract of green stem of "bhendi" is used for clarifying sugarcane juice in jaggery preparation (Chauhan, 1972).

Okra is said to be very useful against genitourinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). Among the limiting factors for its production, the pest problem on okra is the important one. Butani and Verma (1976) gave a list of 20 pests on okra. The most important are shoot and fruit borer (*Earias vitella* Fab. and *Earias insulana* Boisduval), jassids (*Amrasca biguttulla biguttulla* Ishida.), aphids (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Genn.) and red spider mites (*Tetranychus cinnabarinus* Boisduval and *Tetranychus telarius* L.). Shoot and fruit borer is the most important pest causing direct damage to marketable produce i.e. green fruits. It is alone reported to cause 57.1% fruit damage and 54.04% net yield loss in okra (Chaudhary and Dadheech, 1989). Jassid is the second important pest causing severe infestation.

In summer crop population of 4.78 individuals/leaf was recorded in Rajasthan (Chaudhary and Dadheech, 1989).

The use of pesticides has gradually become a part of our modern agricultural practices and its consumption has increased remarkably in the recent past causing serious health and environmental problems in developing countries including India.

The indiscriminate use of synthetic pesticides, since last four to five decades led to wide spectrum of problems, like pest-resistance. The resistance has been reported in almost 500 species of insect and mites (Georghiou, 1986). Resurgence of pest such as mites was also reported. (Basha *et al.*, 1982; Sandhu *et al.*, 1987).

The pesticidal residue in plants, soil and water is responsible for various mutagenic and teratogenic defects in human. Liver and kidney damages were observed in response to a long exposure to organochlorine pesticides, whereas, organo phosphorous toxicity results in decline of memory (Korsak and Sato, 1977) and destruction of beneficial organisms, flora and fauna.

All these factors led to search for safer and more compatible alternatives to overcome these problems. In such a context 'Neem' offers highly attractive option to the world, which performs as tree of 'Sarva rogha nivarini'. *Azadirachta indica* A. Juss. commonly known as 'Neem' or 'Margosa' tree is indigenous to South Asia. For centuries the tree has been held in esteem by Indian folk because of its medicinal and insecticidal values. Centuries before commercial insecticides were available, various parts of neem tree were being used by farmers for the protection of agricultural crops and stored products. Use of neem seed, leaves, kernel oil, seed cakes, etc. are also being used in pest management. However, systematic studies on insecticidal properties of different parts of neem and its products started only in early sixties, when Pradhan *et al.* (1962) first reported the antifeedant properties of neem seed kernels against the desert

locust, *Schistocerca gregaria* Forskal.

In recent years, research workers have made efforts to find out effective and safe constituents of neem for pest control.Neem possesses the properties like antifeedant (Pradhan *et al.*, 1962, De *et al.*, 1992), ovipositional deterrent and ovicidal (Singh, 1984; Patel *et al.*, 1996), antibacterial (Chopra *et al.*, 1958), antiviral (Rao *et al.*, 1969), nematicidal (Singh and Sitaramaiah, 1966; Dev Kumar *et al.*, 1985).

Looking to the pesticidal hazards, the use of pesticidal formulations based on plant products appears to be promising area for pest control. The neem preparations are comparatively more economical, biodegradable, safe to human being and less harmful to beneficial organisms. Secondly, the chances of developing resistance in insects to neem products are very less; no data are available on pest resistance developed due to applications of neem derivatives and it is unlikely in future too. Vollinger (1987) confirmed this in respect of kernel extract by which fecundity of *Plutella xylostella* adults for about 35 generations was always much low levels than adults of untreated larvae. Further, the continuous use of one insecticide though found effective against a particular pest, it causes resurgence of other pests (Bari, 1995; Basha *et al.*, 1982).

Keeping this in mind, to avoid the possibility of developing resistance to synthetic insecticides and also to neem products in near future and resurgence of non-target pests, the studies were undertaken in the present investigations with following objectives:

1. Bioefficacy of promising neem formulations in alternation with synthetic insecticides against okra pests.

2. Effect of number and application interval of neem formulations in alternation with synthetic insecticides against okra pests.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Indiscriminate use of pesticides cause many hazardous side effects like environmental pollution, toxicity to non-target beneficial organisms resulting in upsetting the ecological balance, several pests develop resistance to the chemical pesticides, resurgence of pest due to frequent sprayings of synthetic pyrethroids (David *et al.*, 1989; Basha *et al.*, 1982; Watson *et al.*, 1985). The ideal pesticide, which would kill only the target pests, persist long enough to do so and then disappear without leaving toxic residues and be completely safe, is not yet available. As a result, the use of naturally occurring plant products received a fresh impartial look in the present strategy of developing environmentally sound method of pest control. The search for plants having insecticidal properties began with medicinal plants and several workers have screened number of such plants for their insecticidal properties.

Mc Indoo (1924) reported 1182 species of plants having insecticidal properties and Frear (1948) further enlisted 1451 plants for which insecticidal tests have been carried out.

Chopra *et al.*, (1940) in their book "Poisonous plants of India" listed about 700 plant species reported to be poisonous to man and other animals, insects and further, Dhaliwal *et al.*, (1996) enumerated as many as 2121 plant species, reported to posses pest management properties, among them, 1005 species of plants exhibiting insecticidal, 384 with antifeedant, 297 with repellent, 27 with attractant and 31 with growth inhibiting property, have been identified. Among all plants neem plays important role in pest control now a days.

The literature pertaining to effect of neem and its products against pests of okra and other crops is reviewed as under.

2.1. Properties and Bio-efficacy of neem, *Azadirachta indica* A. Juss.

In earlier days before invention of commercial insecticides, neem (*Azadirachta indica* A. Juss) was used in pest control in agricultural crops. The neem tree has played a big role in ayurvedic medicinal system of India and it has been used for treatment of various ailments (Nadkarni, 1954; Chopra *et al.*, 1958).

The systematic work on neem however started in early 60's, when antifeedant property of neem has been identified by Pradhan *et al.* (1962).

Neem has also known to possess ovipositional detterent and ovicidal properties (Singh, 1984; EI. Sayed, 1985; Patel *et al.*, 1996). Grain protectant properties of neem reported by several workers (Pathak and Krishna, 1985; Das and Karim, 1986; Sharma,1999). Besides neem also known to possess antibacterial (Chopra *et al.*, 1958), antiviral (Rao *et al.*, 1969), nematicidal (Singh and Sitaramaiah, 1966; Dev Kumar *et al.*, 1985) properties. However, the literature related to present investigation is only reviewed in this chapter.

2.2 Effect of neem formulations and insecticides on okra shoot and fruit borer

2.2.1 Neem Products

Chauhan and Quadri (1989) studied the antifeedant and insecticidal activities of extract of neem, garlic and datura against the okra pest, *Earias vittella*. The mortality was highest for feeding stage. Highest efficacy of neem, garlic and datura extract was obtained at 1250, 2000 and 2250 ppm concentrations, respectively.

Mallik and Lal (1989) conducted field trials in India and found reduction in *E. vittella* infestation and increase in yield in okra by application of neem oil cake (neem seed cake) and fertilizer @ 2.5 kg each

/200 sq.m. plots or neem seed cake alone @ 5 kg/plot.

Sardana and Kumar (1990) conducted field trials in Karnataka and demonstrated that weekly application of neem oil at 2% was effective in controlling. *E. vittella* on okra. Neem oil was as effective as monocrotophos at 0.05 per cent.

Samuthiravelu and David (1991) tested neem oil alone at the concentrations of 0.1, 0.3 and 0.5% and in combination with endosulfan at 0.035 and 0.07% for the control of *E. vittella* on okra. Application of neem oil and endosulfan, alone and in combination, were effective in reducing the damage. However, the maximum yield was obtained with endosulfan at 0.07%.

De and Hague (1992) recorded 11.70 per cent fruit infestation of shoot and fruit borer in okra crop treated with 0.1% Achook (neem product) against 54.67 per cent infestation in untreated control. The treatment with 0.1 per cent Achook gave 27.16 t/ha yield of edible fruits against the yield of 9.6 t/ha in untreated control.

Bhatnagar and Kandaswamy (1993) conducted laboratory trial on two neem formulations *viz.*, Neemrich 20 EC and Neemrich 80 EC against insect pest of cotton which indicated that Neemrich 20 EC @ 0.1 per cent exhibited 51.1 per cent antifeedant activity against larvae of *E. vittella*. The cotton bolls treated with neem-based formulation reduced the larval feeding to varying degrees.

Parade (1993) evaluated effective control of shoot and fruit borer on okra seed crop with applications of monocrotophos (0.04%), phosphamidon (0.04%), azadirachtin (0.025%) alternated with phosphamidon (0.04%), endosulfan (0.07%) and phosalone (0.07%).

Shukla *et al.* (1994) conducted field experiments during summer of

1993-94 in India to determine the efficacy of neem oil, Achook (neem based formulation), fenvalerate, cypermethrin, Karanj (*Pongamia pinnata*) oil dichlorvos and malathion for control of *E. vittella* infesting okra. Four sprays were applied fortnightly. Fenvalerate 20 EC (0.005%) gave the highest level of control and highest healthy fruit yield (70.75 q/ha) and was also highly cost-effective with a cost-benefit ratio of 1:10.3. There was no statistical difference between crop yields following treatment with cypermethrin 10 EC (0.005%),malathion 50 EC (0.05%),Achook (1.0%) and neem oil (1.0%) sprays (which produced 69.46, 64.43, 64.37 and 64.04 q/ha healthy fruits, respectively).

Ganeshan *et al.* (1995) evaluated efficacy of extracts of three non medicinal plants *viz.*, custard apple (*Annona squamosa*), Jatropha (*Jatropha curcus*) and Mahua (*Madhuca latifolia*) in comparison with commercial neem formulations individually and in combination against *E. vittella* under laboratory conditions. All the treatments of extracts affected the test larvae by direct kill or interference with metamorphosis both individually and in combinations. Individually, the order of effectiveness was; Annona > Neem > Jatropha > Mahua and in combinations Neem + Annona + Mahua > Neem + Annona + Jatropha > Neem + Mahua + Jatropha.

Raja *et al.* (1996) carried out field experiment during the summer and kharif (monsoon) seasons of 1996 in Tamil Nadu on "bhendi" (okra), the control of *E. vittella* by endosulfan (0.07%), neem oil (2 or 4%) or parasitoid *Trichogramma chilonis* was examined. All the treatments decreased pest damage by 49-73% compared with untreated control. Treatment with neem oil (4%) produced the lowest pest damage and the highest fruit yield of 13.77 t/ha. Treatment with endosulfan produced a fruit yield of 13.40 t/ha and the highest net returns.

Tomar (1996) conducted field studies to determine the efficacy of

Bacillus thuringiensis sub sp. *kurstaki* (Dipel) mixed with lower concentrations of endosulfan, fenvalerate, multineem (neem extract), carbaryl or acephate for the control of *E. vittella* infesting okra. Dipel + endosulfan and Dipel + fenvalerate were very effective in reducing the percentage shoot and fruit infestation.

Butler *et al.* (1997) tested the neem products *viz.*, Margoside and Godrej Achook against boll worm complex of cotton in India and showed that both products were more effective than untreated control. Ambekar *et al.* (2000) carried out a field experiment to evaluate the efficacy of certain neem products against okra fruit borer *(Earias* spp.) with due comparsion with synthetic insecticides. The results revealed that all insecticidal treatments significantly reduced the per cent fruit borer infestation than all other treatments. Among the neem products Achook 0.5% was the best in reducing the fruit borer infestation and was at par with ZA-199 at 0.5 per cent.

2.2.2 Insecticides

Singh and Misra (1983) studied 9 combinations of synthetic pyrethroids with other insecticides for control of okra pests. Maximum control of the noctuids *Agrotis ipsilon*, *A. flammatra* (*Ochropleura flammatra*), *E. vittella* and *Earias insulana* was obtained with phorate granules (10 kg/ha), monocrotophos granules (20 kg/ha) aldrin seed treatment(10 ml/kg seed), carbofuran seed treatment, carbofuran granules (30 kg/ha) seed soaking with 0.025% methyl oxydemeton (Oxydemeton-methyl). Phorate and carbofuran granules were most effective against leaf eating insects. Spraying with 0.0025% decamethrin (deltamethrin), 0.005% fenvalerate, 0.05% endosulfan, 0.005% cypermethrin, 0.1% carbaryl and 0.04% monocrotophos reduced the percentage of fruits damaged by *E. vittella* and *E. insulana* to 0.38, 0.74, 1.94, 1.95, 2.12 and 2.41 per cent

respectively, in comparison to untreated plots (25.55%).

Jadhav and Nawale (1984) studied the effectiveness of various insecticides against the *E. vittella* and *E. insulana* on okra in Maharashtra and found that 0.05% endosulfan and monocrotophos applied 4 times at 10 days interval from the flowering stage were most effective.

Krishna Kumar and Srinivasan (1985) carried out summer and winter trials with the cv. Pusa sawani. Four insecticides were applied at 35 or 25 days interval. A fifth insecticide (endosulfan) was applied at 15 days interval. A significant reduction in *E. vittella* incidence was obtained with the fenvalerate, cypermethrin and deltamethrin at 50, 30 and 10 g a.i./ha respectively, when applied at 25 days interval compared with 35 days interval. However, there were no significant differences in marketable yields between 25 and 35 days intervals, suggesting a possibility of extending the spray interval. Endosulfan and permethrin gave poor results.

Pawar *et al.* (1985) tested eleven insecticides for the control of okra fruit borer *E. vittella*. All the treatments tested reduced *E. vittella* infestations, but a single spray of endosulfan at 500g a.i./ha followed by 3 applications of cypermethrin or fenvalerate at 50 g a.i./ha at an interval of 14 days were the most effective.

Rai (1985) conducted field trials to determine the effectiveness of cypermenthrin, permethrin, fenvalerate, decamethrin, biophenothin, methamidophos, endosulfan, chlorpyriphos, dimethoate and fenthion against pest complex of okra and found that decamethrin at 0.0065% is the most effective in controlling the major pests of okra. Chlorpyriphos at 0.048% and methamidophos at 0.04% were comparatively less effective against jassids and fruit borer but were significantly more effective against aphids and mites. Highest profit was obtained with deltamethrin and the lowest with chlorpyriphos.

Khaire and Naik (1986) conducted field trials with cv. Pusa sawani, 7 pesticides were applied 3 times at 14 days intervals starting 36 days after sowing. All pesticides gave good control of *Amrasca biguttula bigiittula, Aphis gossypii, Tetranychus telarius* and *E. vittella*. Fluvalinate at 0.012% gave the highest yield of 39.7q/ha compared with 19.2q/ha in control.

Gandhale *et al.* (1987) evaluated various synthetic pyrethroids and other insecticides against *Earias* spp. on okra. Two sprays were given at an interval of 15 days, starting at the time of fruit formation. deltamethrin @ 15g a.i./ha was the most effective treatment in reducing the incidence of *Earias* spp.

Singh and Singh (1991) studied various spray combinations of endosulfan, malathion, oxydemeton-methyl, dimethoate and monocrotophos, all at 500g a.i./ha with permethrin, and combinations of endosulfan with deltamethrin at 10g a.i./ha resulted in effective control of *A. biguttula biguttula* and *Earias* spp. and increased the marketable fruit yield.

David and Kumarswami (1991) reported that cypermethrin 0.016%, deltamethrin 0.003% and 0.002% and fenvalerate 0.01% were the most effective treatments against *Earias* spp. on okra. However, highest cost benefit ratio was in endosulfan 0.07%.

Similarly, Patil *et al.* (1991) studied efficacy of various insecticides, each of 2 applications, one at fruit formation and second 10 days later, against *E. vittella* and reported that cypermethrin @ 12.5-15.0 g a.i./ha and 37.5 g a.i./ha to be most effective in reducing fruit infestation and gave the best yield.

Sreelatha and Divakar (1992) evaluated four insecticides against *E. vittella* on okra, alphamethrin (alpha-cypermethrin) applied at 0.05% was the most effective, resulting in an infestation level of 2.7 and 2.4% in summer and winter crop respectively, followed by flufenoxuron at 0.02% (3.1 and

2.8% infestaion), fluvalinate at 0.02% (3.2 and 3.8%) and carbaryl at 0.15% (3.5 and 4.%). All four insecticides were therefore effective in keeping infestation below the suggested economic threshold of 5.3%.

Prasad *et al.* (1993) evaluated acephate, triazophos, cypermethrin, alphamethrin and biofenthrin against *A. gossypii, A. biguttula biguttula* and *E. vittella* on okra var. Pusa sawani. Acephate (0.1 and 0.15%) and triazophos (0.1%) were effective againsts aphids and jassids while alpha-cypermethin (0.006%), biofenthrin (0.005%) and cypermethrin (0.006%) were effective against *E. vittella*.

Dubey *et al.* (1998) carried out experiment and compared nine treatments on okra, variety Parbhani- Kranti, for the control of *E. vittella*. The basal application of phorate 1kg a.i./ha + single spray of monocrotophos (0.05%) 30 days after sowing, followed by 4 sprays of cypermethrin (0.006%) (45, 55, 65 and 75 days) produced the lowest infestation level on fruits (12.68%) and the highest marketable fruit yield (10.42 t/ha).

Singh and Choudhary (1999) studied six insecticides to control *E. vittella* in okra crop. Endosulfan resulted in great yields, however the greatest cost-benefit ratios were obtained with cypermethrin and fenvalerate.

2.3 Effects of neem formulations and insecticides on sucking pest complex of okra

2.3.1 Neem Products

Sardana and Kumar (1987) gave weekly applications of various plant oils, especially neem oil at 2%, which was found to be effective in controlling leafhopper and *E. vitella* on okra. Treated plots recorded lower fruit damage and increased yields in comparison with control. Neem oil was as effective as integrated control scheme for the pest.

Venkatesan *et al.* (1987) studied the efficacy of various neem products and insecticides against *A. gossypii* and reported that endosulfan 0.07% was highly significant in reducing the aphid population among the treatments at 7 days after application. Similarly 3% neem leaf extract reduced the aphid population more than the other neem products tested but the difference among the neem treatments were not significant.

Joshi (1989) reported that Neemark at 0.5 % and Indiara at 1% were effective in controlling the aphids, jassids and white fly on cotton but failed to control thrips.

Kumar and Sharma (1991) conducted studies on population dynamics and control of *Tetranychus hudeni* on okra. The mite appeared in the 1st week of April. The population peak was recorded in June and a sharp decline in mite density was observed in July. No mites were observed later in the year after September. Predatory *Amblyseius spp.* (including *A. tetranychivorus* and *A. multidentatus*) appeared in the 2nd week of June. Sulphur, dicofol, tetradifon and seed kernel extract of neem were effective for controlling the pest.

Thombare (1991) carried out studies on efficacy of neem preparations against some crop pests and reported that the neem seed extract was promising one at 0.6% for the control of jassids on okra, recording 56.82% reduction of jassid population.

Kulkarni (1993) reported that cypermethnin at 0.007% was most effective against bollworm complex in cotton. Neem products like ZA-199, 2% neem oil and 1% Neem guard gave moderate control of aphids and jassids.

Lowery *et al.* (1993) conducted laboratory and field trials with formulated neem seed oil (NSO) and neem seed extract (NSE) and demonstrated significant reduction in aphid population on pepper

Capsicum, lettuce and strawberry. NSO reduced aphid numbers in a close dependent manner with estimated concentration for 50% reduction in aphid population (EC 50) ranging from 0.2 to 1.4% under field conditions in British Colombia, NSO and NSE treatments were as effective as the botanical insecticide *viz.*, pyrethrum (pyrethrins) for the control of aphids on pepper and strawberry.

Patel *et al.* (1993) conducted studies on the effectiveness of the botanical insecticides. Neemark (0.5%) (based on *A. indica*), Repelin (1%) (of unstated composition), Margocide (CK 0.1%) (of unstated composition) and margocide (CK 0.8%) (of unstated composition) were compared with that of conventional insecticides against *Tetranychus cinnabarinus* and *Tetranychus macfarlanei* in brinjal, okra and Indian bean. The effectiveness of the botanical insecticides was comparable with that of conventional insecticide/acaricide, but varied against the same species on different food plants.

Patel and Patel (1994) carried out studies to evaluate plant extract for their oviposition deterrent, repellant and growth inhibitory effects on *Amarasca biquttula biguttula*, spraying the okra crop with Neemark 1%, Repelin 1% (both based on *A. indica*) , Ardusa 5% (*Ailanthus excelsa*) leaf suspension and Nemol 1% and neem (*A. indica*) 5% seed kernel suspension resulted in an ovipositional deterrent effect on females. Spray of neem leaves suspension 5%, Repelin 1% and Neemark 1% showed repellent and growth inhibitory effect no pest.

Bari (1995) reported that an alternate application of neem seed kernel extract and fenvalerate were quite effective against sucking pest as well as bollworm complex on cotton and produced higher yield. Continuous use of fenvalerate alone though found effective against bollworms, it cause resurgence of aphids.

Singh and Singh (1995) conducted field trials to evaluate four acaricides and neem pesticide (Azadirachtin 0.03%) for management of *Tetranychus urticae* on lady's finger (okra). Azadirachtin 0.03% was applied alone at 6.0, 5.0, 4.0, 3.0, and 2.0 ml/litre, with ethion at 3 +1 or 0.5 ml/litre, and with sulphur at 3 + or 1.5 g/litre. Dicofol, ethion and sulphur were also applied alone at 2ml, 1ml and 3g/litre respectively. Dicofol alone and in combination with azadirachtin resulted in 100% mortality of the pest after 14 days. Mixtures of azadirachtin with conventional insecticide gave greater control than azadirachtin alone.

Kulat *et al.* (1996) conducted field trials to determine efficacy of six plant extracts and 2 insecticides for the control of *A. gossypii* and *Amrasca devanstans* on okra. Aqueous leaf extracts of tobacco (2%) *Ipomoea carnea* (5%) and seed extract of *A. indica* and *Pongamia glabra* (both at 5%) gave a similar level of control compared to endosulfan (0.06%) and monocrotophos (0.05%).

Chitra *et al.* (1997) studied efficacy of Allitin (Garlic extract), Neknool (neem extract), Neemguard, monocrotophos 0.04%, endosulfan 0.07%, extract of sweet sop (*Annona* spp.), custard apple (*Annona squamosa*) and margosa (*A. indica*) in controlling aphids on cotton. All plant extracts gave over all efficacy of 88.81 – 90.06 per cent.

2.3.2 Insecticides

Kakar and Dogra (1985) carried out studies on the most important pests, the cicadellid *A. biguttula biguttula* and the meloid *Mylabris pustulata* of okra. A single spray of permethrin, cypermethrin, fenvalerate all at 0.008% or deltamethrin at 0.002% gave control of these pests. Malathion, monocrotophos and dichlorvos (at 0.05%) were also effective.

Mohan (1985) reported that permethrin, fenvalerate, endosulfan and carbaryl were the most effective in controlling the cicadellid *A. biguttula biguttula*. Similarly, methomyl, profenofos, bromofos and endosulfan were the most effective in controlling the aphids. Satisfactory control of the noctuid *E.vittella* was obtained only by the fenvalerate. The highest yield of marketable produce was obtained by sprays of fenvalerate, followed by carbaryl.

Fifteen insecticides were tested by Pareek *et al.* (1987) for the control of insect pests, especially *A. biguttula biguttula*, *A. gossypii* and *Earias* spp. on okra, under field conditions. They observed that 5 sprays of fenvalerate 0.02% at 15 days interval throughout the growing period were most effective in reducing the infestation of these pests and obtained maximum yield of marketable fruits with highest net profits.

Kakar and Dogra (1988) studied the efficacy of different insecticides against pest complex of okra and found that a single spray of permethrin, cypermethrin, fenvalerate (at 0.008%) or deltamethrin at 0.002% gave effective control of pest complex of okra.

Yadav and Singh (1989) studied the commonly used ten commercial formulations against *A. biguttula biguttula* (*A. devastans*) on okra under field conditions. They observed that endosulfan (0.05%), carbaryl (0.15%) and oxydemeton-methyl (0.025%) were the most effective compounds and also observed maximum mortality of the pest at 7 days, after treatment. They also concluded that in the seed crop, any of 3 compounds can be used safely, but in the vegetable crop of okra use of oxydemeton-methyl should be discontinued after the inhibition of square formation. After fruit formation endosulfan, carbaryl or malathion at 0.05% can be used.

Dahiya *et al.* (1990) tested 16 insecticides against cicadellid *A. biguttulla biguttulla* on okra. Cypermethrin, fenvalerate and flucythrinate

(all at 0.06%), deltamethrin (0.002%) and endosulfan (0.07%) were the mostpersistent and controlled the pest population for 15 days. Fenthion, diazinon and phenthoate (all at 0.05%), malathion (0.075%) and carbaryl (0.1%) were effective for a week.

Nagia *et al.* (1990) reported satisfactory control of *A. biguttula biguttula* in okra with dimethoate at 600 g a.i./ha. The resurgence of the cicadellid was not observed.

Waryamsingh *et al.* (1991) reported that endosulfan at 0.053, 0.07 and 0.087 per cent and decamethrin (deltamethrin) at 0.0014, 0.0028 and 0.0042 per cent were the most effective treatments at 3, 7 and 14 days after spraying against *A. biguttula biguttula* on okra. Similarly, malathion at 0.05, 0.067, and 0.084% was intermediate in effectiveness; while quinolphos and chlorpyriphos were relatively ineffective.

Goel *et al.* (1992) reported that cypermethrin, fenpropathrin and fenvalerate were initially effective but 7th day onward they resurged the leaf hopper population on okra. Malathion and quinolphos were ineffective and also enhanced the leaf hopper population leading to resurgence.

Mote *et al.* (1994) tested imidacloprid 70 WS as seed treatments on okra @ 5,7.5,10 and 15 g/kg seed for the control of sucking pests. Carbofuran 5% seed treatment and methyl demeton at 0.03% spray at 20 and 35 days after emergence were taken as checks. Imidacloprid 15 g/kg seed treatment was found promising against sucking pests of okra *viz.*, aphids, jassids ,thrips, mites and white fly, so also least percentage of yellow vein mosaic affected plants and highest yield were recorded in these treatments. Plant growth characters *viz.*, plant height, greenness of leaves , leaf area, no. of fruits/plant and yield were quite superior in imidacloprid treated plots than others.

Similarly, imidacloprid 70 WS as seed treatments @ 1 to 6 per cent along with soil application of carbofuran 3 G @ 1 kg a.i./ha and two sprays of dimethoate 0.03% were tested against initial sucking pest of cotton, i.e., aphids, jassids and thrips and their effects on the plant growth characters. All insecticidal treatments effectively checked the pest population up to 60 days. Amongst the seed treatments, higher concentration i.e., 6, 5, 4 and 3 per cent of imdacloprid were highly effective against these pest. However concentrations from 1 to 2 per cent also checked these pests effectively, with increase in concentration of imidacloprid seed treatment there was decrease in population of aphids, jassids, and thrips and increase in plant height, number of leaves/plant, leaf area/plant, chlorophyll and nitrogen contents of leaves. Imidacloprid at 1 per cent appeared to be optimum as a seed treatment for the control of initial sucking pest of cotton. (Mote *et al.,* 1995).

Sosamma Jacob and Sheila (1996) evaluated efficacy of cypermethrin, fenvalerate, fenpropathrin, fluvalinate, cartap and carbaryl against aphid, it was observed that cypermethrin at 0.02% was most effective insecticide 14 days after spraying. Cypermethrin at 0.02% could bring about 71.84% reduction of aphid population after 14 days of spraying.

Sreelatha and Divakar (1997) studied the seed treatment with imidacloprid and found increase in the plant height, leaf area and yield of okra in addition to effective control of aphids and jassids *(Empoasca* spp.). Treatment with 7.5 g of imidacloprid per kg of okra seed was found optimal. Two foliar sprays during the vegetative stage of the crop can be avoided if the seed is treated.

Calafiori *et al.*(1998) tested insecticide for control of thrips and aphids on cotton in Sao Paulo Brazil. The treatments were demeton-methyl (Metasystox) at 0.8 lit/ha, imidacloprid (Provado at 0.25 lit./ha) and

tricloprid (of unstated composition),(Calypso at 0.07 and 0.1 lit/ha) and carbosulfan (Marshal at 6.6 lit/ha). Imidacloprid and carbosulfan gave 80% control of aphid with effect up to 20 days.

Lucas *et al.* (1999) evaluated the efficacy of imidacloprid at different concentrations and in different formulations and dosage as a seed treatment for control of cotton pests in Brazil. The treatments were imidacloprid (as Gaucho 700 PM) at 0.3 and 0.5 kg a.i./ha and Guacho plus Provado 200 SC at 0.5 kg and 250 ml a.i./ha, respectively. Gaucho 600 SC at 450 and 600ml a.i./ha and aldicarb (as Temik 150 G) at 5.0 kg a.i./ha. Imidacloprid (Gaucho 700 PM and 600 SC) as seed treatment and dialdicarb applied in furrow at sowing significantly reduced the incidence of aphids up to 20 days after emergence as foliar spray controlled the pest for 10 days after application.

2.4 Bio efficacy of neem products against important crop pests

Mansour *et al.* (1987) studied the effects of neem extracts in methanol, ethanol, acetone and pentane on predacious mite, *Phytoseiulus persimilis* and the phytophagous mite, *T. cinnabarinus* and observed that all extracts were more toxic to *T. cinnabarinus* than to *P. persimilis.*

The efficacy of Neemark was evaluated against pupae and nymphs of white flies, *Bemisia tabaci* (Genn.) on brinjal and it was observed that Neemark at 0.5% concentration was the most effective against pupae, provided that the lower leaf surface is thoroughly covered (Anonymous, 1987). On the same lines Phadke *et al.* (1988) studied the effect of Neemark formulations on the incidence of white flies on cotton and reported that Neemark at 0.5% concentration is superior over other treatments *viz.*, endosulfan 0.1% and fenvalerate 0.12% for the control of whitefly eggs.

Pisal (1988) carried out studies under glasshouse condition to find out

the effect of neem products on the incidence of whitefly, *B. tabaci* nymphs on brinjal. Studies revealed that the treatment with Neemark 1.0% was significantly effective and recorded minimum incidence of whitefly i.e., 2.15 nymphs per plant.

Investigations made by Meisner *et al.* (1990) in Israel to study the effect of Margaosan-O on the development of larvae of *E. insulana* and their rate of penetration into cotton bolls in laboratory by incorporating Margosan-O into cotton bolls in laboratory by incorporating into semi synthetic diet, spraying cotton leaves and bolls or standing cotton seedlings or twigs (with the boll/twig) in aqueous dilution of the compound, revealed that after 11 days on Margosan-O treated diet, practically none of the larva survived at any of the concentrations tested (0.02-0.2%) whereas on untreated diet 62% of the larvae survived.

Serra and Schmutterer (1993) conducted field trials in Dominican Republic and tested 3 formulations of neem extracts *viz.*, aqueous extracts from crushed neem seeds (at 40 to 50 g/lit.) or neem cake oil (at 15 g/lit.); formulated neem seed oil (at 1 to 1.5%) and commercial insecticidal soap which showed a clear reduction of numbers of puparia of *B. tabaci* on the lower surface of leaves of tomato plants as a consequence of pupal mortality; all neem products also reduced oviposition due to a repellent effect on adults.

Saucke (1994) carried out studies on neem seed kernel extracts (NSKE), and gave excellent control for diamond back moth (*Plutella xylostella*) and associated pests in cabbage in Papua New Guinea. The mode of action, selective properties of neem and environmental aspects were discussed and emphasized the need to move from a solely chemical control approach towards an integrated pest management.

Walunj *et al* .(1996) tested a neem based insecticide, ZA-199 (Nimbitor) at 0.5, 1.0, 1.5 and 2.0% ,combination of ZA-199 + endosulfan (0.05 and 0.025%) , cypermethrin (0 007 and 0.0035%) and Neemark (0.5%). The treatment of ZA-199 plus cypermethrin at 0.007% showed the least infestation of fruit borer with highest yield followed by 1% ZA-199 plus cypermethrin 0.0035% or endosulfan 0.05% and alone cypermethrin 0.007% on brinjal. ZA-199 at 1% appeared to be optimum dose for the control of fruit borer and it was more or less equal to endosulfan.

Sharma *et al.* (1998) examined the oviposition deterrent and antifeedant activity of 2 formulations containing Neemrich I + oil of *Salvadora oleoides* and Neemrich I + neem extract (Plant mix I and plant mix II respectively) against *Phthorimaea operculella*. Both formulations showed greater activity than individual. The oviposition deterrent activity of plant mix I and II continued for 30 and 18 days respectively, compared to 12 days for the individual constituents at the lowest concentration tested.

Srinivasan *et al.* (1998) reported that the neem based products were comparable or better than endosulfan in controlling brinjal shoot borer, *L. orbonalis*. Fruit yields with Nimbecidine (13.02 t/ha) and Neemazal (12.80 t/ha) were higher than with endosufan (10.92 t/ha).

Srinivasan and Sundara Babu (1999) conducted field trials to find out the efficacy of neem products against brinjal leaf hopper, *A. biguttula biguttula* Popular cv. CO. 2 was selected and total of three sprayings were given at 15 days interval during the experimental period. The neem products tested gave effective control of leaf hopper nymphs. The mean population of leaf hopper nymphs after three sprays in various treatments ranged from 1.44 to 3.44 as against 8.55 in control.

2.5 Resurgence of Mite

Patel *et al.* (1982) showed that application of 3 sprays (with 21 days interval) of carbaryl at 0.15 – 0.20 per cent and to a lesser extent of endosulfan at 0.05 - 0.075% to eggplant (brinjal) after the initiation of flowering, resulted in an increase in population of *T. urticae*. This increase might have been due to the destruction of natural enemies.

Basha *et al.* (1982) tested the synthetic pyrethroids against *L. orbonalis* on brinjal. Cypermethrin, delt amethrin, fenvalerate, permethrin and fenpropathrin were applied at various concentrations. Deltamethrin at 50 g toxicant/ha gave very effective control followed by the same compound at 25g which gave highest fruit yield. Some control of cicadellids was also observed but the pyrethroids were ineffective against aphids and appeared to cause out break of Tetranychid mites, except for fenpropathrin at 50g/ha for which mite numbers were about the same as those for no treatment.

Watson *et al.* (1985) carried out laboratory and field studies on soybean in Egypt on the effect of sequential application of cypermethrin (effective against *Spodoptera littoralis*), omethoate (effective against *Thrips tabaci*, *B. tabaci* and *Empoasca* sp) and dicofol (effective against mite) over 3 generations on the susceptibility, biology and population density of *T. cinnabarinus*. In the laboratory, the life span of selected mite was prolonged especially in strains selected with the 3 pesticides during 3 generations. In the field plots sprayed with cypermethrin only had the largest mite population. This indicated the necessity of using a specific acaricide on soybean to prevent out breaks of mites.

Sandhu *et al.* (1987) screened cypermethrin, carbaryl, endosulfan and phenthoate against bollworms in cotton, and reported that carbaryl and cypermethrin induced the build up of population of *T. cinnabarinus*.

David and Kumarswami (1989) conducted field trails in Tamil Nadu, and showed that the application of synthetic pyrethroids (deltamethrin, cypermethrin, permethrin and fenvalerate) for the control of *T. cinnabarinus* on okra resulted in resurgence of populations of the pest to levels higher than in untreated variants, pot experiments confirmed that the innocuous residues of all the pyrethroids stimulated reproduction of the pest to varying degrees.

Singh and Singh (1993) carried out studies on incidence of *T. cinnabarinus* in relation to weather factors at Varanashi on lady's finger (okra) plant. They observed the peak population of mites during the months of May and June, which indicated that increasing population was associated with period of high temperature (34^0C) and low humidity. They concluded that temperature is the major regulatory factor for population build up of mite. Resurgence of sucking pests, especially of mites as a result of repeated use of synthetic pyrethroids has become an established phenomenon (Pecock *et al.*,1978; Hoyt *et al.*,1978; Bower and Kaldor, 1980).

MATERIALS AND METHODS

3. MATERIAL AND METHODS

The experiments were undertaken to study the effectiveness of three promising neem formulations in alternation with synthetic insecticides against okra pests.

The research work was carried out in summer season of 2001 at the experimental farm of Entomology section, College of Agriculture, Pune. The material used and the methods followed during the studies are presented in this chapter.

3.1 Material

3.1.1 Seeds of okra

The seeds of okra variety, 'Arka Anamika' were obtained from Entomology section, College of Agriculture, Pune.

3.1.2 Seeds of Neem

Dried seeds of neem *(Azadirachta indica* A. Juss) were collected from the Agronomy farm, college campus, College of Agriculture, Pune.

3.1.3 Insecticides

Commercial neem based formulations and synthetic insecticides used in the experiments were obtained from the manufacturers. The details of these products are given below :-

Name of product	Formulation	Concentrat-ion used	Manufacturer
Achook (azadirachtin)	0.15 % EC	0.5%	M/s. Bahar Agrochem and Feeds Pvt. Ltd., Ratnagiri.
Nimbitor (ZA-199) (azadirachtin)	0.03% EC	0.5%	M/s. Zandu Pharmaceutical works Ltd., Mumbai-25.
Neem seed kernel extract	Suspension	5%	Prepared in laboratory
Bilcyp (cypermethrin)	10% EC	0.01%	M/s. Bayer (India) Ltd., Powai, Mumbai-76.
Confidor (imidacloprid)	200 SL	0.004%	M/s. Bayer (India) Ltd., Powai, Mumbai-76.

Details of the Experiment :

A) **Title of experiment** : To study the bioefficacy of promising neem formulations in alternation with synthetic insecticides against okra pests.

Crop :- Okra.

Variety :- Arka Anamika

Design :- Randomized Block design.

Replications :- Three

Treatments :- Twelve

Plot Size :- Gross : 3.5 x 2.5m^2

Net : 3 x 2 m^2

Spacing :- 30 x 10cm

Date of sowing :- 13-02-2001

Date of harvesting:- 25-05-2001

Treatment Details:

T1- Achook 0.5% - 4 sprays at 15 days interval

T2- ZA 199 0.5% - 4 sprays at 15 days interval

T3- NSKE 5% - 4 sprays at 15 days interval

T4- cypermethrin 0.01% - 4 sprays at 15 days interval

T5- imidacloprid 0.004% - 4 sprays at 15 days interval

T6- Achook 0.5% - cypermethrin 0.1% - Achook 0.5% - cypermethrin 0.01% (4 sprays alternated at 15 days interval)

T7- ZA-199 0.5% - cypermethrin 0.01% - ZA-199 0.5% - cypermethrin 0.01% (4 sprays alternated at 15 days interval)

T8- NSKE 5% - cypermethrin 0.01% - NSKE 5% - cypermethrin 0.01% (4 sprays alternated at 15 days interval)

T9- Achook - 0.5% - imidacloprid 0.004% - Achook - 0.5% -

imidacloprid 0.004% (4 sprays alternated at 15 days interval)

T10- ZA-199 0.5% - imidacloprid 0.004% - ZA-199 0.5% - imidacloprid 0.004% (4 sprays alternated at 15 days interval)

T11- NSKE 5% - imidacloprid 0.004% - NSKE 5% - imidacloprid 0.004% (4 sprays alternated at 15 days interval)

T12- Untreated control

B) Title of experiment : To study the effect of number and interval of application of neem formulations in alternation with synthetic insecticides against okra pests.

Crop : Okra

Vareity : Arka Anamika

Design : Randomised block design

Replications : 2

Treatments : 17

Plot size : Gross – 3.5 x 2.5m^2

Net - 3 x 2m^2

Spacing : 30 x 10cm

Date of sowing: 23-02-2001

Date of harvesting: 23-06-2001

Treatment Details: 4 sprays at 15 days interval

T1- Achook 0.5% - cypermethrin 0.01% - Achook 0.5% - cypermethrin 0.01%

T2- ZA-199 0.5% - cypermethrin 0.01% - ZA-199 0.5% - cypermethrin 0.01%

T3- NSKE 5% - cypemethrin 0.01% - NSKE 5% - cypermethrin 0.01%

T4- Achook 0.5% - imidacloprid 0.004%- Achook 0.5% - imidacloprid 0.004%

T5- ZA-1990.5% - imidacloprid 0.004% - ZA-1990.5%-imidacloprid 0.004%

T6- NSKE - 5% - imidacloprid 0.004% - NSKE 5% - imidacloprid 0.004%

T7- cypermethrin 0.01%

T8- imidacloprid 0.004%

3 sprays at 21 days interval

T9- Achook 0.5% - cypermethrin 0.01% - Achook 0.5%

T10- ZA-199 0. 5% - cypermethrin 0.01% - ZA-199 0.5%

T11- NSKE 5% - cypermethrin 0.01% - NSKE 5%

T12- Achook 0.5% - imidacloprid 0.004% - Achook 0.5%

T13- ZA-199 0.5% - imidacloprid 0.004% - ZA-199 0.5%

T14- NSKE 5% - imidacloprid 0.004% - NSKE 5%

T15- cypermethrin 0.001%

T16- imidacloprid 0.004%

T17- Untreated control

3.2 Methodology

3.2.1 Raising of the okra crop

Flat beds of 3.5 x 2.5m^2 size were prepared and seeds of variety 'Arka Anamika' were dibbled at 30 x 10cm spacing. Two seeds were dibbled 20-25 mm deep per hill. The recommended fertilizer (N:P:K 100:50:50 kg/ha) dose was given as usual. Irrigations were given at weekly intervals and intercultural operations were carried out as per the recommendations.

3.2.2 Preparation of an aqueous suspension of neem seed kernels

An aqueous suspension of neem seed kernels was prepared as per the method suggested by Pradhan *et al.* (1962). Kernels were removed from mature dried neem fruits as when required for each set of treatments.

The seeds were broken to remove kernels, then, with help of domestic hand grinder they were crushed into coarse powder. The weighed quantity of kernel powder was taken on a piece of muslin cloth and was tied in such a manner to form a close pouch. This pouch was submerged into little quantity of water and kept in it, over night. Afterwards the pouch was agitated in that water and squeezed completely. It was again agitated in water to obtain creamy oily suspension. To prepare an aqueous suspension of 5% strength 50 g of powder weighed and 1 g Nirma, 0.5ml Teepol and 0.1ml sesamum oil per litre, were mixed and stock suspension was prepared as stated above and final volume was made to litre by addition of water. The fresh suspension was prepared just before the spraying.

3.2.3 Insecticide application

The sprays of neem formulations and synthetic insecticides were applied with the help of hand compression sprayer. Requirement of spray fluid per plot was calculated by spraying control plots with water. The quantity of insecticide was mixed in required quantity of water. Care was taken to cover all plant parts thoroughly while spraying and to avoid the drift to the neighbouring plots. Spraying was done in the morning and care was taken to wash the pump with water while switching on from one insecticide to another.

3.2.4 Methods of recording observations

Shoot and fruit borer

All the plants from each treatment plot were taken for recording observations except guard rows. Since, there was negligible infestation on shoots, the observations on shoot damage could not be recorded. The data on healthy and infested fruits (number and weight basis) were recorded from each plot by critically examining the fruits for borer damage at each picking.

Total ten pickings were carried out, in each experiment. Percentage of damaged fruits was calculated on the basis of infested and healthy fruits.

Sucking pest complex

Observations on aphids and jassids were recorded on randomly selected five plants per plot. Number of aphids and nymphs of jassids were recorded from three leaves of randomly selected plants, one upper, one middle and one lower (Singh and Kaushik, 1990). Observations were recorded just before first spray (as pre-treatment count) and on 2^{nd}, 5^{th} and 15^{th} days and an additional observations on 21^{st} days in second experiment, after each spraying (post treatment count). Average number of pest individuals per three leaves of a plant for each plot were calculated. Data thus obtained were superimposed and presented in the tables.

Effect of insecticidal treatments on population build up of red spider mites

The observations on mite population were recorded in order to study the effects of treatments on population build up of mites. For this, a piece of one cm^2 was removed from card board and the observations on mite population of one cm^2 were recorded from three leaves, one upper, one middle and one lower with the help of 20 (x) magnifying lens. Five plants were randomly selected from each treatment for recording the observations. Total three counts were taken at two, five and twenty one days after 3^{rd} spraying.

3.3. Statistical analysis

The data on average per cent of fruit borer infestation was subjected to statistical analysis. The superimposed average survival population of jassids and aphids was transferred into square root transformation by

Poisson formula $\sqrt{x + 0.5}$ and standard statistical method of analysis of variance was applied for the analysis of data. The "F" test of significance at 5% level was used for testing the null hypothesis in order to determine whether the treatment effects were real or otherwise.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

Two field experiments were conducted during summer season of 2001, on the experimental farm of Entomology section, College of Agriculture, Pune. The bioefficacy of promising neem formulations in alternation with synthetic insecticides against the okra pests was evaluated. Three promising neem based formulations *viz.*, Neem seed Kernel extract 5%, ZA -199 and Achook at 0.5% (Ambekar et al., 2000) and two synthetic insecticides *viz.*, cypermethrin 0.01% (recommended concentration) and imidacloprid 0.004% were used.

The effect of number and interval of applications of neem formulations was also studied in alternation with synthetic insecticides, against okra pests. Four and three sprays were given at an interval of 15 and 21 days, respectively. Results obtained are presented and discussed in this chapter.

4.1 Bioefficacy of promising neem formulations alone and in alternation with synthetic insecticides against okra pests

4.1.1 Shoot and Fruit borer

A) Number of infested fruit basis

The data on fruit borer infestation of okra on number basis are presented in Table 1 and graphically presented in Fig. 1

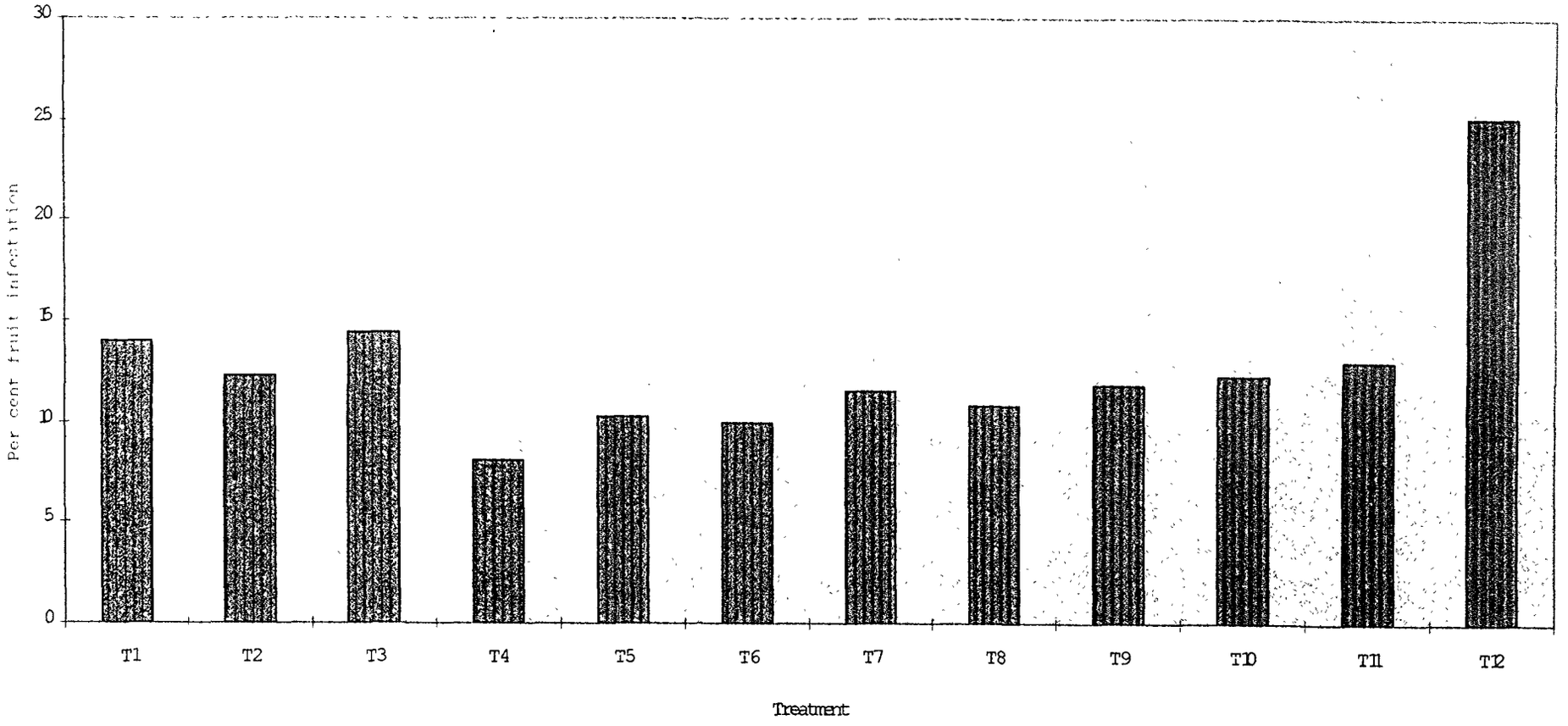
It was observed that all the treatments including neem formulations and synthetic insecticides recorded significantly lower infestation of fruit borer, *E. vittella* on number basis than that of untreated control. The average fruit borer infestation in the treatments ranged from 8.05 to 14.38% as against 25.03% in untreated control. The treatment with cypermethrin 0.01% was most effective and recorded significantly low fruit infestation of 8.05% than rest of the treatments. Among the treatments of neem formulations alternated with synthetic insecticides, Achook 0.5% alternated with cypermethrin 0.01% proved to be the second best treatment which registered 9.92% fruit borer infestation and was on par with NSKE 5% and ZA -199 0.5% both alternated with cypermethrin 0.01% and recorded 10.86

Table 1. Effect of neem formulations alone and in alternation with synthetic insecticides against *E. vittella* infesting okra (Number of fruits infested basis)

Sr. No.	Treatment	Average per cent fruit infestation			
		R-I	R-II	R-III	Mean
1.	Achook 0.5%	15.26 (22.99)	13.11 (21.22)	13.49 (21.54)	13.95 (21.92)
2.	ZA-199 0.5%	12.68 (20.86)	12.61 (20.80)	11.52 (19.84)	12.27 (20.50)
3.	NSKE 5%	14.36 (22.26)	13.70 (21.72)	15.10 (22.86)	14.38 (22.28)
4.	Cypermethrin 0.01%	8.09 (16.52)	8.34 (16.78)	7.74 (16.15)	8.05 (16.48)
5.	Imidacloprid 0.004%	9.95 (18.38)	10.11 (18.54)	10.46 (18.87)	10.17 (18.59)
6.	Achook 0.5% alternated with Cypermethrin 0.01%	12.40 (20.61)	8.28 (16.72)	9.09 (17.54)	9.92 (18.29)
7.	ZA-199 0.5% alternated with Cypermethrin 0.01%	13.05 (21.17)	11.57 (19.88)	10.11 (18.54)	11.57 (19.86)
8.	NSKE 5% alternated with Cypermethrin 0.01%	10.85 (19.23)	11.53 (19.85)	10.21 (18.63)	10.86 (19.23)
9.	Achook 0.5% alternated with Imidacloprid 0.004%	12.34 (20.56)	11.20 (19.55)	12.00 (20.26)	11.84 (20.12)
10.	ZA-199 5% alternated with Imidacloprid 0.004%	12.64 (20.82)	11.42 (19.75)	12.60 (20.79)	12.22 (20.45)
11.	NSKE 5% alternated with Imidacloprid 0.004%	15.52 (23.20)	13.12 (21.23)	10.25 (18.67)	12.96 (21.03)
12.	Untreated control	24.67 (29.78)	25.99 (30.65)	24.44 (29.62)	25.03 (30.02)
	S.E.±				0.56
	C.D. at 5%				1.64

Figures in parentheses are means of arcsin transformed values

Fig. 1. Effect of neem formulations alone and in alternation with synthetic insecticides against E. vittella infesting okra
(Number basis)



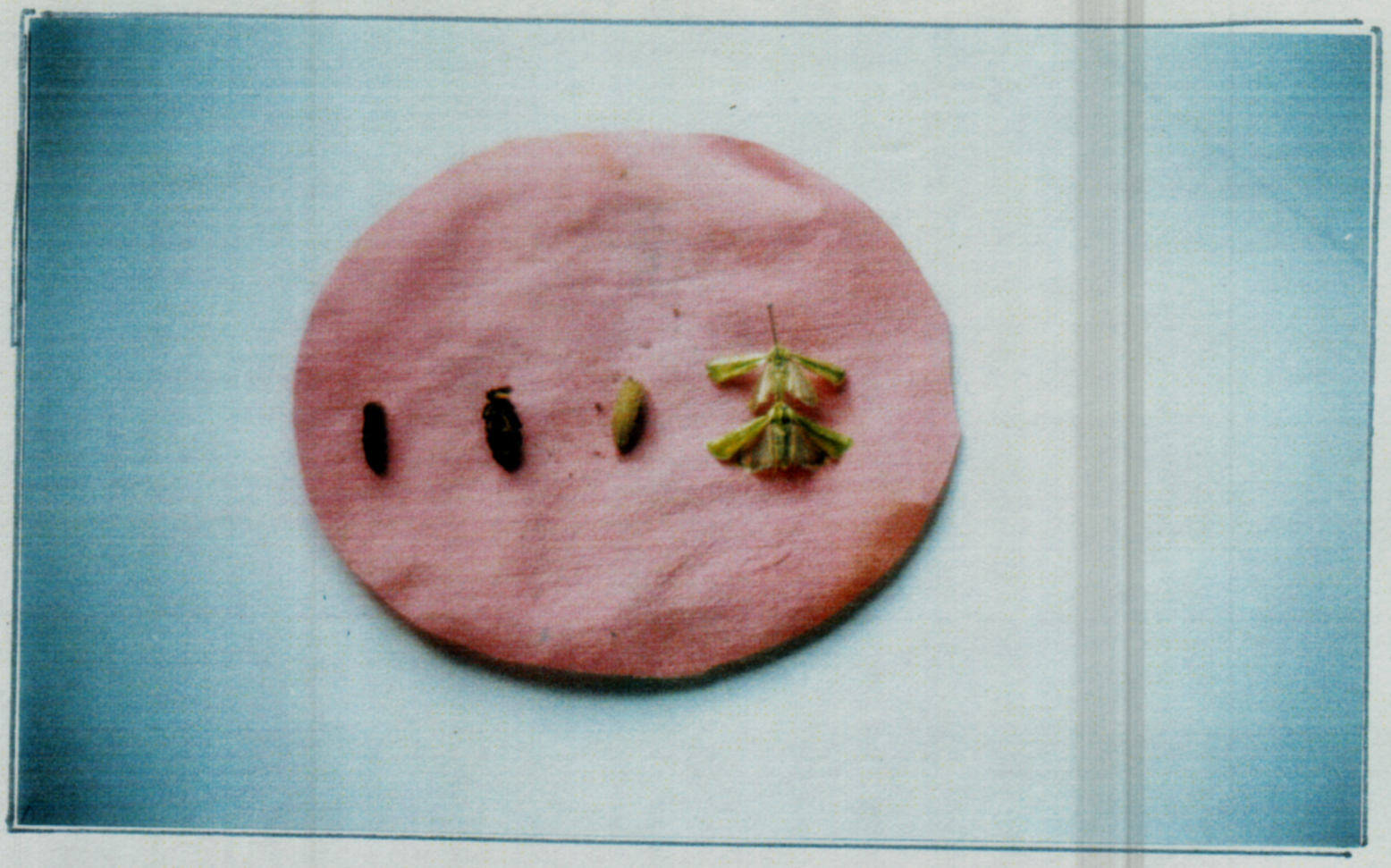


Plate 1: Larva, pupae and adults of *Earias vittella*

Plate 2: a) Fruit damaged by *Earias vittella*

b) Larva affecting fruit

c) Healthy fruit

and 11.5% fruit borer, infestation, respectively. Imidacloprid 0.004% recorded 10.17% fruit borer infestation and was on par with above alternated treatments. The rest of the treatments including neem formulations alone were found to be less effective.

B) Fruit weight basis

The data on the average percentage of fruit borer infestation on weight basis are presented in Table 2 and graphically represented in Fig. 2

It was revealed that all the treatments of neem formulations and neem formulations alternated with synthetic insecticides were significantly effective over the untreated control. The fruit borer infestation in the treatments ranged from 4.95 to 7.70% as against 11.96% in untreated control.

The treatment with cypermethrin 0.01% was the most effective and recorded the lowest fruit borer infestation of 4.95% (24.91q/ha marketable fruits) and was significantly superior over rest of the treatments except imidacloprid 0.004% (5.23% fruit borer infestation and 25.03q/ha marketable fruits) and the treatments of neem formulations alternated with synthetic insecticides *viz.*, Achook 0.5%, ZA -199 0.5% and NSKE 5% all alternated with cypermethrin 0.01% which recorded 5.52, 5.87 and 5.88% fruit borer infestation and 23.57, 21.66 and 21.41 q/ha. marketable fruits, respectively. These results indicated that alternated treatments gave effective control of fruit borer in comparison with the treatments of neem formulations alone.

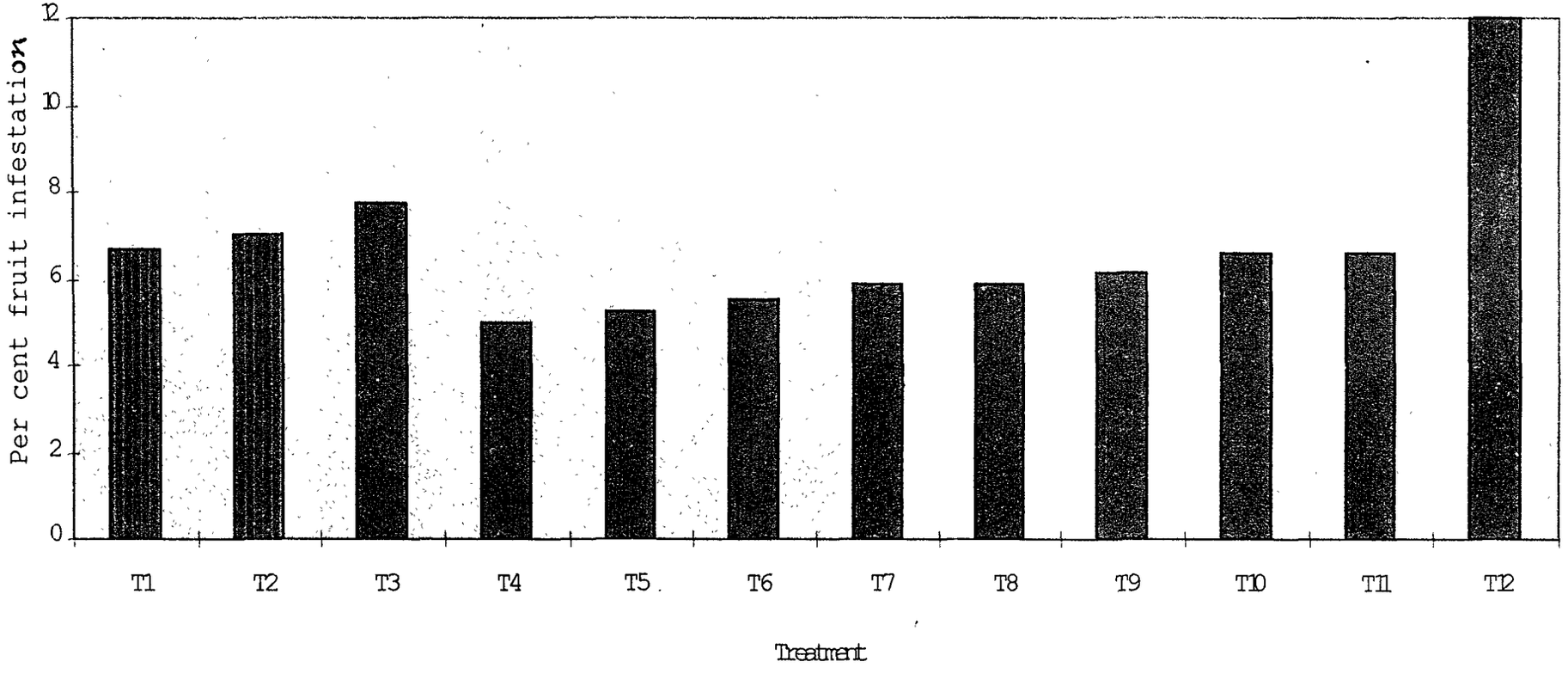
The over all efficacy of various treatments in the reduction of fruit borer infestation on okra, considering number and weight basis indicated that the treatment with cypermethrin 0.01% was most superior followed by imidacloprid 0.004% and neem formulations *viz.,* Achook 0.5% ZA-199 0.5% and NSKE 5% all alternated with cypermethrin 0.01%; rest of the treatments were less effective. The present findings of effectiveness of cypermethrin against okra fruit borer are in conformity, with the findings of

Table 2. Effect of Neem formulations alone and in alternation with synthetic insecticides against *E. vittella* infesting okra (Fruit weight basis)

Sr. No.	Treatment	Average per cent fruit infestation				Yield (q/ha)
		R-I	R-II	R-III	Mean	
1.	Achook 0.5%	6.72 (15.02)	7.16 (15.52)	6.21 (14.43)	6.69 (14.99)	21.91
2.	ZA-199 0.5%	8.13 (16.56)	6.76 (15.07)	6.16 (14.37)	7.01 (15.33)	21.41
3.	NSKE 5%	8.26 (16.70)	7.77 (16.18)	7.08 (15.43)	7.70 (16.10)	19.91
4.	Cypermethrin 0.01%	5.07 (13.01)	5.34 (13.36)	4.45 (12.17)	4.95 (12.17)	24.91
5.	Imidacloprid 0.004%	5.57 (13.65)	5.18 (13.15)	4.95 (12.85)	5.23 (13.22)	25.03
6.	Achook 0.5% alternated with Cypermethrin 0.01%	6.64 (14.93)	4.52 (12.27)	4.51 (12.26)	5.52 (13.15)	23.57
7.	ZA-199 0.5% alternated with Cypermethrin 0.01%	6.05 (14.23)	5.36 (13.38)	6.22 (14.44)	5.87 (14.02)	21.66
8.	NSKE 5% alternated with Cypermethrin 0.01%	6.03 (14.21)	5.46 (13.51)	6.16 (14.37)	5.88 (14.03)	21.41
9.	Achook 0.5% alternated with Imidacloprid 0.004%	7.65 (16.05)	5.86 (14.00)	4.87 (12.74)	6.12 (14.27)	24.16
10.	ZA-199 5% alternated with Imidacloprid 0.004%	8.01 (16.44)	6.73 (15.03)	4.91 (12.80)	6.55 (14.76)	22.41
11.	NSKE 5% alternated with Imidacloprid 0.004%	7.25 (15.62)	6.81 (15.12)	5.68 (13.78)	6.58 (14.84)	21.93
12.	Untreated control	12.19 (20.43)	11.11 (19.47)	12.58 (20.77)	11.96 (20.22)	16.58
	S.E.±				0.46	0.68
	C.D. at 5%				1.36	2.00

Figures in parentheses are means of arcsin transformed values

Fig. 2. Effect of neem formulations alone and in alternation with synthetic insecticides against E. vittella infesting okra
(Fruit weight basis)



David and Kumarswami (1991), Patil *et al.* (1991), Prasad *et al.* (1993) and Ambekar *et al.* (2000).

In the present findings treatments of neem formulations alone *viz.*, Achook, 0.05% ZA-199 0.5% and NSKE 5% and when alternated with imidacloprid 0.004% were found to be less effective against fruit borer on okra.

In the present investigations the neem formulations when alternated with synthetic insecticides showed significantly low fruit borer infestation in comparison with the treatment of neem formulations alone.

The literature about the efficacy of neem formulations when alternated with synthetic insecticides with which the present findings could be compared is not available. However, Parade (1993) reported that the staggered applications of monocrotophos 0.04%, phosphamidon 0.04%, azadirachtin 0.025% alternated with phosphamidon 0.004% and endosulfan 0.07% gave the promising results against *E. vittella* on seed crop of okra.

Hajare (1996) also studied effectiveness of azadiractin 0.00015% and endosulfan 0.05% alternated with *B. t.* 0.03% and malathion 0.05% and two strip application of azadiractin 0.00015% and *B. t.* 0.03% and reported that these treatments were superior than untreated control.

4.1.2 Effect on jassid population

The effect of various treatment schedules under investigation, on the survival of jassid nymphs is illustrated in Table 3 and graphically depicted in Fig. 3

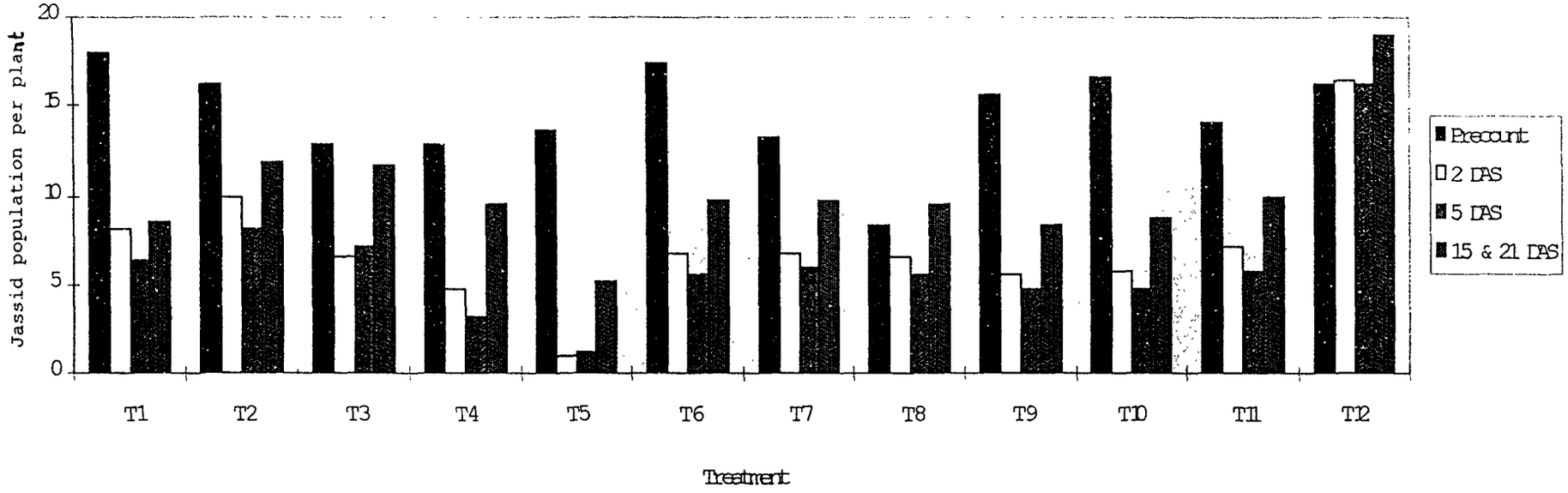
The average number of jassid nymphs prior to insecticidal treatments ranged from 8.40 to 18.00. The differences among the treatments, were non significant. The data on survival population of jassids recorded 2 days after spraying revealed that all the insecticidal treatments were significantly superior over untreated control. The average number of jassid nymphs ranged from 1.03 to 9.87 in the insecticidal treatments as against 16.46 in untreated control. The treatment with imidacloprid 0.004% was the most effective treatment against jassids and registered 1.03 average jassid

Table 3. Effect of neem formulations alone and in alternation with synthetic insecticides against jassids infesting okra

Sr. No.	Treatment	Precount	Number of jassids per plant days after spraying											
			2				5				15			
			R-I	R-II	R-III	Mean	R-I	R-II	R-III	Mean	R-I	R-II	R-III	Mean
1.	Achook 0.5%	18.00 (4.19)	9.15 (3.02)	6.80 (2.60)	8.25 (2.87)	8.06 (2.83)	7.05 (2.65)	5.30 (2.30)	6.60 (2.56)	6.31 (2.50)	8.30 (2.88)	7.50 (2.73)	9.65 (3.10)	8.48 (2.90)
2.	ZA-199 0.5%	16.20 (3.98)	15.60 (3.95)	8.35 (2.89)	5.65 (2.37)	9.86 (3.07)	11.95 (3.45)	7.60 (2.75)	5.05 (2.24)	8.20 (2.82)	17.95 (4.13)	7.80 (2.79)	9.65 (3.10)	11.80 (3.37)
3.	NSKE 5%	12.80 (3.56)	5.75 (2.39)	7.70 (2.77)	7.10 (2.66)	6.5 (2.61)	9.95 (3.15)	5.80 (2.40)	5.95 (2.43)	7.13 (2.66)	17.95 (4.23)	7.80 (2.79)	9.55 (3.09)	11.76 (3.37)
4.	Cypermethrin 0.01%	12.80 (3.56)	5.75 (2.39)	3.70 (1.92)	4.50 (2.21)	4.78 (2.17)	3.95 (1.98)	2.55 (1.59)	3.15 (1.77)	3.21 (1.78)	11.40 (3.37)	8.10 (2.80)	9.05 (3.00)	9.51 (3.07)
5.	Imidacloprid 0.004%	13.60 (3.39)	1.30 (1.14)	0.55 (0.74)	1.25 (1.11)	1.03 (1.00)	0.90 (0.54)	0.75 (0.86)	2.10 (1.44)	1.25 (1.08)	5.75 (2.39)	3.90 (1.97)	5.65 (2.37)	5.10 (3.10)
6.	Achook 0.5% alternated with Cypermethrin 0.01%	17.46 (4.03)	5.55 (2.35)	8.90 (2.98)	6.00 (2.44)	6.81 (2.59)	3.96 (1.99)	7.45 (2.72)	5.15 (2.26)	5.52 (2.33)	9.55 (3.09)	8.8 (2.98)	10.45 (3.25)	9.62 (3.10)
7.	ZA-199 0.5% alternated with Cypermethrin 0.01%	13.26 (3.47)	5.80 (2.40)	10.45 (3.23)	3.85 (1.96)	6.70 (2.53)	5.65 (2.37)	8.30 (2.88)	3.65 (1.91)	5.86 (2.38)	10.30 (3.20)	10.70 (3.27)	7.85 (2.80)	9.61 (3.09)
8.	NSKE 5% alternated with Cypermethrin 0.01%	8.40 (2.89)	4.20 (2.04)	11.65 (3.41)	3.72 (1.92)	6.52 (2.46)	3.25 (1.80)	10.10 (3.17)	3.20 (1.78)	5.51 (2.25)	7.30 (2.70)	13.30 (3.64)	8.00 (2.82)	9.53 (3.08)
9.	Achook 0.5% alternated with Imidacloprid 0.004%	15.66 (3.80)	7.40 (2.72)	4.40 (2.09)	4.60 (2.14)	5.46 (2.32)	6.10 (2.47)	4.35 (2.08)	3.90 (1.97)	4.78 (2.17)	8.75 (2.95)	7.95 (2.82)	8.15 (2.85)	8.28 (2.87)
10.	ZA-199 5% alternated with Imidacloprid 0.004%	16.73 (3.96)	7.72 (2.77)	4.80 (2.19)	4.55 (2.13)	5.69 (2.36)	6.80 (2.60)	3.50 (1.87)	4.15 (2.03)	4.81 (2.17)	8.60 (2.93)	9.45 (3.07)	7.85 (2.80)	8.63 (2.93)
11.	NSKE 5% alternated with Imidacloprid 0.004%	14.06 (3.74)	7.00 (2.64)	7.10 (2.66)	7.15 (2.67)	7.08 (2.66)	5.35 (2.31)	6.05 (2.46)	5.85 (2.41)	5.75 (2.39)	9.20 (3.03)	11.35 (3.36)	9.25 (3.04)	9.93 (3.14)
12	Untreated control	16.53 (3.95)	16.95 (4.11)	18.25 (4.27)	14.20 (3.76)	16.46 (4.05)	16.45 (4.05)	17.10 (4.13)	14.95 (3.86)	16.16 (4.01)	20.25 (4.50)	19.75 (4.44)	17.20 (4.14)	19.06 (4.36)
	S.E.±	0.57				0.25				0.23				0.21
	C.D. at 5%	N.S.				0.72				0.68				0.63

Figures in parentheses are means of $\sqrt{x + 0.5}$ transformed values

Fig. 3. Effect of neem formulations alone and in alternation with synthetic insecticides against jassids infesting okra



population/plant and was significantly superior over rest of the treatments. The treatment with cypermethrin 0.01% recorded 4.78 jassid population which was found to be second best effective treatment and was on par with rest of the treatments except ZA-199 0.5%.

The observations on survival population of jassids recorded 5 days after spraying showed that the average number of jassids ranged from 1.25 to 8.20 in the insecticidal treatment as against 16.16 jassids in untreated control. The treatment with imidacloprid 0.004% again was found to be the most effective treatment for controlling jassids and registered 1.25 jassid population/plant and was significantly superior over rest of the treatments. The treatment with cypermethrin 0.01% recorded 3.21 jassid population which was found to be second best effective treatment and was on par with all the neem formulation treatments alternated with both the synthetic insecticides. Neem formulations alone were found less effective. The descending order of effectiveness of neem formulations alternated with synthetic insecticides was; Achook 0.5% - imidacloprid 0.004% > ZA -199 0.5% - imidacloprid 0.004% > NSKE 5% - cypermethrin 0.01% > Achook 0.5% - cypermethrin 0.01% > NSKE 5% - imidacloprid 0.004% > ZA -199 0.5% - cypermethrin 0.01% which recorded, 4.78, 4.81, 5.51, 5.52, 5.75, 5.86 jassids nymphs per plant, respectively.

The observations on survival population of jassids recorded 15 days after spraying indicated that all the insecticidal treatments were significantly superior over untreated control. The average number of jassid nymphs ranged from 5.10 to 11.80 in the insecticidal treatments as against 19.06 in untreated control. The treatment with imidacloprid 0.004% was the most effective treatment against jassids which registered 5.10 jassid population/plant and was significantly superior over rest of the treatments except Achook 0.5% alternated with imidacloprid 0.04% which recorded 8.28 jassids/plant. The next effective treatment was Achook 0.5% which recorded 8.48 jassids/plant and was on par with rest of the treatments.

From the Table 3 it is evident that all the insecticidal treatments were found significantly effective in checking jassid population on okra at 2, 5 and 15 days after spraying as against untreated control. The treatment with imidacloprid 0.004% was found to be the most superior treatment which was followed by cypermethrin 0.01%. The treatments with neem formulations when alternated with synthetic insecticides were also found promising in controlling the jassid population. However, neem formulations alone were found to be comparatively less effective.

The studies by Mote *et al.* (1994), Mote *et al.* (1995),and Sreelatha and Divakar (1997), demonstrated the effectiveness of imidacloprid 70 WS as seed dresser against sucking pest of okra and cotton, which are in conformity with the present findings.

The present findings in respect with effectiveness of cypermethrin are in agreement with the studies of, Khaire and Naik (1986). They reported that cypermethrin effectively controlled jassids and aphids. Similarly, Kagar and Dogra (1988) showed that single spray of 0.008% cypermethrin gave effective control of pest complex of okra.

Joshi (1989) reported that Neemark at 0.5% and Indira at 1% effectively controlled jassids , aphids and whiteflies on cotton. Similarly, Thombare (1991) reported that Neem seed extract was promising at 0.60% for control of jassids on okra. These results of neem formulations .are in confirmation with results of present findings.

4.1.3 **Effect on Aphid population**

The effect of various treatment schedules under investigation, on the survival of aphids per plant is given in Table 4 and graphically represented in Fig.4

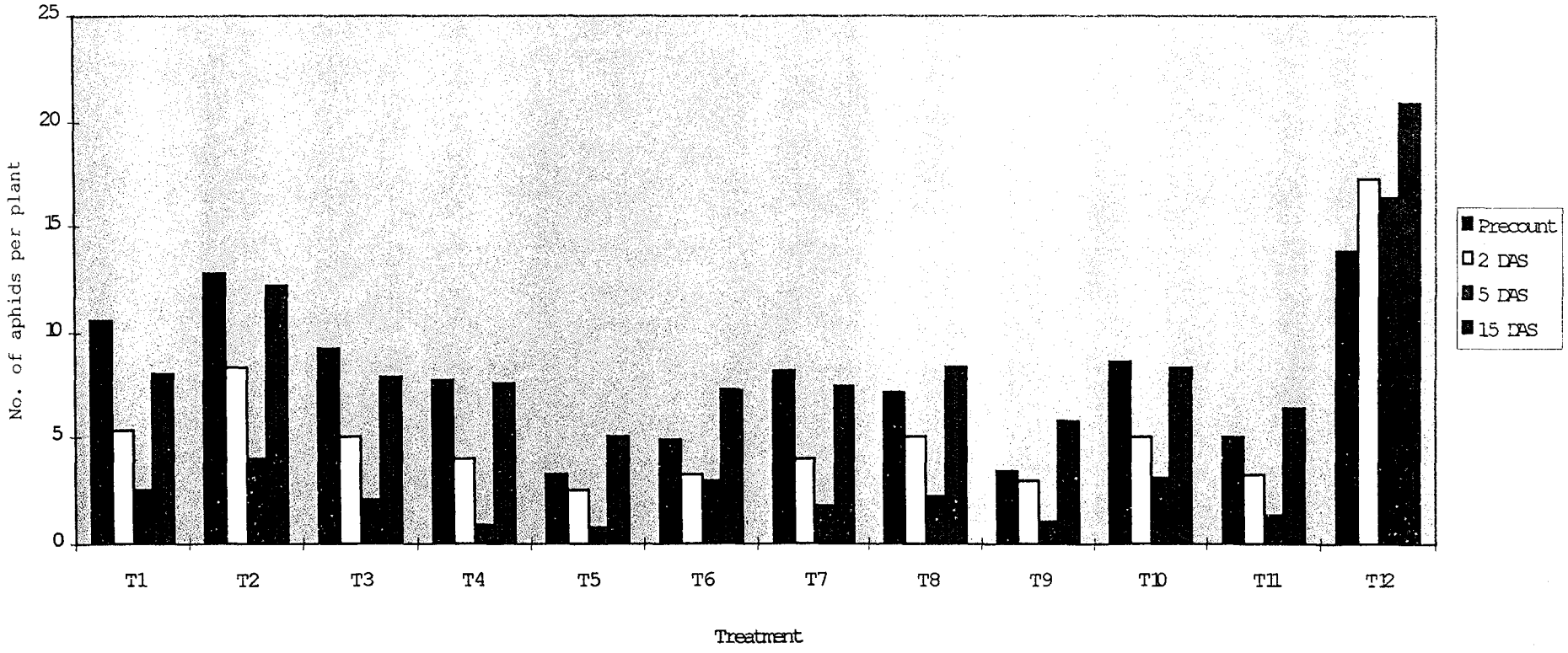
The average number of aphids prior to insecticidal treatments was ranged from 3.2 to 13.86. The difference among the treatments were non significant.

Table 4. Effect of neem formulations alone and in alternation with synthetic insecticides against aphids infesting okra

Sr. No.	Treatment	Precount	Number of aphids per plant days after spraying											
			2				5				15			
			R-I	R-II	R-III	Mean	R-I	R-II	R-III	Mean	R-I	R-II	R-III	Mean
1.	Achook 0.5%	10.53 (2.62)	3.30 (1.81)	9.10 (3.01)	3.55 (1.88)	5.31 (2.23)	1.65 (1.28)	4.65 (2.15)	1.30 (1.14)	2.53 (1.52)	7.80 (2.79)	9.00 (3.00)	7.50 (2.73)	8.10 (2.84)
2.	ZA-199 0.5%	12.86 (3.34)	3.15 (1.77)	8.80 (2.96)	13.00 (3.60)	8.31 (2.78)	2.45 (1.56)	1.15 (1.07)	8.50 (2.91)	4.03 (1.85)	9.55 (3.09)	6.95 (2.63)	20.30 (4.50)	12.26 (3.41)
3.	NSKE 5%	9.26 (2.66)	5.05 (2.24)	6.05 (2.54)	3.90 (1.97)	5.13 (2.25)	1.75 (1.32)	2.53 (1.59)	1.75 (1.32)	2.01 (1.41)	8.10 (2.84)	8.85 (2.97)	6.75 (2.99)	7.90 (2.80)
4.	Cypermethrin 0.01%	7.80 (2.54)	3.90 (1.97)	4.70 (2.16)	3.50 (1.87)	4.03 (2.00)	0.85 (0.92)	0.75 (0.86)	1.15 (1.07)	0.91 (0.95)	7.75 (2.78)	6.20 (2.49)	8.70 (2.95)	7.55 (2.74)
5.	Imidacloprid 0.004%	3.20 (1.78)	1.60 (1.26)	3.15 (1.77)	3.05 (1.74)	2.60 (1.59)	0.55 (0.74)	0.40 (0.63)	1.45 (1.20)	0.80 (0.85)	2.30 (1.51)	6.45 (2.54)	6.55 (2.55)	5.10 (2.20)
6.	Achook 0.5% alternated with Cypermethrin 0.01%	4.93 (2.21)	2.30 (1.51)	3.75 (1.93)	3.91 (1.97)	3.32 (1.81)	5.80 (2.40)	1.20 (1.09)	1.85 (1.07)	2.95 (1.62)	7.45 (2.72)	6.30 (2.51)	8.15 (2.85)	7.30 (2.69)
7.	ZA-199 0.5% alternated with Cypermethrin 0.01%	8.13 (2.79)	6.30 (2.51)	3.40 (1.84)	2.50 (1.58)	4.06 (1.97)	3.40 (1.84)	1.25 (1.11)	0.90 (0.94)	1.85 (1.30)	9.40 (3.06)	6.55 (2.52)	6.45 (2.54)	7.40 (2.70)
8.	NSKE 5% alternated with Cypermethrin 0.01%	7.13 (2.67)	5.95 (2.43)	4.35 (2.08)	4.75 (2.17)	5.01 (2.23)	3.50 (1.87)	1.25 (1.11)	2.05 (1.36)	2.26 (1.47)	10.20 (3.19)	7.15 (2.67)	7.75 (2.78)	8.36 (2.88)
9.	Achook 0.5% alternated with Imidacloprid 0.004%	3.46 (1.84)	2.25 (1.50)	1.50 (1.22)	5.10 (2.25)	2.95 (1.66)	1.15 (1.07)	1.10 (1.04)	0.90 (0.94)	1.05 (1.02)	5.75 (2.39)	5.80 (2.40)	5.95 (2.43)	5.83 (2.41)
10.	ZA-199 5% alternated with Imidacloprid 0.004%	8.60 (2.79)	6.60 (2.56)	5.90 (2.42)	2.85 (1.68)	5.11 (2.22)	5.30 (2.30)	3.00 (1.73)	1.15 (1.43)	3.15 (1.70)	5.45 (2.33)	10.50 (3.24)	9.05 (3.00)	8.33 (2.86)
11.	NSKE 5% alternated with Imidacloprid 0.004%	5.06 (2.17)	3.80 (1.94)	3.45 (1.85)	2.65 (1.62)	3.30 (1.81)	2.00 (1.41)	1.15 (1.07)	0.95 (0.94)	1.36 (1.15)	6.50 (2.55)	5.70 (2.38)	6.95 (2.63)	6.38 (2.52)
12	Untreated control	13.86 (3.33)	17.00 (4.12)	17.90 (4.23)	16.70 (4.08)	17.20 (4.14)	18.00 (4.24)	18.75 (4.33)	12.35 (3.51)	16.36 (4.02)	20.80 (4.56)	21.36 (4.62)	20.20 (4.49)	20.78 (4.55)
	S.E.±	0.71				0.26				0.28				0.23
	C.D. at 5%	N.S.				0.77				0.82				0.67

Figures in parentheses are means of $\sqrt{x + 0.5}$ transformed values

Fig. 4. Effect of neem formulations alone and in alternation with synthetic insecticides against aphids infesting okra



The data on survival population of aphids recorded 2 days after spraying revealed that all the insecticidal treatments were significantly superior over untreated control. The average number of aphids ranged from 2.60 to 8.31 in the insecticidal treatments as against 17.20 in untreated control. The treatment with imidacloprid 0.004% was the most effective treatment for controlling aphids and registered 2.60 aphid population/plant and was on par with rest of the treatments except ZA-199 0.5%.

The observations on survival population of aphids recorded 5 days after spraying indicated that the average number of aphids ranged from 0.80 to 4.03 in the insecticidal treatments as against 16.36 aphids in untreated control. The treatment with imidacloprid 0.004% was the most effective treatment which recorded 0.80 aphids per plant and was on par with all other treatments except ZA-199 0.5% and ZA-199 0.5% alternated with imidacloprid 0.004%.

The observations on survival population of aphids recorded 15 days after sprayings, indicated that all the insecticidal treatments were significantly superior over untreated control. The average number of aphids ranged from 5.10 to 12.26 in the insecticidal treatments as against 20.78 in untreated control. The treatment with imidacloprid 0.004% proved to be the most effective treatment against aphids which registered 5.10 aphids/plant and was on par with all other treatments except ZA-199 0.5% and NSKE 5% alternated with cypermethrin 0.01%. The descending order of effectiveness was Achook 0.5%- imidacloprid 0.004% > NSKE 5% - imidacloprid 0.004% > Achook 0.5% - cypermethrin 0.01% > ZA-199 0.5% - cypermethrin 0.01% > cypermethrin 0.01% > NSKE 5% > Achook 0.5% > ZA-199 0.5% - imidacloprid 0.004% which recorded 5.83, 6.38, 7.30, 7.40, 7.55, 7.90, 8.10, 8.33 aphids per plant, respectively.

From the Table 4 it is evident that all the insecticidal treatments were superior in checking aphid population on okra at 2, 5 and 15 days after spraying as against untreated control. The treatment with imidacloprid

0.004% was found to be the most effective treatment followed by cypermethrin 0.01% and rest of all treatments except ZA-199 0.5%.

The studies by Mote *et al.* (1994) and Sreelatha and Divakar (1997) demonstrated the effectiveness of imidacloprid 70 WS as seed dresser against initial sucking pest of okra. Similarly Lucas *et al.* (1999) observed that imidacloprid 0.3 and 0.5 kg a.i./ha significantly reduced the incidence of aphids up to 20 days after sowing and after emergence as foliar spray controlled the pest for 10 days after application in cotton crop. Calafiori *et al.* (1998) tested imidacloprid at different concentration of 0.07 and 0.1 lit/ha which gave 80% control of aphids with effect up to 20 days. The present investigation in respect with effectiveness of imidacloprid is in conformity with the work carried out by these workers.

In confirmation with effectiveness of cypermethrin, Sasamma Jacob and Sheila (1996) showed that cypermethrin 0.02% effectively controlled aphids up to 14 days after spraying on okra.

The studies carried out by Venkateson *et al.* (1987), Joshi (1989), Kulkarni (1993) and Chitra *et al.* (1997) are in conformity with effectiveness of neem formulations against aphids.

The literature about the efficacy of neem products when alternated with synthetic insecticides with which the present findings could be compared is not available. However, Bari (1995) alternated neem seed kernel extract and fenvalerate, which were effective against sucking pests on cotton. Similarly, Patil (1996) reported that NSKE 2% + 0.0075% cypermethrin alternated with cypermethrin 0.0075% alternated with NSKE 2% alternated with *B.t.* 0.03% gave effective control of jassids and aphids, on okra.

4.2 Effect of number and interval of applications of neem formulations in alternation with synthetic insecticides

4.2.1 Shoot and Fruit borer

A) Number of infested fruit basis

The data on fruit borer infestation on okra on number basis are presented in Table 5 and graphically represented in Fig.5

The observations recorded on percentage of fruit infestation revealed that all the insecticidal treatments significantly reduced the per cent fruit damage due to fruit borer, *E. vittella* in comparison with untreated control. The average fruit infestation in the treatments ranged from 7.32 to 16.20% as against 26.80% in untreated control.

The treatment with cypermethrin 0.01% comprising 4 sprays at 15 days interval was found to be the most effective treatment and recorded the lowest fruit infestation of 7.32%. The second most effective treatment was Achook 0.5% alternated with cypermethrin 0.01% comprising 4 sprays at 15 days interval and recorded 8.36% fruit infestation, followed by the treatment with ZA -199 0.5% alternated with cypermethrin 0.01% comprising 4 sprays at 15 days interval which recorded 8.93% infestation.

The descending order of effectiveness of alternated treatments with effect of number and interval of applications of insecticides were, Achook 0.5% - cypermethrin 0.01% > ZA-199 0.5% - cypermethrin 0.01% > Achook 0.5% - imidacloprid 0.004% > ZA -199 0.5% - imidacloprid 0.004% > NSKE 5% -imidacloprid 0.004%.

These results indicated that alternated treatments with 4 sprays at 15 days interval were most promising against *E.vittella* on okra.

B) Fruit weight basis

The data on the average percentage of fruit borer infestation on weight basis are presented in Table 6 and graphically depicted in Fig. 6

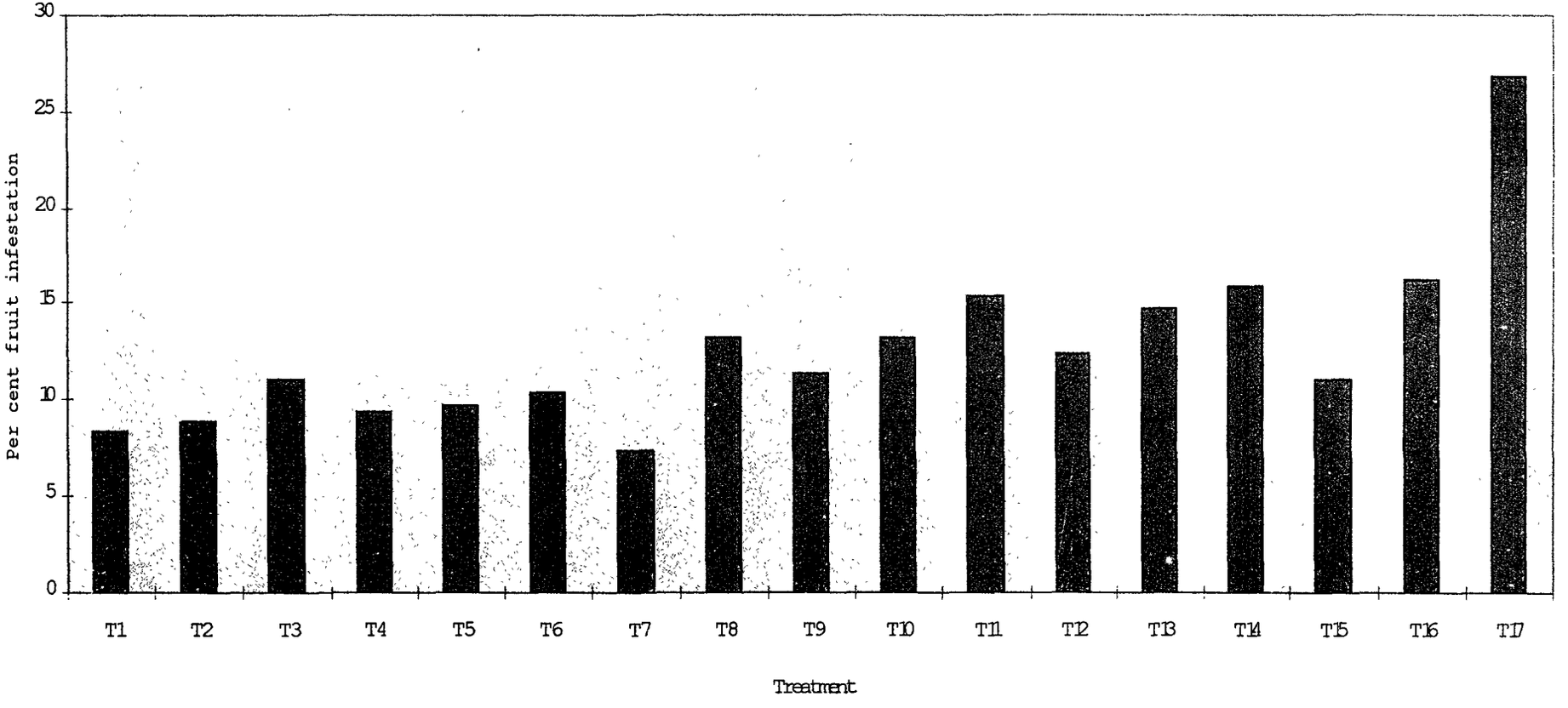
The observations recorded on fruit borer infestation indicated that all the treatments with 4 sprays at 15 days interval and 3 sprays at 21 days interval were found effective against fruit borer infestation over the untreated control.

Table 5. Effect of neem formulations in alternate with synthetic insecticides on *E. vittella* infesting okra (Number and application interval of spray)

Sr. No.	Treatment	Fruit infestation (%)		
		R-I	R-II	Mean
1.	Achook 0.5% alternated with Cypermethrin 0.01%	7.72 (16.13)	9.01 (17.46)	8.36 (16.80)
2.	ZA-199 0.5% alternated with Cypermethrin 0.01%	8.65 (17.16)	9.22 (17.67)	8.93 (17.39)
3.	NSKE 5% alternated with Cypermethrin 0.01%	10.58 (18.98)	11.59 (19.90)	11.08 (19.44)
4.	Achook 0.5% alternated with Imidacloprid 0.004%	9.03 (17.48)	9.90 (18.33)	9.46 (17.91)
5.	ZA-199 0.5% alternated with Imidacloprid 0.004%	9.30 (17.75)	10.30 (18.72)	9.80 (18.23)
6.	NSKE 5% alternated with Imidacloprid 0.004%	10.84 (19.22)	9.79 (18.23)	10.31 (18.72)
7.	Cypermethrin 0.01%	7.11 (15.46)	7.53 (15.92)	7.32 (15.69)
8.	Imidacloprid 0.004%	13.34 (21.42)	13.28 (21.37)	13.31 (21.29)
9.	Achook 0.5% alternated with Cypermethrin 0.01%	10.72 (19.11)	11.92 (20.19)	11.32 (19.65)
10.	ZA-199 0.5% alternated with Cypermethrin 0.01%	12.58 (20.77)	13.96 (21.94)	13.27 (21.35)
11.	NSKE 5% alternated with Cypermethrin 0.01%	15.15 (22.90)	15.57 (23.24)	15.36 (23.07)
12.	Achook 0.5% alternated with Imidacloprid 0.004%	12.22 (20.46)	12.44 (20.65)	12.33 (20.55)
13.	ZA-199 5% alternated with Imidacloprid 0.004%	14.55 (22.42)	15.06 (22.83)	14.80 (22.62)
14.	NSKE 5% alternated with Imidacloprid 0.004%	16.36 (23.85)	15.64 (23.29)	16.00 (23.57)
15.	Cypermethrin 0.01%	10.39 (18.80)	11.80 (20.09)	11.10 (19.44)
16.	Imidacloprid 0.004%	16.39 (23.88)	16.02 (23.59)	16.20 (23.73)
17.	Untreated control	26.14 (30.74)	27.47 (31.66)	26.80 (31.17)
	S.E.±			0.33
	C.D. at 5%			1.00

Figures in parentheses are means of arcsin transformed values
Treatments 1 to 8 given at 15 days and treatments 9 to 16 given at 21 days interval

Fig. 5. Effect of neem formulations in alternation with synthetic insecticides on *E. vittella* infesting okra
(Number and application interval of spray)



The average fruit infestation in the treatments ranged from 5.19 to 9.32% as against 13.29% in untreated control. The treatment with cypermethrin 0.01% with 4 sprays at 15 days interval was the most effective, and recorded the lowest fruit infestation of 5.19% and 24.47 q/ha marketable fruits, and was significantly superior over rest of the treatments except Achook 0.5% alternated with cypermethrin 0.01% (5.67% fruit damage and 22.80 q/ha marketable fruits), ZA -199 0.5% alternated with cypermethrin 0.01% (5.76% fruit damage and 21.60 q/ha. marketable fruits), ZA-199 0.5%alternated with imidacloprid 0.004% (5.92% fruit damage and 22.76 q/ha marketable fruits), Achook 0.5%alternated with imidacloprid 0.04% (5.94% fruit damage and 23.06 q/ha marketable fruits)all with 4 sprays at 15 days interval and cypermethrin 0.01% with 3 sprays (6.14% fruit damage and 23.78 q/ha marketable fruits).The next effective treatments were NSKE 5% alternated with imidacloprid 0.004% and recorded average 6.67% fruit damage (22.47 q/ha marketable fruits) followed by NSKE 5% alternated with cypermethrin 0.01% (6.76 fruit damage and 21.20 q/ha marketable fruits) all with 4 sprays and Achook 0.5% alternated with cypermethrin 0.01% with 3 sprays (7.19% fruit damage and 21.98 q/ha marketable fruits), Achook 0.5% alternated with imidacloprid 0.004% with 3 sprays recorded 7.23 fruit damage (22.03q/ha marketable fruits) ZA-199 0.5% alternated with cypermethrin 0.01% with 3 sprays recorded 7.36 fruit damage (21.18 q/ha marketable fruits) and imidacloprid 0.004% with 4 sprays which recorded 7.71% fruit damage (24.24 q/ha marketable fruits).

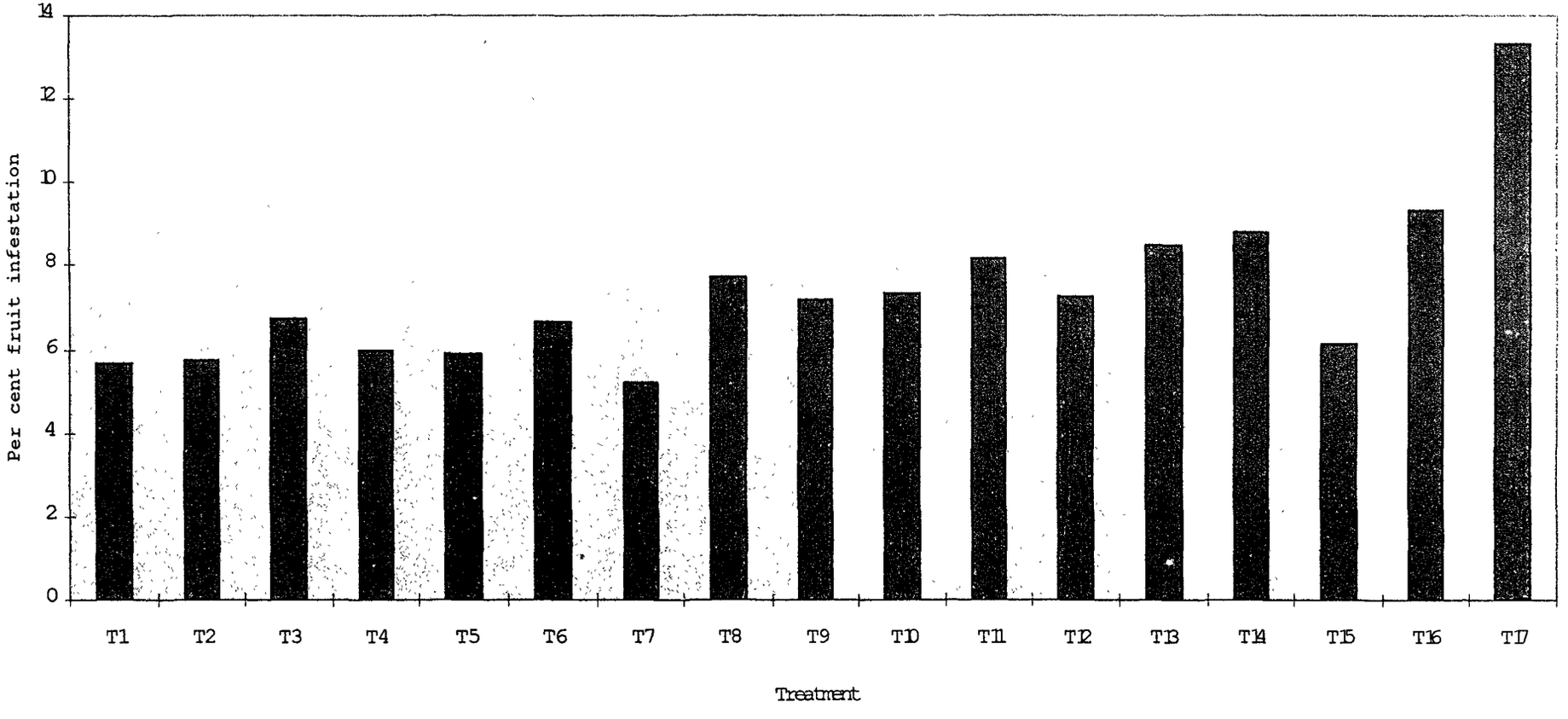
The over all effects of various treatments in the reduction of fruit borer infestation on okra considering number and weight basis (number and days of intervals of spray) indicated that the treatment with cypermethrin 0.01% (4 and3 sprays at 15 and 21 days interval) was at the top. The second most effective treatment was Achook 0.5% alternated with cypermethrin 0.01% and ZA-199 0.5% alternated with cypermethrin 0.01%, 4 sprays at 15 days interval.

Table 6. Effect of neem formulations in alternation with synthetic insecticides against *E. vittella* infesting okra (Number and application interval of spray)

Sr. No.	Treatment	Fruit infestation (%)			Yield (q/ha)
		R-I	R-II	Mean	
1.	Achook 0.5% alternated with Cypermethrin 0.01%	5.03 (12.96)	6.32 (14.56)	5.67 (13.76)	22.80
2.	ZA-199 0.5% alternated with Cypermethrin 0.01%	5.42 (13.46)	6.10 (14.29)	5.76 (13.88)	21.60
3.	NSKE 5% alternated with Cypermethrin 0.01%	6.23 (14.45)	7.30 (15.67)	6.76 (15.06)	21.20
4.	Achook 0.5% alternated with Imidacloprid 0.004%	5.41 (13.45)	6.48 (14.74)	5.94 (14.09)	23.06
5.	ZA-199 0.5% alternated with Imidacloprid 0.004%	5.24 (13.23)	6.62 (14.91)	5.92 (14.07)	22.76
6.	NSKE 5% alternated with Imidacloprid 0.004%	7.01 (15.35)	6.33 (14.57)	6.67 (14.96)	22.47
7.	Cypermethrin 0.01%	4.24 (11.88)	6.14 (14.34)	5.19 (13.11)	24.47
8.	Imidacloprid 0.004%	7.88 (16.30)	7.55 (14.94)	7.71 (16.12)	24.24
9.	Achook 0.5% alternated with Cypermethrin 0.01%	6.85 (15.17)	7.54 (15.93)	7.19 (15.55)	21.98
10.	ZA-199 0.5% alternated with Cypermethrin 0.01%	6.81 (15.12)	7.91 (16.33)	7.36 (15.73)	21.18
11.	NSKE 5% alternated with Cypermethrin 0.01%	8.08 (16.51)	8.31 (16.75)	8.19 (16.63)	21.19
12.	Achook 0.5% alternated with Imidacloprid 0.004%	7.21 (15.57)	7.26 (15.63)	7.23 (15.60)	22.03
13.	ZA-199 5% alternated with Imidacloprid 0.004%	8.61 (17.06)	8.37 (16.81)	8.49 (16.94)	22.39
14.	NSKE 5% alternated with Imidacloprid 0.004%	9.07 (17.52)	8.54 (16.99)	8.80 (17.26)	22.28
15.	Cypermethrin 0.01%	5.51 (13.57)	6.78 (15.09)	6.14 (14.33)	23.78
16.	Imidacloprid 0.004%	9.37 (17.82)	9.27 (17.72)	9.32 (17.77)	23.67
17.	Untreated control	13.40 (21.47)	13.18 (21.28)	13.29 (21.38)	17.55
	S.E.±			0.47	0.70
	C.D. at 5%			1.41	2.08

Figures in parentheses are means of arcsin transformed values
Treatments 1 to 8 given at 15 days and treatments 9 to 16 given at 21 days interval

Fig. 6. Effect of neem formulations in alternation with synthetic insecticides against *E. vittella* infesting okra
(Number and application interval of spray)



The results of the studies conducted by David and Kumarswami (1991), Patil *et al.* (1991), Prasad *et al.* (1993) and Ambekar *et al.* (2000) indicated the effectiveness of cypermethrin on okra fruit borer which are in conformity with present findings.

In the present investigations above two treatments of neem formulations when alternated with synthetic insecticides gave significantly low fruit borer infestation. Since no published literature is available on bioefficacy of neem formulations when alternated with synthetic insecticides, the present findings could not be compared with earlier studies.

4.2.2 Effect on Jassid population

The effect of neem formulations in alternation with synthetic insecticides on jassid nymphs is illustrated and presented in Table 7 and graphically represented in Fig. 7. The data indicated that prior to insecticidal treatments the average number of jassid nymphs ranged from 6.90 to 10.20. The difference among the treatments were non significant.

All the treatments of 4 and 3 sprays at 15 and 21 days interval respectively, were found significantly effective in reducing the population of jassids at 2, 5 and 15 days after spraying over untreated control.

The data on survival population of jassids recorded 2 days after spraying revealed that all the treatments proved significantly superior over untreated control. The treatment with 4 sprays of imidacloprid 0.004% was found to be most effective and registered 5.15 jassid nymphs/plant and was on par with rest of the treatments except NSKE 5% alternated with cypermethrin 0.01% (4 sprays).

The data on the survival population of jassids recorded 5 days after spraying showed that the average number of jassids ranged from 1.62 to 4.16 as against 19.60 in untreated control. Four sprays of imidacloprid 0.004% was the most effective treatment which recorded 1.62 jassids, followed by Achook 0.5% alternated with imidacloprid 0.004% with 4 sprays (2.12 jassids) and 3 sprays of imidacloprid 0.004% (2.13 jassids).

Table 7. Effect of number and application interval of neem formulations in alternation with synthetic insecticides against jassids infesting okra

Sr. No.	Treatment	Precount	Mean survival jassid population per plant days after spraying								
			2			5			15 and 21		
			R-I	R-II	Mean	R-I	R-II	Mean	R-I	R-II	Mean
1.	Achook 0.5% alternated with Cypermethrin 0.01%	8.30 (2.86)	6.90 (2.62)	6.55 (2.55)	6.72 (2.59)	3.00 (1.73)	4.25 (2.06)	3.62 (1.89)	9.70 (3.11)	10.20 (3.19)	9.95 (3.15)
2.	ZA-199 0.5% alternated with Cypermethrin 0.01%	8.70 (2.94)	6.65 (2.57)	6.90 (2.62)	6.77 (2.60)	2.40 (1.54)	3.55 (1.88)	2.97 (1.74)	10.70 (3.27)	10.10 (3.17)	10.40 (3.22)
3.	NSKE 5% alternated with Cypermethrin 0.01%	7.60 (2.75)	7.60 (2.75)	8.60 (2.93)	8.10 (2.84)	2.90 (1.70)	3.40 (1.84)	3.15 (1.77)	10.45 (3.23)	9.50 (3.08)	9.97 (3.15)
4.	Achook 0.5% alternated with Imidacloprid 0.004%	7.30 (2.70)	6.35 (2.52)	5.45 (2.33)	5.90 (1.80)	1.80 (1.34)	2.45 (1.56)	2.12 (1.45)	10.15 (3.18)	9.00 (3.00)	9.51 (3.09)
5.	ZA-199 0.5% alternated with Imidacloprid 0.004%	9.00 (2.99)	6.95 (2.63)	7.00 (2.64)	6.97 (2.64)	2.85 (1.68)	3.45 (1.85)	3.15 (1.77)	10.70 (3.27)	10.95 (3.30)	10.82 (3.29)
6.	NSKE 5% alternated with Imidacloprid 0.004%	6.90 (2.61)	6.00 (2.44)	6.15 (2.48)	6.07 (2.46)	2.70 (1.64)	3.10 (1.76)	2.90 (1.70)	10.20 (3.19)	9.10 (3.01)	9.65 (3.10)
7.	Cypermethrin 0.01%	7.20 (2.68)	6.70 (2.58)	6.20 (2.49)	6.45 (2.53)	2.60 (1.61)	3.30 (1.81)	2.95 (1.71)	10.70 (3.27)	9.45 (3.07)	10.07 (3.17)
8.	Imidacloprid 0.004%	6.90 (2.61)	5.25 (2.29)	5.05 (2.24)	5.15 (2.26)	1.50 (1.22)	1.75 (1.32)	1.62 (1.27)	8.95 (2.99)	8.65 (2.94)	8.80 (2.96)

Contd ....

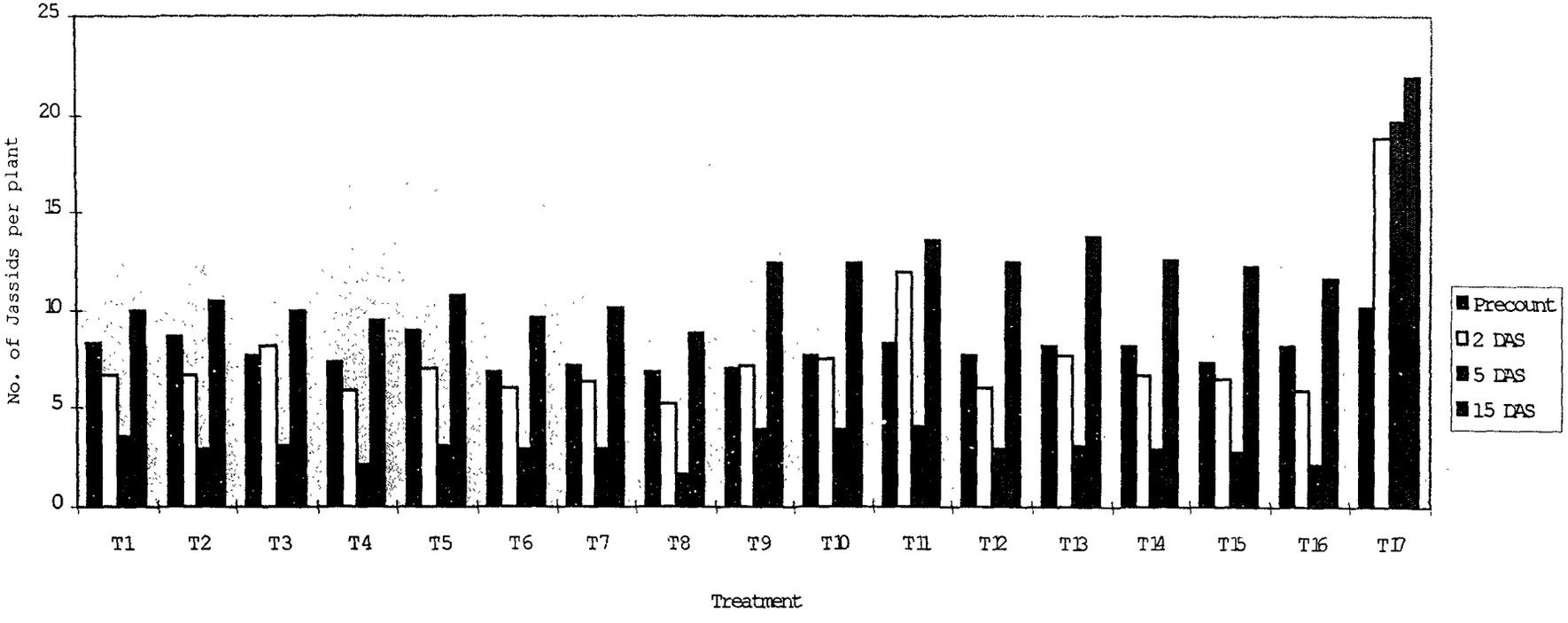
Table 7. ***Contd ....***

Sr. No.	Treatment	Precount	Mean survival jassid population per plant days after spraying								
			2			5			15 and 21		
			R-I	R-II	Mean	R-I	R-II	Mean	R-I	R-II	Mean
9.	Achook 0.5% alternated with Cypermethrin 0.01%	7.10 (2.66)	6.80 (2.60)	7.73 (2.78)	7.26 (2.69)	2.60 (1.61)	5.13 (2.26)	3.86 (1.93)	12.40 (3.52)	12.53 (3.54)	12.46 (3.53)
10.	ZA-199 0.5% alternated with Cypermethrin 0.01%	7.70 (2.77)	7.33 (2.70)	7.80 (2.79)	7.56 (2.75)	3.00 (1.73)	4.73 (2.17)	3.86 (1.95)	12.00 (3.46)	12.93 (3.59)	12.46 (3.53)
11.	NSKE 5% alternated with Cypermethrin 0.01%	8.40 (2.89)	17.95 (4.23)	5.90 (2.42)	11.92 (3.33)	2.96 (1.71)	5.40 (2.32)	4.16 (2.01)	13.06 (3.61)	14.13 (3.75)	13.59 (3.68)
12.	Achook 0.5% alternated with Imidacloprid 0.004%	7.60 (2.75)	5.33 (2.30)	6.73 (2.59)	6.03 (2.45)	1.93 (1.38)	3.93 (1.98)	2.93 (1.68)	12.80 (3.57)	12.13 (3.48)	12.46 (3.53)
13.	ZA-199 5% alternated with Imidacloprid 0.004%	8.10 (2.84)	7.13 (2.67)	8.20 (2.86)	7.66 (2.76)	2.60 (1.61)	3.53 (1.87)	3.06 (1.74)	13.60 (3.68)	13.87 (3.7)	13.73 (3.70)
14.	NSKE 5% alternated with Imidacloprid 0.004%	8.20 (2.86)	6.60 (2.56)	6.73 (2.59)	6.66 (2.58)	2.20 (1.48)	3.80 (1.94)	3.00 (1.71)	12.40 (3.52)	12.67 (3.55)	12.53 (3.54)
15.	Cypermethrin 0.01%	7.40 (2.71)	6.47 (2.54)	6.53 (2.55)	6.50 (2.55)	2.67 (1.63)	3.00 (1.73)	2.83 (1.68)	12.40 (3.52)	12.07 (3.47)	12.23 (3.49)
16.	Imidacloprid 0.004%	8.10 (2.84)	6.20 (2.49)	5.67 (2.38)	5.93 (2.43)	2.00 (1.41)	2.27 (1.50)	2.13 (1.46)	12.13 (3.48)	11.07 (3.32)	11.60 (3.40)
17.	Untreated control	10.20 (3.19)	19.30 (4.39)	18.40 (4.29)	18.85 (4.34)	20.20 (4.49)	19.00 (4.35)	19.60 (4.42)	21.80 (4.66)	22.15 (4.70)	21.97 (4.68)
	S.E.±	0.13			0.23			0.11			0.06
	C.D. at 5%	N.S.			0.69			0.33			0.17

Figures in parentheses are means of $\sqrt{x + 0.5}$ transformed values

Treatments 1 to 8 given at 15 days and treatments 9 to 16 given at 21 days interval

Fig. 7. Effect of number and application interval of neem formulations in alternation with synthetic insecticides against jassids infesting okra



The next effective treatment was 3 sprays of cypermethrin 0.01% which recorded 2.83 jassids/plant. All other treatments were on par with 3 sprays of cypermethrin 0.01% except NSKE 5% alternated with cypermethrin 0.01% (3 sprays).

The data on survival population of jassids 15 days after spraying indicated that all the insecticidal treatments were superior over untreated control in reducing the population of jassids. The average number of jassid/plant ranged from 8.80 to 13.73 as against 21.97 in untreated control. The most effective treatment again was 4 sprays of imidacloprid 0.004% which recorded 8.80 jassids, followed by Achook 0.5% alternated with imidacloprid 0.004% (4 sprays) and recorded 9.57 jassids and NSKE 5% alternated with imidacloprid 0.004% (4 sprays) which recorded 9.65 jassids.

The next effective treatment was Achook 0.5% alternated with cypermethrin 0.01% with 4 sprays and recorded 9.95 jassids/plant followed by NSKE 5%alternated with cypermethrin 0.01% (9.97% jassid), cypermethrin 0.01% (10.07 jassids), ZA-199 0.5% alternated with cypermethrin 0.01% (10.40 jassids) , ZA-199 0.5% alternated with imidacloprid 0.004% (10.82 jassids) all with 4 sprays.

From the Table 7 it is evident that all the insecticidal treatments were superior in reducing jassid population on okra at 2, 5 and 15 days after application in comparison with untreated control. The treatment with 4 sprays of imidacloprid 0.004% was most effective against Jassid on okra up to 15 days after spraying. It was followed by Achook 0.5% alternated with imidacloprid 0.004% (4 sprays) and NSKE 5% alternated with imidacloprid 0.004% (4 sprays).Studies by Mote *et al.* (1994) and Sreelatha and Divakar (1997) demonstrated the effectiveness of imidacloprid 70 WS as seed dresser on sucking pests of okra and Mote *et al.* (1995) on cotton, which are in conformity with the present findings.

There is no published literature available about the efficacy of neem formulations when alternated with synthetic insecticides with which the present findings could be compared. However, Bari (1995) reported that

alternate application of neem seed kernel extract and fenvalerate were effective against sucking pests of cotton. Similarly, treatment with 2% NSKE + 0.0075% cypermethrin mixture alternated with cypermethrin 0.0075% - NSKE 2% *B.t.* 0.03% (alternated) were reported to be effective against jassid (Patil,1996).

4.2.3 Effect on Aphid population

The observations on survival population of aphids was recorded 2, 5 and 15 days after each spraying. The effect of various treatments on aphids are presented in Table 8 and graphically represented in Fig. 8

The data on average population prior to the insecticidal sprays were found to range between 3.40 to 7.55. The difference among the treatments were non-significant.

All the insecticidal treatments of 4 and 3 sprays at 15 and 21 days interval, respectively were significantly effective at 2, 5 and 15 days after spraying, over untreated control.

The data recorded on survival population of aphids 2 days after spraying (Table 8) showed that the average aphid number per plant ranged from 4.63 to 9.17 as against 20.82 in untreated control.

Among the treatments, the treatment with 4 sprays of imidacloprid 0.004% emerged as the most effective treatment which registered 4.63 aphids. The second best effective treatment was found to be Achook 0.5% alternated with imidacloprid 0.004% (4 sprays) which recorded 6.03 aphids, followed by 4 sprays of cypermethrin 0.01% (6.37 aphids), ZA-199 0.5%alternated with cypermethrin 0 01% (4 sprays) (6.40 aphids), NSKE 5% alternated with imidacloprid 0.004% (6.50 aphids), ZA-199 0.5% alternated with imidacloprid 0.004% with 4 sprays (6.60 aphids), 3 sprays of imidacloprid 0.004% (6.90 aphids) and Achook 0.5% alternated with cypermethrin 0.01% with 4 sprays (6.93 aphids) which were on par.

Table 8. Effect of number and application interval of neem formulations in alternation with synthetic insecticides against aphids infesting okra

Sr. No.	Treatment	Precount	Mean survival aphid population per plant days after spraying								
			2			5			15 and 21		
			R-I	R-II	Mean	R-I	R-II	Mean	R-I	R-II	Mean
1.	Achook 0.5% alternated with Cypermethrin 0.01%	4.50 (2.12)	6.40 (2.53)	7.46 (2.73)	6.93 (2.63)	2.93 (1.71)	4.87 (2.20)	3.90 (1.95)	12.07 (3.47)	17.67 (4.20)	14.87 (3.83)
2.	ZA-199 0.5% alternated with Cypermethrin 0.01%	6.70 (2.58)	5.80 (2.40)	7.00 (2.64)	6.40 (2.52)	2.50 (1.58)	3.87 (1.96)	3.18 (1.77)	13.55 (3.68)	16.95 (4.11)	15.25 (3.89)
3.	NSKE 5% alternated with Cypermethrin 0.01%	4.80 (2.14)	7.67 (2.76)	6.41 (2.53)	7.03 (2.65)	3.67 (1.91)	3.33 (1.82)	3.50 (1.87)	15.90 (3.98)	17.05 (4.12)	16.47 (4.05)
4.	Achook 0.5% alternated with Imidacloprid 0.004%	4.70 (2.16)	5.67 (2.38)	6.41 (2.53)	6.03 (2.45)	1.67 (1.29)	3.07 (1.75)	2.37 (1.52)	15.05 (3.87)	16.50 (4.06)	15.77 (3.97)
5.	ZA-199 0.5% alternated with Imidacloprid 0.004%	5.00 (2.22)	6.93 (2.63)	6.27 (2.50)	6.60 (2.56)	2.40 (1.54)	3.07 (1.75)	2.73 (1.65)	15.00 (3.87)	18.13 (4.25)	16.56 (4.06)
6.	NSKE 5% alternated with Imidacloprid 0.004%	3.80 (1.94)	6.27 (2.50)	6.73 (2.59)	6.50 (2.54)	2.47 (1.57)	2.67 (1.63)	2.57 (1.60)	13.90 (3.72)	14.35 (3.78)	14.12 (3.75)
7.	Cypermethrin 0.01%	4.10 (2.02)	6.27 (2.50)	6.47 (2.54)	6.37 (2.15)	2.47 (1.57)	2.40 (1.54)	2.43 (1.56)	13.25 (3.64)	16.35 (4.04)	14.80 (3.84)
8.	Imidacloprid 0.004%	4.90 (2.21)	4.67 (2.16)	4.60 (2.14)	4.63 (2.15)	1.47 (1.21)	1.60 (1.26)	1.53 (1.23)	14.55 (3.81)	13.50 (3.67)	14.02 (3.74)

Contd ....

Table 8. ***Contd ....***

Sr. No.	Treatment	Precount	Mean survival jassid population per plant days after spraying								
			2			5			15 and 21		
			R-I	R-II	Mean	R-I	R-II	Mean	R-I	R-II	Mean
9.	Achook 0.5% alternated with	7.30	8.75	9.60	9.17	4.70	6.35	5.52	17.40	21.27	19.33
	Cypermethrin 0.01%	(2.69)	(2.95)	(3.09)	(3.02)	(2.16)	(2.52)	(2.34)	(4.17)	(4.61)	(4.39)
10.	ZA-199 0.5% alternated with	5.30	7.80	9.55	8.67	3.90	5.05	4.47	16.40	18.27	17.33
	Cypermethrin 0.01%	(2.30)	(2.79)	(3.09)	(2.94)	(1.97)	(2.24)	(2.11)	(4.05)	(4.27)	(4.16)
11.	NSKE 5% alternated with	6.20	8.90	9.20	9.05	4.10	5.50	4.80	17.93	17.73	17.83
	Cypermethrin 0.01%	(2.48)	(2.98)	(3.03)	(3.00)	(2.02)	(2.34)	(2.18)	(4.23)	(4.21)	(4.22)
12.	Achook 0.5% alternated with	6.10	7.60	7.10	7.35	3.30	4.50	3.90	15.60	17.37	16.48
	Imidacloprid 0.004%	(2.47)	(2.75)	(2.66)	(2.71)	(1.81)	(2.12)	(1.96)	(3.95)	(4.16)	(4.05)
13.	ZA-199 5% alternated with	6.70	8.05	9.15	8.60	4.30	3.80	16.95	16.35	16.35	16.65
	Imidacloprid 0.004%	(2.58)	(2.83)	(3.02)	(2.93)	(2.07)	(2.01)	(4.11)	(4.04)	(4.04)	(4.08)
14.	NSKE 5% alternated with	7.55	7.70	9.85	8.77	3.80	5.15	4.47	16.33	17.27	16.80
	Imidacloprid 0.004%	(2.74)	(2.77)	(3.13)	(2.95)	(1.94)	(2.26)	(2.10)	(4.04)	(4.15)	(4.09)
15.	Cypermethrin 0.01%	3.90	8.15	8.15	8.15	4.60	4.30	4.45	15.73	18.13	16.93
		(1.97)	(2.85)	(2.85)	(2.85)	(2.14)	(2.07)	(2.10)	(3.96)	(4.25)	(4.11)
16.	Imidacloprid 0.004%	3.40	6.90	6.90	6.90	3.30	3.50	3.40	15.50	16.55	16.02
		(1.84)	(2.62)	(2.62)	(2.62)	(1.81)	(1.87)	(1.84)	(3.93)	(4.06)	(4.00)
17.	Untreated control	7.50	19.85	21.80	20.82	20.55	20.65	20.60	21.10	27.47	24:28
		(2.73)	(4.45)	(4.66)	(4.56)	(4.53)	(4.54)	(4.53)	(4.59)	(5.24)	(4.91)
	S.E.±	0.10			0.08			0.10			0.12
	C.D. at 5%	N.S.			0.24			0.30			0.36

Figures in parentheses are means of $\sqrt{x + 0.5}$ transformed values

Treatments 1 to 8 given at 15 days and treatments 9 to 16 given at 21 days interval

Fig. 8. Effect of number and application interval of neem formulations in alternation with synthetic insecticides against aphids infesting okra

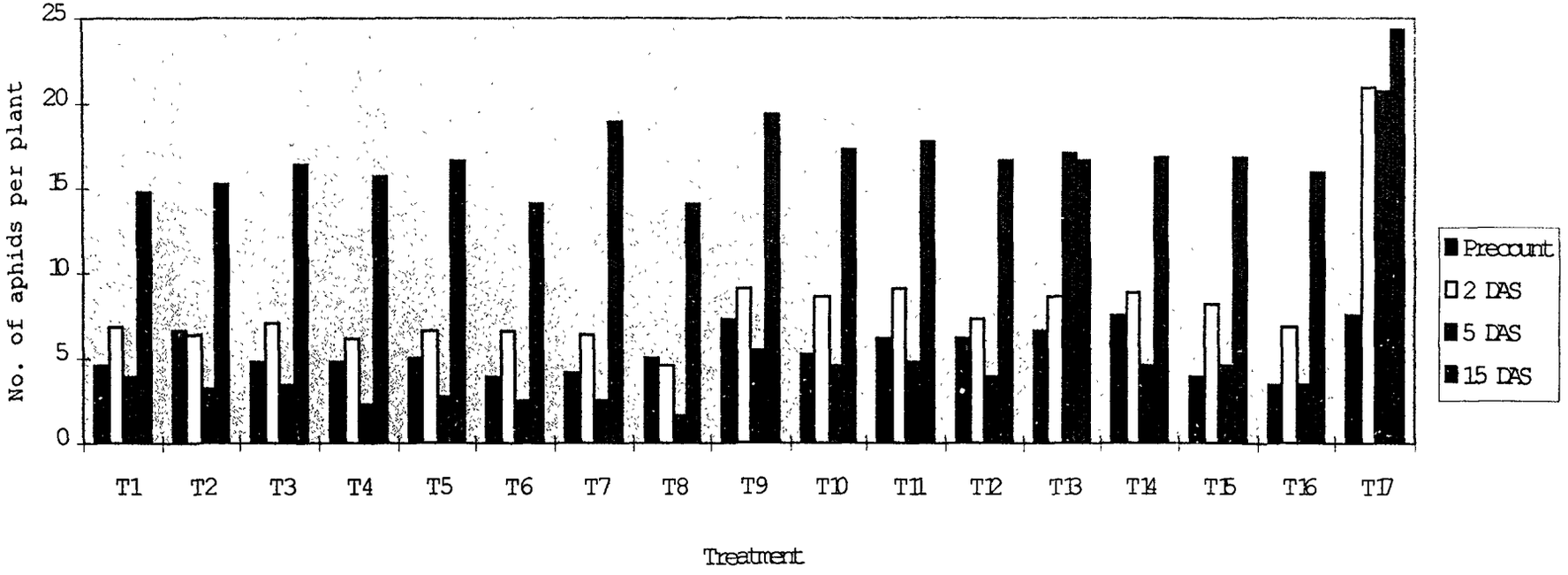


Plate 3: a) Symptomes of jassid injury on leaf.

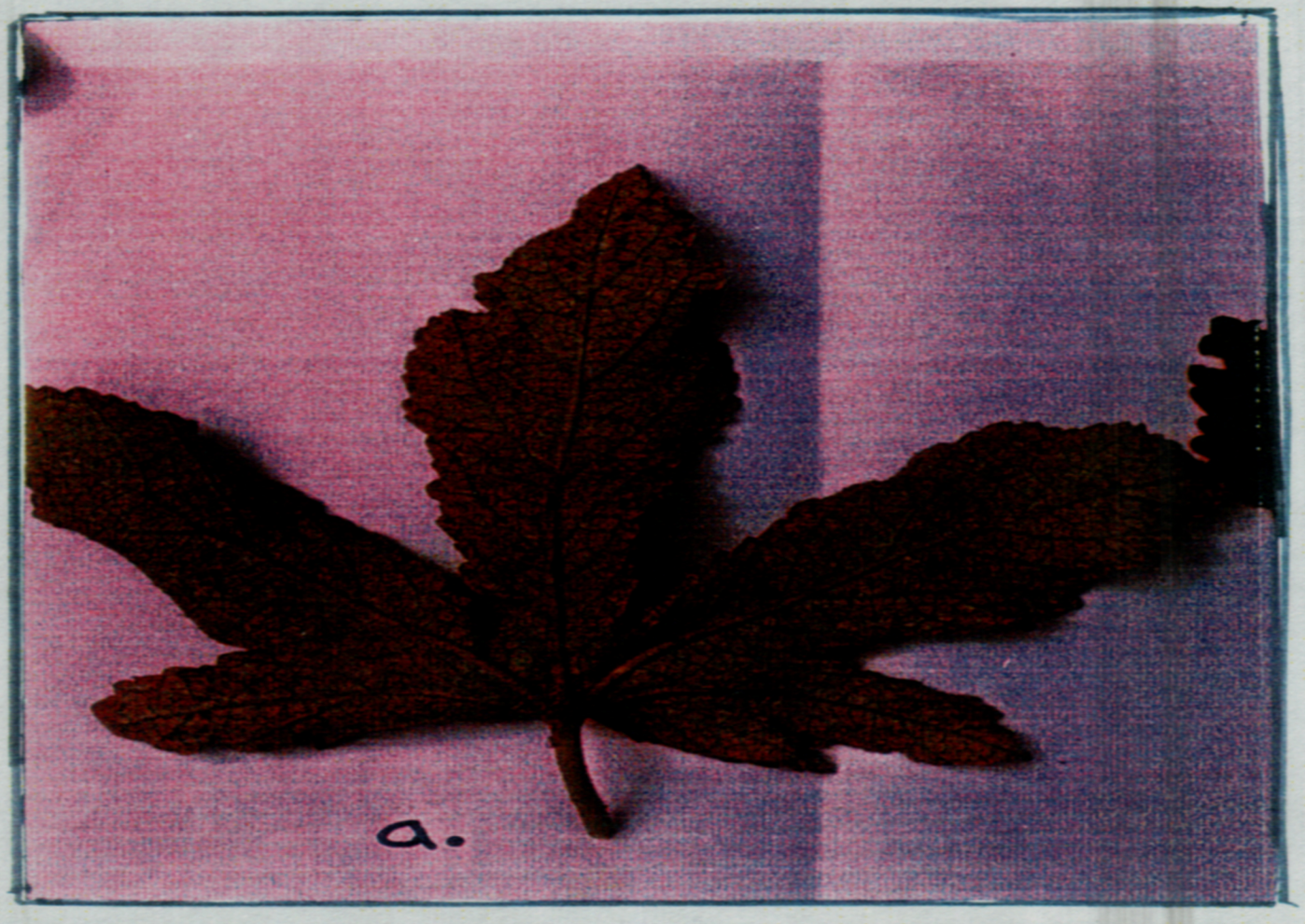


Plate 4: a) Symptoms of mite injury on leaf

Observations on survival population of aphids recorded 5 days after spraying indicated that the average survival population of aphids per plant ranged from 1.53 to 5.52 as against 20.60 aphids in untreated control. Among the treatments, 4 sprays of imidacloprid 0.004% was the most effective treatment which recorded 1.53 aphids per plant followed by Achook 0.5% alternated with imidacloprid 0.004% with 4 sprays (2.37 aphids per plant). The second most effective treatment was 4 sprays of cypermethrin 0.01% which recorded 2.43 aphids followed by NSKE 5% alternated with imidacloprid 0.004%, ZA-199 0.5% alternated with imidacloprid 0.004%, ZA-199 0.5% alternated with cypermethrin 0.01% all with 4 sprays and 3 sprays of imidacloprid 0.004% recorded 2.57, 2.73, 3.18 and 3.40 aphids per plant respectively, and were on par.

The data on the survival population of aphids recorded 15 days after spraying revealed that the average aphid number per plant ranged from 14.02 to 19.33 in insecticidal treatment as against 24.28 in untreated control. imidacloprid 0.004% with 4 sprays was found to be the most effective treatment which recorded 14.02 aphids per plant and was on par with rest of the treatments except the treatment with cypermethrin 0.01%, Achook 0.5%, ZA-199 0.5% and NSKE 5% all alternated with cypermethrin 0.01% with 3 sprays at 21 days interval.

From table 8 it is evident that all the insecticidal treatments were found superior in checking aphid population on okra, in comparison with untreated control. The 4 sprays of imidacloprid 0.004% was found to be the most effective treatment at 2, 5 and 15 days after spraying. The second most effective treatment was Achook 0.5% and ZA-199 0.5% both alternated with imidacloprid 0.004%, ZA-199 0.5% alternated with cypermethrin 0.01% and cypermethrin 0.01% all with 4 sprays at 15 days interval were found to be the next effective treatments against aphids. The treatments with Achook 0.5%, ZA-199 0.5% and NSKE 5% when alternated with imidacloprid 0.004% were also found effective at 21 days after spraying.

Studies were carried by Mote *et al.* (1994), Mote *et al.* (1995) and Sreelatha and Divakar (1997) on effectiveness of imidacloprid 70 WS as seed dresser against sucking pests. Similarly, Lucas *et al.* (1999) studied imidacloprid as foliar spray, for the control of aphids in okra and reported effective control of aphids for 10 days after application. Calafiori (1998) used imidacloprid 0.25 lit./ha and reported 80% control of aphids with effect up to 20 days. The present observations are in conformity with the findings of these workers.

Sasamma Jacob and Sheila (1996) reported that cypermethrin at 0.02% was most effective against aphids up to 14 days after spraying. The present findings on effectiveness of cypermethrin are also in conformity with the results obtained in the present studies.

Bari (1995) reported the effective control of sucking pests of cotton when neem seed kernel extract was alternated with fenvalerate.

4.3 Effect of synthetic insecticides and neem formulations alternated with synthetic insecticides on the population build up of red spider mites (*Tetranychus* spp.)

The effect of synthetic insecticides and neem formulations alternated with synthetic insecticides on the population build up of okra red spider mites, was studied and the data obtained on the population build up of mites in various treatments are presented in Table 9 and depicted graphically in Fig. 9.

It was observed that the incidence of red spider mites in the treatments was not noticed after first and second sprayings. However, mite population flared up in the treatments after third spraying only.

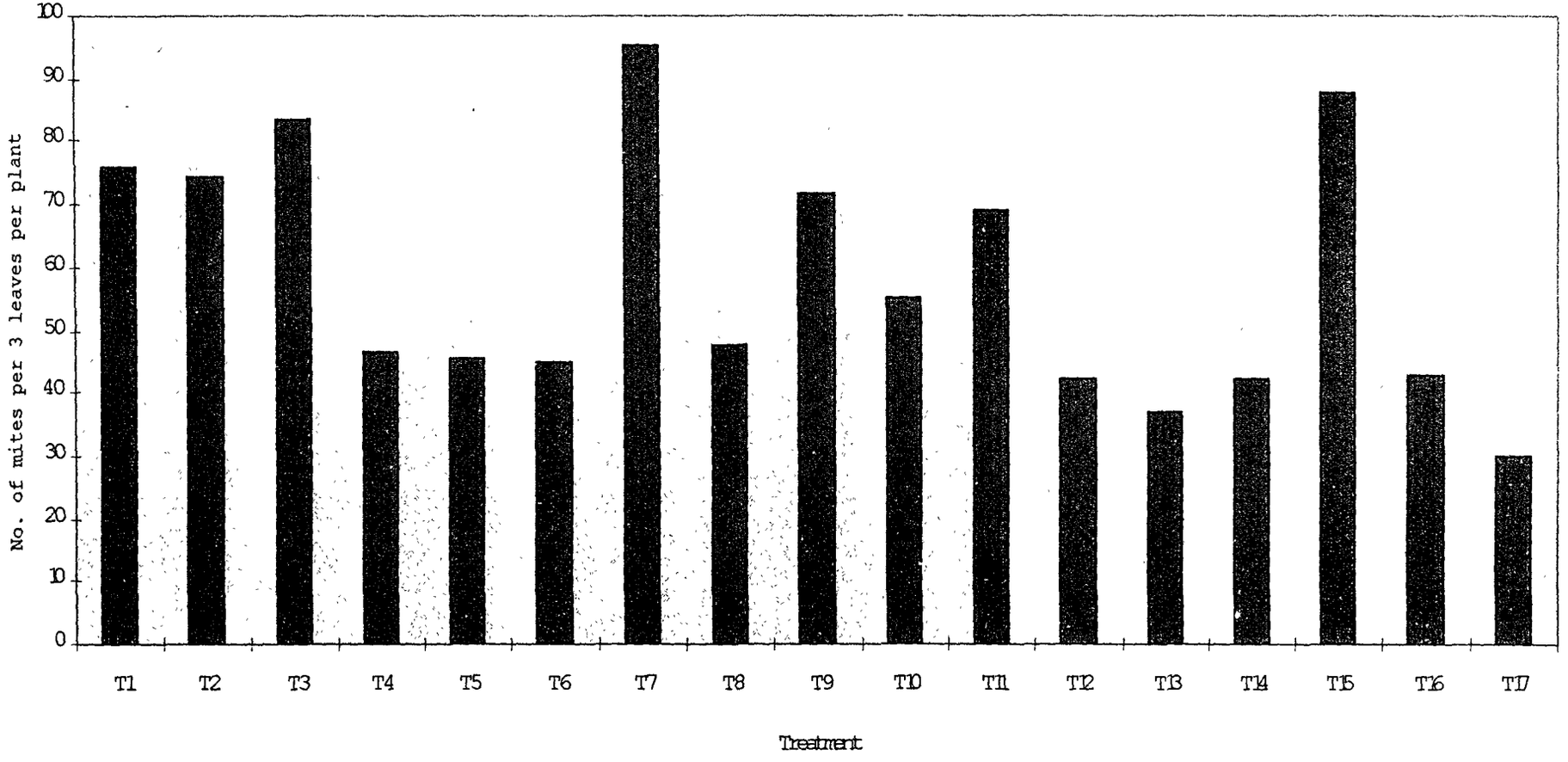
The average mite population in the treatments ranged from 36.86 to 95.23 as against 29.85 in untreated control. This indicated that all the insecticidal treatments showed higher mite population than untreated control.

Table 9. Effect of synthetic insecticides alone and neem formulations in alternation with synthetic insecticides on the population build-up of red spider mite *Tetranychus* spp.

Sr. No.	Treatment	Number of mites per 3 leaves per plant		
		R-I	R-II	Mean
1.	Achook 0.5% alternated with Cypermethrin 0.01%	64.57 (8.03)	87.65 (9.36)	76.11 (8.69)
2.	ZA-199 0.5% alternated with Cypermethrin 0.01%	23.55 (4.85)	125.22 (11.19)	74.38 (8.02)
3.	NSKE 5% alternated with Cypermethrin 0.01%	34.70 (5.89)	132.55 (11.51)	83.62 (8.70)
4.	Achook 0.5% alternated with Imidacloprid 0.004%	47.10 (6.86)	45.50 (6.70)	46.34 (6.78)
5.	ZA-199 0.5% alternated with Imidacloprid 0.004%	29.55 (5.43)	61.12 (7.81)	45.33 (6.62)
6.	NSKE 5% alternated with Imidacloprid 0.004%	27.12 (5.20)	62.72 (7.92)	44.92 (6.56)
7.	Cypermethrin 0.01%	66.72 (8.16)	123.75 (11.12)	95.23 (9.64)
8.	Imidacloprid 0.004%	49.72 (7.06)	45.40 (6.73)	47.66 (6.90)
9.	Achook 0.5% alternated with Cypermethrin 0.01%	46.52 (6.82)	97.10 (9.85)	71.81 (8.33)
10.	ZA-199 0.5% alternated with Cypermethrin 0.01%	24.22 (4.92)	86.30 (9.29)	55.26 (7.10)
11.	NSKE 5% alternated with Cypermethrin 0.01%	49.27 (7.01)	88.55 (9.41)	68.91 (8.21)
12.	Achook 0.5% alternated with Imidacloprid 0.004%	49.15 (7.01)	35.32 (5.94)	42.23 (6.47)
13.	ZA-199 5% alternated with Imidacloprid 0.004%	26.42 (5.14)	47.30 (6.87)	36.86 (6.00)
14.	NSKE 5% alternated with Imidacloprid 0.004%	38.95 (6.24)	45.70 (6.76)	42.32 (6.50)
15.	Cypermethrin 0.01%	26.95 (5.19)	148.07 (12.16)	87.51 (8.68)
16.	Imidacloprid 0.004%	37.55 (6.12)	48.27 (6.94)	42.91 (6.53)
17.	Untreated control	22.50 (4.74)	37.20 (6.09)	29.85 (5.42)
	S.E.±			1.16
	C.D. at 5%			N.S.

Figures in parentheses are means of arcsin transformed values
Treatments 1 to 8 given at 15 days and treatments 9 to 16 given at 21 days interval

Fig. 9. Effect ofsynthetic insecticides alone and neem formulations alternate with synthetic insecticides on the population build-up of red spider mite Tetranychus spp.



The mite population was higher in the treatments comprising with 4 and 3 sprays of cypermethrin 0.01% which registered 95.23 and 87.51 mites per plant, respectively. The data on population build up of mites in the treatments of neem formulations alternated with synthetic insecticides revealed that comparatively higher population of mites was observed in the treatments of neem formulations alternated with cypermethrin than the treatments of neem formulations alternated with imidacloprid.

The treatments of neem formulations *viz.*, NSKE 5%, Achook 0.5% and ZA-199 0.5% all alternated with cypermethrin 0.01% comprising 4 sprays at 15 days interval recorded 83.62, 76.11 and 74.38 average mite population per plant and the treatments of neem formulations *viz.*, Achook 0.5% NSKE 5%, ZA-199 0.5% all alternated with cypermethrin 0.01% comprising 3 sprays at 21 days interval recorded, 71.81, 68.91, 55.26 average mite population.

These observations revealed that the treatments of neem formulations alternated with cypermethrin comprising 4 sprays at 15 days interval recorded comparatively higher population of mites than the treatments of neem formulations alternated with cypermethrin comprising 3 sprays at 21 days interval.

Both the treatments of imidacloprid 0.004% comprising 4 and 3 sprays and all the treatments of neem formulations alternated with imidachloprid comprising of 4 and 3 sprays at 15 and 21 days interval showed lower level of mite population.

Basha *et al.* (1982) conducted field trials for the control of brinjal shoot and fruit borer and revealed that cypermethrin appeared to cause outbreak of tetranychid mite. Similarly, David and Kumarswami (1989), Sandhu *et al.* (1987) and Watson *et al.* (1985) reported that the repeated use of pyrethroids like cypermethrin resulted in resurgence of *T.cinnabarinus*. The present observations regarding resurgence of mites in cypermethrin treatment are on the lines of findings of these workers.

The over all observations recorded on average population of mites in various treatments indicated that the population build up of mites was noticed in the plots treated with pyrethroid insecticide *viz.*, cypermethrin and the treatments of neem formulations alternated with cypermethrin. This proved that the repeated use of synthetic insecticides particularly pyrethroids increases the mite population.

SUMMARY AND CONCLUSIONS

5. SUMMARY AND CONCLUSION

5.1 Summary

Okra *Abelmoschus esculentus* Linn. under ideal conditions and good management gives quite high yield. The crop is grown all the year round in different parts of Maharashtra State. A number of insect pests, mites and nematodes infest this crop during different growth stages, which causes serious damage. The damage caused by these pests is one of the limiting factors for low productivity in okra. Therefore, pest management is must to realise the full potential of okra.

In the present study, use of pesticides based on neem being good alternative to synthetic insecticides, were tested in alternation with synthetic insecticides against pest complex of okra at Entomology Section, College of Agriculture, Pune during summer 2001.

Three promising neem formulations *viz.*, Achook, ZA-199 and neem seed kernel extract (NSKE) alternated with two synthetic insecticides *viz.*, cypermethrin and imidacloprid were used. The effect of number and application interval of neem formulations in alternation with synthetic insecticides was also studied to exploit the possibility of reducing one spray of insecticide by increasing the spray interval from 15 to 21 days.

The results of this investigation are summarised and concluded in this chapter.

5.1.1 Bioefficacy of promising neem formulations in alternation with synthetic insecticides against okra pest complex

Shoot and Fruit borer

The treatment with cypermethrin 0.01% registered 8.055 and 4.95% average fruit infestation considering number and weight basis, respectively and was found to be the most superior among all the insecticidal treatments. All the neem formulations *viz.*, Achook 0.5% ZA-199 0.5 and NSKE 5%

when alternated with cypermethrin 0.01% recorded 9.92, 11.57, 10.86% on number basis and 5.52, 5.87, 5.88% on weight basis fruit infestation, respectively and imidacloprid 0.004% registered 10.17% and 5.23 fruit infestation on number and weight basis respectively, indicating effectiveness of these treatments against fruit borer *E. vittella* infesting okra.

Jassids

The survival population of jassids in treatment with imidacloprid 0.004% was found to be minimum i.e., 1.03, 1.25, 5.10 jassids at 2, 5 and 15 days after spraying, respectively. The next promising treatment was cypermethrin 0.01% which recorded 4.78, 3.21 and 9.51 jassids at 2, 5 and 15 days after spraying. Achook, ZA-199 and NSKE when alternated with synthetic insecticides *viz.*, imidacloprid and cypermethrin were found as effective as cypermethrin 0.01% in checking the jassid population.

Aphids

The imidacloprid 0.004% was found to be the most superior treatment recording 2.60, 0.80, 5.10 aphids at 2, 5 and 15 days after spraying followed by cypermethrin 0.01% which recorded 4.03, 0.91, 7.55 aphids at 2, 5 15 days after spraying. The neem formulations when alternated with synthetic insecticides and the neem formulation treatments *viz.*, Achook 0.5% and NSKE 5% were found to be as effective as imidacloprid in controlling the aphids.

5.1.1 Effect of number and application interval of promising neem formulations in alternation with synthetic insecticides.

Shoot and Fruit Borer

On number basis, the treatment with cypermethrin 0.01% comprising 4 sprays at 15 days interval recorded 7.32% average fruit infestation and it was found to be the most superior among all the insecticidal treatments.

The neem formulations *viz.,* Achook 0.5% and ZA-199 0.5% when alternated with cypermethrin 0.01%, comprising 4 sprays were found to be the next effective treatments which registered 8.36 and 8.93% fruit infestation, respectively.

On weight basis, the treatment with cypermethrin 0.01% comprising 4 sprays registered 5.19% fruit infestation was found to be most effective followed by the treatments of neem formulations *viz.,* Achook 0.5 % and ZA-199 0.5% alternated both with cypermethrin 0.01% and imidacloprid 0.004% comprising 4 sprays recorded 5.67, 5.76, 5.94 and 5.92% fruit infestation, respectively and cypermethrin 0.01% comprising 3 sprays, which registered 6.14% fruit infestation.

Jassids

The average survival population of jassid was least in imidacloprid 0.004% both with 4 and 3 sprays application at 2 days after spraying, which registered 5.15 and 5.93 jassids/plant, respectively. All the rest of the treatments were on par with imidacloprid except treatment comprising 3 sprays of NSKE 5% alternated with cypermethrin 0.01%.

At 5 days after spraying the treatment with imidacloprid 0.004% comprising 4 and 3 sprays was found to be most effective which registered 1.62 and 2.13 jassids/plant respectively, followed by the treatment with Achook 0.5% alternated with imidacloprid 0.004% comprising 4 sprays which registered 2.12 jassids/plant.

At 15 days after spraying the most effective treatment was imidacloprid comprising 4 sprays which recorded 8.80 jassids followed by the treatments with Achook 0.5% and NSKE 5% both alternated with imidacloprid 0.004% comprising 4 sprays which recorded 9.51 and 9.65 jassids/plant, respectively.

Aphids

The effect of various treatments indicated that at 2 days after spraying imidacloprid 0.004% was found to be the most effective treatment against aphids which registered 4.63 aphids per plant, followed by Achook 0.5% alternated with imidacloprid 0.004% comprising 4 sprays, which registered 6.03 aphids per plant.

At 5 days after spraying, the treatment with imidacloprid 0.004% comprising 4 sprays (1.53 aphids/plant) followed by Achook 0.5% alternated with imidacloprid 0.004% comprising 4 sprays was most effective against aphids (2.37 aphids/plant).

At 15 days after spraying, imidacloprid 0.004% alone comprising 4 sprays was found to be most effective recording 14.02 aphids/plants followed by the neem formulations *viz.*, Achook 0.5%, ZA-199 0.5% and NSKE 5% all alternated with synthetic insecticides *viz.*, cypermethrin 0.01% and imidacloprid 0.004%.

5.1.3 Effect of synthetic insecticides and neem formulations alternated with synthetic insecticides on population build up of red spider mites

It was found that the mite population was higher in the treatments comprising 4 and 3 sprays of cypermethrin 0.01% which registered 95.23 and 87.51 mites per plant, respectively.

The treatments with neem formulations when alternated with cypermethrin comprising 4 sprays at 15 days interval recorded comparatively higher population of mites than the treatments of neem formulations alternated with cypermethrin comprising 3 sprays at 21 days interval.

The treatments with imidacloprid 0.004% comprising 4 and 3 sprays and all the treatments of neem formulations alternated with imidacloprid comprising 3 and 4 sprays at 21 and 15 days interval respectively, showed

lower level of mite population. The least population of 29.85 mites was observed in untreated control.

5.2 CONCLUSIONS

Following conclusions have been drawn from the results obtained in the present investigations.

Three sprays of cypermethrin 0.01% alone was the most effective against fruit borer, *E.vittella* followed by treatments with neem formulations *viz.*, Achook 0.5%, ZA-199 0.5% and NSKE 5% alternated with cypermethrin 0.01% comprising 4 sprays.

Three sprays of imidacloprid 0.004% and 4 sprays of cypermethrin 0.01% alone were found to be promising against jassids and aphids infesting okra. The treatments with neem formulations when alternated with Imidacloprid and cypermethrin were also effective against jassids, where as, neem formulations in alternation with synthetic insecticides and neem formulations alone *viz.*, Achook 0.5% and NSKE 5% comprising 4 sprays were found to be effective against aphids.

The population build up of mites was found to be higher in the plots treated with cypermethrin and neem formulations alternated with cypermethrin. This proved that the repeated use of synthetic insecticides particularly pyrethroides increases the mite populations.

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- Originals not seen.

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