"EFFICACY OF SELECTED NEEM OIL FORMULATIONS AGAINST IMPORTANT PESTS OF BRINJAL"

By

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CERTIFICATE

Ms. **G. ANITHA** has satisfactorily prosecuted the course of research and that the thesis entitled "EFFICACY OF **SELECTED NEEM OIL FORMULATIONS AGAINST IMPORTANT PESTS OF BRINJAL"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: 13.8.97

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CERTIFICATE

This is to certify that the thesis entitled "**EFFICACY OF SELECTED NEEM OIL FORMULATIONS AGAINST IMPORTANT PESTS OF BRINJAL**" submitted in partial fulfilment of the requirements for the degree of **Master of Science** in Agriculture in the major field of **Entomology** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafied research work carried out by Ms. G. **ANITHA** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigation have been duly acknowledged by the author of the thesis.

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DECLARATION

I, Ms. G. ANITHA hereby declare that the thesis entitled "**EFFICACY OF SELECTED NEEM OIL FORMULATIONS AGAINST IMPORTANT PESTS OF BRINJAL**" submitted to the Acharya N.G. Ranga Agricultural University for the degree of Master of Science in Agriculture in the major field of Entomology is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier.

Date: 13/08/97

Anitha G

[G. ANITHA]

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LIST OF ABBREVIATIONS

a.i.	:	active ingredient
@	:	at the rate of
cm	:	centimetres
CD (P=0.05)	:	Critical difference at 5 per cent probability
DAS	:	days after spraying
etc	:	etcetra
Fig.	:	figure
g	:	grams
ha	:	hectare
hrs	:	hours
kg	:	kilograms
l	:	litres
m	:	metres
MT	:	Metric tons
µg	:	micrograms
viz.,	:	namely
NS	:	non-significant
ppm	:	parts per million
A^{-1}	:	per acre
%	:	per cent
ha^{-1}	:	per hectare
$plot^{-1}$	:	per plot
$pupa^{-1}$	:	per pupa
Sig.	:	significant
m^2	:	square metres
i.e.	:	that is
t	:	tons

ABSTRACT

Name of the Author	:	**G. ANITHA**
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A field experiment to evaluate the efficacy of certain selected neem oil formulations against the pests of brinjal, their damage potential and natural enemies was conducted at Agricultural College Farm, Bapatla during Rabi, 1996-97 with eleven treatments replicated thrice in a simple randomised block design. The pests and natural enemies observed were shoot and fruit borer, Leucinodes orbonalis Guen., jassid, Amrasca biguttula biguttula Ish., whitefly, Bemisia tabaci Genn.; aphid, Aphis gossypii (Glov.) and predatory beetles, Verania vincta and Menochilus sexmaculatus.

The first spraying was scheduled at 40 days after planting to synchronise with the appearance of jassids, whiteflies, aphids and shoot and fruit borer. Thereafter the treatments were imposed at fortnightly interval. A total of six sprayings were imposed during the experimental period. Pest and predatory population counts were recorded one day before and one, five and ten days after each spray. The damage by shoot and fruit borer was assessed in terms of per cent infestation of shoots and fruits.

The results obtained were summarised as follows.

All the treatments recorded lower pest populations of all the insect pests studied and higher yields than the untreated check. Neemgold 0.25%, Neemol (1.5%) and Multineem (1.5%) recorded significantly lesser damage to shoots and fruits compared to untreated check, thus proving their efficacy against this pest. Endosulfan proved to be highly effective against the sucking pest complex viz., jassids, aphids and whiteflies by recording significantly lower populations than untreated check. The neem formulations were found to be more safer to predatory beetles than endosulfan as they recorded higher beetle populations. Neemol (1.5%) registered the maximum yield.

INTRODUCTION

CHAPTER I

INTRODUCTION

Brinjal, *Solanum melongena* Linn. is an important commercial vegetable crop and is grown all over the world. It is grown in an area of 556 thousand ha in the world with a production of 8979 thousand MT and in Asia in an area of 501 thousand ha with a production of 7791 thousand MT (FAO, 1994). In Andhra Pradesh it is grown in an area of 16929 ha (Statistical Abstract of Andhra Pradesh, 1994) and is the most common, popular and principal vegetable crop grown for its fruits which are boiled, fried or baked. It is eaten by the rich and poor alike, hence called as 'Common Man's Vegetable'.

Brinjal is high in nutritive value, containing 4.0 per cent carbohydrates, 1.4 per cent proteins, 0.3 per cent fats, 0.018 per cent calcium, 0.0009 per cent iron and 0.047 per cent phosphorus. It is rich in vitamin 'C' (0.012 per cent). It has got much potential as raw material in pickle making and dehydration industries (Singh *et al.*, 1963). White brinjal is said to be good for diabetic patients (Choudhury, 1976). The fruit fried in til oil cures toothache and acts as an excellent remedy for those suffering from liver complaints (Chauhan, 1981).

Insect and non-insect pest infestation is one of the most limiting factors for accelerating yield potential of brinjal (Som and Maity, 1986). Nair (1975) reported as many as 51 insect and mite pests on this crop. Some of the commonly occurring pests on brinjal are shoot and fruit borer, Leucinodes orbonalis Guen., spotted beetle, Henosepilachna vigintioctopunctata Fabricius; whitefly, Bemisia tabaci Genn.; aphid, Aphis gossypii (Glov.), jassid, Amrasca biguttula biguttula Ish.; tingid bug, Urentius hystricellus Dist., red spider mite, Tetranychus telarius etc. For the control of these pests, chemical pesticides are being used indiscriminately. The extensive and indiscriminate use of synthetic organic insecticides has led to the development of several deletrious effects such as resistance in insects against pesticides, pest resurgence, secondary infestation, pesticide residues, destruction of non-target and beneficial organisms like parasitoids and predators, atmospheric pollution, high input cost etc. Above all, being a vegetable crop, fruits are used immediately after harvest. Hence pesticides of non-persistant nature and non-toxic to human beings are to be used especially in the fruiting stage. So there is a need to utilise the new groups of chemicals which are eco-friendly and effective, with relatively less mammalian toxicity. In this direction, the use of neem products is becoming more common now-a-days in pest management of various crops. Neem oil exhibits a multimode action i.e., it acts as an insecticide, antifeedant, repellent, ovipositional deterrent, hormone mimic, growth regulator, growth inhibitor. It is not harmful to the natural fauna, is safe to the user and is not expensive. So it is gaining prominence as a key component of integrated pest management programmes all around the world. As such the pesticidal industries developed a number of neem oil formulations and released into the market.

The vegetable growers in this area are also using neem oil formulations against the pest complex of brinjal. As a variety of neem oil formulations are available in the local market, it is highly essential to study their efficacy against the major pests of brinjal. Keeping this in view, the present studies were undertaken to test the efficacy of certain locally used selected neem formulations with the following objectives:-

(1) To evaluate the efficacy of certain selected formulations of neem oil on the incidence of various pests of brinjal.

(2) To study the efficacy of these selected products on the damage potential of brinjal shoot and fruit borer, *L. orbonalis*.

(3) To study the effect of these neem products on natural enemies.

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

The information regarding the efficacy of certain selected neem oil formulations and endosulfan on major pests of brinjal and their impact on yield in India and elsewhere has been reviewed and presented below.

2.1 NEEM OIL AND NEEM SEED PRODUCTS

Neem oil is obtained from the seed kernels of the tree, Azadirachta indica, A. Juss and possess maximum insecticidal activity among different parts of the tree (Singh, 1993). National Research Council (1992) reported that neem oil contains compounds like Salanin and Meliantriol besides azadirachtin, which are also useful in the control of some insects. Azadirachtin is known to have anti-feedant, anti-ovipositional, growth disrupting and fecundity reducing properties against different insects as reported by Schmutterer (1990).

According to Rajan Asari and Nair (1972) 1.0 per cent neem seed suspension recorded 74.51 per cent fruit damage by brinjal fruit borer, Leucinodes orbonalis Guen. which was on par with control (83.02%). Mohan (1988) reported that neem oil 3.0 per cent and neem seed kernel extract 5.0 per cent effectively checked the infestation of *L. orbonalis* on brinjal. Udaiyan and Ramarathinam (1994) recorded 39.94 per cent reduction of shoot and fruit borer incidence on brinjal with 1.0 per cent neem oil.

As the literature on the effect of neem oil and neem seed products against brinjal shoot and fruit borer is meagre, literature pertaining to their effect on other lepidopterous internal feeders is also reviewed hereunder.

Thangavel *et. al.* (1975) observed considerable reduction of bollworm incidence on cotton treated with neem oil @ 10 l ha^{-1}. According to Kadam (1976) the application of neem oil 0.25 per cent against *Plutella xylostella* (Linn.) on mustard resulted in 30.14 and 77.25 per cent mortality at 24 and 72 hrs after treatment respectively. Gujar and Mehrotra (1983) recorded 100 per cent pupal mortality of *Spodoptera litura* Fabr. when treated with neem oil @ 200 µg $pupa^{-1}$ and pupal-adult intermediates with 100 µg $pupa^{-1}$. Neem oil @ 10 l ha^{-1} reduced the infestation of rice stem borer and recorded 8.1 per cent white ears as against 14.9 in control (Krishnaiah and Kalode, 1984). Shelke *et. al.* (1985) tested seven vegetable oils against the ovipositional activity of tubermoth, Pthorimaea operculella (Zeller) and concluded that neem oil 0.05 per cent and 0.1 per cent registered 91.96 to 100 per cent ovipositional deterrence. Kumar and Sangappa (1986) observed significant reduction of damage caused by Heliothis armigera (Huebner) on bengalgram sprayed with 3.0 per cent neem oil. Kathiravel (1988) recorded only 1.44 per cent bhendi fruit damage by Earias vitella (F.) with 3.0 per cent neem oil as against 37.71 per cent in control. Venkateswarlu et. al. (1988) concluded that neem oil 8.0 and 16.0 per cent exhibited complete repellency to larvae of S. litura in urdbean. Neem oil at 25, 50, 100, 250, 500, 1000 and 2000 ppm was found to deter the feeding of rice skipper, Pelopidas mathias F. and army worm, Mythimna separata (Walker) (Suresh et. al., 1989). Krishnaiah and Kalode (1990) reported that neem cake (150 kg ha^{-1}) incorporated in soil followed by neem oil 3.0 per cent sprays at ten days interval effectively checked the leaf folder, Cnaphalocrocis medinalis Linn. on rice. Neem oil 1.0 per cent was found to be superior to other plant products against S. litura on chillies as reported by Rajasri (1990). Neem oil 0.1, 0.3 and 0.5 per cent showed poor persistent toxicity against freshly emerged larvae of bhendi fruit borer, E. vitella 24 hrs after treatment (Samuthiravelui and David, 1990). Venugopal Rao *et. al.* (1990) recorded 14.8 per cent square damage on cotton by *Helicoverpa armigera* (Huebner) with neem oil 1.0 per cent that differed significantly from untreated check (30.4). Mallikharjuna Rao (1995) observed effective control of *S. litura* on chillies by the application of neem cake @ 500 kg ha^{-1} as basal dressing followed by weekly sprays of 1.0 per cent neem oil.

Neem seed suspension 1.0 per cent recorded a jassid (*Amrasca biguttula biguttula* Ish.) population of 82.3 per plant one day after treatment on brinjal which was on par with pretreatment count of 87.3 as reported by Rajan Asari and Nair (1972). Sardana and Krishnakumar (1989) concluded that neem oil at 0.5, 1.0 and 2.0 per cent recorded higher population of leaf hopper, *A. biguttula biguttula* on okra compared to check insecticide Monocrotophos 0.5 per cent. Bhendi plots that received only neem oil 1.0 per cent throughout the crop growth recorded higher population of jassid, *A. biguttula biguttula* than the plots that received alternate sprays of conventional insecticides and neem oil (Bhavani Sankara Rao, 1990). Venugopal Rao *et. al.* (1990) stated that neem oil 0.5 per cent recorded lower population of jassid (*A. biguttula biguttula*) compared to control on cotton. According to Brar *et. al.* (1994) 15 1 of 2.0 per cent neem oil per hectare was effective against the cotton jassid, *A. biguttula biguttula*.

Brown plant hopper on rice, *Nilaparvata lugens* (Stal.) was observed to avoid the plants sprayed with 3.0, 5.0 and 12.0 per cent crude emulsified neem oil as reported by Saxena *et. al*. (1981). Mariappan and Saxena (1983) reported only 2.5 per cent survival of rice leaf hopper (*Nephotettix virescens* Distant) two days after treating with 3.0 and 5.0 per cent neem oil; survival was near zero three days after feeding in most of the neem treatments. Neem oil 2.0 per cent was found to give 90 per cent mortality of *N. virescens* on rice one day after spraying as reported by Krishnaiah and Kalode (1984). Neem oil @ 10 l and 15 l per hectare was reported less effective and inferior in reducing the population of leaf hopper, *Empoasca fascialis* on egg plant, although it increased the yield significantly at 10 l ha^{-1} while aqueous extract of 25 or 50 g pulverized neem seed kernels per litre gave good reduction in infestation and damage especially at higher concentration (Dreyer, 1987). Saxena and Khan (1988) reported that the crude oil expelled from decorticated neem seeds at 50 per cent reduced the survival of plant hopper, *N. lugens* and suppressed the transmission of viral diseases of rice.

Neem oil 4.0 per cent was found effective against rice leaf hopper, *N. virescens* by recording 3.8 and 3.2 hoppers per 10 hills as compared to 48.3 and 47.8 in control in two different experiments conducted by Nigam and Sen (1989).

Coudriet *et. al.* (1986) observed 100 per cent mortality of immature stages of sweet potato whitefly, *Bemisia tabaci* Genn. with 2.0 per cent aqueous solution of neem seed extract; reduction of egg viability and oviposition, prolonged larval period and increased larval mortality were also observed. Natarajan *et. al.* (1986) reported that spraying neem oil 4.5 l ha^{-1} (5 ml oil and 1 ml of teepol mixed per litre of water) suppressed whitefly, *B. tabaci* on cotton. According to Natarajan and Sundaramurthy (1990) 14.3 and 13.0 per cent nymphs of cotton whitefly, *B. tabaci* reached adult stages after treating with 0.5 and 1.0 per cent neem oil respectively while 84.3 per cent of nymphs reached adult stage with monocrotophos (0.08%). Venugopal Rao *et. al.* (1990) reported significant reduction in the population of cotton whitefly, *B. tabaci* with 0.5 and 1.0 per cent neem oil.

Cherian and Gopala Menon (1944) recorded 100 per cent mortality of *Aphis gossypii* (Glov.) and *Aphis malvae* with an emulsion of 0.5 ounce of neem oil and 0.5 ounce of soap per gallon of water. They also reported that neem seed kernel infusion of 0.25 ounce and 0.25 ounce soap per gallon of water gave 75 per cent mortality of A. gossypii while it was 82 per cent without soap. Rajan Asari and Nair (1972) concluded that 1.0 per cent neem seed suspension did not record significant reduction in population of A. gossypii on brinjal. Mohan (1988) observed that root dipping of brinjal seedlings in 3.0 per cent neem oil followed by a spray with 5.0 per cent neem seed kernel extract significantly reduced the infestation of aphid, A. gossypii. 41.17 to 42.67 per cent redction in aphid infestation was reported by Bhavani Sankara Rao (1990) with 1.0 per cent neem oil. No incidence of aphid, A. gossypii was recorded in cotton grown in rice fallows after treating with 0.1 per cent neem oil as reported by Venugopal Rao et. al. (1990).

Three to four sprays of 0.1 - 0.4 per cent neem seed kernel suspension and 0.2 - 0.8 per cent neem oil emulsion exhibited a strong repellent and anti-feedant effect against aphid, Brevicoryne brassicae Linn. on cauliflower and cabbage (Singh and Sharma, 1986). Kabir and Mia (1987) tested six indigenous materials viz., extracts of neem, garlic, onion, tobacco, straw ash and a mixture of soap with kerosene against Lipaphis erysimi Kaltenback on mustard and observed that all extracts were ineffective in reducing the infestation. Mani et. al. (1990) recorded 100 per cent mortality of L. erysimi on mustard with neem oil 1.5 per cent and endosulfan 0.07 per cent.

TOXICITY TO PARASITES AND PREDATORS

Joshi et. al. (1982) demonstrated that application of 2.0 per cent neem seed kernel suspension to the eggs of S. litura parasitised by Telenomus remus Nixon did not adversely affect the emergence of parasites or oviposition by female; the suspension was also observed to be safe to Chrysopa scelestes. Krishnaiah and Kalode (1984) reported relatively higher population of mirid bug predators in plots treated with neem oil compared to insecticidal treated plots. Singh et. al. (1985) found that most of the botanical pesticides were safe to aphid predator, Coccinella septumpunctata. Wu (1986) observed that neem seed oil was the safest to Lycosa pseudoannulata (Bosenberg and Stand) and Apanteles cypris (Nixon). Kareem et. al. (1988) observed lower populations of mirids and spiders in plots treated with monocrotophos than in plots treated with neem at 48 days after transplantation.

Plots treated with neem seed bitters (NSB) systemic + NSB 10,000 ppm sprayed fortnightly contained greater number of spiders and mirids than monocrotophos treated plots (Saxena et. al., 1989). Sontakke (1993) reported that neem oil was the safest to mirid bug and spider population (4.2 and 3.1/clump respectively) since it did not significantly differ from untreated check (4.6 and 4.2 where as Chlorpyriphos alone (0.9 and 0.5) and in combination with neem oil (0.8 and 1.0) proved toxic to both mirid bugs and spiders.

EFFECT ON YIELD

Neem oil 4.0 per cent recorded highest yield of paddy (1555 kg ha^{-1}) as against 880 and 1505 in control and monocrotophos respectively as reported by Nigam and Sen (1989). Venugopal Rao et. al. (1990) observed neem oil 1.0 per cent registered a kapas yield of 913 kg ha^{-1} which was on par with untreated check 917 kg ha^{-1}. Brar et. al. (1994) stated that neem oil at 10 l ha^{-1} and 15 l ha^{-1} recorded a yield of 34.92 kg ha^{-1} and 35.17 in okra, both being significantly superior to control 10.92.

2.2 COMMERCIAL NEEM OIL FORMULATIONS

Since no literature is available on the selected neem oil formulations used in the present investigation, literature pertaining to other commercial formulations of neem oil is reviewed hereunder.

NEEMARK

Phadke et. al. (1988) recorded lower number of eggs (0.5) of whitefly, B. tabaci on Neemark (0.5%) treated cotton plots compared to control (1.0) or endosulfan 0.1 per cent (1.0). The treatments that received 1.0 per cent Neemark for all rounds of spray were less effective in reducing population of A. biguttula biguttula and A. gossypii on okra compared to coventional insecticides as reported by Bhavani Sankara Rao (1990). Patel et. al. (1994) recorded 30.39 per cent oviposition of B. tabaci on cotton plants treated with Neemark 0.5 per cent as against 69.6 in untreated plants. Neemark 0.5 per cent recorded significantly lesser fruit damage on brinjal by L. orbonalis (9.65%) compared to control (19.36%) as reported by Walunj et. al. (1996a).

Patel et. al. (1994) stated that the females of H. armigera and E. vitella laid just 15.47 and 29.86 per cent eggs respectively on an average on plants treated with 0.5 per cent Neemark as against 84.53 and 70.14 per cent in their respective controls. Neemark (0.5%) recorded 34.03 per cent boll damage by bollworm complex on cotton as against 40.08 per cent in control (Walunj et. al., 1996b).

NIMBECIDINE

Udaiyan and Ramarathinam (1994) found that Nimbecidine at 0.5, 1.0 and 2.0 per cent resulted in 38.69, 40.28 and 45.48 per cent reduction of L. orbonalis on brinjal, 65.39 to 69.67 per cent reduction of B. tabaci and 47.76 to 52.56 per cent reduction of A. gossypii on cotton. They further recorded 57.63 to 77.10 per cent and 67.92 to 72.18 per cent reduction of square damage by H. armigera and Pectinophora gossypiella Saunders on cotton with these treatments.

NEEMGUARD

Neemguard (0.5%) recorded lower per cent reduction (33.34) of L. orbonalis on brinjal than endosulfan 0.07 per cent (47.17) as reported by Chitra et. al. (1993). It also resulted in 82.45 per cent reduction of

A. gossypii over control in brinjal. Nimbkar et. al. (1994) concluded that Neemguard @ 1.0 kg a.i. A^{-1} gave 40 per cent reduction of A. biguttula biguttula on okra.

NEEMAX

Nimbkar et. al. (1994) recorded 47 per cent reduction of B. tabaci on okra with Neemax @ 1.0 kg a.i. A^{-1}. It was the most effective treatment for the control of A. malvae on okra.

ZA-199

Walunj et. al. (1996a) observed ZA-199 (a neem based insecticide) 1.0 per cent to be an optimum dose for the control of L. orbonalis on brinjal and it was more or less equal to endosulfan 0.07 per cent. It also significantly reduced the damage (25.46) by bollworm complex on cotton compared to control (40.08) (Walunj et.al., 1996b).

NEEM 2 EC

Clement Peter and Govindarajulu (1994) recorded higher levels of L. orbonalis on brinjal with Neem 2 EC @ 2 l ha^{-1} (28.3) but lower population of aphid, A. gossypii (11.2/leaf) and whitefly, B. tabaci (2.8 nymphs) compared to control (20.6 and 10.8 respectively).

NEEMAZAL F

Clement Peter (1994) recorded significantly lower population of jassid, A. biguttula biguttula on cotton (9.73 nymphs per 3 leaves) compared to control (14.63) with Neemazal F 50 ppm. It was also found to record lower population of A. gossypii on cotton (20.26 nymphs/ 3 leaves as against 93.26 in control).

Neemazal F 50 ppm recorded lesser per cent boll infestation by H. armigera and E. vitella on cotton (9.90%) than Neemazal 50 ppm + endosulfan 500 g a.i. ha^{-1} (10.61), endosulfan 500 g a.i. ha^{-1} (11.33) and control (22.09).

NEEMRICH

Praduman Bhatnagar and Kandasamy (1993) recorded 84 per cent mortality of A. gossypii on cotton with Neemrich 80 EC (0.8%).

Nagasampangi and Sharma (1983) concluded that potatoes stored in small holdings of farmers were effectively protected from infestation by P. operculella by Neemrich I, developed at National Chemical Laboratory, Pune. Neemrich 20 EC at 1.0 per cent exhibited 51.1 and

60.8 per cent anti-feedant activity against larvae of *E. vitella* and *Euproctis lunata* (Walker) on cotton as reported by Praduman Bhatnagar and Kandasamy (1993).

NEEMOLIN

Trace to low infestation (2 larvae/10 plants) of *H. armigera* and low to moderate egg laying (2 eggs/ 10 plants) in cotton 'NHH-4' plots treated with Neemolin @ 600 ml in 150 l of water per acre were recorded compared to 28 and 8 in control respectively (Singh, 1996). Highest growth reduction of *Spilosoma obliqua* Walker by 80.48 per cent over control was obtained by Singh *et. al.* (1996) with 1.0 per cent Neemolin.

TOXICITY TO PREDATORS AND PARASITES

Neem 2 EC @ 2.0 l ha^{-1} was found to be safer to the grubs of Coccinellid predators by recording 5.6 grubs/plant while no grubs could be recorded in Cypermethrin and Fluvalinate treated plants as reported by Clement Peter and Govindarajulu (1994).

EFFECT ON YIELD

Narasimha Rao (1994) reported higher yield of brinjal (13.48 kg $plot^{-1}$) with Repelin 0.5 per cent which was significantly higher than untreated check (10.30) but lesser than endosulfan (19.7).

2.3 ENDOSULFAN

Endosulfan is a chlorinated hydrocarbon and broad spectrum insecticide with contact and stomach action.

Shah **(1979)** reported that endosulfan 0.07 per cent gave lower per cent infestation of brinjal fruit by L. orbonalis as compared to endosulfan 0.04 per cent and 0.05 per cent. Gupta and Kawal Dhari (1981) found endosulfan (0.05%) and sevin (0.25%) as the most effective insecticides in reducing the fruit borer (L. orbonalis) damage on brinjal. Good control of L. orbonalis with endosulfan @ 0.7 kg a.i. ha^{-1} was reported by Choudhury (1982). Sangma et. al. (1988) assessed certain insecticides on fourth instar larvae of L. orbonalis and recorded the order of toxicity in terms of LD 50 values as Quinalphos (6.84) followed by Fenitrothion (7.11), Endosulfan (7.58) and Malathion (8.28). Two conventional insecticides i.e. endosulfan (0.07%) and monocrotophos (0.06%) sprayed at biweekly interval from 40 days after planting did not perform well when compared to synthetic pyrethroids in reducing the infestation of brinjal shoot and fruit borer, L. orbonalis (Rajavel et. al., 1989).

Endosulfan 0.5 kg a.i. ha^{-1} recorded the highest cost-benefit ratio of 1:27.9 among different treatments tested against L. orbonalis as reported by Sontakke et. al. (1990). Further they inferred that three sprayings of endosulfan at 30, 50 and 70 days after planting @ 0.5 kg a.i. ha^{-1} was the most effective and economical measure to control L. orbonalis on brinjal. Chitra et. al. (1993) concluded that endosulfan (0.07%) recorded 47.17 per cent reduction of L. orbonalis over control.

Rama Subba Rao et. al. (1984) reported that endosulfan at 0.05 per cent significantly lowered the population of A. biguttula biguttula recording 13.67 and 3.67 jassids/30 leaves on the first and third day after spraying as against 50 and 24.17 in control. According to Balasubramanian and Chelliah (1985), three rounds of endosulfan (0.05%) (25, 35 and 45 DAS) was more effective than two rounds (25 and 35 DAS) in reducing the leaf hopper, A. biguttula biguttula infestation of sunflower by recording 58.18 per cent reduction over control. Jagan Mohan (1985) found endosulfan @ 0.7 kg a.i. ha^{-1} was effective in controlling the leaf hopper, A. biguttula biguttula on okra. Yadav et. al. (1988) reported highest mortality (97.57%) of jassid, A. biguttula biguttula on okra one day after treating with 0.05 per cent endosulfan; no population of jassid was observed during the spray intervals in the endosulfan treated plots. Bhavani Sankara Rao (1990) revealed that application of endosulfan (0.07%) alternated with carbaryl (0.15%) registered highest per cent reduction of jassid (A. biguttula biguttula) on okra by recording 71.53 and 60.33 in kharif and rabi seasons respectively. Endosulfan 0.053, 0.07 and 0.087 per cent was effective in reducing the population of A. biguttula biguttula on okra upto fourteen days after spraying as reported by Waryam Singh et. al. (1991). Goel Ira et. al. (1992) observed that endosulfan was the most effective insecticide throughout the period of observation with 67.70 per cent reduction of A. biguttula biguttula on okra. Shashi Verma (1992) stated that endosulfan (0.05%) recorded half the population of jassid, A. biguttula biguttula compared to control at one day after treatment on brinjal.

Rama Subba Rao et. al. (1984) reported that endosulfan (0.05%) recorded 21.00 and 33.33 white flies (B. tabaci) per 30 leaves of brinjal as against 80.67 and 63.17 in control on first and third day after spraying. Balasubramanian and Chellaiah (1985) revealed that three rounds of endosulfan (0.05%) (25, 35 and 45 DAS) were more effective than two rounds (25 and 35 DAS) in reducing the infestation of *B. tabaci* on sunflower by recording 69.60 per cent reduction over control. A basal application of phorate @ 1.5 kg a.i. ha^{-1} at the time of sowing followed by three sprays of endosulfan (0.07%) at 10-15 days interval starting immediately after germination was a good measure to control whitefly, *B. tabaci* on soybean as suggested by Bhattacherjee (1990). Venugopal Rao *et. al*. (1990) stated that endosulfan 0.05 per cent recorded significantly lesser population of whitefly, *B. tabaci* on cotton. Endosulfan @ 2 l ha^{-1} recorded 22.66, 18.66, 16.17 and 15.67 whiteflies (*B. tabaci*) per plant on cotton after 24, 48, 72 hrs. and one week respectively compared to 65.16, 61.83, 59.5 and 61.33 in control as reported by Joseph Dominick and Mohanasundaram (1992). According to Shashi Verma (1992) endosulfan 0.05 per cent recorded significant reduction of whitefly, *B. tabaci* on brinjal.

Spray application of endosulfan at 0.05-0.07 per cent or 0.5 kg a.i. ha^{-1} was effective in controlling aphid, *A. gossypii* on okra (Mohan, 1986; Yadav *et. al*., 1988). Venkatesan *et. al*. (1987) reported that endosulfan (0.07%) recorded 46.55 per cent reduction of cotton aphid, *A. gossypii* over control. Endosulfan at 0.05-0.07 per cent or 0.5 kg a.i. ha^{-1} was effective in controlling aphid, *A. gossypii* on musk melon according to Pareek and Kavadia (1988). Endosulfan 0.07 per cent alternated with carbaryl 0.15 per cent resulted in 59.08 per cent reduction of *A. gossypii* over control in bhendi as reported by Bhavani Sankara Rao (1990). Venugopal Rao *et. al.* (1990) observed significant reduction of aphid (*A. gossypii*) population on cotton with endosulfan 0.05 per cent. Chitra *et. al.* (1993) revealed that endosulfan (0.07%) recorded 96.69 per cent reduction of *A. gossypii* over control in brinjal.

EFFECT OF ENDOSULFAN ON PREDATORS

Endosulfan was found to be less toxic to *Coccinella repanda* Thunberg than monocrotophos (Kay, 1980; Chaudhuri and Ghosh, 1982 and Broadley, 1983). According to Singh and Sircar (1983) *Coccinella septumpunctata* was not very sensitive to endosulfan. Endosulfan was quoted to be one of the insecticides least toxic to *C. septumpunctata* by Sharma and Adlakha (1986). Shukla *et. al.* (1990) reported that endosulfan, chlorpyriphos, phosphamidon recorded 20-46 per cent mortality of *C. septumpunctata* while dimethoate and oxydemeton methyl recorded 60 and 63.3 per cent respectively.

EFFECT ON YIELD

Gupta and Kawal Dhari (1981) recorded significantly higher yield of brinjal (33.67 kg $plot^{-1}$) with endosulfan (0.05%) compared to control (23.30). Endosulfan (0.061%) was found to record 49.51 q ha^{-1} of marketable yield of brinjal which was significantly higher than control that recorded 13.50 (Khaire et. al., 1986). Rajavel et. al. (1989) reported that endosulfan 700 ppm produced a yield of 9.810 kg $plot^{-1}$ of brinjals which differed significantly from untreated check that recorded 9.330. Endosulfan 0.5 kg a.i. ha^{-1} recorded a brinjal fruit yield of 219 q ha^{-1} which was significantly superior to untreated check (136) according to Sontakke et. al. (1990).

NEEM OIL FORMULATIONS IN COMBINATION WITH OTHER PESTICIDES

Clement Peter (1994) concluded that a combination of Neemazal F 50 ppm and endosulfan 500 g a.i. ha^{-1} recorded significantly lower population of jassid, A. biguttula biguttula and aphid, A. gossypii on cotton when compared with either control or individual chemicals. A neem based insecticide ZA-199 (1.0%) mixed with endosulfan (0.05%) was very effective in controlling the brinjal fruit borer, *L. orbonalis* by recording 9.81 per cent fruit damage as against 17.34 in endosulfan, 18.48 in ZA-199 and 28.67 in control (Walunj *et. al*., 1996a).

Literature pertaining to neem oil combined with other pesticides against brinjal pests is meagre. Hence the efficacy against other related pests was also reviewed hereunder.

Ramachandra Rao (1989) observed that combination of Quinalphos 0.075 per cent and Neemark 1.0 per cent was the most effective treatment against bollworm, *E. vitella* on cotton followed by a combination treatment of Quinalphos (0.075%) and Repelin (1.0%). Krishnaiah and Kalode (1990) reported that neem cake 150 kg ha^{-1} incorporated in soil followed by neem oil 3.0 per cent sprayed at ten days interval effectively checked the leaf folder (*Cnaphalocrocis medinalis*) on rice. Mani *et. al*. (1990) registered 100 per cent mortality of mustard aphid, *Lipaphis erysimi* Kaltenback and 85.28 per cent webworm, *Crocidolomia binotalis* Zell. with a combination treatment of neem oil (1.5%) and endosulfan (0.07%). A combination of Neemazal F 50 ppm and endosulfan 500 g a.i. ha^{-1} resulted in significant reduction of bollworm (*E. vitella*) damage on cotton

(10.61%) when compared with either control (22.09) or endosulfan 500 g a.i. ha^{-1} alone (11.33) as reported by Clement Peter (1994). Endosulfan 0.07 per cent (Khatau Endo 35 EC) followed by Nimbecidine 0.2 per cent proved to be the most effective treatment against pod borer, H. armigera on chickpea that recorded 4.6 per cent pod damage as against 26.3 per cent in control (Srivastava et. al., 1994). In a laboratory experiment carried out by Ganeshan et. al. (1995), combination treatments Achook (a commercial neem oil formulation) with annona, mahua and jatropha oils had resulted in more larval mortality of H. armigera, E. vitella and S. litura than individual treatments. Mallikharjuna Rao (1995) recorded effective control of S. litura on chillies with the application of neem cake @ 500 g a.i. ha^{-1} basal dressing followed by weekly sprays of 1.0 per cent neem oil. A combination of neem based insecticide ZA-199 (1.5%) and endosulfan (0.05%) resulted in 21.19 per cent damage by bollworm complex on cotton, which was significantly lower when compared to control (40.08%) or ZA-199 (1.5%) alone (27.58%) or endosulfan (0.05%) alone (22.94%) as reported by Walunj et. al. (1996b).

EFFECT ON YIELD

Srivastava *et. al.* (1994) reported that a combination of Nimbecidine (0.2%) and endosulfan (0.07%) recorded the highest yield in chickpea (2.53 t ha^{-1}) which was superior to endosulfan (0.07%) alone 2.12 t ha^{-1} or Nimbecidine (0.2%) alone 2.22 t ha^{-1} and control 1.48 t ha^{-1}.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

A field trial was conducted during rabi 1996-97 in the orchard block of Agricultural College Farm, Bapatla to evaluate certain selected neem oil formulations against the commonly occurring pests and their natural enemies on brinjal. The materials utilized in conducting the experiment and the methods adopted during the period of experimentation are given below.

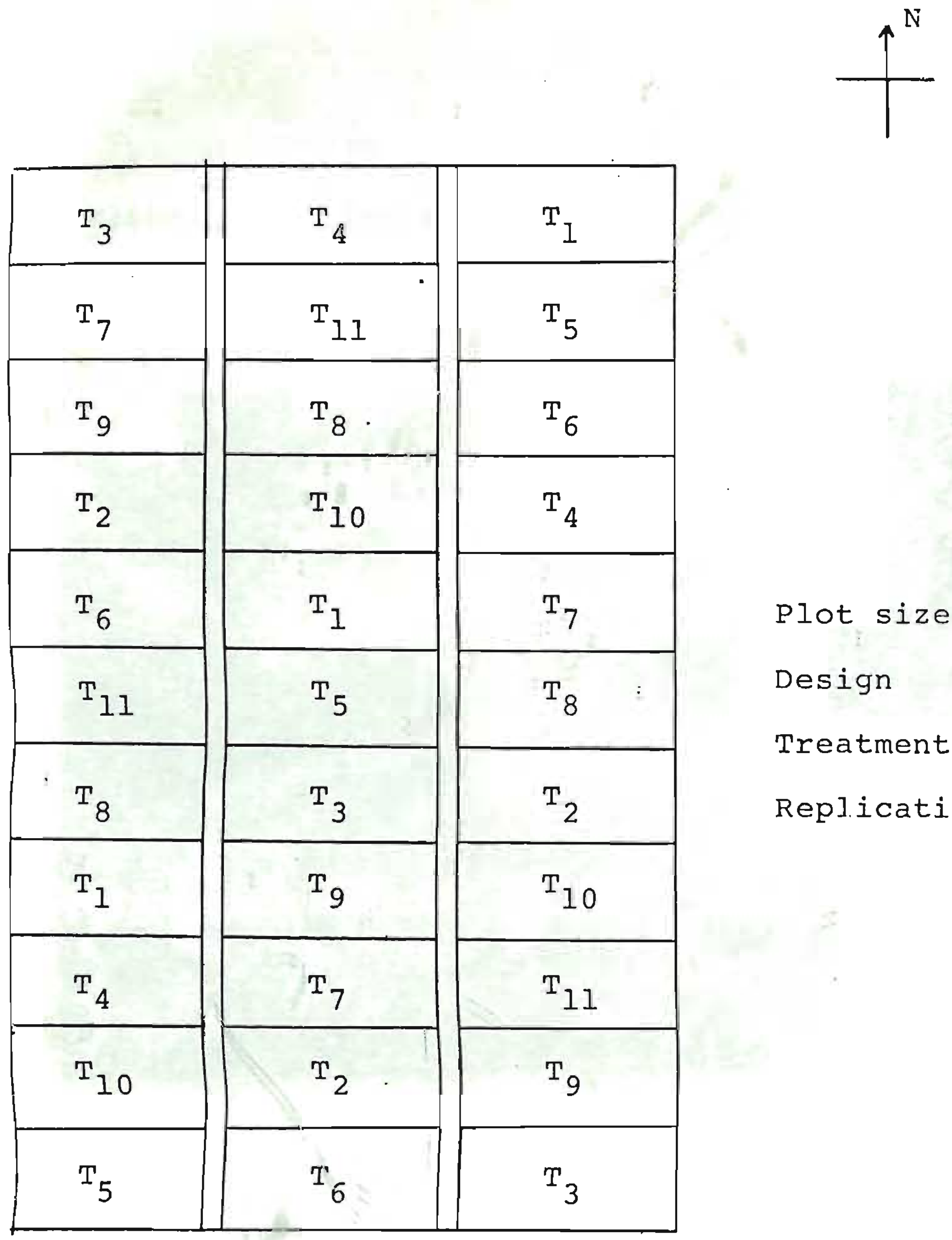
3.1 PREPARATORY CULTIVATION

The field was thoroughly ploughed thrice with a tractor-drawn cultivator and farm yard manure was applied @ 25 cartloads per hectare. It was thoroughly incorporated into the soil. The field was evenly levelled after removing the stubbles and weeds.

3.2 LAYOUT

The experiment was laid out in a randomised block design with eleven treatments including untreated check and was replicated thrice as shown in Fig.1, Plate 1. Plots measuring a net area of 24.0 m^2 (6.0 x 4.0 m) were prepared by forming bunds all around the plots. Irrigation channels were dug between the replications.

Fig.1 Layout of the experiment



Plot size = 6.0 x 4.0 m

Design = RBD

Treatments = 11

Replications = 3

TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

Plate 1.   View of the experimental plot

3.3 VARIETY OF THE CROP

A popular brinjal variety (purple long) extensively grown in Bapatla area was selected for the present experiment. It comes to harvest in about 70 days after planting. Fruits are long, purple and glossy. Seedlings of one month age were purchased from a progressive farmer and were planted immediately.

3.4 FERTILIZER APPLICATION

Recommended fertiliser dose of 100:60:60 kg NPK ha^{-1} was applied in all the plots in the form of urea, superphosphate and muriate of potash respectively. Half the dose of nitrogen and entire doses of phosphorus and potash were broadcasted and incorporated in the plots before planting and the remaining nitrogen was applied by placement method a month after planting.

3.5 RAISING THE CROP

Seedlings of 30 days age were planted on 15.11.1996 adopting a spacing of 90 cm between the rows and 75 cm within the row. Two seedlings per hill were planted. Pot irrigation was given twice daily till the establishment of the seedlings. Gap filling was done one week after planting. The experimental field was irrigated as and when required i.e., whenever the top 2-3" soil was found dry. Earthing up of the soil between the rows was done once a month to keep the plots free of weeds (mainly Cyprus sp.).

3.6 APPLICATION OF INSECTICIDAL TREATMENTS

The insecticidal treatments were applied as foliar sprays. The details of insecticides used are presented in Table 1.

First round of treatments were imposed 40 days after planting when jassid, Amrasca biguttula biguttula Ish., whitefly, Bemisia tabaci Genn., aphid, Aphis gossypii (Glov.) and shoot and fruit borer, Leucinodes orbonalis Guen. were noticed in the experimental plots. There after the treatments were applied at fortnightly interval. Six sprayings were given during the period of crop growth.

3.7 PREPARATION AND APPLICATION OF SPRAY FLUID

Calculated quantities of different insecticides were first mixed with a small quantity of water, stirred well and then the remaining quantity of water was added

Table 1. Insecticides used and their source

No.	Trade Name	Formulation	Concentration of formulation tested (%)	Source
1.	Neemol	0.03EC	1 & 1.5	Ramson Agrotech Pvt. Ltd., Hyderabad.
2.	Multineem	0.03EC	1 & 1.5	Multiplex Fertilizers Pvt. Ltd., Bangalore.
3.	Bioneem	0.03EC	1 & 1.5	Zuari Agro Chemicals Ltd., Goa.
4.	Neemgold	0.15EC	0.25 & 0.5	Southern Petrochemical Industries Corporation Ltd., Madras.
5.	Endosulfan	35EC	0.035 & 0.07	Anu Products Ltd., Haryana.

for obtaining the desired concentration of spray fluid. The spray fluid was thoroughly stirred before spraying. A hand compression knapsack sprayer was used for imposing the treatments. Sprayings were undertaken during morning hours. All the plants in each treatment were sprayed upto the point of run off. The sprayer and accessories used for preparing spray fluid were thoroughly cleaned with water before changing the treatment and rinsed with the subsequent spray fluid to be imposed.

3.8 FIELD OBSERVATIONS

The efficacy of treatments was studied against the following pests and natural enemies.

No.	Common Name	Scientific Name	Family	Order
1.	Shoot and fruit borer	*Leucinodes orbonalis* Guen.	Pyralidae	Lepidoptera
2.	Jassid	*Amrasca biguttula biguttula* Ish.	Cicadellidae	Homoptera
3.	Cotton whitefly	*Bemisia tabaci* Genn.	Aleurodidae	Homoptera
4.	Aphid	*Aphis gossypii* (Glov.)	Aphididae	Homoptera
5.	Predatory beetle	*Verania vincta* Gorham.	Coccinellidae	Coleoptera
6.	Predatory beetle	*Menochilus sexmaculatus* Fab.	Coccinellidae	Coleoptera

3.8.1 Shoot Borer

The damage of shoot and fruit borer on shoots of brinjal was observed upto third spraying and thereafter became negligible with the appearance of fruits (Plate 2). The infestation of shoot and fruit borer on shoots was recorded on ten randomly selected and tagged plants per plot leaving border rows. The damage was estimated by counting the healthy as well as infested shoots at one day before and five and ten days after each spray. The shoot damage was calculated in terms of percentage of damaged shoots.

3.8.2 Sucking Pests

Populations of both nymphs and adults of jassid, whitefly and aphid were recorded early in the morning when the insects were inactive (Plate 3). The populations of sucking pests were recorded on ten randomly selected and tagged plants per plot leaving border rows. In each plant two top, two middle and one bottom leaves were randomly selected for counting the population. The data was recorded one day before and one, five and ten days after each spraying.

Plate 2. Shoot and fruit borer damage on shoots

Plate 3. Shoot and fruit borer damage on fruits

3.8.3 Fruit Borer

The number and weight of healthy and bored fruits from ten randomly selected and tagged plants were recorded separately for each treatment at every picking (Plate 4). The percentage of bored fruits was calculated both in terms of number and weight.

3.8.4 Natural Enemies

Adult stages of predatory beetles i.e., V. vincta and M. sexmaculatus were recorded on ten randomly selected and tagged plants per plot leaving the border rows. In each plant two top, two middle and one bottom leaves were considered for counting the population. The data was recorded one day before and one, five and ten days after each spray.

3.8.5 Yield

Yield data was recorded by weighing healthy fruits in each treatment separately during every picking. The yield of all pickings was computed and expressed in kgs plot^{-1} from which the yield ha^{-1} was calculated.

3.9 STATISTICAL ANALYSIS

The experiment was laid out in a simple randomised block design. Mean population levels of different pest species recorded at different intervals for the six sprayings were analysed by using analysis of variance technique. Yield data recorded at periodic intervals of harvest was also subjected to statistical scrutiny. The per cent reduction of population of pests (except shoot and fruit borer) and natural enemies over untreated check in different treatments was calculated by following the modified Abbot's formula as given by Flemming and Retnakaran (1985).

Percentage population reduction =

$$\left[1 - \left(\frac{\text{Post-treatment population in treatment}}{\text{Pre-treatment population in treatment}} \times \frac{\text{Pre-treatment population in untreated check}}{\text{Post-treatment population in untreated check}}\right)\right] \times 100$$

These values were further subjected to angular transformation as they ranged from 0 to 90 and the data were subjected to statistical analysis.

The data pertaining to percentage shoot damage was subjected to square root $[(x + 0.5)^{1/2}]$ as their values ranged between 0 and 30 (Gomez and Gomez, 1984). These transformed values were subjected to statistical scrutiny.

Per cent fruit damage values were subjected to angular transformation ($\sin^{-1}\sqrt{x}$) as their percentages ranged from 0 to 90. These transformed values were subjected to statistical analysis.

RESULTS

CHAPTER IV

RESULTS

Field evaluation of certain selected neem oil formulations was undertaken to assess their efficacy against the pests of brinjal and to find out the influence of these formulations on the damage potential of brinjal pests at Agricultural College Farm, Bapatla during rabi 1996-97. The results obtained are presented hereunder.

4.1 *FIELD EVALUATION OF VARIOUS TREATMENTS AGAINST MAJOR* **PESTS OF BRINJAL**

4.1.1 Influence of Treatments on the damage potential of Shoot and Fruit Borer, Leucinodes orbonalis Guen. on shoots

The shoot damage by shoot and fruit borer, *L. orbonalis* was observed 30 days after planting and continued upto 70 days after which the damage to shoots became negligible with the commencement of fruit setting. The total number of shoots and damaged shoots in each of the ten tagged plants were recorded separately one day before and five and ten days after imposing the treatments and per cent shoot infestation was arrived at and is presented in Table 2, Fig. 2.

The pretreatment counts revealed that higher percentage of shoot borer was observed in untreated check that recorded 5.78 while lower damage below 2.0 per cent was observed in Neemgold 0.25 per cent, Neemol 1.5 per cent and Multineem 1.5 per cent.

Five days after application of treatments also, the same trend was observed with significantly highest shoot infestation of 7.08 per cent in untreated check as against 1.38 and 1.93 in Neemgold 0.25 per cent and Neemol 1.5 per cent respectively.

Similar trend was observed ten days after spraying with significantly higher percentage of shoot damage (9.18) in untreated check as against 2.13 to 2.67 in Neemgold 0.25 per cent, Neemol 1.5 per cent and Multineem 1.5 per cent which were on par with one another. Other neem treatments, Endosulfan and Neemol mixed with endosulfan registered shoot infestation between 5.99 and 7.19 per cent.

The overall efficacy of different treatments against shoot damage revealed that maximum shoot infestation of 8.13 per cent was observed in untreated

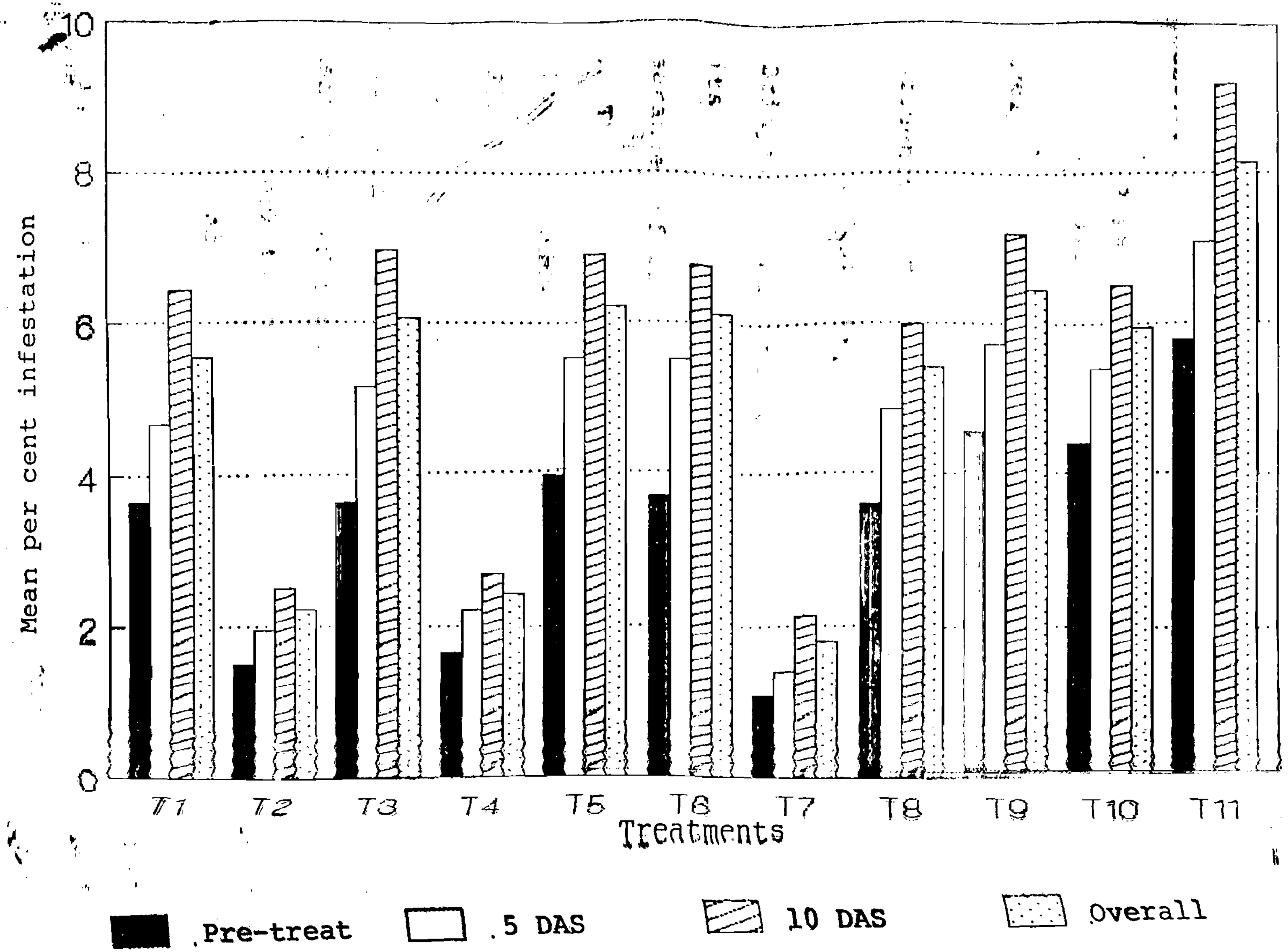
Table 2. Influence of treatments on the damage potential of shoot and fruit borer, *L. orbonalis* on brinjal shoots

Treatments	Mean per cent Infestation			
	pre-treatment	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	3.63^{c} (2.02)	4.66^{c} (2.25)	6.43^{bc} (2.63)	5.54^{c} (2.45)
2. Neemol (1.5%)	1.51^{de} (1.41)	1.93^{de} (1.54)	2.52^{d} (1.73)	2.23^{de} (1.64)
3. Multineem (1.0%)	3.62^{c} (2.01)	5.13^{bc} (2.37)	6.98^{b} (2.73)	6.06^{bc} (2.55)
4. Multineem (1.5%)	1.65^{d} (1.46)	2.22^{d} (1.64)	2.67^{d} (1.78)	2.42^{d} (1.70)
5. Bioneem (1.0%)	3.95^{bc} (2.11)	5.53^{bc} (2.45)	6.89^{bc} (2.71)	6.21^{bc} (2.58)
6. Bioneem (1.5%)	3.69^{c} (2.04)	5.50^{bc} (2.44)	6.76^{bc} (2.69)	6.13^{bc} (2.56)
7. Neemgold (0.25%)	1.04^{e} (1.24)	1.38^{e} (1.37)	2.13^{d} (1.62)	1.76^{e} (1.49)
8. Neemgold (0.5%)	3.59^{c} (2.01)	4.83^{bc} (2.31)	5.99^{c} (2.55)	5.41^{c} (2.43)
9. Neemol (1.0%) + Endosulfan (0.035%)	4.56^{b} (2.25)	5.73^{b} (2.48)	7.19^{b} (2.77)	6.46^{b} (2.64)
10. Endosulfan (0.07%)	4.38^{bc} (2.21)	5.39^{bc} (2.43)	6.50^{bc} (2.65)	5.95^{bc} (2.54)
11. Untreated check	5.78^{a} (2.49)	7.08^{a} (2.75)	9.18^{a} (3.11)	8.13^{a} (2.93)
F-test	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	0.197	0.226	0.172	0.179

Figures in parentheses are transformed by $(x + 0.5)^{1/2}$

Figures in columns followed by the same letter are not significantly different.

Fig. 2 Influence of treatments on damage potential of shoot and fruit borer, L. orbonalis on brinjal shoots



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

check though it was on par with other treatments except Multineem 1.5 per cent, Neemol 1.5 per cent and Neemgold 0.25 per cent. The lowest infestation of 1.76 per cent was observed in Neemgold 0.25 per cent which was on par with Neemol 1.5 per cent and Multineem 1.5 per cent that recorded 2.23 and 2.43 per cent shoot infestation respectively.

4.1.2 Influence of Treatments on the damage potential of Shoot and Fruit Borer, *L. orbonalis* on fruits

Brinjal shoot and fruit borer, *L. orbonalis* started its damage on fruits 70 days after planting with the appearance of fruits and continued till the end of the crop. The data pertaining to the percentage of fruit damage (both by number and weight basis) is given in Table 3, Fig.3.

The data on percentage fruit infestation on number basis revealed that the highest damage was observed in untreated check (39.96%) and was on par with Bioneem 1.0 per cent, endosulfan, Bioneem 1.5 per cent and Multineem 1.0 per cent. The lowest fruit damage of 20.57 per cent was observed in Neemgold 0.25 per cent and it was on par with Neemol mixed with endosulfan, Neemol 1.5 per

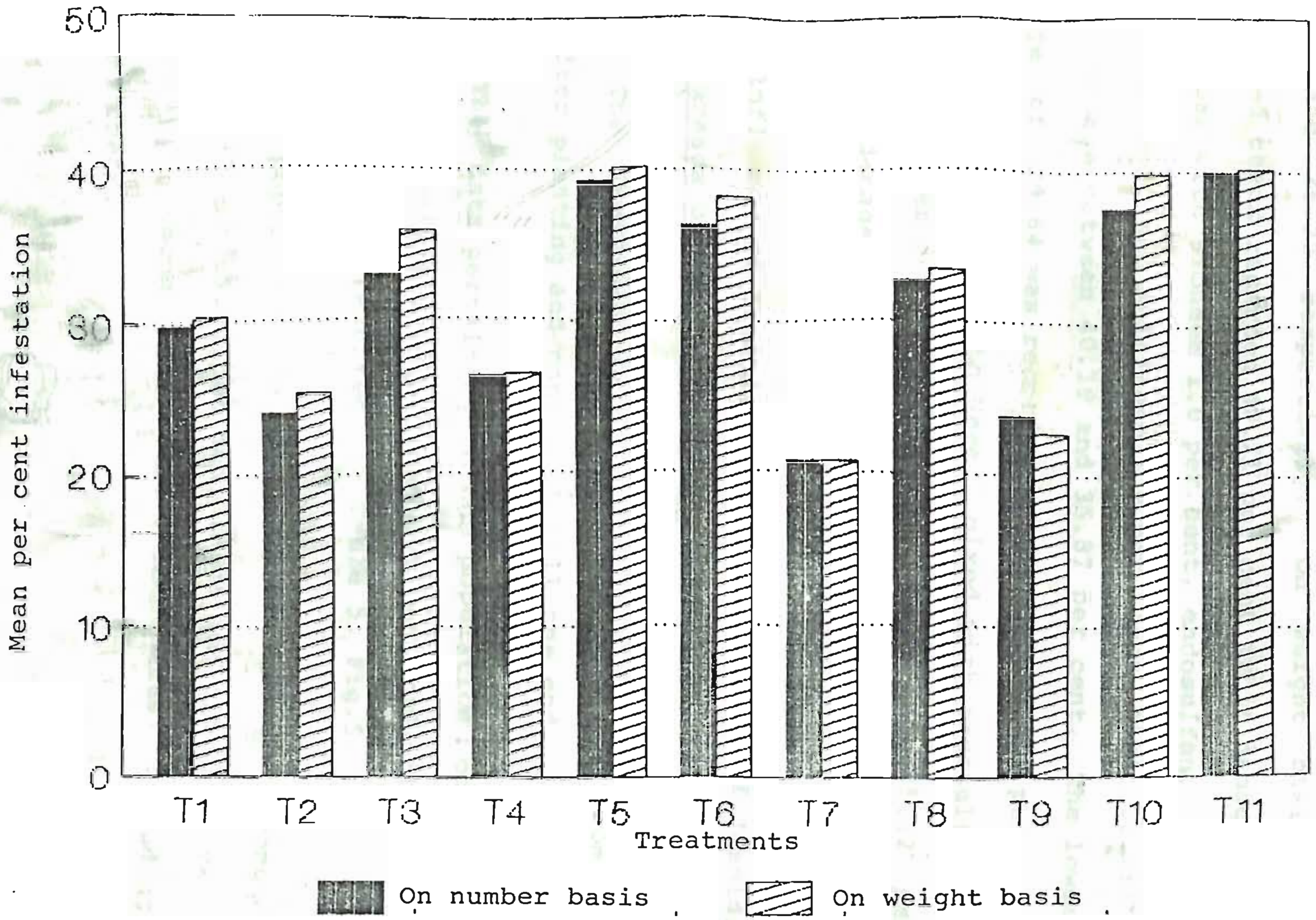
Table 3. Influence of treatments on the damage potential of shoot and fruit borer, *L. orbonalis* on brinjal fruits

Treatments	Mean per cent infestation	
	On number basis	On weight basis
1. Neemol (1.0%)	29.80[cd] (33.07)	30.21[cd] (33.31)
2. Neemol (1.5%)	24.11[de] (29.38)	25.32[def] (30.07)
3. Multineem (1.0%)	32.99[abc] (35.00)	35.87[abc] (36.75)
4. Multineem (1.5%)	26.22[de] (30.69)	26.36[de] (30.80)
5. Bioneem (1.0%)	39.34[ab] (38.79)	40.19[a] (39.31)
6. Bioneem (1.5%)	36.32[abc] (37.05)	38.21[ab] (38.13)
7. Neemgold (0.25%)	20.57[e] (26.97)	20.64[f] (27.02)
8. Neemgold (0.5%)	32.60[bc] (34.79)	33.33[bc] (35.22)
9. Neemol (1.0%) + Endosulfan (0.035%)	23.82[de] (29.18)	22.64[ef] (28.40)
10. Endosulfan (0.07%)	37.69[ab] (37.80)	39.79[a] (39.03)
11. Untreated check	39.96[a] (39.21)	40.21[a] (39.50)
F-test	Sig.	Sig.
C.D. (0.05)	4.29	3.53

Figures in parentheses are angular transformed values ($\sin^{-1}\sqrt{x}$)

Figures in columns followed by the same letter are not significantly different.

Fig. 3 Influence of treatments on the damage potential of shoot and fruit borer, _L. orbonalis_ on brinjal fruits



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

cent and Multineem 1.5 per cent that recorded 23.82, 24.11 and 26.22 respectively. On weight basis, the untreated check recorded 40.21 per cent fruit damage and was on par with Bioneem 1.0 per cent, endosulfan, Bioneem 1.5 per cent and Multineem 1.0 per cent that recorded fruit damage between 40.19 and 35.87 per cent. The lowest damage of 20.64 was recorded in Neemgold 0.25 per cent though it was on par with Neemol mixed with endosulfan and Neemol 1.5 per cent which recorded 22.64 and 25.32 per cent fruit damage respectively.

4.1.3 Influence of Treatments on the Incidence of Jassid, *Amrasca biguttula biguttula* Ish.

The incidence of the pest was observed from 40 days after planting and continued till the end.

The data pertaining to the population counts is presented in Table 4, Fig. 4 and per cent reduction over untreated check is presented in Table 5, Fig.5.

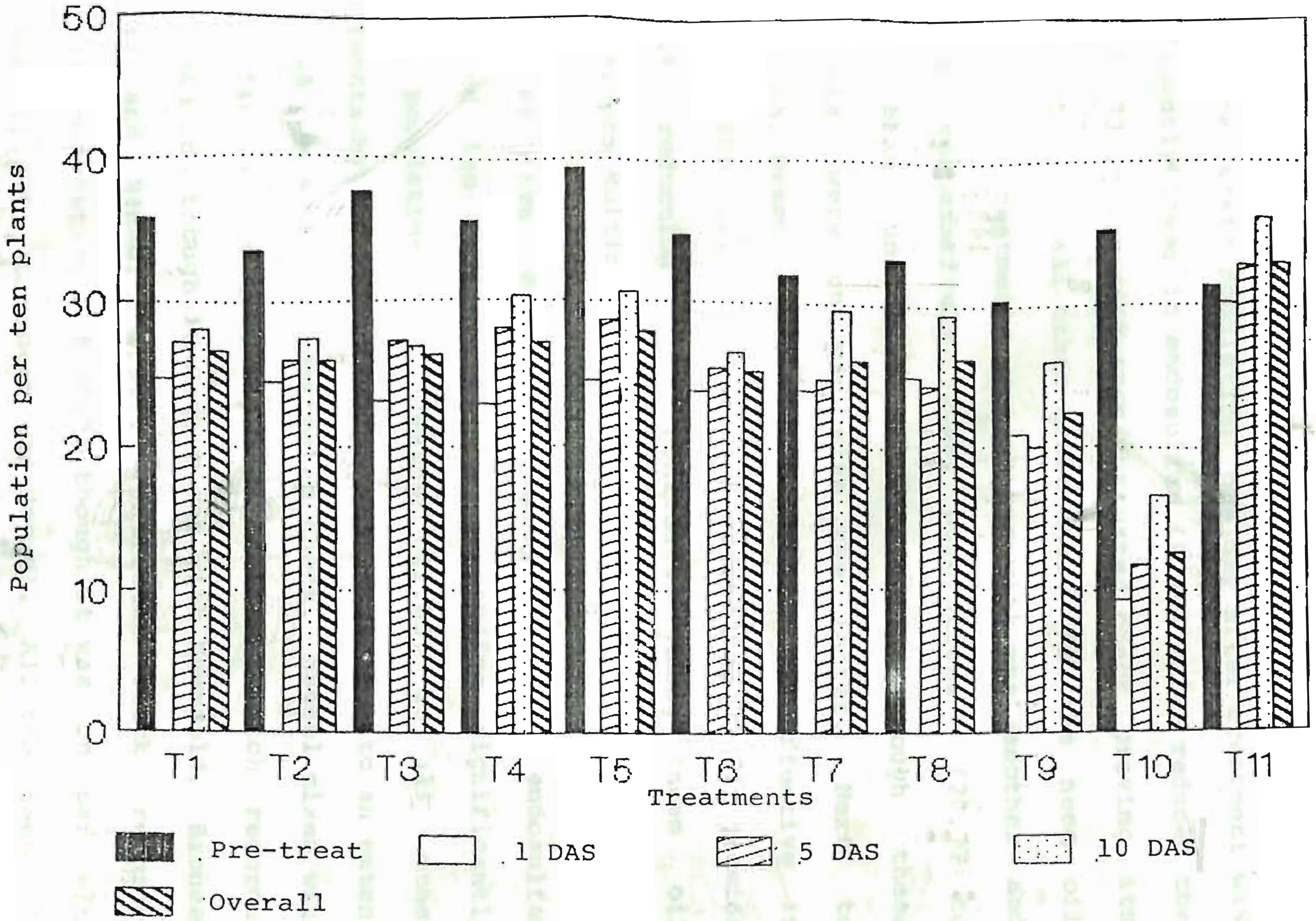
The population in pretreatment counts ranged between 30.33 and 39.27 per ten plants and did not vary significantly among different treatments including untreated check.

Table 4. Influence of treatments on the incidence of jassid, *A. biguttula biguttula*

Treatments	Population per ten plants				
	Pre-treatment	1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	35.88[abc]	24.62[ab]	27.12[ab]	28.03[b]	26.59[b]
2. Neemol (1.5%)	33.45[abc]	24.50[ab]	25.98[abc]	27.45[b]	25.98[b]
3. Multineem (1.0%)	37.50[ab]	23.17[b]	27.23[ab]	26.83[b]	26.30[b]
4. Multineem (1.5%)	35.55[abc]	22.90[b]	28.05[ab]	30.22[ab]	27.06[ab]
5. Bioneem (1.0%)	39.27[a]	24.47[ab]	28.63[ab]	30.62[ab]	27.91[ab]
6. Bioneem (1.5%)	34.72[abc]	23.83[ab]	25.43[bc]	26.57[b]	25.28[b]
7. Neemgold (0.25%)	31.90[bc]	24.00[ab]	24.72[bc]	29.57[ab]	26.09[b]
8. Neemgold (0.5%)	33.22[abc]	25.00[ab]	24.33[bc]	29.37[ab]	26.23[b]
9. Neemol (1.0%) + Endosulfan (0.035%)	30.33[c]	20.77[b]	19.88[c]	26.00[b]	22.22[b]
10. Endosulfan (0.07%)	35.23[abc]	9.40[c]	11.85[d]	16.67[c]	12.64[c]
11. Untreated check	31.32[bc]	30.13[a]	32.77[a]	36.05[a]	32.98[a]
F-test	NS	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)		6.33	7.04	6.77	6.04

Figures in columns followed by the same letter are not significantly different.

Fig. 4 Influence of treatments on the incidence of jassid, A. biguttula biguttula



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

The jassid population one day after treatment was significantly lower in endosulfan (9.40) which reduced the pest by 73.29 per cent over untreated check proving its superiority to all other treatments. All the neem oil formulation treatments were on par with one another and recorded comparatively lower populations (20.77 to 25.00) than untreated check (30.13) though these treatments were on par with the latter. Next to endosulfan, Neemol mixed with endosulfan was effective in reducing the jassid population recording 20.77 jassids (31.41% reduction over control). Among neem oil formulations Multineem recorded lower population.

At five days after spraying also, endosulfan continued its superiority by recording significantly lowest population of jassids (11.85) to all other treatments by reducing the jassid population to an extent of 66.48 per cent over untreated check. Neemol mixed with endosulfan was the next superior treatment which recorded 19.88 jassids though it was on par with Neemgold, Bioneem (1.5%) and Neemol (1.5%). Untreated check recorded highest population of 32.77 though it was on par with Bioneem (1.0%), Multineem and Neemol. All the neem oil formulations were on par with one another; however, Neemgold recorded comparatively lower population where as

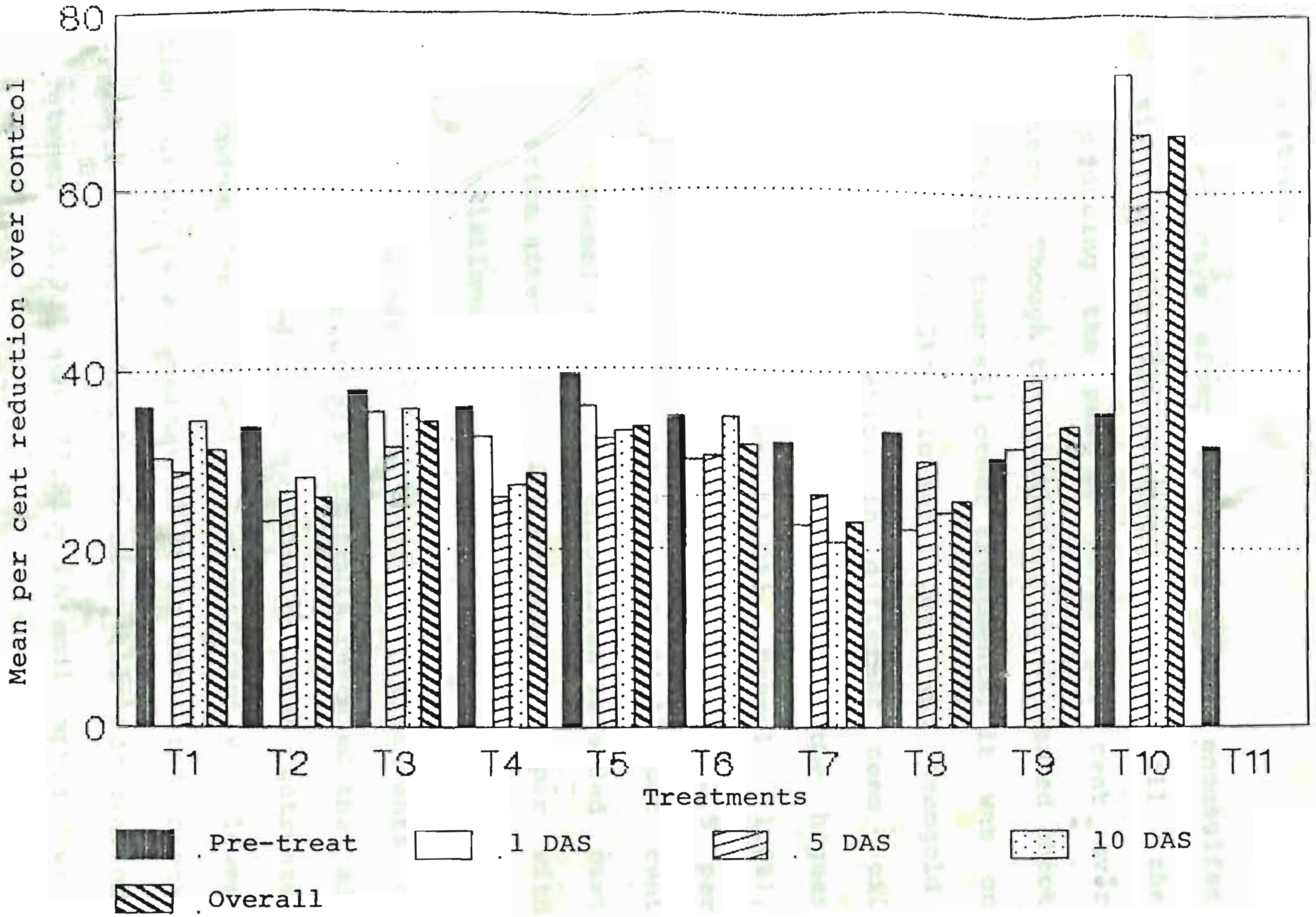
Table 5. Efficacy of treatments against jassid, *A. biguttula biguttula*

Treatments	Pre-treatment population per ten plants	Mean per cent reduction over control			
		1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	35.88	30.15[bcd] (32.44)	28.65[b] (32.21)	34.38[bc] (35.52)	31.06[bc] (33.59)
2. Neemol (1.5%)	33.45	23.27[bcd] (28.37)	26.44[b] (29.68)	28.01[bc] (31.59)	25.90[bc] (30.38)
3. Multineem (1.0%)	37.50	35.20[bc] (35.99)	31.35[b] (33.83)	35.44[b] (36.48)	33.99[b] (35.59)
4. Multineem (1.5%)	35.55	32.36[bcd] (33.60)	25.80[b] (29.37)	27.12[bc] (30.75)	28.42[bc] (31.66)
5. Bioneem (1.0%)	39.27	35.78[b] (36.29)	32.24[b] (34.05)	32.98[bc] (34.44)	33.58[b] (35.23)
6. Bioneem (1.5%)	34.72	29.85[bcd] (32.90)	30.27[b] (33.93)	34.57[bc] (35.27)	31.56[bc] (33.95)
7. Neemgold (0.25%)	31.90	22.85[d] (26.99)	26.12[b] (27.78)	20.83[c] (26.33)	23.07[c] (27.55)
8. Neemgold (0.5%)	33.22	22.25[cd] (27.69)	29.99[b] (31.97)	24.27[bc] (28.38)	25.55[bc] (29.83)
9. Neemol (1.0%) + Endosulfan (0.035%)	30.33	31.41[bcd] (33.83)	39.27[b] (38.32)	30.82[bc] (31.49)	33.83[bc] (35.02)
10. Endosulfan (0.07%)	35.23	73.29[a] (58.31)	66.48[a] (54.64)	60.28[a] (51.01)	66.38[a] (54.51)
11. Untreated check	31.32	0.00[e] (4.05)	0.00[c] (4.05)	0.00[d] (4.05)	0.00[d] (4.05)
F-test	NS	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)		8.58	10.56	9.97	7.66

Figures in parentheses are angular transformed values ($\sin^{-1}\sqrt{x}$)

Figures in columns followed by the same letter are not significantly different.

Fig. 5 Efficacy of treatments against jassid, *A. biguttula biguttula*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

Bioneem (1.0%) and Multineem (1.0 and 1.5%) recorded higher population.

At ten days after spraying also endosulfan recorded significantly lowest population of all the treatments reducing the pest by 60.28 per cent over untreated check. Though the population in untreated check was higher (36.05) than all other treatments, it was on par with Multineem (1.5%), Bioneem (1.0%) and Neemgold. The reduction in population in different neem oil formulations ranged between 20.83 and 35.44, the higher reduction being in Multineem (1.0%), Neemol (1.0%), Bioneem (1.5% and 1.0%). Neemgold at 0.25 and 0.5 per cent reduced the pest by 20.83 and 24.27 per cent respectively. Neemol mixed with endosulfan recorded next lower population after endosulfan and was on par with other neem formulations.

The overall efficacy of different treatments on the incidence of A. <u>biguttula</u> <u>biguttula</u> revealed that all the treatments recorded lower population than untreated check. Endosulfan recorded significantly lowest population of 12.64 as against 32.98 in untreated check. The population levels in other neem oil formulations ranged between 25.28 and 27.91. Neemol mixed with endosulfan recorded 22.22 jassids and was on par with other treatments. Percentage reduction of population over untreated check was significantly higher in endosulfan (66.38) while in other treatments though it ranged between 23.07 and 33.91, they were on par with one another.

4.1.4 Influence of Treatments on the Incidence of whitefly, Bemisia tabaci Genn.

The incidence of the pest was observed 40 days after planting and continued till the end. The data on population counts is presented in Table 6, Fig.6 and per cent reduction over untreated check is presented in Table 7, Fig.7.

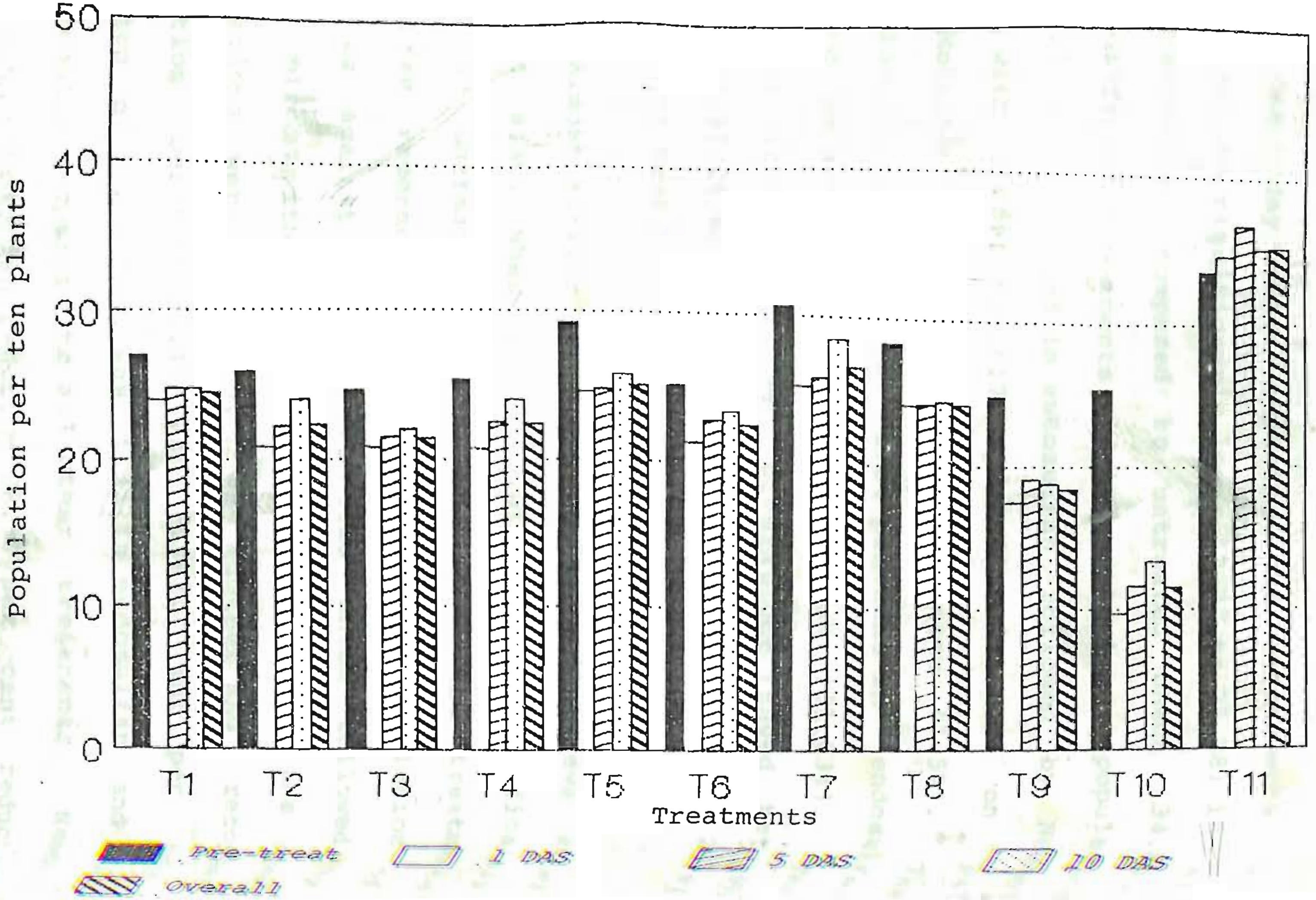
Population in pretreatment counts ranged between 24.55 and 33.57, highest being in the untreated check, which was on par with Neemgold 0.25 per cent (30.6). The latter was in turn on par with Bioneem 1.0 per cent, Neemgold 0.5 per cent and Neemol 1.0 per cent which were inturn on par with other treatments. The lowest population of 24.55 was observed in Multineem 1.0 per cent; however it was on par with other treatments except Neemgold (0.25%) and Bioneem (1.0%).

Table 6. Influence of treatments on the incidence of whitefly, B. tabaci

Treatments	Population per ten plants				
	Pre-treatment	1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	26.95[bcd]	23.95[bc]	24.73[b]	24.70[bc]	24.46[bc]
2. Neemol (1.5%)	25.85[cd]	20.73[cd]	22.13[bc]	23.92[c]	22.26[cd]
3. Multineem (1.0%)	24.55[e]	20.75[cd]	21.45[bc]	21.93[cd]	21.38[cd]
4. Multineem (1.5%)	25.27[cd]	20.63[cd]	22.50[cd]	23.90[c]	22.35[c]
5. Bioneem (1.0%)	29.12[bc]	24.60[bc]	24.75[b]	25.73[bc]	25.03[bc]
6. Bioneem (1.5%)	25.12[cd]	21.28[bcd]	22.77[bc]	23.32[c]	22.45[c]
7. Neemgold (0.25%)	30.60[ab]	25.28[b]	25.87[b]	28.48[b]	26.54[b]
8. Neemgold (0.5%)	28.25[bcd]	24.07[bc]	24.15[b]	24.35[bc]	24.19[bc]
9. Neemol (1.0%) + Endosulfan (0.035%)	24.75[d]	17.42[d]	19.02[c]	18.72[d]	18.38[d]
10. Endosulfan (0.07%)	25.37[cd]	9.70[e]	11.67[d]	13.30[e]	11.56[e]
11. Untreated check	33.57[a]	34.67[a]	36.03[a]	35.20[a]	35.30[a]
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	4.11	4.07	4.48	4.34	3.93

Figures in columns followed by the same letter are not significantly different.

Fig. 6 **Influence** of treatments on the incidence of whitefly, <u>B. tabaci</u>



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

One day after imposing the treatments the population was significantly lower (9.77 to 25.28) in all the treatments compared to untreated check (34.67). Among different treatments significantly lowest population of 9.7 was recorded in endosulfan followed by Neemol mixed with endosulfan (17.42) which was inturn on par with Multineem, Neemol (1.5%) and Bioneem (1.5%). The reduction of population was 62.64 per cent in endosulfan followed by Neemol mixed with endosulfan (31.63%). The population in different neem formulations ranged between 20.63 and 25.28 which accounted for a reduction of 21.91 to 14.23 per cent.

Almost similar trend was observed five days after treatment also, where the population was significantly higher in untreated check. Among different treatments endosulfan recorded significantly lowest population of 11.67 as against 36.03 in untreated check followed by Neemol mixed with endosulfan (19.2). All the neem formulations were on par with one another and recorded population between 21.45 and 25.87. The per cent reduction of population was 56.11 in endosulfan and was significantly superior to all other treatments. Neemol mixed with endosulfan recorded 28.57 per cent reduction and was on par with other neem formulations.

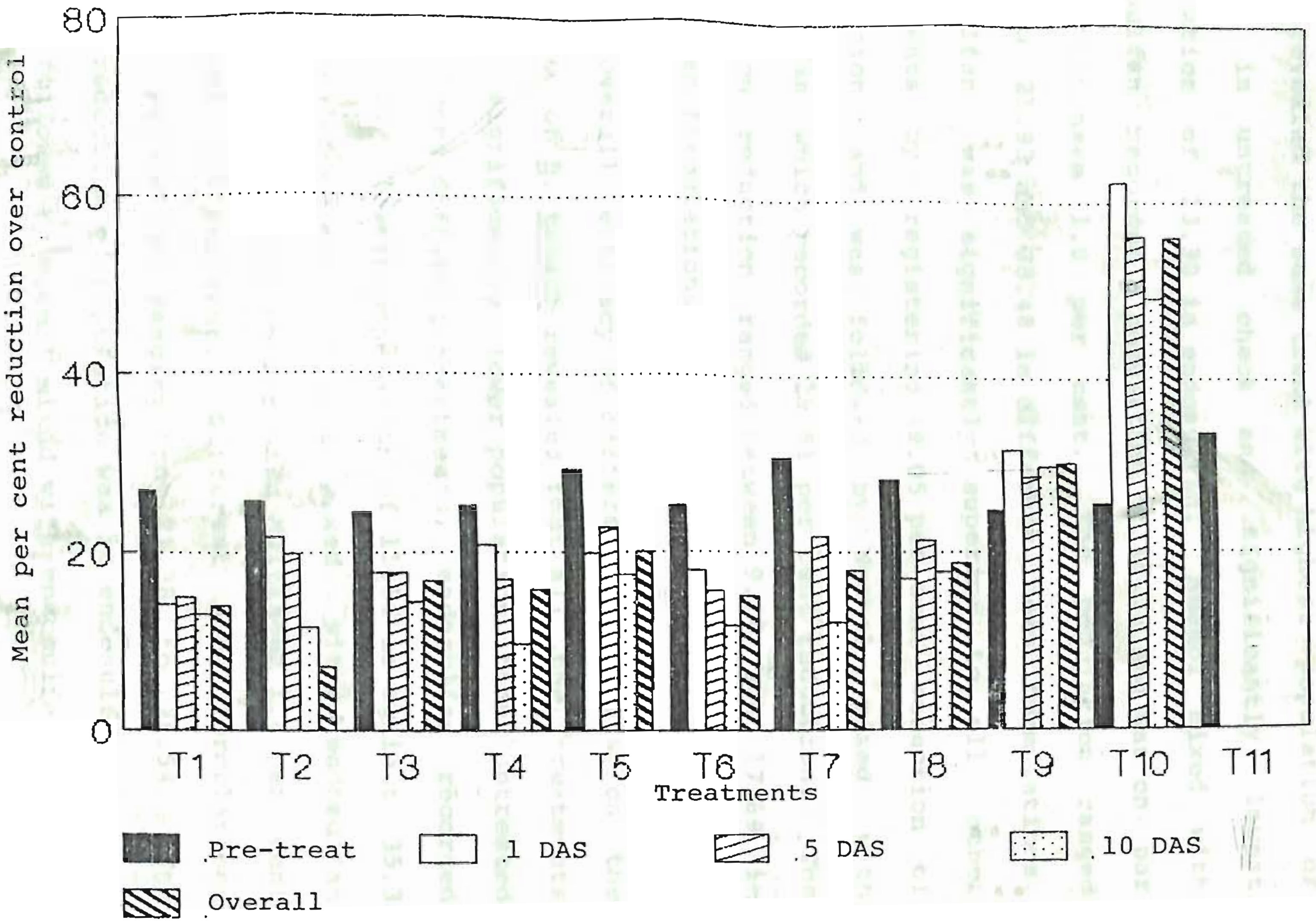
Table 7. Efficacy of treatments against whitefly, *B. tabaci*

Treatments	Pre-treatment population per ten plants	Mean per cent reduction over control			
		1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	26.95 bcd	14.23 c (22.14)	15.11 c (22.87)	13.15 cd (21.30)	14.16 c (22.14)
2. Neemol (1.5%)	25.85 cd	21.91 bc (27.90)	19.83 bc (26.42)	11.68 cd (20.00)	7.26 c (15.68)
3. Multineem (1.0%)	24.55 e	17.85 c (25.03)	17.85 c (25.03)	14.66 cd (22.54)	16.79 c (24.20)
4. Multineem (1.5%)	25.27 cd	20.84 bc (27.13)	17.01 c (24.35)	9.74 d (18.15)	15.86 c (23.50)
5. Bioneem (1.0%)	29.12 bc	19.85 bc (26.49)	22.72 bc (28.45)	17.43 cd (24.65)	20.00 bc (26.57)
6. Bioneem (1.5%)	25.12 cd	18.06 c (25.18)	15.78 c (23.42)	11.86 cd (20.18)	15.24 c (22.87)
7. Neemgold (0.25%)	30.60 ab	20.04 bc (26.85)	21.87 bc (27.90)	12.15 cd (20.44)	18.02 c (25.10)
8. Neemgold (0.5%)	28.25 bcd	17.09 c (24.43)	21.42 bc (27.56)	17.89 c (25.03)	18.79 c (25.70)
9. Neemol (1.0%) + Endosulfan (0.035%)	24.75 d	31.63 b (34.20)	28.57 b (32.33)	29.61 b (32.96)	29.93 b (33.15)
10. Endosulfan (0.07%)	25.37 cd	62.24 a (52.06)	56.11 a (48.50)	49.05 a (44.48)	55.93 a (48.39)
11. Untreated check	33.57 a	0.00 d (4.05)	0.00 d (4.05)	0.00 e (4.05)	0.00 d (4.05)
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	4.11	8.18	6.92	5.95	5.33

Figures in parentheses are angular transformed values ($\sin^{-1}\sqrt{x}$)

Figures in columns followed by the same letter are not significantly different.

Fig. 7 Efficacy of treatments against whitefly, *B. tabaci*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

Population counts recorded ten days after spraying also revealed the same trend with highest population of 35.20 in untreated check and significantly lowest population of 13.30 in endosulfan. Neemol mixed with endosulfan recorded a population of 18.72 and was on par with Multineem 1.0 per cent. The population ranged between 21.93 and 28.48 in different neem formulations. Endosulfan was significantly superior to all other treatments by registering 49.05 per cent reduction of population and was followed by Neemol mixed with endosulfan which recorded 29.61 per cent reduction. The population reduction ranged between 9.74 and 17.89 in other neem formulations.

Overall efficacy of different treatments on the incidence of B. tabaci revealed that all the treatments recorded significantly lower population than untreated check. Among different treatments, endosulfan recorded significantly lowest population of 11.56 as against 35.3 in untreated check. Neemol mixed with endosulfan recorded 18.38 and was on par with Multineem 1.0 per cent and Neemol 1.5 per cent. Different neem formulations recorded population ranging from 21.38 to 26.54. The highest reduction of population was in endosulfan (55.93%) and was followed by Neemol mixed with endosulfan (29.93%).

All the neem formulations were on par with one another and reduced the pest incidence by 14.16 to 20.0 per cent.

4.1.5 Influence of Treatments on the Incidence of aphid, *Aphis gossypii* (Glov.)

The appearance of the pest was noticed 40 days after planting during the second fortnight of December. An increase in population was observed during February and March and declined afterwards. The data on population counts recorded is presented in Table 8, Fig.8. Data pertaining to per cent reduction over untreated check is presented in Table 9, Fig.9.

Pretreatment counts recorded one day before spraying revealed that the aphid population was comparatively lower in endosulfan (19.72) and Neemol mixed with endosulfan (20.83), however, these treatments were on par with Neemol (1.5%). In other treatments the population ranged between 25.92 and 38.30 and was on par with untreated check 34.22.

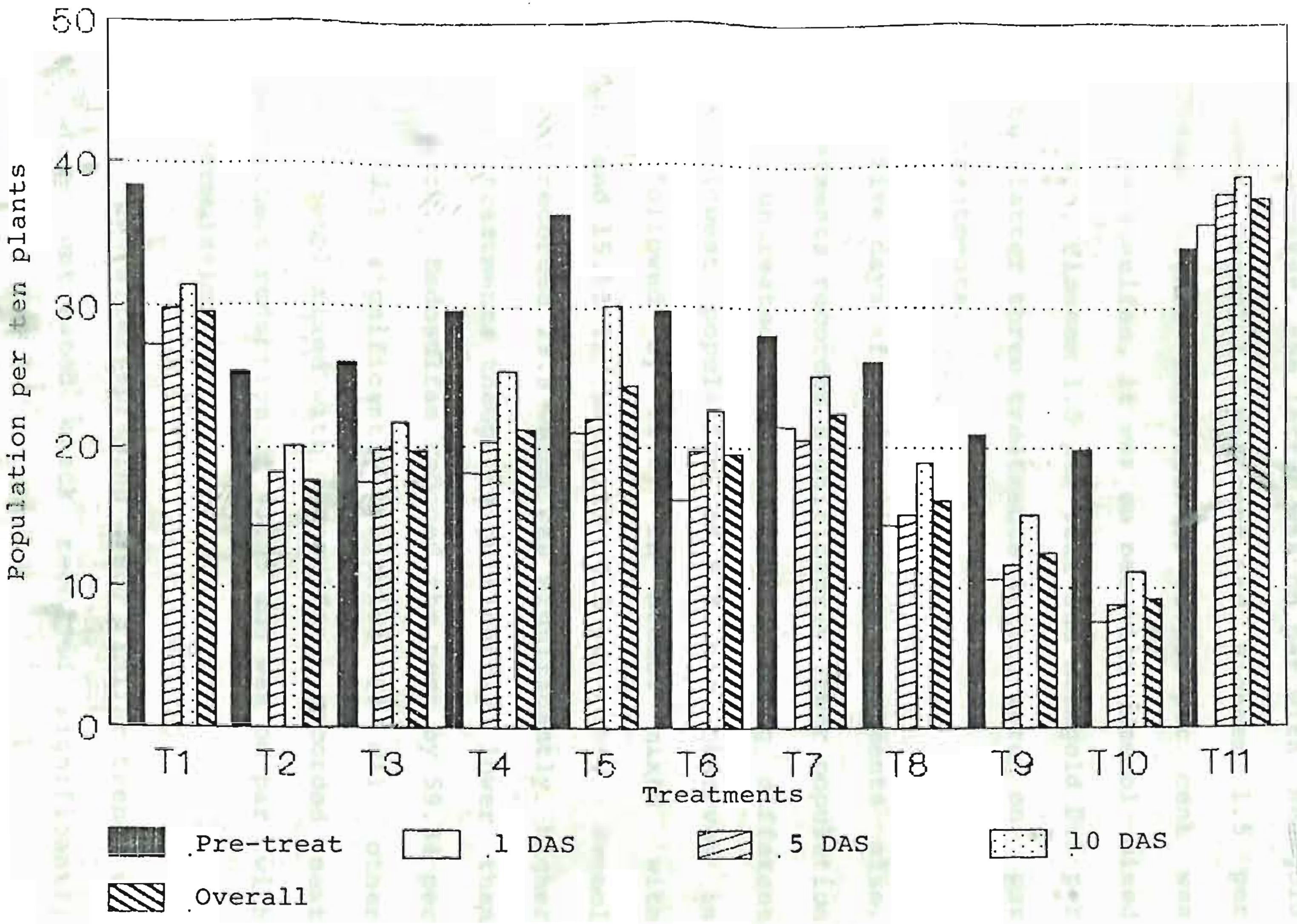
The data recorded one day after spraying revealed that the aphid population was significantly lower in all the treatments compared with untreated check (35.88). Among different treatments, endosulfan recorded lowest

Table 8. Influence of treatments on the incidence of aphid, A. gossypii

Treatments	Population per ten plants				
	Pre-treatment	1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	38.30[a]	27.15[b]	29.80[b]	31.35[b]	29.43[b]
2. Neemol (1.5%)	25.28[cde]	14.35[de]	18.15[cd]	20.05[def]	17.52[def]
3. Multineem (1.0%)	25.92[cd]	17.42[cd]	19.77[cd]	21.67[de]	19.62[cde]
4. Multineem (1.5%)	29.67[bc]	18.05[cd]	20.32[cd]	25.42[bcd]	21.26[cde]
5. Bioneem (1.0%)	36.62[a]	21.08[c]	22.03[c]	30.03[bc]	24.39[bc]
6. Bioneem (1.5%)	29.58[bc]	16.15[cde]	19.68[cd]	22.53[cd]	19.45[cde]
7. Neemgold (0.25%)	28.10[bc]	21.45[bc]	20.52[cd]	25.15[cd]	22.37[cd]
8. Neemgold (0.5%)	26.05[cd]	14.33[de]	15.15[de]	18.87[ef]	16.12[ef]
9. Neemol (1.0%) + Endosulfan (0.035%)	20.83[de]	10.68[ef]	11.67[ef]	15.10[fg]	12.48[fg]
10. Endosulfan (0.07%)	19.72[e]	7.67[f]	8.80[f]	11.18[g]	9.22[g]
11. Untreated check	34.22[ab]	35.88[a]	37.98[a]	39.17[a]	37.68[a]
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	6.18	5.92	5.64	6.19	5.36

Figures in columns followed by the same letter are not significantly different.

Fig. 8 Influence of treatments on the incidence of aphid, *A. gossypii*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

population of 7.67 and was on par with Neemol mixed with endosulfan. However, the latter was on par with Neemgold 0.5 per cent, Neemol 1.5 per cent and Bioneem 1.5 per cent. Though higher reduction of 62.29 per cent was observed in endosulfan, it was on par with Neemol mixed with endosulfan, Bioneem 1.5 per cent and Neemgold 0.5 per cent. The latter three treatments inturn were on par with other treatments.

At five days after imposing the treatments also, all the treatments recorded significantly lower population compared to untreated check (37.98). Among different treatments, lowest population of 8.8 was observed in endosulfan followed by 11.67 in Neemol mixed with endosulfan and 15.15 in Neemgold 0.5 per cent. Neemol 1.0 per cent recorded 29.8 which was significantly higher than other treatments though significantly lower than untreated check. Endosulfan reduced the pest by 59.84 per cent which was significantly superior to all other treatments. Neemol mixed with endosulfan recorded next higher percentage reduction of 43.55 and was on par with other neem formulations.

Ten days after spraying also, similar trend was observed where untreated check recorded significantly

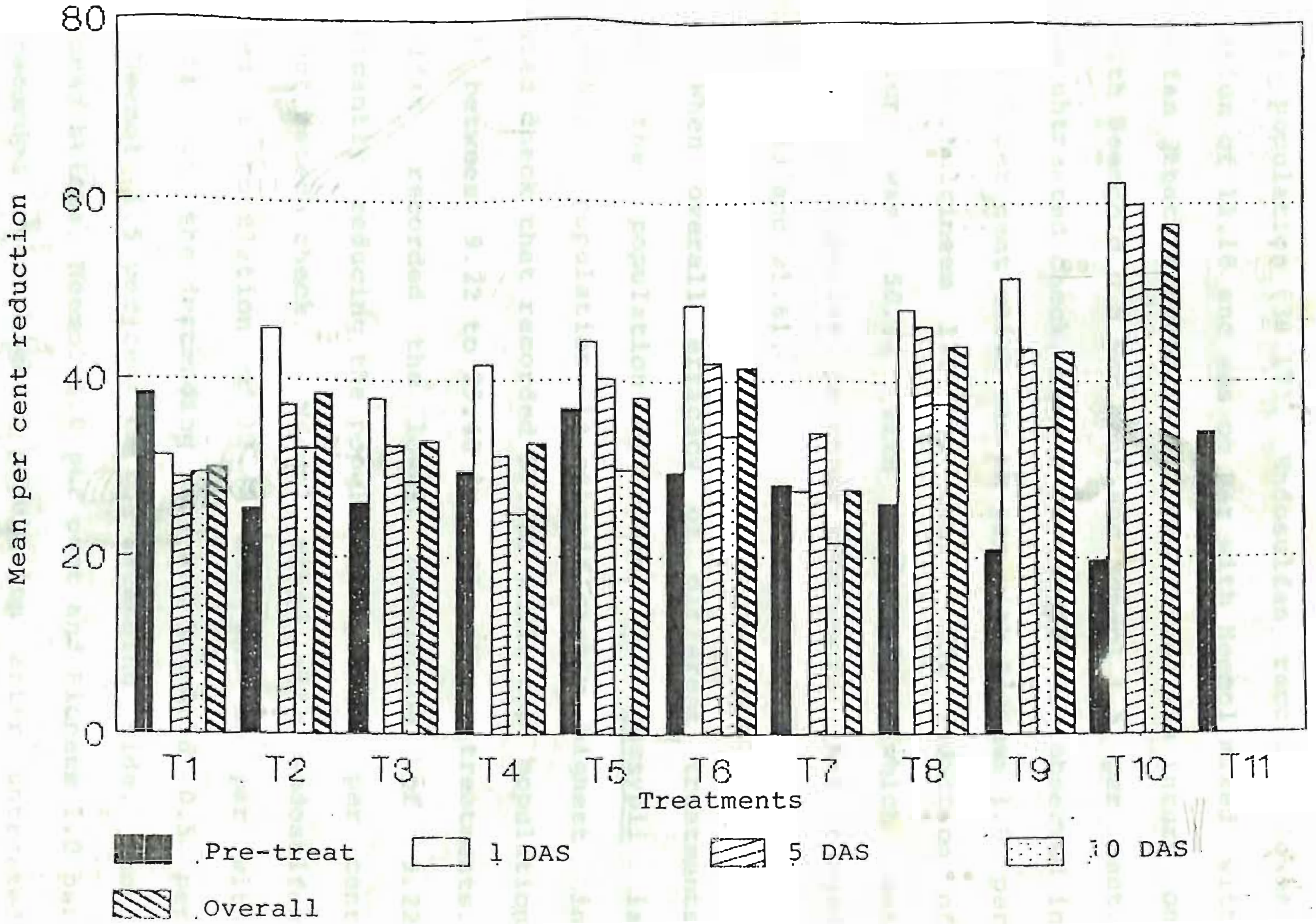
Table 9. Efficacy of treatments against aphid, *A. gossypii*

Treatments	Mean per cent reduction				
	Pre-treatment	1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	38.30[a]	31.52[de] (32.87)	29.04[d] (30.34)	29.47[bcd] (32.66)	30.01[de] (32.69)
2. Neemol (1.5%)	25.28[cde]	45.73[bcd] (42.51)	37.07[bcd] (37.32)	32.19[bc] (34.29)	38.33[bcd] (38.19)
3. Multineem (1.0%)	25.92[cd]	37.89[cde] (35.55)	32.58[bcd] (34.57)	28.53[bcd] (32.01)	33.00[cde] (34.61)
4. Multineem (1.5%)	29.67[bc]	41.65[bcde] (40.15)	31.39[cd] (33.82)	24.94[cd] (29.56)	32.66[cde] (34.69)
5. Bioneem (1.0%)	36.62[a]	44.28[bcd] (41.38)	40.02[bc] (39.09)	29.82[bcd] (32.87)	38.04[bcd] (37.86)
6. Bioneem (1.5%)	29.58[bc]	48.61[abc] (44.15)	42.04[bc] (40.32)	33.61[bc] (35.32)	41.42[bc] (40.04)
7. Neemgold (0.25%)	28.10[bc]	27.43[e] (30.96)	33.96[bcd] (35.55)	21.61[d] (27.54)	27.67[e] (31.68)
8. Neemgold (0.5%)	26.05[cd]	48.14[abc] (43.82)	46.22[bc] (40.79)	37.33[b] (37.58)	43.89[b] (41.47)
9. Neemol (1.0%) + Endosulfan (0.035%)	20.83[de]	51.67[ab] (45.98)	43.55[b] (41.22)	34.70[b] (35.73)	43.31[b] (41.05)
10. Endosulfan (0.07%)	19.72[e]	62.29[a] (53.20)	59.84[a] (50.71)	50.42[a] (45.27)	57.51[a] (49.47)
11. Untreated check	34.22[ab]	0.00[f] (4.05)	0.00[e] (4.05)	0.00[e] (4.05)	0.00[f] (4.05)
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	6.18	10.24	7.11	6.14	6.09

Figures in parentheses are angular transformed values ($\sin^{-1}\sqrt{x}$)

Figures in columns followed by the same letter are not significantly different.

Fig. 9 Efficacy of treatments against aphid, *A. gossypii*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

highest population (39.17). Endosulfan recorded lowest population of 11.18 and was on par with Neemol mixed with endosulfan that recorded 15.1. The latter was inturn on par with Neemgold 0.5 per cent and Neemol 1.5 per cent. Next to untreated check, higher population was observed in Neemol 1.0 per cent which was on par with Bioneem 1.0 per cent and Multineem 1.5 per cent. The reduction of population was 50.42 with endosulfan which was significantly superior to other treatments that ranged between 37.33 and 21.61.

When overall efficacy of different treatments against the population of aphid, A. gossypii is considered, population is significantly highest in untreated check that recorded 37.68, while the population ranged between 9.22 to 29.43 in all other treatments. Endosulfan recorded the lowest population of 9.22 significantly reducing the population by 57.51 per cent over untreated check. Neemol mixed with endosulfan recorded a population of 12.48 and was on par with endosulfan on the descending side and Neemgold 0.5 per cent, Neemol 1.5 per cent on the ascending side. Among neem formulations, Neemol 1.0 per cent and Bioneem 1.0 per cent recorded next higher population after untreated check. The reduction in aphid population in different neem formulations ranged between 27.67 and 43.89, the highest being in Neemgold 0.5 per cent and lowest in Neemgold 0.25 per cent. The reduction in aphid population that was recorded in Neemgold 0.5 per cent was also on par with Neemol mixed with endosulfan, Bioneem 1.5 per cent, Neemol 1.5 per cent and Bioneem 1.0 per cent.

4.1.6 Influence of Treatments against Predatory Beetle, *Verania vincta* Gorham

The predatory beetle *V. vincta* appeared 40 days after planting along with aphid infestation on the crop and continued till the end. The population counts recorded are presented in Table 10, Fig.10. The data pertaining to the per cent reduction of *V. vincta* over untreated check is presented in Table 11, Fig.11.

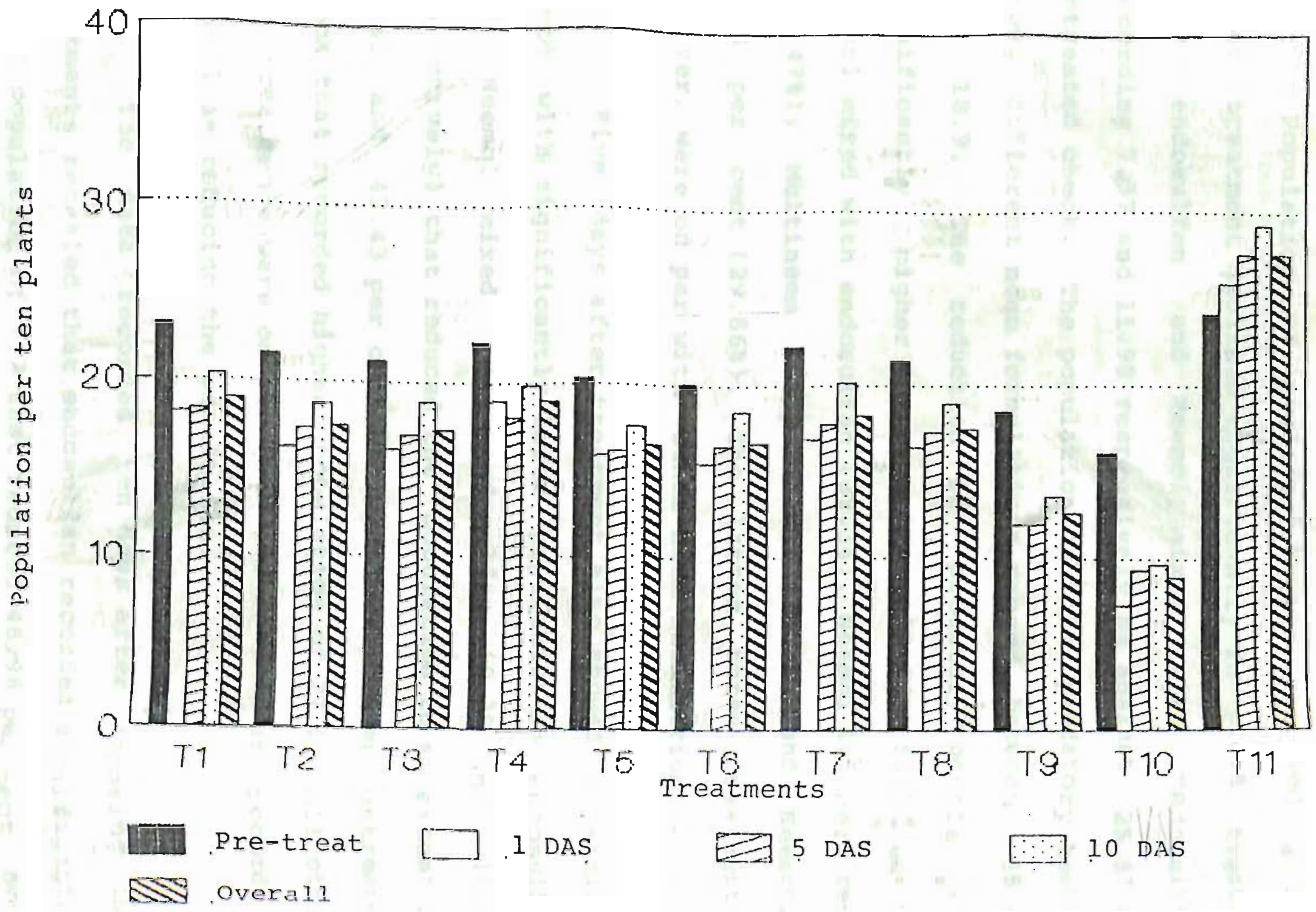
Pretreatment counts showed that the population ranged between 16.05 and 24.15 in different treatments including untreated check. Comparatively lower population was observed in endosulfan and Neemol mixed with endosulfan treated plots while higher population was observed in untreated check and Neemol 1.0 per cent, though these treatments were on par with other neem formulations except Bioneem.

Table 10. Influence of treatments on the incidence of predatory beetle, *V. vincta*

Treatments	Population per ten plants				
	Pre-treatment	1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	23.12[ab]	18.15[bc]	18.28[b]	20.27[b]	18.90[b]
2. Neemol (1.5%)	21.57[abc]	16.17[bc]	17.28[b]	18.70[b]	17.38[b]
3. Multineem (1.0%)	21.22[abcd]	16.10[bc]	16.90[b]	18.83[b]	17.28[b]
4. Multineem (1.5%)	22.28[abc]	18.90[b]	18.00[b]	19.77[b]	18.89[b]
5. Bioneem (1.0%)	20.30[bcd]	15.88[c]	16.12[b]	17.57[b]	16.52[b]
6. Bioneem (1.5%)	20.05[cd]	15.48[c]	16.45[b]	18.43[b]	16.62[b]
7. Neemgold (0.25%)	22.23[abc]	16.87[bc]	17.72[b]	20.15[b]	18.24[b]
8. Neemgold (0.5%)	21.38[abcd]	16.38[bc]	17.22[b]	18.90[b]	17.44[b]
9. Neemol (1.0%) + Endosulfan (0.035%)	18.43[de]	11.98[d]	11.92[c]	13.57[c]	12.58[c]
10. Endosulfan (0.07%)	16.05[e]	7.37[e]	9.38[c]	9.70[d]	9.02[d]
11. Untreated check	24.15[a]	25.87[a]	27.60[a]	29.27[a]	27.58[a]
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	2.99	2.89	2.79	2.93	2.71

Figures in columns followed by the same letter are not significantly different.

Fig.10 Influence of treatments on the incidence of predatory beetle, V. *vincta*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

Population of predatory beetle recorded a day after treatment declined significantly in plots treated with endosulfan and Neemol mixed with endosulfan recording 7.37 and 11.98 respectively as against 25.87 in untreated check. The population of this predatory beetle among different neem formulations ranged between 15.48 and 18.9. The reduction of predatory beetle was significantly higher in endosulfan (55.96%) followed by Neemol mixed with endosulfan (39.3%), Neemol 1.5 per cent (30.47%), Multineem 1.0 per cent (29.3%) and Neemgold 0.25 per cent (29.86%). The latter three treatments, however, were on par with other neem formulations.

Five days after treatment also showed a similar trend with significantly lower population in endosulfan and Neemol mixed with endosulfan (9.38 and 11.92 respectively) that reduced the population to an extent of 48.81 and 43.43 per cent respectively over untreated check that recorded highest population of 27.6. All other neem treatments were on par with one another in recording as well as reducing the population.

The data recorded ten days after imposing the treatments revealed that endosulfan recorded significantly lowest population of 9.7 that reduced 48.96 per cent over untreated check followed by Neemol mixed with endosulfan

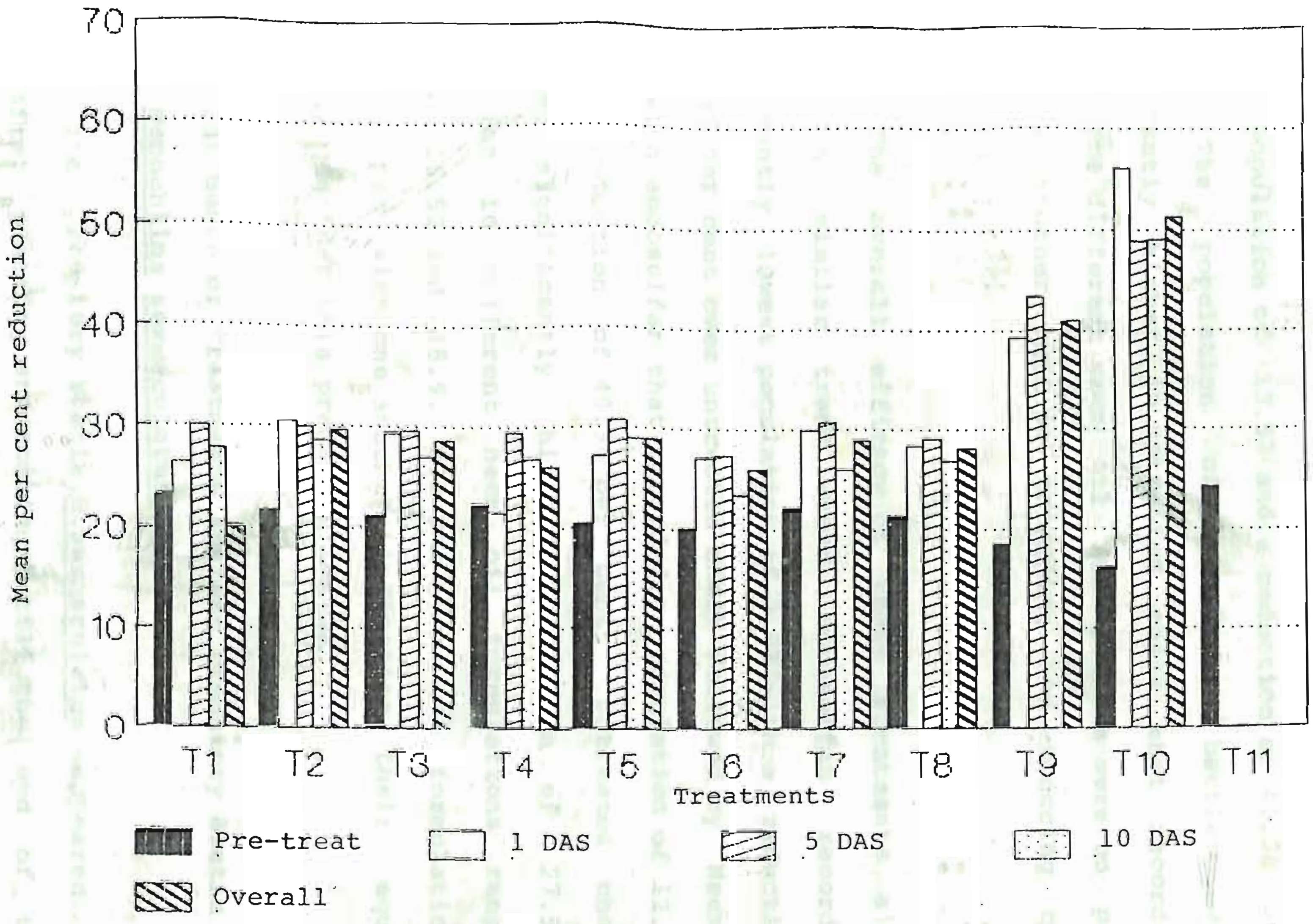
Table 11. Efficacy of treatments against predatory beetle, V. vincta

Treatments	Pre-treatment population per ten plants	Mean per cent reduction over control			
		1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	23.12[ab]	26.38[c] (29.59)	30.11[b] (32.24)	27.78[c] (31.34)	20.09[c] (31.20)
2. Neemol (1.5%)	21.57[abc]	30.47[bc] (33.44)	29.91[b] (33.02)	28.44[c] (32.04)	29.61[c] (32.89)
3. Multineem (1.0%)	21.22[abcd]	29.30[bc] (32.76)	29.68[b] (32.57)	26.99[c] (31.19)	28.66[c] (32.28)
4. Multineem (1.5%)	22.28[abc]	21.52[c] (27.25)	29.52[b] (32.50)	26.87[c] (31.00)	25.97[c] (30.32)
5. Bioneem (1.0%)	20.30[bcd]	27.06[c] (31.25)	30.74[b] (33.41)	28.94[c] (32.25)	28.91[c] (32.34)
6. Bioneem (1.5%)	20.05[cd]	27.13[c] (30.84)	27.44[b] (30.73)	23.49[c] (28.69)	26.02[c] (30.23)
7. Neemgold (0.25%)	22.23[abc]	29.86[bc] (32.75)	30.80[b] (33.39)	25.98[c] (30.29)	28.88[c] (32.19)
8. Neemgold (0.5%)	21.38[abcd]	28.32[c] (31.99)	29.02[b] (32.26)	26.82[c] (30.96)	28.05[c] (31.80)
9. Neemol (1.0%) + Endosulfan (0.035%)	18.43[de]	39.30[b] (38.76)	43.43[a] (41.18)	40.08[b] (39.22)	40.94[b] (39.73)
10. Endosulfan (0.07%)	16.05[e]	55.96[a] (48.68)	48.81[a] (44.32)	48.96[a] (44.38)	51.25[a] (45.76)
11. Untreated check	24.15[a]	0.00[d] (4.05)	0.00[c] (4.05)	0.00[d] (4.05)	0.00[d] (4.05)
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	2.99	6.38	6.27	4.63	5.07

Figures in parentheses are angular transformed values ($\sin^{-1}\sqrt{x}$)

Figures in columns followed by the same letter are not significantly different.

Fig.11 Efficacy of treatments against predatory beetle, *V. vincta*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

with a population of 13.57 and a reduction of 40.08 per cent. The population of predatory beetles was significantly higher in untreated check that recorded 29.27. The different neem oil formulations were on par with one another both in recording and reducing the population.

The overall efficacy of these treatments also showed a similar trend where endosulfan recorded significantly lowest population of 9.02 with a reduction of 51.25 per cent over untreated check followed by Neemol *mixed with endosulfan* that recorded a population of 12.58 with a reduction of 40.94 per cent. Untreated check recorded significantly highest population of 27.58. Population in different neem oil formulations ranged between 16.52 and 18.9. All the neem oil formulations were on par with one another indicating their equal toxicity against this predatory beetle.

4.1.7 Influence of Treatments Against Predatory Beetle *Menochilus sexmaculatus* Fab.

The predatory beetle, *M. sexmaculatus* appeared 60 days after planting and continued till the end of the crop. The population counts recorded are presented in

Table 12, Fig.12. The data pertaining to the per cent reduction over untreated check is presented in Table 13, Fig.13.

Pretreatment counts recorded population between 8.78 and 14.98 in different treatments including untreated check. Endosulfan and Neemol mixed with endosulfan recorded lower population of 8.78 and 10.27 respectively and were on par with each other. Untreated check recorded highest population of 14.98 and was on par with Multineem 1.5 per cent which was inturn on par with the remaining neem oil formulations.

At one day after spraying, the population counts revealed a significant decrease in endosulfan and Neemol mixed with endosulfan. Lowest population of 3.98 was observed in endosulfan followed by Neemol mixed with endosulfan 5.87 as against untreated check (16.88). All the remaining treatments registered significantly lower population compared to untreated check and were on par with one another. The reduction of beetle population was significantly higher in endosulfan 59.55 per cent and was followed by Neemol mixed with endosulfan with 48.78 per cent. All other neem oil formulations were on par with one another and reduced the beetle population by 34.09 to 40.74 per cent.

Table 12. Influence of treatments on the incidence of predatory beetle, *M. sexmaculatus*

Treatments	Population per ten plants				
	Pre-treatment	1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	13.00[b]	8.90[b]	9.15[b]	10.03[b]	9.36[b]
2. Neemol (1.5%)	13.00[b]	8.67[b]	9.22[b]	9.60[b]	9.16[b]
3. Multineem (1.0%)	12.65[ab]	8.82[b]	9.05[b]	9.58[b]	9.15[b]
4. Multineem (1.5%)	12.37[b]	9.03[b]	9.55[b]	9.88[b]	9.49[b]
5. Bioneem (1.0%)	12.48[b]	8.27[b]	9.32[b]	9.55[b]	9.05[b]
6. Bioneem (1.5%)	11.93[bc]	8.50[b]	9.12[b]	9.93[b]	9.18[b]
7. Neemgold (0.25%)	11.53[bc]	8.23[b]	8.88[b]	9.33[bc]	8.82[b]
8. Neemgold (0.5%)	12.22[bc]	8.25[b]	9.28[b]	9.22[bc]	8.92[b]
9. Neemol (1.0%) + Endosulfan (0.035%)	10.27[cd]	5.87[c]	6.82[c]	7.55[c]	6.74[c]
10. Endosulfan (0.07%)	8.78[d]	3.98[d]	3.77[d]	4.70[d]	4.15[d]
11. Untreated check	14.98[a]	16.88[a]	18.12[a]	17.48[a]	17.50[a]
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	1.98	1.76	1.74	1.80	1.63

Figures in columns followed by the same letter are not significantly different.

Table 12, Fig.12. The data pertaining to the per cent reduction over untreated check is presented in Table 13, Fig.13.

Pretreatment counts recorded population between 8.78 and 14.98 in different treatments including untreated check. Endosulfan and Neemol mixed with endosulfan recorded lower population of 8.78 and 10.27 respectively and were on par with each other. Untreated check recorded highest population of 14.98 and was on par with Multineem 1.5 per cent which was inturn on par with the remaining neem oil formulations.

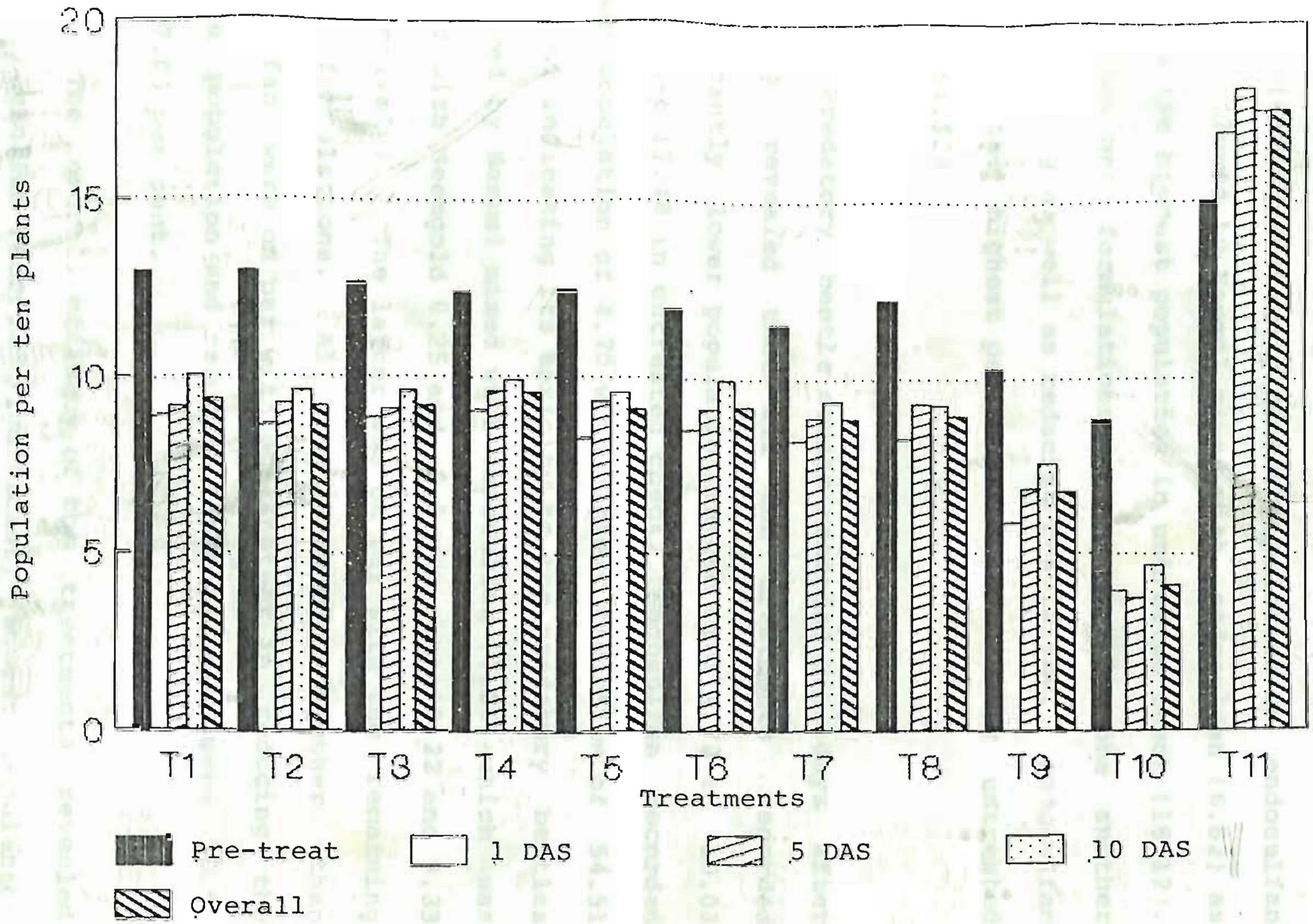
At one day after spraying, the population counts revealed a significant decrease in endosulfan and Neemol mixed with endosulfan. Lowest population of 3.98 was observed in endosulfan followed by Neemol mixed with endosulfan 5.87 as against untreated check (16.88). All the remaining treatments registered significantly lower population compared to untreated check and were on par with one another. The reduction of beetle population was significantly higher in endosulfan 59.55 per cent and was followed by Neemol mixed with endosulfan with 48.78 per cent. All other neem oil formulations were on par with one another and reduced the beetle population by 34.09 to 40.74 per cent.

Table 12. Influence of treatments on the incidence of predatory beetle, M. sexmaculatus

Treatments	Population per ten plants				
	Pre-treatment	1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	13.00[b]	8.90[b]	9.15[b]	10.03[b]	9.36[b]
2. Neemol (1.5%)	13.00[b]	8.67[b]	9.22[b]	9.60[b]	9.16[b]
3. Multineem (1.0%)	12.65[ab]	8.82[b]	9.05[b]	9.58[b]	9.15[b]
4. Multineem (1.5%)	12.37[b]	9.03[b]	9.55[b]	9.88[b]	9.49[b]
5. Bioneem (1.0%)	12.48[b]	8.27[b]	9.32[b]	9.55[b]	9.05[b]
6. Bioneem (1.5%)	11.93[bc]	8.50[b]	9.12[b]	9.93[b]	9.18[b]
7. Neemgold (0.25%)	11.53[bc]	8.23[b]	8.88[b]	9.33[bc]	8.82[b]
8. Neemgold (0.5%)	12.22[bc]	8.25[b]	9.28[b]	9.22[bc]	8.92[b]
9. Neemol (1.0%) + Endosulfan (0.035%)	10.27[cd]	5.87[c]	6.82[c]	7.55[c]	6.74[c]
10. Endosulfan (0.07%)	8.78[d]	3.98[d]	3.77[d]	4.70[d]	4.15[d]
11. Untreated check	14.98[a]	16.88[a]	18.12[a]	17.48[a]	17.50[a]
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	1.98	1.76	1.74	1.80	1.63

Figures in columns followed by the same letter are not significantly different.

Fig.12 Influence of treatments on the incidence of predatory beetle, *M. sexmaculatus*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

Five days after spraying also showed a similar trend with significantly lowest population in endosulfan (3.77) followed by Neemol mixed with endosulfan (6.82) as against the highest population in untreated check (18.12). All other neem formulations were on par with one another in recording as well as reducing population. Endosulfan recorded the highest per cent reduction over untreated check (64.52).

Predatory beetle counts recorded ten days after spraying revealed that all the treatments recorded significantly lower population ranged from 4.70 to 10.03 as against 17.48 in untreated check. Endosulfan recorded lowest population of 4.70 with highest reduction of 54.51 per cent indicating its toxicity to the predatory beetles followed by Neemol mixed with endosulfan (7.55) which was on par with Neemgold 0.25 and 0.5 per cent (9.22 and 9.33 respectively). The latter was on par with the remaining neem formulations. All the treatments other than endosulfan were on par with one another in reducing the beetle population and recorded a reduction between 30.58 and 37.03 per cent.

The overall efficacy of the treatments revealed that endosulfan recorded significantly lowest population

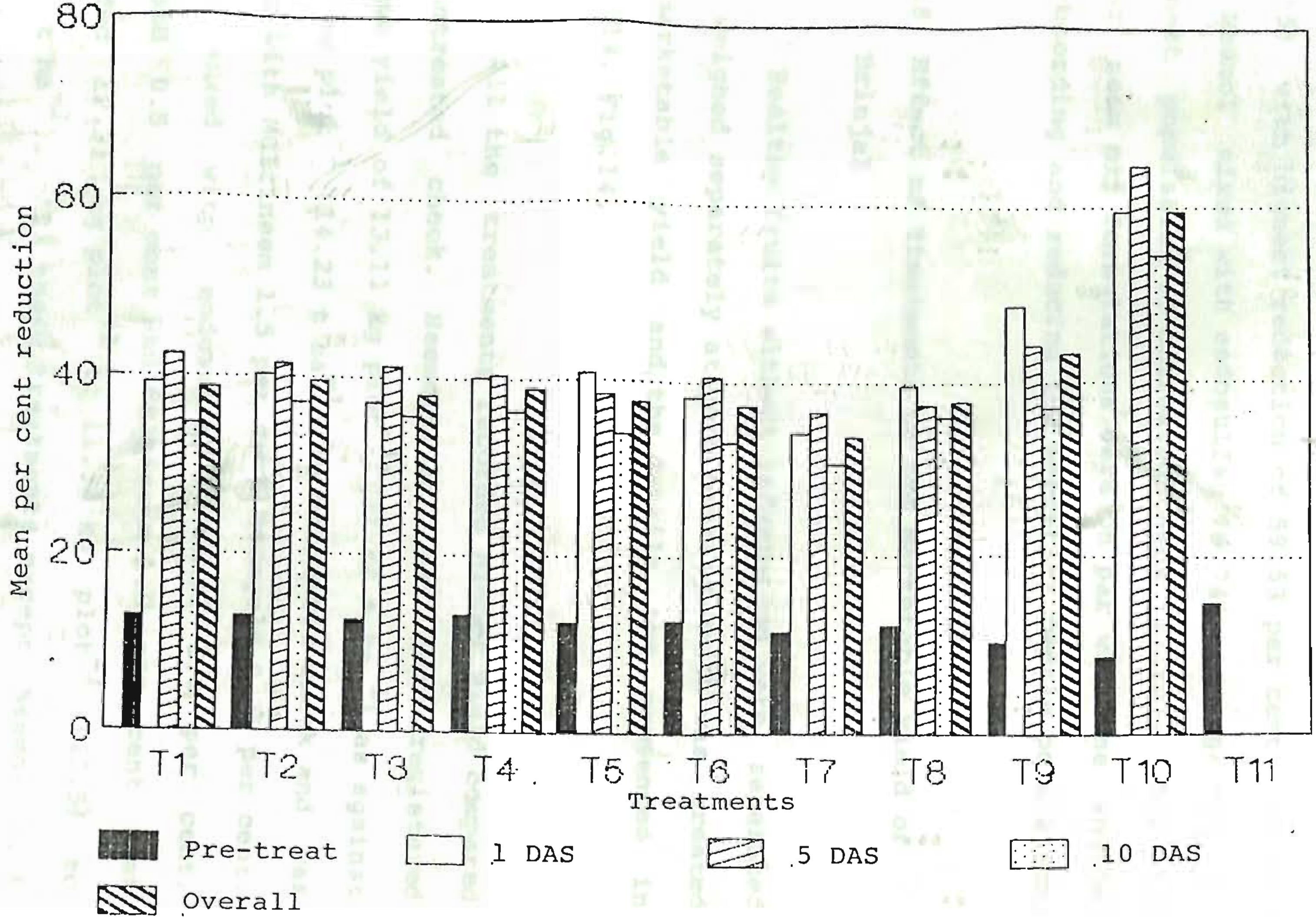
Table 13. Efficacy of treatments against predatory beetle, *M. sexmaculatus*

Treatments	Pre-treatment population per ten plants	Mean per cent reduction over control			
		1 DAS	5 DAS	10 DAS	Overall efficacy
1. Neemol (1.0%)	13.00[b]	39.13[c] (38.69)	42.30[b] (40.55)	34.65[b] (36.03)	38.69[bc] (38.45)
2. Neemol (1.5%)	13.00[b]	40.05[c] (39.18)	41.43[b] (39.99)	37.03[b] (37.46)	39.50[bc] (38.91)
3. Multineem (1.0%)	12.65[b]	37.09[c] (37.39)	41.21[b] (39.90)	35.56[b] (36.51)	37.95[bc] (38.01)
4. Multineem (1.5%)	13.37[bc]	40.07[c] (39.13)	40.42[b] (39.39)	36.18[b] (36.89)	38.89[bc] (38.52)
5. Bioneem (1.0%)	12.48[b]	40.74[c] (39.57)	38.26[b] (38.11)	33.84[b] (35.43)	37.61[bc] (37.78)
6. Bioneem (1.5%)	12.93[b]	38.15[c] (37.69)	40.62[b] (39.47)	33.03[b] (34.99)	37.27[bc] (37.49)
7. Neemgold (0.25%)	11.53[bc]	34.09[c] (35.65)	36.32[b] (37.01)	30.58[b] (33.55)	33.66[c] (35.44)
8. Neemgold (0.5%)	12.22[bc]	39.60[c] (38.49)	37.42[b] (37.66)	35.89[b] (36.76)	37.64[bc] (37.74)
9. Neemol (1.0%) + Endosulfan (0.035%)	10.27[cd]	48.78[b] (44.29)	44.24[b] (41.03)	36.93[b] (36.65)	43.32[b] (40.92)
10. Endosulfan (0.07%)	8.78[d]	59.55[a] (50.51)	64.52[a] (53.60)	54.51[a] (47.61)	59.53[a] (50.55)
11. Untreated check	14.98[a]	0.00[d] (4.05)	0.00[c] (4.05)	0.00[c] (4.05)	0.00[d] (4.05)
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. (0.05)	1.98	4.68	5.22	5.71	3.95

Figures in parentheses are angular transformed values ($\sin^{-1}\sqrt{x}$)

Figures in columns followed by the same letter are not significantly different.

Fig.13 Efficacy of treatments against predatory beetle, *M. sexmaculatus*



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

(4.15) with highest reduction of 59.53 per cent followed by Neemol mixed with endosulfan (6.74) as against the highest population of untreated check (17.50). All the other neem oil formulations were on par with one another in recording and reducing the predatory beetle population.

4.1.8 Effect of Treatments on the Marketable yield of Brinjal

Healthy fruits without infestation were separated and weighed separately at each picking which was treated as marketable yield and the details are presented in Table 14, Fig.14.

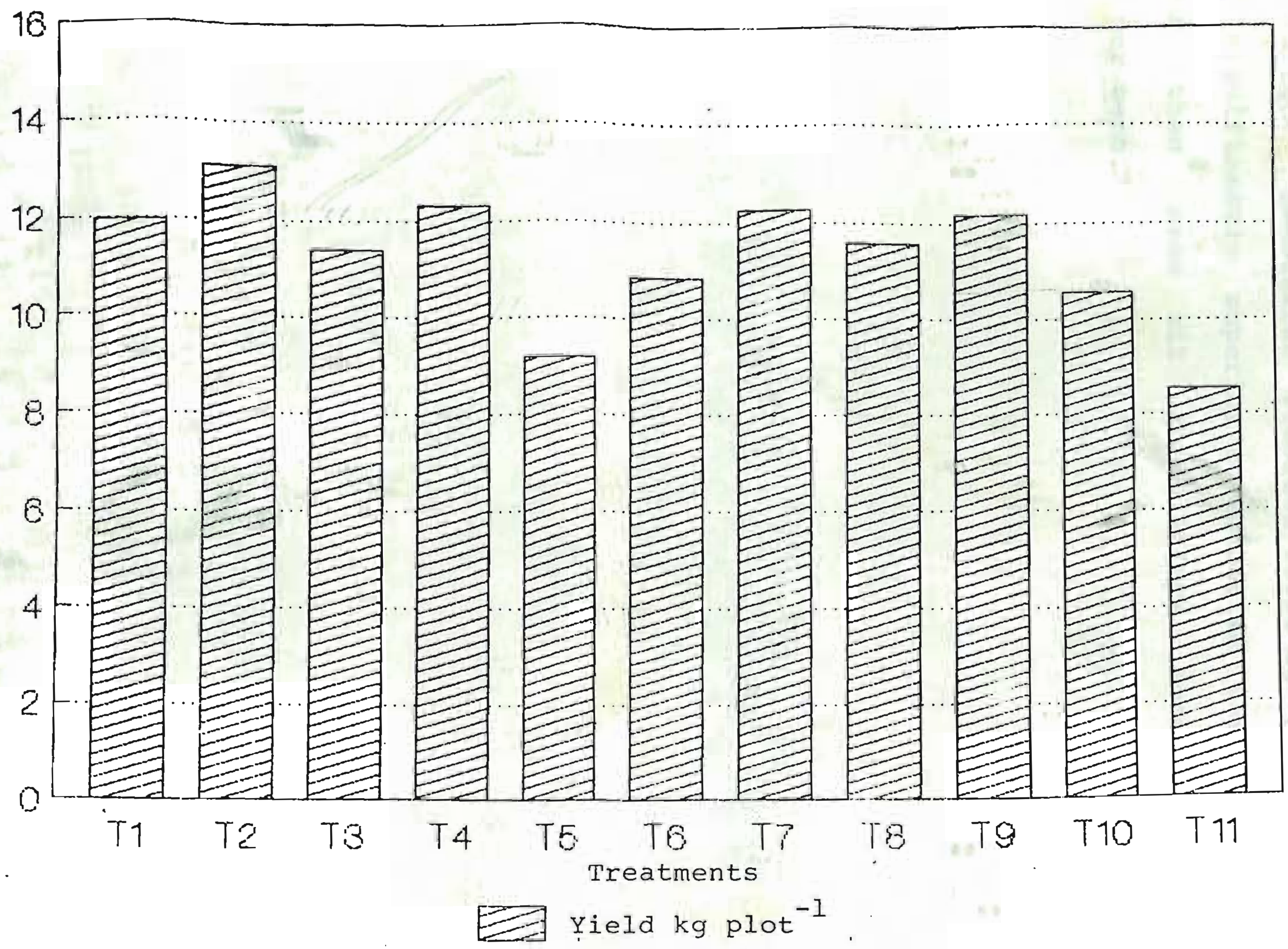
All the treatments recorded higher yield compared to untreated check. Neemol 1.5 per cent registered maximum yield of 13.11 kg $plot^{-1}$ (21.84 t ha^{-1}) as against 8.54 kg $plot^{-1}$ (14.23 t ha^{-1}) in untreated check and was on par with Multineem 1.5 per cent Neemgold 0.25 per cent, Neemol mixed with endosulfan, Neemol 1.0 per cent, Neemgold 0.5 per cent and Multineem 1.0 per cent that recorded 12.31 kg $plot^{-1}$ to 11.38 kg $plot^{-1}$ (20.51 to 18.97 t ha^{-1}). All these treatments except Neemol 1.5% were inturn on par with Bioneem 1.5 per cent and

Table 14. Influence of treatments on the marketable yield of brinjal

Treatments	Yield kg $plot^{-1}$	Yield t ha^{-1}
1. Neemol (1.0%)	11.97^{ab}	19.95
2. Neemol (1.5%)	13.11^{a}	21.84
3. Multineem (1.0%)	11.38^{ab}	18.97
4. Multineem (1.5%)	12.31^{ab}	20.51
5. Bioneem (1.0%)	9.21^{cd}	15.35
6. Bioneem (1.5%)	10.86^{bc}	18.10
7. Neemgold (0.25%)	12.25^{ab}	20.42
8. Neemgold (0.5%)	11.56^{ab}	19.27
9. Neemol (1.0%) + Endosulfan (0.035%)	12.18^{ab}	20.29
10. Endosulfan (0.07%)	10.58^{bc}	17.63
11. *Untreated check*	8.54^{d}	14.23
F-test	Sig.	
C.D. (0.05)	1.75	

Figures in columns followed by the same letter are not significantly different.

Fig. 14 Influence of treatments on marketable yield of brinjal



TREATMENTS

T1	Neemol	1.0 per cent
T2	Neemol	1.5 per cent
T3	Multineem	1.0 per cent
T4	Multineem	1.5 per cent
T5	Bioneem	1.0 per cent
T6	Bioneem	1.5 per cent
T7	Neemgold	0.25 per cent
T8	Neemgold	0.5 per cent
T9	Neemol + Endosulfan	1.0 per cent + 0.035 per cent
T10	Endosulfan	0.07 per cent
T11	Untreated check	

Endosulfan. Endosulfan recorded 10.58 kg $plot^{-1}$ which was significantly superior to untreated check but was lower than neem oil formulations except Bioneem 1.0 per cent.

DISCUSSION

CHAPTER V

DISCUSSION

A field trial was conducted at Agricultural College Farm, Bapatla during rabi 1996-97 with eleven treatments replicated thrice to study the influence of certain selected neem oil formulations on the major pests of brinjal and their damage potential besides natural enemies. The results obtained in the present studies are discussed in the light of available literature and presented below.

5.1 EFFICACY OF DIFFERENT TREATMENTS AGAINST MAJOR PESTS OF BRINJAL

5.1.1 Shoot and Fruit Borer, *Leucinodes orbonalis* Guen. on Shoots

All the treatments tested recorded less percentage of shoot infestation compared to untreated check: among treatments Neemgold 0.25 per cent, Neemol 1.5 per cent and Multineem 1.5 per cent were significantly superior to untreated check by recording 1.76 to 2.42 per cent shoot infestation as against 8.13 per cent of untreated check. Narasimha Rao (1994) reported good performance of neem oil formulation i.e. Repelin (0.5%) against shoot infestation of *L. orbonalis* on brinjal.

5.1.2 **Shoot and Fruit Borer, L. orbonalis on Fruits**

Neemgold (0.25%) recorded significantly lowest damage of brinjal fruit borer over untreated check. Neemol mixed with endosulfan, Neemol (1 and 1.5%), Multineem (1.5%) and Neemgold (0.5%) also recorded significantly lesser damage than untreated check. Literature on the efficacy of Neemgold, Neemol and Multineem against brinjal fruit borer is not available. However, Srivastava et. al. (1994) reported good control of chickpea pod borer, Heliothis armigera (Huebner) with endosulfan (0.07%) followed by Nimbecidine (0.2%) but poor control with endosulfan (0.07%) followed by Neemgold (0.5%).

5.1.3 **Jassid, Amrasca biguttula biguttula Ish.**

Endosulfan recorded significantly lowest population of jassids (12.64) with the highest reduction (66.38%) over untreated check that recorded a population of 32.98. The efficacy of endosulfan against jassid, A. biguttula biguttula Ish. was also reported by Rama Subba Rao et. al. (1984) and Shashi Verma (1992) on brinjal, Balasubramanian and Chelliah (1985) on sunflower, Jagan Mohan (1985), Yadav et. al. (1988), Waryam Singh et. al. (1991) and Goel Ira et. al. (1992) on okra and alternated with Carbaryl (0.15%) on okra by Bhavani Sankara Rao (1990).

All the neem formulations recorded higher population of jassid than endosulfan but lower than untreated check. The present results conform with those of Sardana and Krishnakumar (1989) who reported that neem oil 0.5, 1.0 and 2.0 per cent recorded lower population than untreated check but higher than check insecticide, monocrotophos in okra. Effective control of jassid was obtained with neem oil by Venugopal Rao et. al. (1990) on cotton, Brar et. al. (1994) on okra, with Neemguard by Nimbkar et. al. (1994) on okra and with Neemazal F 50 ppm by Clement Peter (1994) on cotton. The latter registered significantly lowest jassid population with a combination of Neemazal F 50 ppm and endosulfan 500 g a.i. ha^{-1}.

5.1.4 **Whitefly, Bemisia tabaci Genn.**

Endosulfan recorded significantly lowest population of 11.56 with highest reduction as against 35.3 of untreated check. Efficacy of endosulfan in reducing population of whitefly B. tabaci was reported by Rama Subba Rao et. al. (1984) and Shashi Verma (1992) on brinjal, Balasubramanian and Chelliah (1985) on sunflower, Bhattacherjee (1990) on soybean, Venugopal Rao et. al. (1990), and Joseph Dominick and Mohanasundaram (1992) on cotton.

Different neem formulations recorded population ranging between 21.38 and 26.54 which was significantly lower than untreated check. Effective reduction of whitefly with neem oil was also reported by Natarajan et. al. (1986), Natarajan and Sundaramurthy (1990) and Venugopal Rao et. al. (1990) on cotton, Coudriet et. al. (1986) on sweet potato. Efficacy of Neemark againt *B. tabaci* on cotton was reported by Phadke et. al. (1988) and Patel et. al. (1994) and of Neemax on okra by Nimbkar et. al. (1994).

5.1.5 **Aphid, *Aphis gossypii* (Glov.)**

Lowest aphid population of 9.22 was observed in endosulfan with the highest per cent reduction of 57.51 over untreated check. The present results are in agreement with the findings of Chitra et. al. (1993) on brinjal; Mohan (1986), Yadav et. al. (1988) and Bhavani Sankara Rao (1990) on okra; Venkatesan et. al. (1987) and Venugopal Rao et. al. (1990) on cotton and on musk melon by Pareek and Kavadia (1988).

Neem oil formulations recorded 27.67 to 43.89 per cent reduction of population over untreated check. The good performance of neem formulations is in agreement with Cherian and Gopala Menon (1944) and Mohan (1988) on brinjal, Bhavani Sankara Rao (1990) on okra and Venugopal Rao et. al. (1990) on cotton.

Effective control of A. gossypii on cotton was also reported by Praduman Bhatnagar and Kandasamy (1993) with Neemrich 80 EC, Udaiyan and Ramarathinam (1994) with nimbicidine and Clement Peter and Govindarajulu (1994) with Neem 2 EC.

5.2 INFLUENCE OF TREATMENTS ON THE INCIDENCE OF PREDATORY BEETLES

Lowest populations of predatory beetles were observed in endosulfan followed by Neemol mixed with endosulfan. All the neem formulations recorded significantly higher populations of predatory beetles over the above two treatments but significantly lower than untreated check indicating their lesser toxicity towards predatory beetles than endosulfan. All the neem formulations were on par with one another indicating their equal toxicity against predatory beetles. Singh et. al. (1985) reported that most of the botanicals were safe to aphid predator, Coccinella septumpunctata. Clement Peter and Govindarajulu (1994) also reported lesser toxicity of neem products against grubs of coccinellid predators. Lesser toxicity of neem products against other predators (other than coccinellids) was also reported by Joshi et. al. (1982), Kareem et. al. (1988), Saxena et. al. (1989), Sontakke (1993) against mirids and spiders and Wu (1986) against predatory spider, *Lycosa pseudoannulata*.

5.3 EFFECT OF TREATMENTS ON THE MARKETABLE YIELD OF BRINJAL

All the treatments recorded higher yield compared to untreated check. Neemol 1.5 per cent recorded maximum yield of 13.11 kg $plot^{-1}$ as against 8.54 in untreated check and was on par with Multineem 1.5 per cent, Neemgold 0.25 per cent, Neemol mixed with endosulfan, Neemol 1.0 per cent, Neemgold 0.5 per cent and Multineem 1.0 per cent which registered 12.31 to 11.38 kg $plot^{-1}$. This increased yield can be attributed to their efficacy against the shoot and fruit borer which has a direct influence on the marketable yield of the crop. Though no literature is available on the influence of these products on the yield of brinjal, Nigam and Sen (1989) recorded higher yield of 1555 kg ha^{-1} paddy with Neem oil 4.0 per cent as against 880 in control and 1505 in monocrotophos. Narasimha Rao (1994) reported significantly higher yield of brinjal fruits (13.48 kg $plot^{-1}$) with repelin 0.5 per cent compared to untreated check (10.3 kg $plot^{-1}$).

Endosulfan registered an yield of 10.58 kg $plot^{-1}$ which was significantly higher than untreated check (8.54 kg $plot^{-1}$). Increased yields with endosulfan were also reported by Gupta and Kawal Dhari (1981), Khaire et. al. (1986), Rajavel et. al. (1989), Sontakke et. al. (1990) and Narasimha Rao (1994) in brinjal.

Increased yields with endosulfan were also reported by several scientists in other crops; Balasubramanian and Chelliah (1985) in sunflower, Jagan Mohan (1985) in okra, Siddappaji et. al. (1986) in chickpea, Bhattacherjee (1990) in soybean and Srivastava et. al. (1994) in combination with Nimbecidine (0.2%) in chickpea.

CONCLUSIONS

The following are the conclusions drawn from the results obtained.

1. All the insecticidal treatments tested were found to be superior to untreated check by recording lower populations of all the pest species studied with significant superiority against whiteflies, aphids and predatory beetles.

2. The treatments Neemgold (0.25%), Neemol (1.5%) and Multineem (1.5%) recorded significantly lower shoot damage by shoot and fruit borer, *L. orbonalis*, Neemgold being the lowest. Neemgold (0.25%) recorded the lowest fruit damage though it was on par with Neemol mixed with endosulfan, Neemol (1.5%) and Multineem (1.5%).

3. Endosulfan recorded the lowest population and highest per cent reduction of sucking pests.

4. Endosulfan was found to be more toxic to predators while neem oil formulations were observed to be safer than endosulfan.

5. Neemol (1.5%) recorded the maximum marketable yield (21.84 t ha^{-1}).

SUMMARY

CHAPTER VI

SUMMARY

Field studies were carried out to test the efficacy of certain selected neem oil formulations against the major pests of brinjal, their damage potential and natural enemies at Agricultural College Farm, Bapatla during rabi, 1996-97. The pests and natural enemies studied were shoot and fruit borer, *Leucinodes orbonalis* Guen.; jassid, *Amrasca biguttula biguttula* Ish.; whitefly, *Bemisia tabaci* Genn.; aphid, *Aphis gossypii* (Glov.); predatory beetles , *Verania vincta* and *Menochilus sexmaculatus*.

The experiment was laid out in a simple randomised block design with eleven treatments replicated thrice. The treatments imposed include endosulfan, Neemol mixed with endosulfan and two concentrations of certain selected neem oil formulations i.e., Neemol, Multineem, Bioneem and Neemgold besides untreated check. A hand compression knapsack sprayer was used for imposing the treatments. The first round of treatments was given 40 days after planting and thereafter at 15 days interval. Population counts of different pests and predatory beetles were recorded one day before and one, five and ten days after each spray. The crop received a total of six sprays. Appearance of different pests started between 30 and 40 days after planting. Brinjal shoot and fruit borer damaged shoots upto 70 days after which the fruit damage became more pronounced. To assess the efficacy of different treatments, the percentage reduction of sucking pests at one, five and ten days after each spray was calculated. In the case of shoot and fruit borer, percentage shoot damage at five and ten days after each spray and percentage fruit damage at each picking were calculated. The effect of treatments on marketable yield of brinjal was also studied. The results obtained from the above studies were summarised below.

All the treatments were found to be superior to untreated check and recorded lower populations of all the insect pests studied. Neemgold (0.25%), Neemol (1.5%) and Multineem (1.5%) were found to be effective against the shoot and fruit borer, L. orbonalis by recording significantly less damage to shoots as well as fruits over untreated check, while endosulfan recorded lowest population of jassids, whiteflies and aphids closely followed by Neemol mixed with endosulfan. Endosulfan was found to be more toxic to predatory beetles also as evidenced by lower population of these beetles in endosulfan as well as Neemol mixed with endosulfan treated plots. All the neem oil formulations were less toxic to predatory beetles compared to endosulfan and were on par with one another. Neemol (1.5%) registered maximum marketable yield (21.84 t ha^{-1}) among all treatments as against the lowest yield in untreated check (14.23 t ha^{-1}).

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