BIOEFFICACY, PHYTOTOXICITY AND COMPATIBILITY OF METHOMYL 40 SP ALONE AND IN COMBINATION WITH *Helicoverpa* NPV AGAINST PESTS OF COTTON

By

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Reg. No. 92068

A Thesis Submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH

RAHURI, 413 722 DIST.- AHMEDNAGAR.

Maharashtra State (India)

in partial fulfilment of the requirements for the degree

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in

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DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
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CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma.

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CERTIFICATE

This is to certify that the thesis entitled BIOEFFICACY, PHYTOTOXICITY AND COMPATIBILITY OF METHOMYL 40 SP ALONE AND IN COMBINATION WITH Helicoverpa NPV AGAINST PESTS OF COTTON", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, District Ahmednagar, (Maharashtra State) in partial fulfilment of the requirement for the degree of MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL ENTOMOLOGY, embodies the results of bona fide research work carried out by MISS SHEELA BHAUSAHEB PATIL under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

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This is to certify that the thesis entitled "BIOEFFICACY, PHYTOTOXICITY AND COMPATIBILITY OF METHOMYL 40 SP ALONE AND IN COMBINATION WITH Helicoverpa NPV AGAINST PESTS OF COTTON", submitted by MISS SHEELA BHAUSAHEB PATIL to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, District Ahmednagar, (Maharashtra State) in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL ENTOMOLOGY, embodies the results of *bona fide* research work carried out by her under the guidance and supervision of Dr. V.M. Pawar.

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Dated : 23/5/94

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S B Patil

(Miss. S.B. PATIL)

Place : Rahuri

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

a.i.	=	Active ingradient
C.D.	=	Critical Difference
Conc.	=	Concentration
DAS	=	Days After Spray
EC	=	Emulsifiable concentrates
et al.	=	Et alli (and others)
Fig.	=	Figure
g	=	Gram (s)
ha	=	Hectare (s)
HaNPV	=	<u>Helicoverpa</u> <u>armigera</u> nuclear polyhedrosis virus
h	=	hour (s)
i.e.	=	That is
kg	=	Kilogram (s)
LD_{50}	=	Lethal dose of toxicant to kill 50 % of test population
L	=	Litre (s)
LE	=	Larval Equivalent
LU	=	Larval unit
Ltd.	=	Limited
m	=	Meter (s)
M/S	=	Messers
Ml	=	Millitre
NPV	=	Nuclear Polyhedrosis Virus
N.S.	=	Non significant

PIBs	=	Polyhedral inclusion bodies
ppm	=	Parts per million
q	=	Quintal (s)
rpm	=	Revolutions per minute
SP	=	Soluble powder
S.E.	=	Standard Error
spp.	=	Species
ULV	=	Ultra low volume
viz.	=	Videlciet (namely)
WP	=	Wettable Powder
%	=	Per cent
@	=	At the rate of
/	=	Per
µg	=	Microgram

ABSTRACT

BIOEFFICACY, PHYTOTOXICITY AND COMPATIBILITY OF METHOMYL 40 SP ALONE AND IN COMBINATION WITH Helicoverpa NPV AGAINST PESTS OF COTTON

By

Miss. S.B. Patil

A candidate for the degree
of
MASTER OF SCIENCE
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Research Guide : Dr. V.M. Pawar

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Bioefficacy, phytotoxicity and compatibility of methomyl (Lannate 40 SP) @ 150, 300, 450 g a.i./ha alone and in combination with Helicoverpa NPV @ 250 LE/ha was studied in comparison with endosulfan @ 350 g a.i./ha and cypermethrin @ 60 g a.i./ha as standards against bollworms and sucking insect pests. The impact of these treatments on the predator, Coccinella septumpunctata was also evaluated.

Each insecticide formulation was tested as a schedule of four sprays given at fortnightly interval by starting the first spray at square formation stage. All the insecticide treatments were effective in minimising the infestation of bollworms. Cypermethrin @ 60 g a.i./ha was the most effective treatment. Methomyl @ 450 g a.i./ha was the next best

ABSTRACT...CONTD...

treatment followed by methomyl @ 450 g a.i./ha + NPV 250 LE/ha. For the control of sucking pests, methomyl @ 450 g a.i./ha and cypermethrin @ 60 g a.i./ha were the most effective treatments, except for the fact that aphid resurgence was noticed in cypermethrin treated plots. Methomyl @ 450 g a.i./ha was highly toxic, while NPV @ 250 and 500 LE/ha did not affect the lady bird bettle. Methomyl at higher dose of 900 g a.i./ha showed phytotoxicity symptoms on cotton crop.

Maximum yield (1571 kg/ha) of seed cotton was recorded in treatment with cypermethrin @ 60 g a.i./ha as against 740 kg/ha in untreated plots. The yield of seed cotton from rest of insecticide treatments was in the range of 814 to 1158 kg/ha.

Pages : 1 to 81

Chapter Opener Page

Introduction

1. INTRODUCTION

Cotton, the 'White Gold' of India, plays a key role in agrarian and industrial economy of India. In India, cotton is grown over an area of 7.3 million hectares with annual production of about 133.5 lakh bales (1989-90). It is considered to be the main crop in the State of Maharashtra, which is the largest cotton growing state of India with an area of about 27.3 lakh hectares and production of about 3.17 lakh tonnes lint per annum.

Though India is a major cotton growing country in the world, the productivity of cotton is very low as compared to world average. Also the production of lint in Maharashtra State is low i.e. 110 kg/ha as compared to average production of India (213 kg/ha). As per an estimate, the annual demand in the State will increase from 18 lakh bales to 30 lakh bales by the year 2000 (Anonymous, 1991). It is, therefore, necessary to increase per hectare production in the State.

Many factors are responsible for low yield of cotton in India and this is largely due to insect pests which ravage the crop from germination to harvest (Nagpal, 1984, Khan and Rao, 1960). In India, as many as 134 insect and non-insect pests are recorded to infest the cotton crop (Sohi, 1964). Thakare et al. (1983) reported that, in the Maharashtra State about 25 pests attack the cotton crop regularly. Out of them, three bollworms including American bollworm (*Helicoverpa armigera* Hubner), pink bollworm (*Pectinophora gossypiella* Saunders) and spotted bollworm (*Earias vittella* Stoll and *Earias insulana* Boised) are the major pests of cotton damaging squares, buds, flowers and bolls inflicting great loss in yield. The loss ranges from 15 to 20 per cent with an annual loss of 10 to 15 thousand bales worth Rs. 150 to 250 crores due to insect pests (Ramchandran *et al.* 1980). Besides bollworms, the sucking pests like aphids (*Aphis gossypii* Glover), jassids (*Amrasca biguttula biguttula* Ishida), thrips (*Anapothrips dorsalis* Hood) and whitefly (*Bemisia tabaci* Genn.), cause considerable loss in yield (Chahal *et al.* 1970).

Bollworms are reported to cause maximum losses of nearly 87 per cent flowers, 34 to 57 per cent of buds and 22 to 69 per cent of bolls (Deshpande and Nadkarni, 1936). Losses in the yield of seed cotton to the extent of 25 to 35 per cent due to pink bollworm attack alone have been reported from North India and Andhra Pradesh (Agrawal and Katiyar, 1979; Rao, 1980). The yield loss to PKV H-2 cotton due to sucking pests alone was 22.85 per cent and due to bollworm complex it was 24.68 per cent (Satpute *et al.* 1990).

Despite the introduction of the concept of pest management, farmers still continue to rely heavily on chemical control. The intensive and indiscriminate use of pesticides, for the protection of crops, from the attack of pests, have given rise to new problems such as resistance of pests to insecticides, resurgence and toxic residues in/on the plant. Application of chemical pesticides is harmful to the beneficial insects and animals which feed on destructive fauna and/ or flora. Environmental pollution is the worst form of pesticide hazards (Anonymous, 1985; Gahukar, 1992).

Emphasis on integrated insect pest management has illustrated the need of multiple strategies and tactics for insect control. On cotton, Helicoverpa nuclear polyhedrosis virus (HaNPV) may be an alternative to the use of broad spectrum chemical insecticides for the control of Helicoverpa Spp. Early in its development, field performance of HaNPV was erratic (Falcon et al. 1965, Ignoffo et al. 1965, Allen et al. 1966, 1967, McGarr and Ignoffo, 1966, Chapman and Bell 1967 and McGarr, 1968) however, with recently developed commercial formulations, efficacy has improved and become more consistent but at moderate to high population level, the protection provided has been insufficient (Yearin, unpublished data).

In India, occurrence of NPV in H. armigera was first time reported by Patel et al. (1968) in Gujarat. Since Baculovirus heliothis alone may not be sufficient to suppress moderate to high Helicoverpa spp. populations, a viable alternative may be the application of virus with low doses of chemical insecticides. Little has been published on the interaction of B. heliothis with chemical insecticides. Ignoffo and

Montoya (1966) reported on compatibility of virus with the most spray additives, adjuvants and chemical insecticides. It has also been found to be compatible with chemical pesticides like endosulfan (Pawar and Thombre, 1990).

The recent development of pyrethriod resistance in bollworms (Dhingra et al., 1989) has increased the necessicity on the use of insecticides with ovicidal and/or larvicidal properties. Methomyl is a broad spectrum carbamate insecticide, having ovicidal and larvicidal properties. The present investigation was planned to study the bioefficacy of new formulation of methomyl (Lannate, 40 SP) alone, and in combination with HaNPV against bollworm complex of cotton. Besides, the effect of these treatments against infestation of sucking pests and coccinellid predator was also studied. Methomyl 40 SP at higher dosage was evaluated for the phytotoxic effects on cotton.

The results obtained during the present investigation are embodied in this presentation and it is hoped that the findings would be useful in the management of cotton pests.

Chapter Opener Page

Review of Literature

2. REVIEW OF LITERATURE

Baculoviruses have been assuming importance in view the hazards of environmental pollution caused by chemical pesticides. These viruses are specific and harmless to human beings and other higher forms of life. As such the literature in past few years has grown by leaps and bounds and excellent reviews are available (Payne, 1982; Entwistle and Evans, 1985, Jayraj et al. 1987). However, the information on use of methomyl on cotton in India is rather scanty. Therefore, the available information on use of methomyl alone and in combination with HaNPV in India and other countries has been reviewed and presented in this chapter.

2.1 Efficacy of Nuclear polyhedroris virus (NPV) against H. armigera on cotton

Coaker (1958) reported for the first time, the use of NPV against Helicoverpa armigera on cotton in Uganda. Cotton plants were sprayed by low volume hand sprayer at 20 ml/plant of different concentrations viz., 1, 2, 3, 10, 20 and 40 x 10^5 PIBs/plant, when larvae were in third and fourth instars. The LD_{50} was approximately 10^6 and LD_{80} about 10^7 PIBs/plant. Treatments with caged plants were successful but the results in the field test were not promising.

Tests conducted by Ignoffo et al. (1965) on the effectiveness of NPV against field population of Helicoverpa spp. on cotton in which no insecticides were used. The virus applied at 6 x 10^{11} and 6 x 10^{12} PIBs/acre controlled heavy population of Helicoverpa spp.

Allen et al. (1966) compared the efficacy of Heliothis NPV with toxaphene, DDT and methyl parathion. The virus was applied at 1.2 x 10^{11} (20 LU), 3.0 x 10^{11} (50 LU) and 6.0 x 10^{11} (100 LU) polyhedral inclusion bodies (PIBs)/ 0.4 ha and the effectiveness of the virus against various instars of larvae was evaluated. NPV controlled satisfactorily the Helicoverpa on cotton at concentrations as low as 20 LU/0.4 ha.

McGarr and Ignoffo (1966) reported that the virus applied at LE ratios of 10, 100 and 1000/acre were compared with those in untreated check plot. The most effective control of Heliothis spp. was obtained with 1000 LE; control decreased as number of larval units applied per acre decreased. The yield of seed cotton with plots treated with 1000 LE was 1608 Lb/acre as compared to that of check (1202 Lb/acre).

Chapman and Bell (1967) reported that the better control of Helicoverpa spp. on cotton was obtained with increase in virus dosage @ 250 LE/ha/application (1 LE = 6 x 10^{9} PIBs). The seed cotton yield with virus was equivalent to that of which secured with chemical insecticide mixture. The results of these test indicate that NPV was effective in reducing

H. armigera population and increasing the yield. They further reported that NPV @ 500 -1000 LE/acre gave the same degree of control as that of standard chemical.

Caudou and Soubrier (1974) conducted field test with two viral preperations and one insecticide viz., viron H (preperation of H. zea NPV), HBEB (local preperation of NPV of H. armigera) and monocrotophos against H. armigera on cotton. They found that virus HBEB was effective than viron H.

Kinzer et al. (1976) conducted field test against H. zea and H. virescens on cotton with compound GL-6506, monocrotophos or methomyl and HaNPV. The HaNPV when applied as a foliar spray 3 times/week was as effective as monocrotophos (used as a foliar spray at 5-7 days interval) in increasing the yield of cotton, but when NPV was applied 1 or 2 times/week, yields were inferior to that achieved with monocrotophos.

Zhang et al. (1981) noticed that the effectiveness of NPV of H. armigera on cotton was greater than that of bacterial or chemical insecticide. The optimum application rate was 75 x 10^9 PIBs/ml and the best time for application was when the eggs began to hatch.

Spray application of Baculovirus heliothis alone or in combination to cotton plots in South Carolina during 1980, reduced the population of Helicoverpa spp. by average of 28 per cent as compared to untreated control (Johnson, 1982). He further tested *Baculovirus heliothis* by adding the feeding adjuvants (Coax and Guastol), reduced the number of larvae by 46 per cent. Purified nuclear polyhedrosis virus suspensions were assayed against third and fourth instar *H. armigera* larvae to provide standards for adaptive and field testing. Third instar larvae proved to be approximately 100 times more susceptible to NPV disease than fourth instar larvae. The minimum time for mortality was 4 days (Flattery, 1983).

Martiner and Swezzy (1983) tested the effectiveness of commercial formulation (Elcar) of the nuclear polyhedrosis virus on *H. zea* on cotton in the field in Nicaragua. Early and frequent application of *Baculovirus heliothis* at 200 g/ha gave control which was equal to chemical method.

Potter and Watson (1983) observed that a dose of 1.24×10^{12} PIBs/ha applied just after egg laying caused 79.7 per cent larval mortality. However, the same concentrations of NPV when applied on newly hatched larvae caused only 19.4 per cent larval mortality in *H. virescens* on cotton. They suggested that application of NPV should coincide as closely as possible with hatching of eggs to maximize the infection.

2.2 Efficacy of methomyl and other conventional insecticides on pest complex of cotton

2.2.1 Methomyl

Whitlock (1973) reported that the effects of 11 topically applied insecticides on the third instar larvae of *H. armigera* in which methomyl was found to be the most effective material, while carbaryl which had been popular for many years proved to be most disappointing.

Kavut (1974) reported that methomyl at 100 g/0.1/ha in two applications ten days apart, against *P. gossypiella*, gave satisfactory control but the effect was of limited duration.

DuRant (1977) reported that various rates of methomyl when added to the standard season long treatment (toxaphene-methyl parathion-chlordimeform at 2.24-1.12-0.14 kg a.i./ha) on selected dates revealed that 3 consecutive early season application of methomyl at 0.75 kg a.i./ha (3 to 7 day schedule) significantly increased yield. The same was true for 3 consecutive applications of methomyl at 0.50 kg a.i./ha, followed 12 days later by 3 additional consecutive applications. All methomyl treatments increased yield due to enhanced control of the bollworm, *Heliothis zea* (Boddie) and the tobacco budworm, *H. virescens* (F.). Application of methomyl to cotton caused reddening of the foliage and moderate late season defoliation.

Campbell *et al.* (1979) reported that reduced rates of methomyl at 0.14 and 0.28 kg a.i./ha, act as effective ovicides against *Helicoverpa* spp. on cotton. Methomyl applied to cotton @ 112 g a.i./ha resulted in 84.5 per cent mortality of eggs and emerging larvae of H. armigera (Hb). (Waite, 1981).

Kabaria and Chari (1984) evaluated sixteen insecticides to determine their ovicidal and larvicidal activity against E. vittella under laboratory conditions. Of which cypermethrin (Ripcord 10 EC) 0.01 per cent and methomyl (Lannate 20 EC) 0.05 per cent proved to be most effective larvicidal and gave cent per cent mortality of first instar larvae at 6 hours after the larval release.

Kaseem et al. (1986) tested efficacy of various insecticides against the noctuid E. insulana and P. gossypiella on cotton. Methomyl (Nudrin 24.1 per cent and Lannate 90 per cent SP) was the most effective followed in descending order by fenvalerate 20 EC,fenitrothion 50 EC , carbaryl,85 WP,profenfos 72 WP and dimilin 25 WP.

Baradley and Agnello (1988) reported that of all the ovicides tested, methomyl @ 0.14 kg a.i./ha reported high mortality after 2 hours as compared to that of control.

Das and Mishra (1991) tested methomyl at 8.0, 12.5 and 24.0 per cent control of H. armigera on cotton. It was observed that there is no difference in bio-efficacy of three formulations tested. Lannate @ 300 g a.i./ha provided about 80 per cent control and @ 600 g a.i./ha provided about 90 per cent control of Helicoverpa larvae. Fenvalerate @ 100 g a.i./ha provided 60-70 per cent control.

Manisegaran *et al.* (1991 a) conducted a field experiment with cotton cultivars MCU-9 and MCU-7 to assess the biological efficacy of methomyl (Lannate 24 L) and EPN 45 EC against bollworms at different doses, using endosulfan (Thiodan 35 EC) as a standard insecticide. They reported that in the control of *Earias* spp. endosulfan @ 700 g a.i./ha registered maximum reduction viz., 39.04 and 40.85 per cent in winter and summer season. In the case of American bollworm, the maximum reduction was recorded for methomyl 600 g a.i./ha and it was at par with rest of the methomyl treatments viz., 300, 450 and 750 g a.i./ha as well as with endosulfan 700 g a.i./ha in winter, whereas during summer endosulfan at 700 g a.i./ha was the most effective in reducing the infestation by 35.65 per cent. In case of pink bollworm, endosulfan 700 g a.i./ha was highly effective against pink bollworm in summer and also recorded the highest total yield (3627.78 and 3858.33 kg/ha) in winter and summer, respectively.

2.2.2 Cypermethrin

Anonymous (1980) reported that cypermethrin at 0.01 per cent spray was significantly superior over carbaryl 0.2 per cent spray in reducing infestation of bollworm in green bolls and locules and increasing the yield of seed cotton. The yield from cypermethrin treated plots was 1262 kg/ha, while in case of carbaryl and untreated check it was 1024 kg/ha and 1005 kg/ha, respectively.

Murugesan and Balsubramanian (1980) reported that the infestation in locule was low in cypermethrin (Ripcord 3.9 %) and cypermethrin (Voltas 11.7 %). Seed cotton yield was the highest in cypermethrin (Ripcord 3.9 %) 1753 kg/ha as compared to that of standard insecticide.

Chari et al. (1983) reported that among the insecticides cypermethrin 80 g a.i./ha was superior to other insecticides. The next best being cypermethrin 60 g a.i./ha was far superior to endosulfan, monocrotophos and GAU schedule. The yield of seed cotton was the highest in cypermethrin @ 80 g a.i./ha with cost benefit ratio 1:6.

Gandhale et al. (1983) reported that as regards the infestation of bollworms in locules, treatment with cypermethrin @ 60 g a.i./ha,decamethrin @ 15 g a.i./ha,fenvalerate @ 80 g a.i./ha ,indothrin @ 75 g a.i./ha and cyfloxylate @ 25 g a.i./ha were equally effective and significantly superior to the rest of the treatments. Increased yield of seed cotton was obtained from the plots treated with cypermethrin @ 60 g a.i./ha which was at par and significantly superior to the rest of the treatments.

Pawar et al. (1984) in a field control test against *Earias* spp., *H. armigera* and *P. gossypiella* on rainfed cotton, reported that cypermethrin 25 EC or permethrin 25 EC applied at various rates effectively reduced damage to green bolls and bolls at harvest, locule damage and bad kapas content and gave highest yield. These pyrethriods gave better results than methomyl applied at 0.02, 0.04 or 0.07 per cent, carbaryl at 0.2 per cent or endosulfan at 0.07 per cent.

Dabalbaji and Deshpande (1985) reported that cypermethrin at 0.005 per cent was more effective in controlling the pests than carbaryl at 0.2 per cent with 3 different spray volumes of carbaryl and cypermethrin against bollworm complex of cotton. Treatment with cypermethrin resulted in higher yield than the treatment with carbaryl.

Agnihotri *et al.* (1986) studied the relative efficacy of synthetic pyrethriods i.e. cypermethrin (60 g a.i./ha), permethrin (90 g a.i./ha) with traditional insecticides viz., carbaryl, acephate and quinalphos (all applied at 300 g a.i./ha) in controlling the bollworms. They found that all insecticide treatments were effective in controlling the pests. However, the pyrethriods performed significantly better than acephate, quinalphos and carbaryl both in reducing damage by the pests and increasing the yield.

The efficacy of cypermethrin 0.01 per cent, fenvalerate 0.015 per cent, permethrin 0.018 per cent, deltamethrin 0.003 per cent and flucythrinate 0.03 per cent in comparison to monocrotophos 0.06 per cent for control of *E. vittella*, *H. armigera* and *P. gossypiella* was evaluated by Shelke *et al.* (1986) on cotton. All pyrethriods were equally effective and superior to monocrotophos.

Field trials were carried out to evaluate the effectiveness of cypermethrin at 0.005, 0.01 and 0.015 per cent against cotton bollworms as compared with that of carbaryl and endosulfan. Pooled analysis of the data revealed that cypermethrin @ 0.01 per cent proved to be the most effective in reducing green and ripe boll damage, locule infestation, bad kapas and increasing the yield and financial gain (Shirshikar _et al._ 1986).

Gupta and Katiyar (1987) tested cypermethrin (75 g a.i./ha), diflubenzuron (600 g a.i./ha), fenpropathrin (100 g a.i./ha), fenvalerate (75 g a.i./ha, Dust and LVC), fluvalinate (75 g a.i./ha) and flucythrinate (50 g a.i./ha) against the bollworms in cotton. They reported that there was no significant difference in controlling the bollworms. However, the yields in all the treatments were significantly greater than control.

Satpute _et al._ (1987) reported EC and ultralow volume formulations of cypermethrin (0.01 % and 1 litre/ha), deltamethrin (0.0025 % and 1.5 litres/ha), permethrin (0.01 % and 1 litre/ha) and phosalone (0.03 % and 2.5 litres/ha) against the bollworm complex of cotton. Overall, cypermethrin was the most effective, followed by deltamethrin and permethrin.

Sharma, (1988) reported that cypermethrin, fenvalerate (both at 100 g a.i./ha), deltamethrin (at 17.5 g a.i./ha) and carbaryl (at 1250 g a.i./ha) were evaluated for control of the noctuids Earias vittella and Earias insulana and the gelechid Pectinophora gossypiella on cotton in Uttar Pradesh, India. The 3 pyrethriod insecticides were equally effective and superior to carbaryl in controlling the pests and increasing the seed yield. The initiation of spraying at 50 per cent square formation gave better results than 50 per cent boll formation.

Nigadge et al. (1990) reported that synthetic pyrethriods viz., cypermethrin 0.01 %, fenvalerate 0.01 %, deltamethrin 0.03 %, monocrotophos 0.04 %, carbaryl 0.2 %, endosulfan 0.07 %, B.t 1 kg/ha and HaNPV 250 LE/ha were employed for control of bollworm complex of cotton. They reported that synthetic pyrethriods reduced, the damage due to bollworms and also the yields were higher as compared to other insecticides.

Rote et al. (1990) reported that cypermethrin 0.015 per cent had recorded the lowest bollworm infestation in green bolls (4.24 %) and it was at par with fenvalerate 0.032 per cent (4.39 %).

2.2.3 Endosulfan

Davies (1976) reported that 8 sprays of endosulfan resulted in significant yield increase. The yield in endosulfan treated plots was 1300-1800 kg/ha, while in that of untreated plots was 300-900 kg/ha.

Shah and Sankpal (1978) observed that 10 applications of endosulfan 0.07 % at 15 days interval reduced the infestation of bollworms and gave significantly highest yield than monocrotophos 0.05 per cent, quinalphos 0.05 per cent, carbaryl 0.15 per cent, endosulfan 0.07 per cent, phosalone 0.07 per cent, quinalphos 0.04 per cent and control. Endosulfan treatment recorded the least i.e. 5.79 per cent of infested bolls and gave maximum yield of seed cotton i.e. 2429.33 kg/ha as compared to control. It was also reported that 10 applications of endosulfan 0.07 per cent at 15 days interval were more effective than 14 application of phosalone 0.07 per cent and quinalphos 0.05 per cent at 10 days interval against bollworms on Hybrid 4 cotton.

Dhawan and Sidhu (1985) evaluated the efficacy of 12 insecticides for the control of P. gossypiella on cotton of which endosulfan 0.8 kg a.i./ha effectively controlled the pink bollworm. Men et al. (1985) reported that endosulfan 0.05 per cent significantly reduced P. gossypiella damage as compared to untreated check.

Patel et al. (1990) reported that among the different insecticides tested, endosulfan 0.07 per cent, monocrotophos 0.05 per cent, quinalphos 0.05 per cent, carbaryl 0.2 per cent, cypermethrin 0.009 per cent or 50 g a.i./ha, fenvalerate 0.015 per cent or 100 g a.i./ha and decamethrin 0.00125 per cent or 15 g a.i./ha were found effective for control of Helicoverpa armigera.

2.3 Compatibility of HaNPV with methomyl and other insecticides

Luttrell *et al.* (1979) carried out laboratory and field tests on the effectiveness of combination of methomyl with Elcar (a formulation of *Baculovirus heliothis*) for control of *Helicoverpa* spp. on cotton. In laboratory no significant differences were detected between the observed and expected toxicity of the chemicals to larvae of *H. zea* (Boddie) infected with virus, although there was slight increase in the toxicity of some materials. In the field test, plots treated with methomyl @ 70, 140 and 280 g/ha in combination with Elcar 148 g/ha, had yields equal to those from plots treated Elcar (148 g/ha) alone.

Pfrimmer (1979) reported that plots treated with Elcar + methomyl (0.15 + 0.2 kg a.i./ha) had fewer injured bolls than the other treatments. The yield in methomyl + Elcar was 1687 kg/ha as compared to untreated check (399 kg/ha).

Dhandapani *et al.* (1987) observed that four rounds of ULV application of virus at 450 LE/ha combined with endosulfan 350 g a.i./ha with adjuvants like crude sugar (C.S.) 17.5 per cent + cotton seed kernal powder (CSKP) 2.5 per cent were highly effective in reducing the larval populations. Evaluation of different spraying systems on the efficacy of NPV indicated that NPV at 450 LE with endosulfan 350 g a.i./ha + adjuvants like CS + CSKP applied as ULV or HV significantly reduced the larval population, damage to squares, flowers, bolls and increased the seed cotton yield.

Jayraj *et al.* (1987) reported that the application of mixture of NPV (125 LE/ha) and endosulfan (0.035 %) resulted in maximum protection against *H. armigera*.

Sathiah *et al.* (1990) reported that a combination of endosulfan (87.5 ppm) with virus (0.5 x 10^3 polyhedral inclusion bodies/ml) resulted in higher mortality (52.3 %) than virus alone (21.5 %).

2.4 Impact of chemical pesticides and HaNPV on non-target pests and predators in cotton

Roome (1975) indicated that NPV was not damaging as carbaryl to population of predators but predators did not control aphids and jassids on the virus sprayed plots.

Steenwyk *et al.* (1976) reported that after the application of methomyl the number of predators decreased. Dzink *et al.* (1977) reported that methomyl was more toxic than dimethoate to convergent lady bird beetles.

There are several reports that the population of aphids and other sucking pests of cotton increased subsquently due to application of synthetic pytethriods.(Kathane and Balsubramanian, 1978, Balsubramanian *et al.* 1984, Chari, 1980, Natarajan *et al.* 1986, Patel *et al.* 1986, Rangarajan *et al.* 1986, Manickvasagam and Gunthaligaraj, 1993).

Pitts and Pieters (1982) reported that in aerial application of methomyl @ 0.14 kg a.i./ha to 8 ha. plots resulted in reduction of predator population.

Mundiwale *et al.* (1983) reported that methomyl 0.05 per cent gave effective control of *Aphis gossypii* upto 7 days and was significantly superior over fenvalerate + DDT and DDT alone. Stefanov *et al.* (1986) reported the effectiveness of methomyl against *Aphis gossypii* and *Thrips tabacii* on cotton at 1 litre/ha, had rapid and lasting effect against *A. gossypii*.

Allen *et al.* (1990) reported that methomyl @ 0.225 lbs a.i./acre supressed the aphid population to below the widely used action level of 25 aphids/leaf. OnlyLannate reduced the aphid population to below 100 aphids/leaf.

Manisegaran *et al.* (1991 b) conducted a laboratory experiment to assess the relative safety of methomyl (Lannate 24 L) @ 300, 450, 600 and 750 g a.i./ha, EPN @ 563, 844, 1125 and 1406 g a.i./ha and methyl demeton @ 125 g a.i./ha against coccinellid predator. They reported that methomyl @ 750 g a.i./ha recorded the highest toxicity (94.44) as the PT index (period x toxicity) was 849.96 upto 9 days after spray, while methomyl @ 600, 450 and 300 g a.i./ha recorded 77.08, 78.57 and 66.66 toxicity with their PT values 616.67, 500 and 400 at 8, 7 and 6 days after spray, respectively.

Manickavasagam and Gunthaligaraj (1993) conducted a field experiment and two pot culture experiments to assess the efficacy of clocythrin @ 10, 12.50, 15.62, 18.75, 25 and 31.25 g a.i./ha, deltamethrin, monocrotophos, fenvalerate, endosulfan and cypermethrin at 10, 135, 125, 350 and 550 g a.i./ha. They reported that cypermethrin 25 EC effectively controlled leaf hoppers, while endosulfan 35 EC was the least effective. Cypermethrin 25 EC (100 ppm) caused resurgence in aphid population.

2.5 Phytotoxic effects of methomyl on cotton

Wolfenbarger and Redfern (1968) reported that Lannate was phytotoxic to cotton at 1.12 kg/ha.

DuRant (1977) reported that methomyl treatments, caused moderate leaf reddening, but defoliation was light. No obvious differences in degree of leaf reddening or defoliation among methomyl treatments were observed. Square and boll counts revealed no methomyl induced decrease in fruiting forms.

Luttrell et al. (1979) reported that phytotoxicity due to excessive amounts of methomyl was observed in all methomyl plots treated @ 70, 140, and 280 g/ha, with more severe symptoms present in plots with higher rates. This phenomenon did not appear to reduce the yield, however. Pfrimmer (1979) reported that mixtures of Elcar + methomyl (0.15 + 0.28 kg a.i./ha) was phytotoxic against cotton.

Material and Methods

3. MATERIAL AND METHODS

During the course of the present investigation, a field trial was undertaken to study the bioefficacy, phytotoxicity and compatability of methomyl (Lannate 40 SP) in combination with Helicoverpa armigera nuclear polyhedrosis virus (HaNPV) on cotton. Further the effect of these treatments on the infestation of sucking pests of cotton and their coccinellid predator was also studied. The experiment was conducted during the kharif season of 1993 on the Instructional Farm of the Department of Agricultural Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.) having a typical medium black soil.

The particulars of materials used and techniques adopted in the conduct of experiment are presented in this chapter.

3.1 Material

3.1.1 Seed

The seed of cotton variety "Laxmi" with germination percentage not less than 80 per cent was made available by the Department of Agricultural Entomology, M.P.K.V., Rahuri.

3.1.2 HaNPV culture

The nucleus culture of HaNPV containing 1.65×10^9 PIBs/ml was made available from the Department of Agricultural

Entomology, M.P.K.V., Rahuri.

3.1.3 Insecticides

The details of insecticides tested viz., common name, chemical name, trade name and source are given in Table 1. The details of the treatments for field experiment on spray formulations are presented in Table 2.

3.2 Layout and conduct of the experiment

3.2.1 Details of the experiment

The experiment was conducted under irrigated condition in the *kharif* season of the year 1993. Recommended tillage and agronomic practices were followed in cultivation of the crop. Other details of the experiment were as under.

Design	: Randomised Block Design.
Replication	: Three
Spacing	: 90 x 60 cm.
Plot size	: Gross - 6.3 x 5.4 m. Net - 4.5 x 4.2 m.
Variety	: Laxmi
Treatments	: Twelve

For the control of sucking pest complex, in the early stages of crop growth phorate 10 G was used @ 1.5 g/plant

3.3 Methods

3.3.1 Preperation of HaNPV suspension

The diseased larvae were allowed to putrefy in a glass

Table 1. Particulars of insecticides evaluated against pest of cotton

Common name	Chemical name	Trade name of formulation	Sources of formulation
Methomyl	S-methyl N-(methyl carbamoyll oxy) thioacetimidate	Lannate 40 SP	M/s Du Pont Far East Inc. (India) Ltd., New Delhi
Cypermethrin	Cyano (3-phenoxy pheny) methyl 3-(2,2 - dichloro ethenyl-2,-dimethyl cyclopropane carboxylate.	Cyperkil 25 EC	M/s Bharat Pulverising Mills Private Ltd., Bombay
Endosulfan	(6,7,8,9,10,10-hexachloro-1,5, 5a, 6,9,9a-hexa-hydro-6-9-methano-2,4,3 benodioxathiepine-3 oxide	Thiodan 35 EC	M/s Hoechst Pharmaceuticals Ltd., Bombay

Table 2. Details of treatments for field experiment

Sr. No.	Treatment	Active ingradient g/ha	Formulated product	
			g/ml/ha	g/ml/plot
1.	Methomyl 40 SP	150 g	375 g	1.26 g
2.	Methomyl 40 SP	300 g	750 g	2.55 g
3.	Methomyl 40 SP	450 g	1125 g	3.82 g
4.	Endosulfan 35 EC	350 g	1000 g	3.40 g
5.	Methomyl 40 SP + HaNPV	150 g + 250 LE	375 g + 500 ml	1.26 g + 1.7 ml
6.	Methomyl 40 SP + HaNPV	300 g + 250 LE	750 g + 500 ml	2.55 g + 1.7 ml
7.	Methomyl 40 SP + HaNPV	450 g + 250 LE	1125 g + 500 ml	3.49 g + 1.7 ml
8.	HaNPV	250 LE	500 ml	1.7 ml
9.	HaNPV	500 LE	1000 ml	3.40 ml
10.	Cypermethrin 25 EC	60 g	250 g	0.85 g
11.	Endosulfan 35 EC + HaNPV	175 g + 250 LE	500 g + 500 ml	1.70 g + 1.7 ml
12.	Untreated control	-	-	-
13.	Methomyl 40 SP (Phyto-test)	900 g	2250 g	7.65 g

stoppered conical flask containing small quantity of distilled water for a period of about one week at room temperature. Two rounds of freezing and thawing were given so as to liberate the polyhedral inclusion bodies (PIBs) from the cadavars. The contents were then triturated and filtered through double layered muslin cloth so as to remove the tissue debris. The suspension was partially purified by differential centrifugation (500 rpm for 1 minute and 5000 rpm for 20 minutes). The pellet thus collected after two cycles of centrifugation was suspended in steriled distilled water and the PIB count was taken NEUBAUER using haemocytometer. The final formulation was prepared by keeping the concentration at 500 LE/litre (1 LE = 1.65×10^9 PIBs).

3.3.2 Application of insecticides

The treatment sprays for bollworms under investigation were started from 60 days after sowing and when the pest reached economic threshold level i.e. above 5 per cent square damage.

The spray fluid was applied with Knapsack sprayer. The quantity of water required for the plot was calculated by spraying with water. All the three plots in three replications were treated at a time. The spraying was done at evening hours and due care was taken to wash the pump with water after every treatment to avoid contamination. The spraying was done at intervals of 15 days. Four treatment sprays were undertaken. For HaNPV application, egg albumin (0.05 %) and Ranipal (0.02 %) were used as additives for protecting the PIBs from sunlight.

3.3.3 Methods of recording observations

(A) Bollworms

(i) Bollworm damage to fruiting bodies

Five randomely selected plants per treatment in each replication were tagged for recording observations on damaged squares and fruiting bodies. Total number of squares, flowers and bolls on the plants and those infested with bollworms were counted at each observation i.e. one day and before at 3, 7 and 14 days after each treatment application. From these observations percentage of bollworm damaged fruiting bodies were calculated. Similarly, the shed material consisting of squares, flower buds and bolls from the selected plants was inspected for bollworm infestation and the damage recorded. After each observation shed material was removed.

At the time of each picking, observations on the total number of bolls retained on five plants and number of damaged bolls were counted. From this data, percentage of damaged bolls was calculated. Similarly the number of good loculi and infested loculi was counted after each picking and the per cent loculi damage was calculated.

(ii) Seed cotton yield

The yield of good quality seed cotton and bad quality seed cotton obtained in each treatment plot was recorded. From this data, the percentage of bad seed cotton and yield of seed cotton per treatment were calculated.

(B) Sucking pests

Observations on sucking pests such as aphids, jassids and thrips were recorded on the randomely selected five plants per plot of each treatment. Number of nymphs and adults in case of aphids, nymphs in case of jassids and adults of thrips were recorded from six leaves (two each from bottom, middle and top) of each selected plant. The pre-treatment count was taken before the first treatment application. The infestation of whitefly, however, throughout trial was negligieble and hence observations were not recorded. The post-spray count in respect of first three application was taken at 3, 7 and 14 days of sprays. However, after fourth spray application, only one count was taken on 3rd day as the sucking pest population was negligible in the subsquent observations. The average number of individuals per six leaves per plant were subjected to statistical analysis.

(C) Predators

Observations on the lady bird beetle (Coccinella septumpunctata) were recorded on randomely selected five plants per plot. Number of grubs and adults of the beetle were recorded from the randomely selected five plants. Pretreatment count was taken a day before the first spray, however post-spray counts in respect of the first two sprays were recorded at 3, 7 and 14 days.

(D) Phytotoxicity studies

One application of methomyl 40 SP @ 900 g a.i./ha was given at 60 days after sowing and observations about the injuries caused were recorded daily upto 15 days on randomely selected five plants.

In order to asses the severity of symptoms the total number of leaves showing phytotoxic symptoms were recorded and percentages of such affected leaves were worked out. This method, however, will not give any accurate idea of extent of phytotoxicity on the leaves as the number of injured leaves taken for working out the percentages might include leaves showing few spots and even completely damaged leaves. In absence of any accurate practical method for quantative assesment of the injury, the extent of leaf area damaged was categorised according to the protocols for evaluation of phytotoxicity of insecticides proposed by Central Insecticides Board which consists of the following scale from I to X.

visual rating of injury* (%)	grade
0 - 10	I
11 - 20	II
21 - 30	III

Contd....

visual rating of injury* (%)	grade
31 - 40	IV
41 - 50	V
51 - 60	VI
61 - 70	VII
71 - 80	VIII
81 - 90	IX
91 -100	X

*Leaf injury on tips, leaf surface, wilting, vein clearing, reddening,yellowing, scorching and necrosis etc.

3.4 Statistical analysis

The experimental data were subjected to the statistical analysis and the percentages were transformed to their angular values. The population count of sucking pests and predator was transformed using poison's formula : $\sqrt{X + 0.5}$.

Results and Discussion

4. RESULTS AND DISCUSSION

A field experiment was conducted to evaluate bioefficacy, phytotoxicity and compatibility of a new formulation of methomyl (Lannate 40 SP) alone and in combination with Helicoverpa armigera nuclear polyhedrosis virus (HaNPV) against bollworms, sucking pests and their predator on cotton. Cypermethrin 25 EC and endosulfan 35 EC were used as standards. Each treatment consisting of a schedule of 4 sprays was given at an interval of about 15 days by initiating the first spray at 60 days after sowing of the crop. The performance of each treatment was judged on basis of damage caused by bollworms viz., American bollworm (Helicoverpa armigera), spotted bollworm (Earias vittella), pink bollworm (Pectinophora gossypiella) and the incidence of sucking pests viz., aphid (Aphis gossypii), jassid (Amarasca bigutella bigutella), thrip (Thrips tabacii) and the predator, lady bird beette (Coccinella septumpunctata). Similarly yield of seed cotton obtained from each plot was also recorded. Phytotoxicity studies were conducted with methomyl 40 SP at a higher dose of 900 g a.i./ha.

4.1 Bio efficacy of methomyl 40 SP alone and in combination with HaNPV against bollworm complex of cotton

4.1.1 Effect of insecticides on square damage

The data on square damage recorded in different treatments are presented in Table 3. All the insecticide treatments were significantly superior to untreated control in minimising the square damage. However, the least damage (1.81 to 3.19 %) was noticed on the crop sprayed with cypermethrin @ 60 g a.i./ha and was significantly superior to rest of the treatments and untreated control. Methomyl @ 450 g a.i./ha was the next best treatment which recorded less damage (1.94 to 4.14 %) as compared to that of methomyl @ 300 g a.i./ha and methomyl @ 150 g a.i./ha. However, the combination of HaNPV @ 250 LE/ha with methomyl @ 150, 300 and 450 g a.i./ha did not show much improvement in reducing the square damage due to bollworm as compared to methomyl alone @ 450, 300 and 150 g a.i./ha respectively. Endosulfan @ 350 g a.i./ha recorded less damage (2.36 to 4.43 %) as compared to that of endosulfan @ 175 g a.i./ha + NPV 250 LE/ha (2.73 to 5.45 %) respectively. Spraying of NPV @ 500 LE/ha was more effective than NPV @ 250 LE/ha in reducing the square damage.

The experimental findings in respect of square damage were in close agreement with Agnihotri et al. (1986). They reported that cypermethrin @ 60 g a.i./ha was effective in controlling the bollworm damage and was significantly superior than acephate, quinalphos and carbaryl (all @ 300 g a.i./ha). Sharma (1988) reported that spraying of cypermethrin @ 100 g a.i./ha was superior to carbaryl @ 1250 g a.i./ha. They also observed that intiation of spraying at 50 per cent square formation gave better results than 50 per cent boll formation.

Table 3. Effect of insecticide sprays on the square damage

Treatment	Square damage (%)						
	Pre spray count	1st spray			2nd spray		
		3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
Methomyl 150 g a.i./ha	9.51 (17.83)	6.13 (14.22)	4.20 (11.55)	6.12 (14.16)	7.28 (15.56)	4.11 (11.43)	5.57 (13.63)
Methomyl 300 g a.i./ha	8.74 (17.10)	4.56 (12.20)	3.68 (10.66)	4.20 (11.63)	5.27 (13.09)	3.77 (10.84)	4.42 (12.14)
Methomyl 450 g a.i./ha	10.16 (18.52)	4.14 (11.47)	2.38 (8.65)	3.13 (9.82)	3.46 (10.56)	2.10 (8.30)	2.15 (8.43)
Endosulfan 350 g a.i./ha	9.25 (17.23)	4.43 (11.85)	3.94 (11.21)	4.13 (11.49)	4.67 (12.31)	3.39 (11.51)	4.11 (11.62)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	7.21 (15.57)	7.56 (15.90)	5.58 (13.54)	6.32 (14.40)	7.87 (16.27)	6.13 (14.30)	7.30 (15.57)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	8.92 (17.35)	5.57 (13.45)	4.03 (11.58)	4.48 (12.11)	5.45 (13.42)	4.18 (11.53)	5.36 (13.28)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	9.03 (17.40)	4.32 (11.94)	2.70 (9.31)	3.55 (10.59)	3.50 (10.54)	3.08 (10.08)	3.04 (10.01)
NPV 250 LE/ha	8.00 (16.21)	8.91 (16.41)	6.75 (14.95)	7.70 (16.05)	13.69 (21.68)	7.51 (15.83)	9.07 (17.91)
NPV 500 LE/ha	6.27 (14.34)	6.13 (14.30)	4.29 (11.69)	5.24 (13.06)	7.18 (15.51)	5.50 (13.42)	6.21 (14.27)
Cypermethrin 60 g a.i./ha	8.54 (16.92)	3.19 (9.97)	2.26 (8.46)	2.00 (8.12)	2.96 (9.52)	2.01 (8.19)	2.05 (8.74)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	13.74 (21.74)	5.45 (13.46)	2.73 (8.99)	3.41 (10.44)	4.33 (11.71)	3.89 (11.16)	4.59 (12.08)
Untreated (control)	8.92 (17.35)	10.18 (18.53)	8.39 (16.82)	12.90 (21.00)	17.10 (24.57)	14.31 (22.19)	19.87 (26.46)
S.E. ±	1.51	1.45	1.49	1.45	1.34	1.25	1.06
C.D. at 5 %	N.S.	4.26	4.37	4.26	3.90	3.68	3.11

DAS = Days after spray

* Figures in parenthesis are arcsin values.

Contd......

Table 3....(Contd....)

Treatment	Square damage (%)								
	3rd spray			4th spray			Pooled		
	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
Methomyl 150 g a.i./ha	5.42 (13.29)	3.90 (11.39)	4.36 (11.98)	4.41 (11.98)	3.88 (11.12)	4.16 (11.47)	5.81 (14.47)	4.02 (11.53)	5.05 (13.36)
Methomyl 300 g a.i./ha	4.16 (11.91)	2.99 (10.02)	3.42 (10.62)	3.96 (11.44)	2.84 (9.43)	3.14 (10.17)	4.48 (12.50)	3.32 (10.23)	3.79 (11.42)
Methomyl 450 g a.i./ha	2.09 (8.31)	2.00 (8.12)	2.01 (8.12)	2.09 (8.31)	1.94 (7.99)	2.01 (8.12)	3.92 (10.26)	2.10 (8.52)	2.32 (8.93)
Endosulfan 350 g a.i./ha	3.36 (10.48)	2.62 (9.26)	2.38 (8.65)	2.40 (8.85)	2.36 (8.65)	2.37 (8.65)	3.71 (11.75)	3.07 (9.86)	3.24 (10.75)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	5.76 (13.67)	4.66 (12.49)	5.03 (12.96)	5.40 (13.18)	4.50 (12.23)	4.93 (12.83)	6.64 (15.42)	5.21 (12.82)	5.89 (14.38)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	4.42 (12.08)	3.69 (10.99)	4.16 (11.60)	4.38 (11.99)	3.40 (10.24)	4.00 (11.45)	4.95 (13.12)	3.82 (11.08)	4.50 (12.50)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	2.53 (9.12)	2.48 (9.04)	2.36 (8.65)	2.39 (8.70)	2.21 (8.57)	2.30 (8.69)	3.18 (10.61)	2.61 (9.03)	2.81 (9.94)
NPV 250 LE/ha	7.55 (15.90)	6.13 (14.30)	5.69 (13.80)	6.36 (14.58)	5.62 (13.71)	5.08 (12.83)	8.94 (18.12)	6.50 (14.33)	6.97 (15.95)
NPV 500 LE/ha	5.49 (13.34)	4.33 (12.04)	4.78 (12.54)	5.10 (13.01)	4.04 (11.34)	4.34 (11.97)	5.97 (14.47)	4.54 (11.87)	5.13 (13.37)
Cypermethrin 60 g a.i./ha	2.08 (8.17)	1.92 (7.99)	1.98 (8.11)	2.00 (8.12)	1.81 (7.77)	1.86 (7.84)	2.55 (9.53)	2.00 (8.12)	1.97 (8.12)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	4.32 (11.71)	3.05 (9.97)	3.96 (11.38)	4.07 (11.58)	3.02 (9.92)	3.51 (10.52)	4.54 (12.50)	3.17 (9.91)	3.86 (11.50)
Untreated (control)	17.45 (24.65)	16.80 (24.14)	15.17 (22.86)	13.41 (21.37)	10.82 (19.16)	14.35 (22.16)	14.53 (22.57)	12.58 (20.08)	15.57 (23.49)
S.E. ±	1.32	0.76	0.99	1.00	1.22	1.15	0.85	0.71	1.03
C.D. at 5 %	3.88	2.24	2.24	2.95	3.59	3.37	2.50	2.10	3.03

DAS = Days after spray

* Figures in parenthesis are arcsin values.

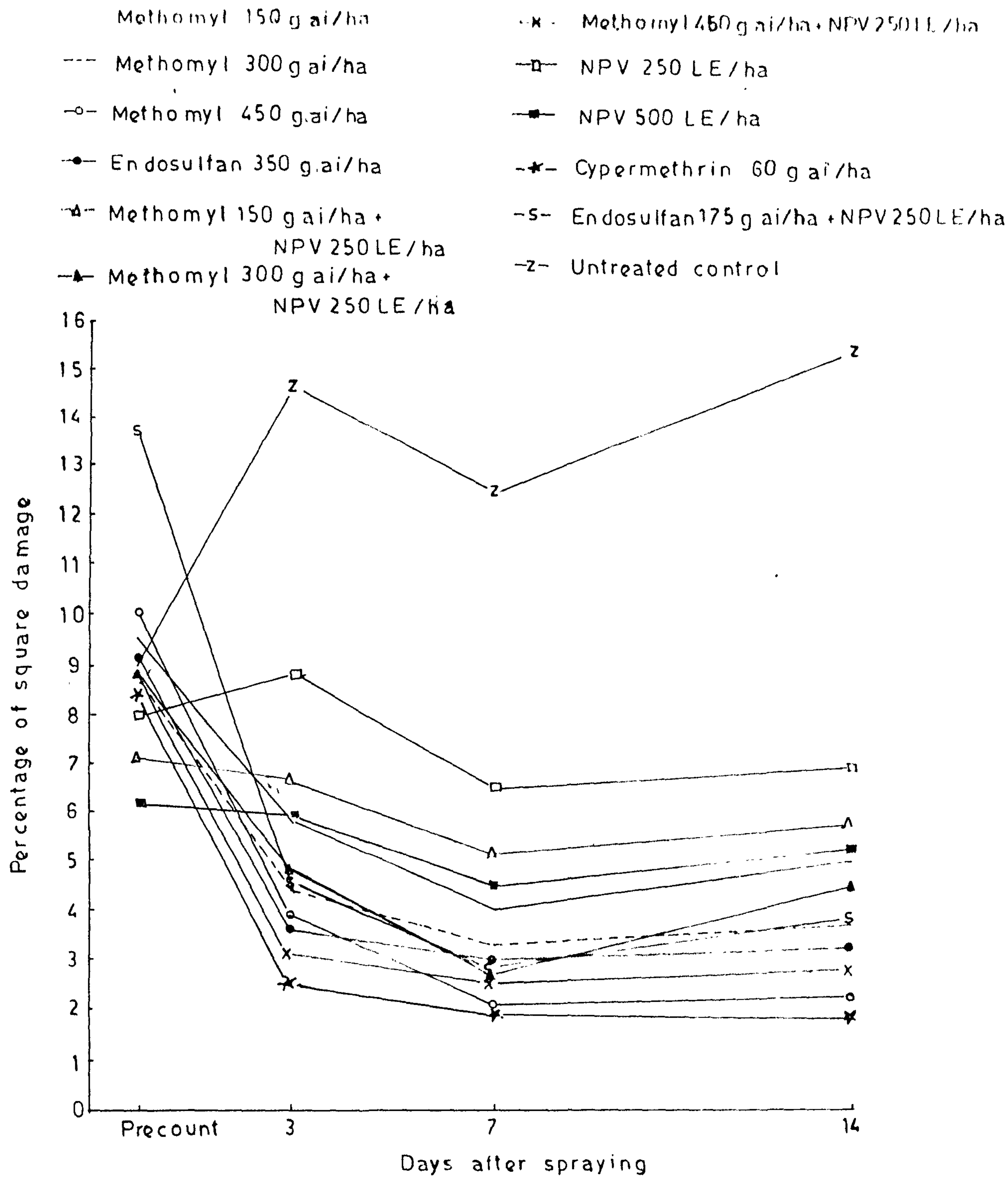


Fig.1 Effect of various insecticide sprays on the incidence of bollworms in cotton squares. (average of 4 sprays)

Patel *et al.* (1990) studied that among the different insecticides tested, the treatments with endosulfan 0.07 % and cypermethrin 0.009 % or 50 g a.i./ha were found effective for control of *Helicoverpa armigera*. Das and Mishra (1991) evaluated methomyl at 80.0, 12.5 and 25.0 per cent for control of *H. armigera* on cotton. Lannate @ 300 g a.i./ha provided about 80 per cent control and @ 600 g a.i./ha provided about 90 per cent control of *Helicoverpa* larvae.

4.1.2 Effect of insecticides on green boll damage

The data representing the percentage of green boll damage predominantly, due to *Helicoverpa* as influenced by various insecticidal treatments are presented in Table 4.

The data on green boll damage indicated that all the insecticidal treatments significantly reduced the bollworm damage to green bolls, when compared with untreated control. At 7 days after third spray, cypermethrin @ 60 g a.i./ha emerged as the most effective treatment and was significantly superior than rest of the treatments except methomyl @ 450 g a.i./ha and endosulfan @ 350 g a.i./ha. This treatment was followed by methomyl @ 450 g a.i./ha + NPV 250 LE/ha which was at par with endosulfan @ 175 g a.i./ha +NPV 250 LE/ha, methomyl @ 300 g a.i./ha, methomyl @ 300 g a.i./ha + NPV 250 LE/ha, methomyl @ 150 g a.i./ha and methomyl @ 150 g a.i./ha + NPV 250 LE/ha and were significantly superior to rest of the

Table 4. Effect of insecticide sprays on green boll damage

Treatment	Green boll damage (%)		
	3rd spray 7 DAS	4th spray 7 DAS	Pooled 7 DAS
Methomyl 150 g a.i./ha	6.10 (14.26)	5.83 (13.84)	5.96 (14.05)
Methomyl 300 g a.i./ha	5.15 (12.92)	4.12 (11.44)	4.63 (12.18)
Methomyl 450 g a.i./ha	2.45 (8.81)	2.28 (8.53)	2.36 (8.67)
Endosulfan 350 g a.i./ha	3.62 (10.95)	3.12 (10.75)	3.37 (10.51)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	6.74 (14.87)	5.34 (13.24)	6.04 (14.05)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	5.97 (13.92)	4.93 (12.89)	5.45 (13.40)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	4.43 (12.00)	3.78 (11.09)	4.10 (11.54)
NPV 250 LE/ha	8.19 (16.51)	7.20 (15.54)	7.69 (16.02)
NPV 500 LE/ha	7.14 (15.45)	6.16 (14.41)	6.65 (14.76)
Cypermethrin 60 g a.i./ha	2.03 (8.02)	1.83 (7.65)	1.93 (7.84)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	4.86 (12.70)	3.98 (11.35)	4.42 (12.02)
Untreated (control)	12.93 (21.00)	11.36 (19.65)	12.14 (20.33)
S.E. ±	1.13	1.31	0.78
C.D. at 5 %	3.32	3.84	2.23

DAS = Days after spray.
* Figures in parenthesis are arcsin values.

treatments. However, the treatments, NPV @ 500 LE/ha and NPV @ 250 LE/ha were at par with each other.

At 7 days after fourth spray it was seen that cypermethrin @ 60 g a.i./ha was at par with methomyl @ 450 g a.i./ha, methomyl @ 450 g a.i./ha + NPV 250 LE/ha, endosulfan @ 350 g a.i./ha, endosulfan @ 175 g a.i./ha + NPV 250 LE/ha. However, the same trend was followed as that of third spray in rest of the treatments.

The results of this investigation in respect of reduction in percentage of green boll damage in the plots treated with cypermethrin @ 60 g a.i./ha were concomitant with those of Shirshikar et al. (1986). They reported that cypermethrin at 0.01 % proved to be most effective in reducing green and ripe boll damage, locule infestation, bad kapas and increasing yield and financial gain. Rote et al. (1990) reported that cypermethrin 0.015 per cent had recorded the lowest bollworm infestation in green bolls (4.24 %) and it was at par with fenvalrate 0.032 per cent (4.39 %). Manisegaran et al. (1991 a) assessed the efficacy of methomyl (Lannate 24 L) against bollworms on MCU 9 and MCU 7 cotton cultivars. The maximum reduction of H. armigera in green bolls was recorded for methomyl @ 600 g a.i./ha and it was at par with rest of the methomyl treatments viz., 300, 450 and 750 g a.i./ha as well as with endosulfan @ 700 g a.i./ha.

4.1.3 Effect of insecticides on boll damage at harvest

The data presented in Table 5 clearly indicate that all the insecticide treatments were significantly superior (10.16 % to 28.97 %) over control (39.44 %) in minimising the boll damage at harvest. A spray schedule with 4 sprays of cypermethrin @ 60 g a.i./ha was significantly superior to rest of the treatments. The next promising treatments was methomyl @ 450 g a.i./ha which was significantly superior over rest of the treatments and at par with methomyl @ 450 g a.i./ha + NPV 250 LE/ha. The succeding treatments in order of merit were endosulfan @ 350 g a.i./ha, methomyl @ 300 g a.i./ha, endosulfan @ 175 g a.i./ha + NPV 250 LE/ha and methomyl @ 300 g a.i./ha + NPV 250 LE/ha.

The per cent infestation of boll, due to bollworms revealed that cypermethrin @ 60 g a.i./ha showed the lowest damage and the same treatment was found to increase the yield of kapas. The above results are in agreement with those reported by Shelke *et al.* (1986). They observed that cypermethrin 0.015 per cent effectively controlled the bollworms and was superior to monocrotophos 0.06 per cent . Nigadge *et al.* (1990) reported that cypermethrin 0.01 per cent recorded lowest damage due to bollworms and also the yields were higher as compared to other insecticides. Manisegaran *et al.* (1991 b) reported that endosulfan @ 700 g a.i./ha registered maximum

Table 5. Effect of insecticide sprays on the bollworm damage at harvest

Treatment	Boll damage (%)			
	RI	RII	RIII	Mean
Methomyl 150 g a.i./ha	25.62 (30.40)	27.12 (31.37)	23.14 (28.73)	25.29 (30.20)
Methomyl 300 g a.i./ha	18.14 (25.18)	20.34 (26.78)	25.05 (30.00)	21.17 (27.83)
Methomyl 450 g a.i./ha	14.41 (22.30)	15.66 (23.34)	18.11 (25.18)	16.06 (23.66)
Endosulfan 350 g a.i./ha	20.43 (26.85)	18.11 (25.18)	22.83 (28.52)	20.45 (26.92)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	28.26 (32.14)	26.31 (30.85)	24.19 (29.47)	26.25 (30.85)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	25.64 (30.40)	20.34 (26.78)	27.12 (31.37)	24.36 (29.60)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	17.41 (24.65)	21.11 (27.35)	19.23 (25.99)	19.25 (26.06)
NPV 250 LE/ha	25.00 (30.00)	32.01 (34.45)	29.90 (33.15)	28.97 (32.58)
NPV 500 LE/ha	27.67 (31.76)	28.42 (32.20)	22.32 (28.18)	26.13 (30.70)
Cypermethrin 60 g a.i./ha	10.10 (18.53)	9.14 (17.56)	11.24 (19.55)	10.16 (18.53)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	25.67 (30.46)	20.16 (26.64)	23.17 (28.97)	23.00 (28.66)
Untreated (control)	39.04 (38.65)	41.82 (40.28)	37.46 (37.76)	39.44 (38.88)
S.E. ±				1.07
C.D. at 5 %				3.14

* Figures in parenthesis are arcsin values.

reduction viz., 39.04 and 40.85 per cent against *Earias* spp. and *Pectinophora* spp.

4.1.4 Effect of insecticides on loculi damage

The data on loculi damage given in Table 6 show that all the insecticidal treatments significantly reduced the bollworm damage to loculi, when compared with untreated control. The percentage of bollworm damaged loculi were significantly less (9.25 %) in the plots treated with cypermethrin @ 60 g a.i./ha as against (37.02 %) in untreated plots. The next best treatment was methomyl @ 450 g a.i./ha and was at par with methomyl @ 450 g a.i./ha + NPV 250 LE/ha and endosulfan @ 350 g a.i./ha. The succeding treatments in order of their efficacy were methomyl @ 300 g a.i./ha, endosulfan @ 175 g a.i./ha + NPV 250 LE/ha and methomyl @ 150 g a.i./ha. They were at par with each other and significantly superior to untreated control.

The present results in respect of superiority of cypermethrin @ 60 g a.i./ha in reducing locule damage were in corrobaration with that of Murugesan *et al.* (1980). They reported that infestation in locule damage was low in cypermethrin (Ripcord 3.9 %) and cypermethrin (Voltas 11.7 %). Cypermethrin @ 60 g a.i./ha was significantly superior in reducing the infestation of bollworms in locules and the same treatment was reported to obtain highest yield, (Gandhale *et al.* 1983). Satpute *et al.* (1987) also reported that

Table 6. Effect of insecticide sprays on the loculi damage

Treatment	Loculi damage (%)			
	RI	RII	RIII	Mean
Methomyl 150 g a.i./ha	22.98 (28.66)	19.29 (20.06)	20.11 (26.64)	20.79 (27.13)
Methomyl 300 g a.i./ha	18.92 (25.77)	16.56 (24.04)	20.81 (27.13)	18.76 (25.70)
Methomyl 450 g a.i./ha	10.68 (18.91)	13.22 (21.30)	15.96 (23.58)	13.28 (21.39)
Endosulfan 350 g a.i./ha	16.78 (24.20)	18.01 (25.10)	14.73 (22.54)	16.50 (23.97)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	23.96 (29.33)	20.63 (26.99)	26.04 (30.66)	23.54 (29.00)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	17.88 (25.03)	18.62 (25.55)	22.53 (28.32)	19.67 (26.35)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	15.13 (22.87)	17.72 (24.88)	13.47 (21.56)	15.44 (23.11)
NPV 250 LE/ha	19.18 (25.99)	26.96 (31.31)	24.28 (29.53)	23.30 (29.20)
NPV 500 LE/ha	22.26 (28.18)	20.18 (26.71)	24.44 (29.60)	22.29 (28.18)
Cypermethrin 60 g a.i./ha	11.02 (19.37)	9.46 (17.95)	7.28 (15.68)	9.25 (17.76)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	19.62 (26.28)	17.14 (24.43)	21.89 (27.90)	19.95 (26.28)
Untreated (control)	36.92 (37.41)	34.59 (36.03)	39.96 (39.23)	37.02 (37.46)
S.E. ±				1.04
C.D. at 5 %				3.05

* Figures in parenthesis are arcsin values.

cypermethrin (0.01 % and 1 litre/ha) was effective in controlling the bollworm damage followed by deltamethrin (0.0025 % and 1.5 litres/ha) and permethrin (0.001 and 2.5 litres/ha).

4.1.5 Effect of insecticides on per cent bad kapas

The data on per cent bad kapas are given in Table 7. It could be seen from the table that the plots which received the insecticidal treatments, produced good kapas over untreated control. Cypermethrin @ 60 g a.i./ha was significantly superior in recording the lowest bad kapas percentage among the treatments. The next promising treatment was methomyl @ 450 g a.i./ha which was at par with methomyl @ 450 g a.i./ha + NPV 250 LE/ha, endosulfan @ 350 g a.i./ha and methomyl @ 300 g a.i./ha. The other treatments in order of thier merit were endosulfan @ 175 g a.i./ha + NPV 250 LE/ha, methomyl @ 300 g a.i./ha + NPV 250 LE/ha, methomyl @ 150 g a.i./ha, methomyl @ 150 g a.i./ha + NPV 250 LE/ha, NPV @ 500 LE/ha and NPV @ 250 LE/ha.

The trends of effectiveness of the synthetic pyrethriod cypermethrin @ 60 g a.i./ha for reducing bollworm incidence and bad kapas and increasing the yield in the present investigation is similar with findings of Shah and Sankpal (1978). They reported that ten applications of endosulfan 0.07 per cent at 15 days interval reduced the infestation of bollworms and gave significantly highest yield. Shirshikar *et al.* (1986) reported that cypermethrin 0.01 per cent was

Table 7. Effect of insecticide sprays on per cent bad seed cotton

Treatment	Bad seed cotton (%)			
	RI	RII	RIII	Mean
Methomyl 150 g a.i./ha	20.11 (26.64)	19.44 (26.13)	16.26 (23.81)	18.60 (25.55)
Methomyl 300 g a.i./ha	18.48 (25.47)	14.27 (22.22)	16.95 (24.35)	16.56 (24.04)
Methomyl 450 g a.i./ha	10.19 (18.63)	10.78 (19.19)	12.92 (21.05)	11.29 (19.64)
Endosulfan 350 g a.i./ha	13.64 (21.64)	31.00 (33.83)	29.96 (33.21)	12.92 (21.05)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	21.84 (27.83)	19.73 (26.35)	20.11 (26.64)	20.56 (26.99)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	19.04 (25.84)	17.71 (24.88)	16.10 (23.66)	17.61 (24.80)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	12.35 (20.62)	9.72 (18.15)	13.81 (21.81)	11.96 (20.27)
NPV 250 LE/ha	29.27 (32.77)	22.35 (28.25)	24.37 (29.60)	21.99 (27.97)
NPV 500 LE/ha	22.29 (28.18)	18.86 (25.77)	20.51 (26.92)	20.55 (26.99)
Cypermethrin 60 g a.i./ha	6.02 (14.18)	6.87 (15.23)	4.20 (26.92)	5.69 (26.99)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	19.65 (26.35)	16.18 (23.73)	14.78 (22.63)	16.87 (24.27)
Untreated (control)	39.81 (39.11)	31.00 (33.83)	29.96 (33.21)	33.59 (35.43)
S.E. ±				1.56
C.D. at 5 %				4.58

* Figures in parenthesis are arcsin values.

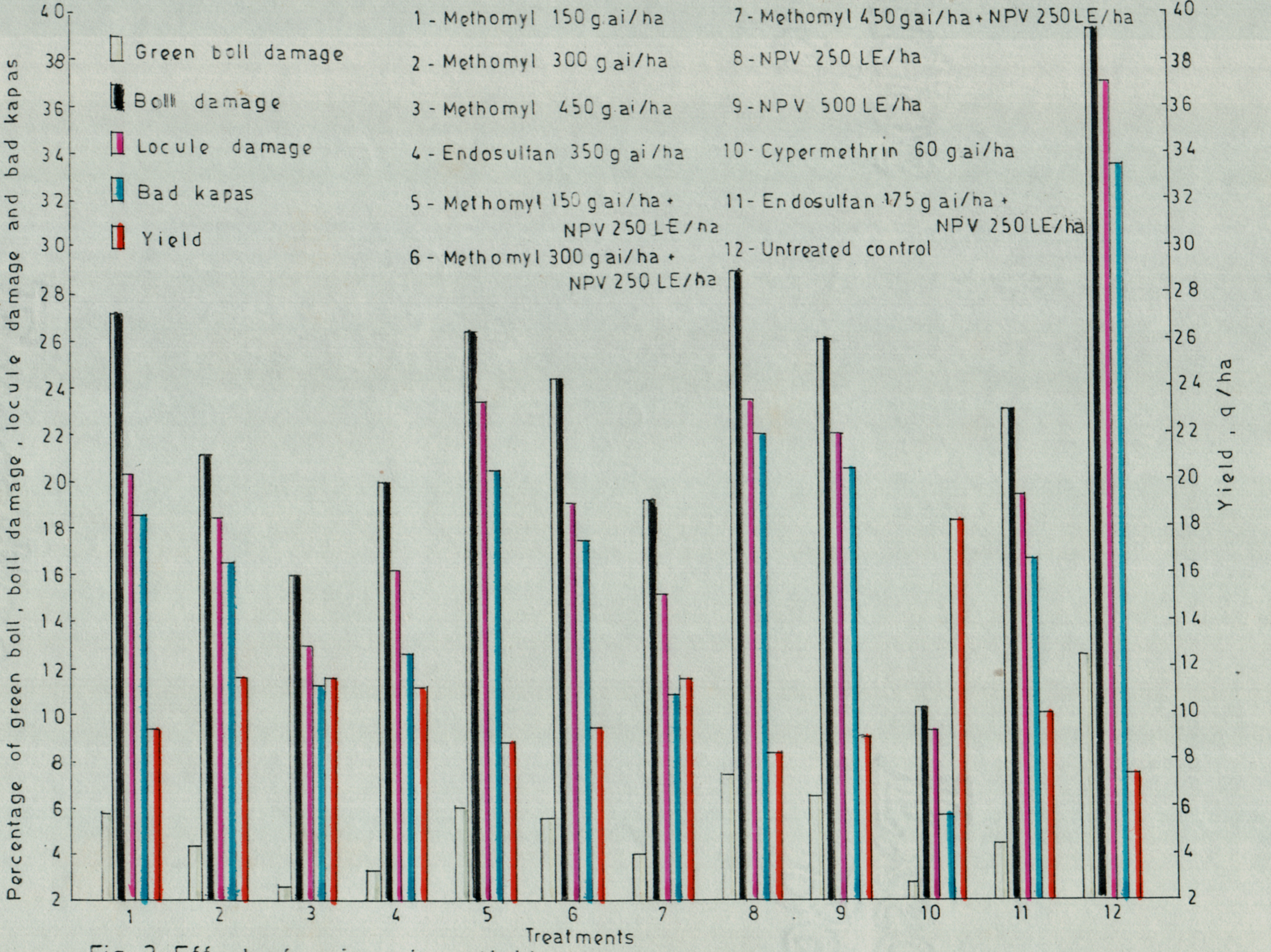


Fig. 2 Effect of various insecticides on green boll damage, boll damage, locule damage, bad kapas due to bollworm complex and yield of good kapas.

T-3108

of 300 and 150 g a.i./ha respectively. However, addition of NPV @ 250 LE/ha with methomyl @ 450 g a.i./ha recorded least number of aphids (0.46 to 12.26). At 3 days after the first spray endosulfan @ 350 g a.i./ha alone and at half the rate in combination with NPV @ 250 LE/ha were par with each other and were moderately effective in controlling aphid population as compared to that of untreated control. However, NPV @ 250 and 500 LE/ha were totally ineffective in controlling the aphid population.

The results of this investigation were in close agreement with those of Mundiwale et al. (1983). They reported that methomyl 0.05 per cent gave effective control of *Aphis gossypii* upto 7 days. Methomyl @ 1 litre/ha had a rapid and lasting effect against *A. gossypii* (Stefanov et al. 1986). Allen et al. (1990) reported that methomyl @ 0.225 lbs a.i./acre suppressed the aphid population.

There are several reports on resurgence of aphid population due to the spraying of cypermethrin (Kathane and Bhamburkar, 1978; Balsubramanian et al. 1980; Chari, 1980; Natarajan et al. 1986; Patel et al. 1986, Rangarajan et al. 1986). From ecological viewpoint resurgence of one insect pest attacking a cultivar is defined as a sudden and dramastic upward shift on the general equilibrium position so that it lies well above the economic injury level (Metcalf, 1986). However, Heinrichs et al. (1982) defined resurgence as a statistically significant increase in population of or damage by the target pest following insecticide application. In present investigation it was observed that the population of aphids started increasing after application of cypermethrin @ 60 g a.i./ha despite a slight intial decrease. The immediate decline in population level might be due to the contact toxicity which has been already reported by Singh and Sircar (1980) in the bioassay studies of Lipaphis erysimi and Aphis craccivara. Of the several possible reasons for this phenomenon of resurgence, hormoligosis seems to be the prime reason (Chelliah, 1979). Luckey (1968) explained the term hormoligosis as sub-harmful quantities of any stressing agent will be stimulatory to the organism. Destruction of natural enemies may be another reason for the population flare-up, as reported by Ripper (1956). Baskaran (1986) reported the enhanced nutrition to the insect population and subsequent metabolic conversion resulting in a higher level of fecundity as the reason for resurgence in pyrethriod treated plants. Manickavasagam and Gunthaligaraj (1993) reported that population build up of aphids was more in cypermethrin 25 EC (100 ppm) treated plots.

4.2.2 Cotton jassids

The average number of jassid nymphs per six leaves per plant on cotton as influenced by various insecticidal treatments are given in Table 9. The count of jassids prior to initiation of spraying was in the range of 14.9 to 21.2, which further remained in the range of 15.43 to 22.32 upto two months

Table 8. Effect of insecticide sprays on population of aphids

Treatment (Mean no of aphids/6 leaves/plant)	Pre spray count	1st spray 3 DAS	1st spray 7 DAS	1st spray 14 DAS	2nd spray 3 DAS	2nd spray 7 DAS	2nd spray 14 DAS	3rd spray 3 DAS	3rd spray 7 DAS	3rd spray 14 DAS	4th spray 3 DAS
Methomyl 150 g a.i./ha	27.7 (5.28)	12.77 (3.61)	13.26 (3.69)	16.24 (4.06)	3.13 (1.88)	5.14 (2.34)	8.20 (2.93)	2.00 (1.58)	4.86 (2.29)	5.06 (2.34)	0.92 (1.24)
Methomyl 300 g a.i./ha	20.66 (5.46)	11.46 (3.43)	12.36 (3.57)	14.43 (3.85)	2.20 (1.71)	4.33 (2.18)	6.46 (2.62)	1.73 (1.44)	1.66 (1.88)	3.06 (1.88)	0.92 (1.19)
Methomyl 450 g a.i./ha	29.68 (5.45)	9.86 (3.20)	6.73 (2.59)	8.07 (2.92)	0.46 (0.97)	1.20 (1.29)	3.00 (1.85)	0.13 (0.55)	0.83 (1.15)	1.40 (1.37)	0.46 (1.18)
Endosulfan 350 g a.i./ha	28.82 (5.38)	18.30 (4.33)	15.93 (4.02)	19.18 (4.42)	8.20 (2.93)	10.24 (3.25)	10.53 (3.31)	7.93 (2.88)	6.56 (2.97)	9.80 (3.20)	9.68 (3.17)
Methomyl 150 g a.i./ ha+NPV 250 LE/ha	28.67 (5.34)	19.00 (4.41)	15.15 (3.94)	18.31 (4.32)	5.10 (2.28)	6.38 (2.61)	7.09 (2.73)	3.48 (1.96)	5.05 (2.35)	4.60 (2.25)	1.80 (1.48)
Methomyl 300 g a.i./ ha+NPV 250 LE/ha	32.46 (5.70)	10.73 (3.31)	14.33 (3.83)	16.63 (4.13)	4.13 (2.13)	5.49 (2.43)	9.23 (3.09)	2.19 (1.61)	2.17 (1.63)	5.21 (2.37)	0.93 (1.16)
Methomyl 450 g a.i./ ha+NPV 250 LE/ha	25.53 (5.07)	5.93 (2.50)	8.40 (2.97)	12.26 (3.56)	0.60 (1.02)	2.66 (1.73)	5.06 (2.15)	0.46 (0.96)	1.16 (1.27)	1.26 (1.31)	0.70 (1.05)
NPV 250 LE/ha	28.49 (5.37)	30.70 (5.58)	34.40 (5.90)	35.00 (5.95)	21.80 (4.42)	23.30 (4.87)	27.80 (5.31)	14.80 (3.90)	13.33 (3.70)	18.27 (4.32)	14.40 (3.00)
NPV 500 LE/ha	26.54 (5.17)	18.80 (4.38)	31.37 (5.64)	34.20 (5.88)	12.80 (3.63)	15.47 (3.98)	15.73 (4.01)	10.31 (3.24)	10.52 (3.03)	13.51 (3.73)	12.40 (3.58)
Cypermethrin 60 g a.i./ha	25.41 (5.08)	34.33 (6.13)	116.20 (10.79)	56.40 (7.54)	170.08 (13.06)	124.60 (11.18)	171.53 (13.11)	132.06 (11.50)	72.53 (8.54)	67.86 (8.26)	53.86 (7.36)
Endosulfan 175 g a.i./ha+NPV 250LE/ha	31.21 (5.62)	15.20 (3.93)	13.20 (3.68)	16.30 (4.09)	9.30 (3.12)	8.27 (2.94)	12.68 (3.62)	8.08 (2.91)	7.10 (2.73)	10.33 (3.27)	12.35 (3.58)
Untreated (control)	24.74 (5.01)	26.11 (4.81)	38.13 (6.22)	40.50 (6.40)	23.26 (4.86)	25.50 (5.08)	31.10 (5.61)	20.38 (4.53)	19.42 (4.45)	41.02 (6.43)	28.00 (5.33)
S.E. ±	0.31	0.22	0.19	0.16	0.16	0.16	0.18	0.19	0.16	0.10	0.28
C.D. at 5 %	N.S.	0.67	0.56	0.47	0.49	0.47	0.55	0.58	0.47	0.31	0.82

DAS = Days after spray

* Figures in parenthesis are Poison values ($\sqrt{X+0.5}$)

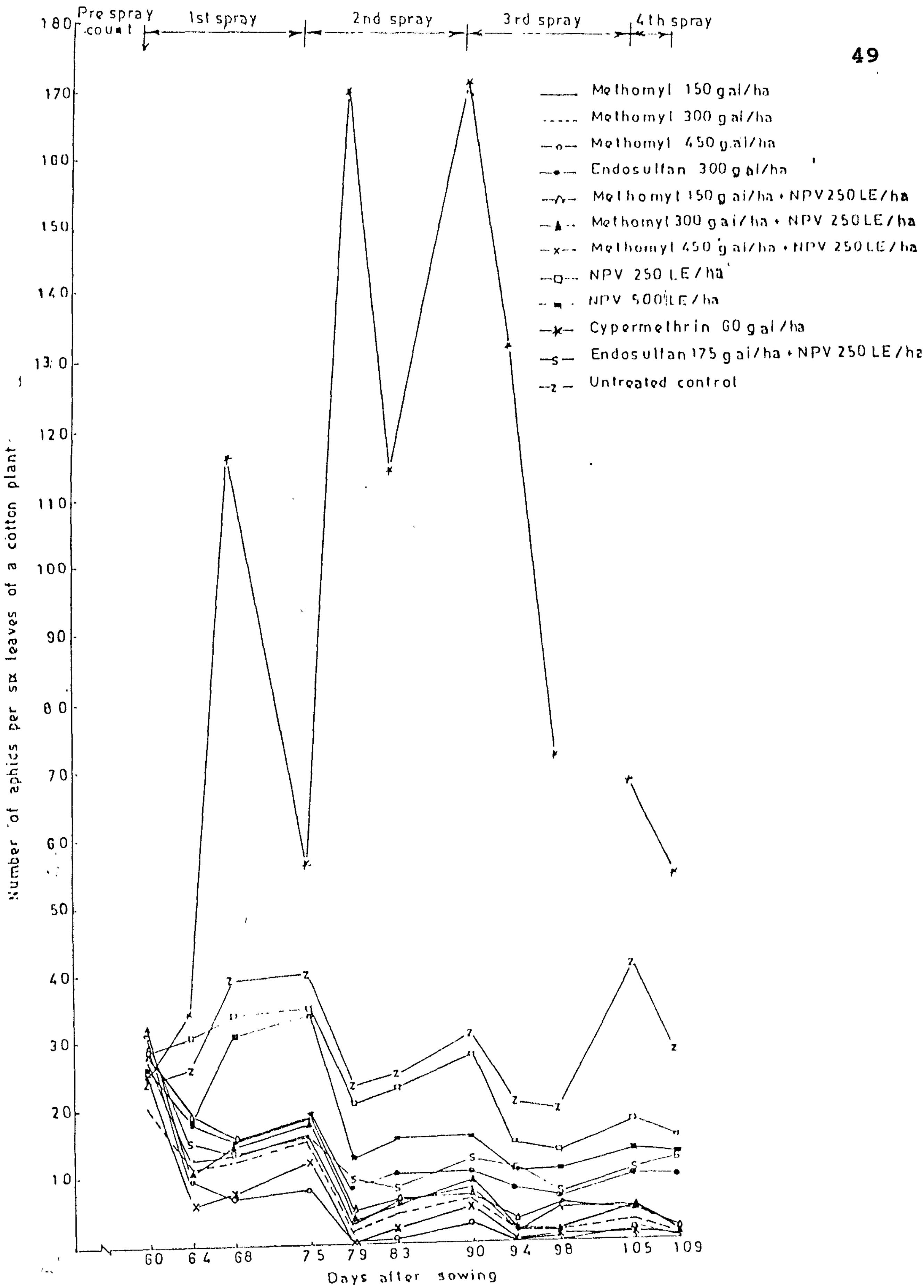


Fig. 3 Effect of various insecticide sprays on the population of aphids on cotton.

and thereafter reduced considerably. All the insecticide treatments were superior in checking the population of jassids during post spray period. The population count recorded in treatment with cypermethrin @ 60 g a.i./ha was lower (0.2 to 11.53) than all other treatments (Fig. 4). This was followed by the treatments with the sprays of methomyl @ 450 g a.i./ha (0.36 to 7.92) and methomyl @ 450 g a.i./ha + NPV 250 LE/ha (0.73 to 11.31). Endosulfan @ 350 g a.i./ha was also promising in reducing the population of jassids (1.34 to 8.13) as compared to endosulfan 175 g a.i./ha + NPV 250 LE/ha (1.94 to 13.86). Methomyl at lower doses of 150 and 300 g a.i./ha were not very effective.

Manickavasagam and Gunthaligaraj (1993) reported that cypermethrin 25 EC @ 50 g a.i./ha controlled the population of jassids which is in close agreement with the present results.

4.2.3 Cotton thrips

The data on average number of thrips per six leaves per plant of cotton are presented in Table 10. The count prior to initiation of spraying was in the range of 89.96 to 104.40. The count in untreated crop remained in the range of 46.65 to 57.23 for 14 days and 27.56 to 33.09 during next 15 days. Thereafter, the population declined to 8.48 in a span of about 28 days. On this background, all the insecticide treatments were superior in minimising the attack of thrips on cotton during post-spraying period. Relative population trend shown

Table 9. Effect of insecticide sprays on population of jassids

Treatment	Mean no. of jassids/5 leaves/plant										
	Pre spray count	1st spray			2nd spray			3rd spray			4th spray
		3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS
Methomyl 150 g a.i./ha	21.20 (6.31)	10.26 (3.27)	8.04 (2.91)	7.46 (2.81)	7.53 (2.82)	6.06 (2.55)	4.70 (2.27)	5.90 (2.52)	5.13 (2.34)	4.26 (2.17)	2.32 (1.66)
Methomyl 300 g a.i./ha	18.80 (4.48)	9.26 (3.12)	6.48 (2.62)	6.40 (2.60)	6.66 (2.58)	5.07 (2.34)	4.00 (2.11)	4.26 (2.17)	4.14 (2.13)	3.82 (2.07)	2.00 (1.57)
Methomyl 450 g a.i./ha	19.46 (4.38)	7.92 (2.89)	5.33 (2.40)	4.86 (2.16)	3.13 (1.87)	2.03 (1.58)	1.57 (1.42)	2.23 (1.64)	1.01 (1.23)	0.92 (1.18)	0.36 (0.92)
Endosulfan 350 g a.i./ha	17.73 (4.26)	8.13 (2.91)	7.12 (2.72)	4.05 (2.12)	5.46 (2.43)	4.00 (2.11)	3.27 (1.93)	4.03 (2.11)	3.05 (1.88)	2.64 (1.66)	1.34 (1.34)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	15.13 (4.27)	13.20 (4.03)	10.67 (3.33)	8.00 (2.91)	5.06 (2.22)	3.97 (2.11)	2.04 (1.57)	3.66 (2.01)	2.02 (1.44)	1.92 (1.55)	1.00 (1.22)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	19.73 (4.48)	12.35 (3.60)	8.97 (3.07)	4.96 (2.33)	4.88 (2.25)	3.87 (2.08)	1.98 (1.57)	2.95 (1.85)	2.38 (1.69)	1.40 (1.36)	0.95 (1.20)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	19.33 (4.44)	11.31 (3.42)	7.43 (2.81)	3.60 (2.02)	2.66 (1.72)	1.58 (1.43)	0.89 (1.17)	1.98 (1.57)	0.98 (1.21)	0.73 (1.10)	0.86 (1.16)
NPV 250 LE/ha	15.00 (3.89)	15.90 (4.04)	14.60 (3.88)	9.03 (3.08)	10.40 (3.28)	8.37 (2.97)	7.19 (2.72)	9.09 (3.08)	7.39 (2.79)	6.32 (2.58)	3.18 (1.90)
NPV 500 LE/ha	16.20 (4.08)	15.46 (3.99)	12.60 (3.61)	9.34 (3.13)	8.26 (2.94)	7.01 (2.73)	5.63 (2.45)	7.07 (2.73)	5.89 (2.52)	5.04 (2.32)	2.49 (1.72)
Cypermethrin 60 g a.i./ha	15.13 (3.94)	11.53 (3.54)	9.11 (3.08)	5.03 (2.34)	2.00 (1.55)	0.76 (1.06)	0.54 (1.37)	1.94 (1.55)	0.61 (1.03)	0.50 (0.99)	0.20 (0.83)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	14.90 (3.92)	13.86 (3.77)	9.45 (3.02)	5.34 (2.41)	5.26 (1.59)	4.98 (2.33)	3.47 (1.95)	3.19 (1.91)	3.96 (2.11)	3.00 (1.86)	1.94 (1.55)
Untreated (control)	18.53 (4.34)	22.32 (4.76)	20.53 (4.58)	18.52 (4.32)	18.31 (4.36)	14.00 (3.80)	11.10 (3.39)	15.43 (3.91)	10.36 (3.28)	9.13 (3.08)	9.92 (3.21)
S.E. ±	0.50	0.15	0.12	0.06	0.29	0.11	0.21	0.14	0.13	0.11	0.08
C.D. at 5 %	N.S.	0.46	0.37	0.20	0.87	0.32	0.64	0.42	0.39	0.33	0.24

DAS = Days after spray

* Figures in parenthesis are Poison values ($\sqrt{X+0.5}$)

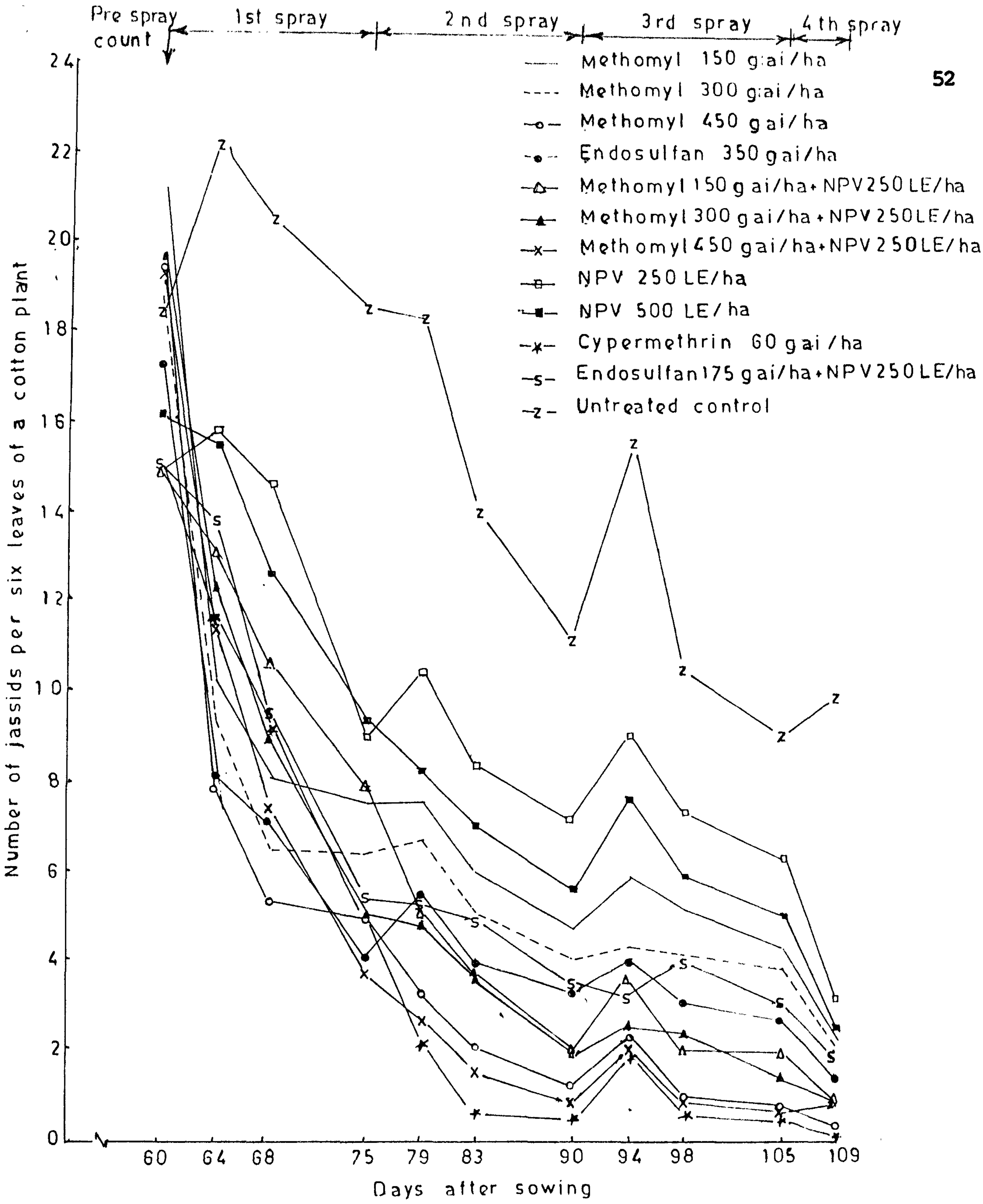


Fig. 4 Effect of various insecticide sprays on population of jassids on cotton.

in Fig. 5 indicates that the performance of sprays with methomyl @ 450 g a.i./ha and methomyl @ 450 g a.i./ha + NPV 250 LE/ha was similar to each other and better than rest of the treatments. Cypermethrin @ 60 g a.i./ha and methomyl @ 300 g a.i./ha were found to be effective upto 14 day of spray with their population count ranging from 0 to 15.30 and 0.13 to 18.20 respectively. The population of thrips was in the range of 1.11 to 26.38 and 1.0 to 21.17 in respect of crop sprayed with methomyl @ 150 g a.i./ha and endosulfan @ 350 g a.i./ha. However, the corresponding population in respect or the NPV 250 LE/ha combined with methomyl @ 150, 300 and 450 g a.i./ha and endosulfan @ 175 g a.i./ha was in the range of 1.34 to 27.19, 0.88 to 24.31, 0.0 to 19.53 and 1.07 to 22.23 respectively.

Stefanov and Dimitrow (1986) reported the effectiveness of methomyl @ 1 litre/ha against *Thrips tabacii* which is in close agreement with above results.

4.3 Efficacy of insecticides against the coccinellid predator of cotton

Data on a average number of predator per five plants are presented in Table 11. The population of lady bird beette *Cocinella septumpunctata* Linn. (grubs + adults) prior to initiation of spraying ranged from 5.88 to 8.43 which was highest than the post-spray observations. However, untreated

Table 10. Effect of insecticide sprays on population of thrips

Treatment	Mean no.of thrips/6 leaves/plant										
	Pre spray count	1st spray			2nd spray			3rd spray			4th spray
		3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS
Methomyl 150 g a.i./ha	93.20 (9.62)	21.49 (4.68)	23.83 (4.87)	26.38 (5.17)	10.35 (3.28)	16.51 (4.10)	19.40 (4.45)	10.05 (3.24)	10.13 (3.25)	14.40 (3.83)	1.11 (1.26)
Methomyl 300 g a.i./ha	93.67 (9.69)	17.12 (4.18)	21.27 (4.66)	23.97 (4.94)	6.93 (2.72)	12.13 (3.54)	15.20 (3.92)	5.00 (2.34)	6.27 (2.58)	11.17 (3.40)	0.78 (1.12)
Methomyl 450 g a.i./ha	101.00 (10.07)	8.23 (2.93)	11.72 (3.49)	18.20 (4.31)	2.06 (1.58)	8.15 (2.92)	10.25 (3.26)	2.00 (1.57)	4.10 (2.10)	5.14 (2.34)	0.13 (0.79)
Endosulfan 350 g a.i./ha	94.16 (9.72)	13.94 (3.79)	14.30 (3.83)	21.17 (4.65)	12.37 (3.57)	10.28 (3.25)	13.33 (3.69)	5.80 (2.50)	8.33 (2.93)	9.60 (3.16)	1.00 (1.22)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	101.16 (10.07)	22.16 (4.75)	24.24 (4.96)	27.19 (5.23)	8.11 (2.92)	17.51 (4.22)	20.10 (4.53)	7.63 (2.84)	11.21 (3.40)	15.28 (3.96)	1.34 (1.35)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	92.60 (9.63)	18.47 (4.34)	21.60 (4.69)	24.31 (4.97)	7.07 (2.73)	13.15 (3.68)	16.15 (4.06)	6.03 (2.55)	7.34 (2.76)	12.03 (3.51)	0.88 (1.17)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	104.40 (10.29)	11.31 (3.42)	17.10 (4.19)	19.53 (4.46)	3.11 (1.86)	8.98 (3.07)	11.11 (3.40)	2.37 (1.68)	4.33 (2.19)	6.17 (2.53)	0.00 (0.70)
NPV 250 LE/ha	90.22 (9.50)	27.18 (5.25)	29.40 (5.46)	34.40 (5.90)	20.47 (4.55)	21.30 (4.66)	24.92 (5.03)	14.03 (3.80)	16.03 (4.06)	18.04 (4.29)	3.09 (1.88)
NPV 500 LE/ha	89.96 (9.50)	25.51 (5.09)	26.43 (5.18)	30.72 (5.58)	17.14 (4.19)	19.19 (4.43)	23.32 (4.86)	11.58 (3.47)	14.18 (3.80)	17.15 (4.19)	2.10 (1.60)
Cypermethrin 60 g a.i./ha	98.37 (9.93)	7.31 (2.76)	10.47 (3.29)	15.30 (3.94)	4.94 (2.32)	6.79 (2.69)	8.04 (2.91)	3.41 (1.95)	5.20 (2.35)	5.99 (2.54)	0.00 (0.70)
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	94.86 (9.75)	14.28 (3.49)	19.17 (4.42)	22.23 (4.76)	13.49 (3.72)	9.42 (3.13)	13.63 (3.72)	8.05 (2.92)	9.21 (3.09)	10.49 (3.31)	1.07 (1.25)
Untreated (control)	94.42 (9.95)	46.65 (6.85)	52.50 (7.27)	57.23 (7.59)	27.56 (5.29)	29.37 (5.46)	33.09 (5.78)	10.20 (4.42)	14.39 (3.84)	20.10 (4.53)	8.48 (3.00)
S.E. ±	0.28	0.21	0.12	0.15	0.15	0.17	0.18	0.06	0.67	0.21	0.06
C.D. at 5 %	N.S.	0.61	0.37	0.46	0.46	0.51	0.55	0.18	0.91	0.62	0.20

DAS = Days after spray

* Figures in parenthesis are Poison values($\sqrt{X+0.5}$)

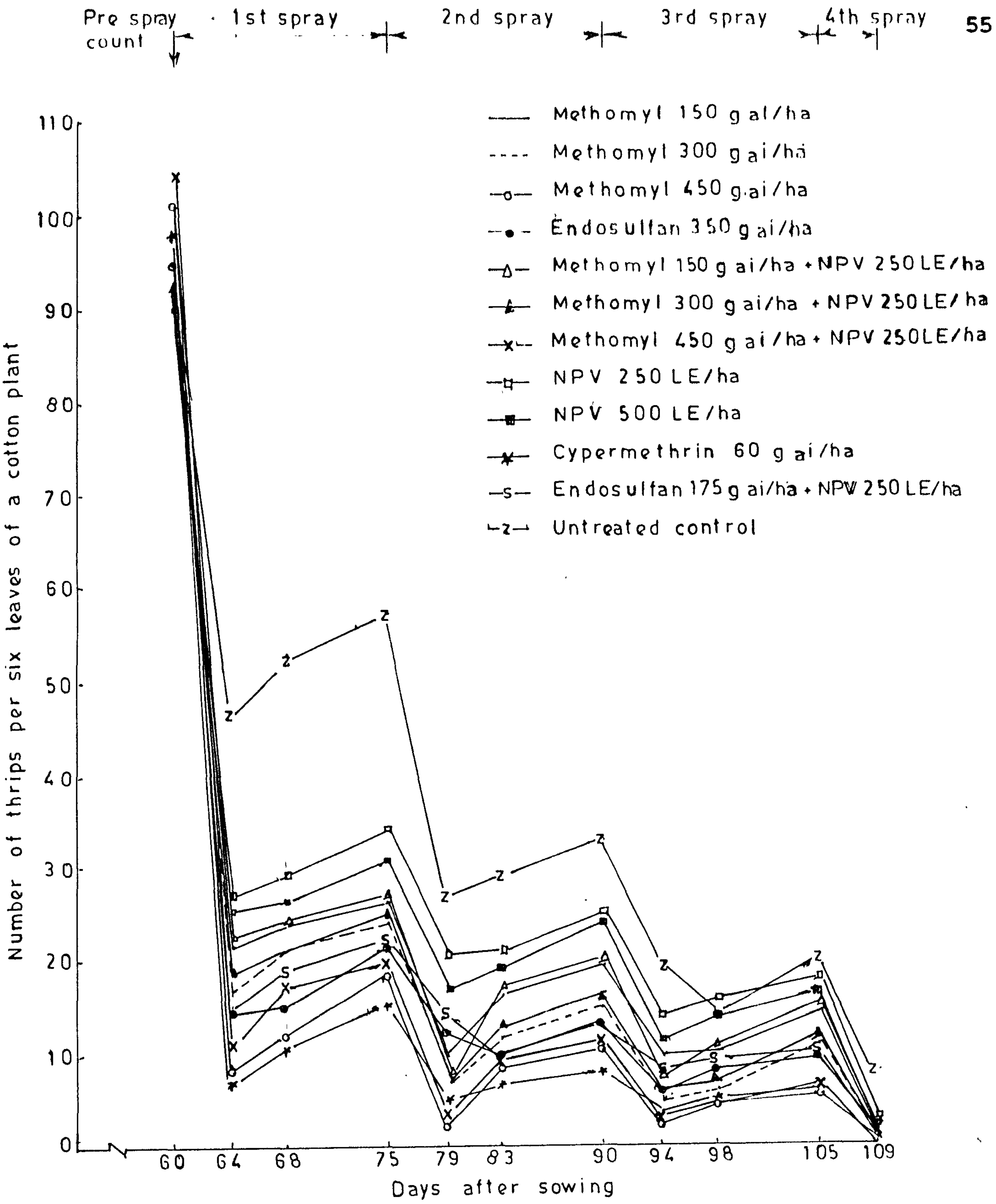


Fig. 5 Effect of various insecticide sprays on population of thrips on cotton.

control plot recorded the highest population (8.33 to 12.30) followed by NPV treatment @ 500 and 250 LE/ha i.e. 7.15 to 9.51 and 6.32 to 9.34 respectively. This clearly indicates that the HaNPV does not adversely affect the coccinellid predator. Methomyl @ 450 g a.i./ha was highly toxic to lady bird beetles and recorded the least population (3.20 to 5.0). However, addition of NPV @ 250 LE/ha with methomyl @ 450 g a.i./ha did not reduce the toxicity to lady bird beetles (2.7 to 6.93). The same trend was followed with methomyl @ 300 and 150 g a.i./ha alone and in combination with NPV @ 250 LE/ha. However, the conventional formulation of endosulfan and cypermethrin were also toxic to the population of lady bird beetle and recorded 4.15 to 5.69 and 4.03 to 5.46 respectively. It was observed that the number of lady bird beetles per five plants was the lowest after 3 days of spray, which however, increased at 7 and 14 days after.

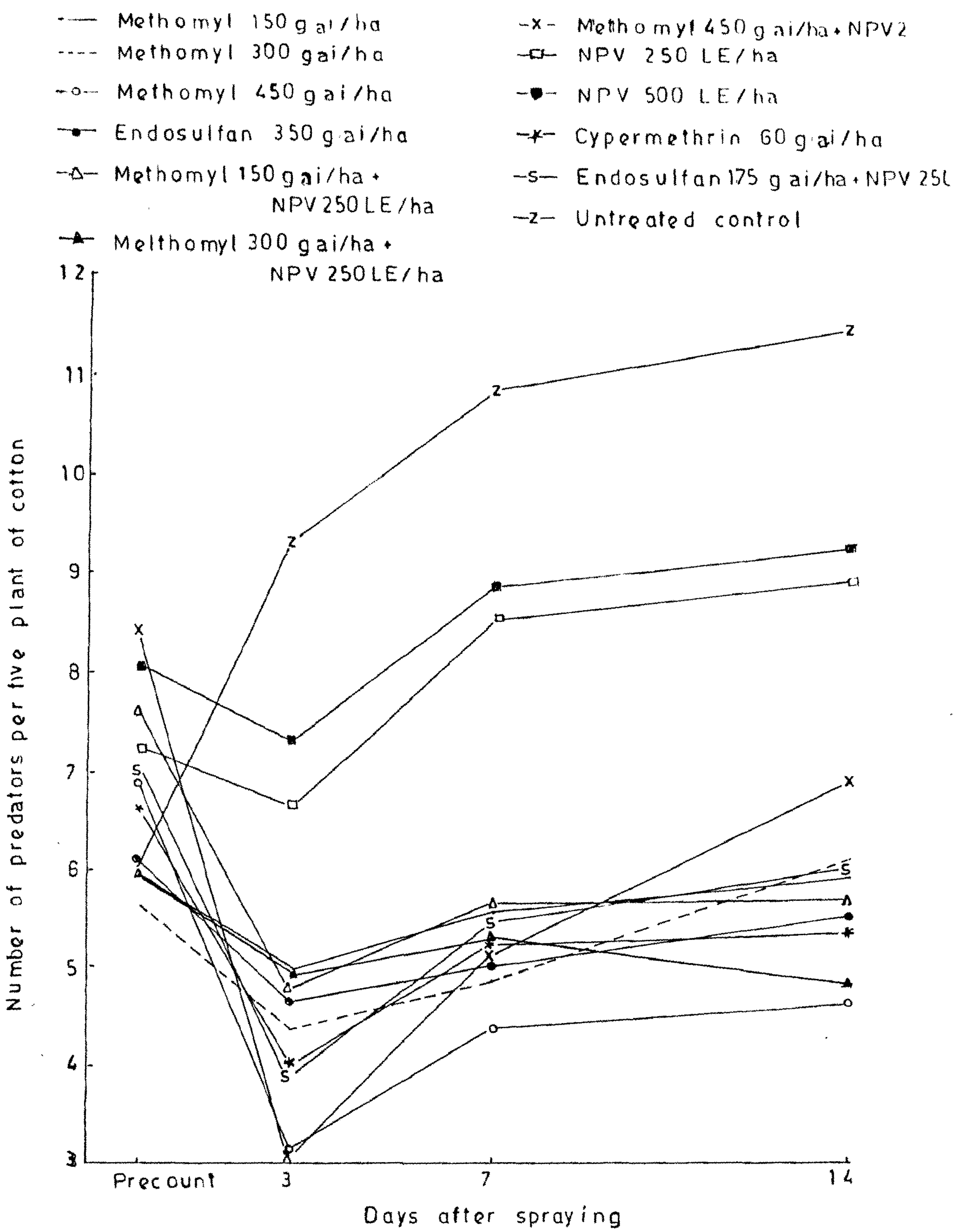
The results of this investigation are in close agreement with those of Roome (1975). He reported that plots treated with NPV were not damaging as compared to carbaryl to the population of predators. Pitts and Pieters (1982) reported that aerial application of methomyl @ 0.14 kg a.i./ha resulted in reduction of predator population. Manisegaran et al. (1991 b) reported that methomyl @ 750 g a.i./ha reported highest toxicity (94.44) to coccinellids upto 9 days after spray, where as methomyl @ 600, 450 and 300 g a.i./ha reported

Table 11. Effect of insecticide sprays on population of predator

Treatment	Mean no.of predator/6 leaves/5 plants									
	Pre spray count	1st spray			2nd spray			Pooled		
		3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
Methomyl 150 g a.i./ha	6.02 (2.54)	4.94 (2.33)	4.98 (2.33)	5.16 (2.47)	5.03 (2.34)	6.04 (2.55)	6.14 (2.57)	4.98 (2.34)	5.51 (2.44)	5.97 (2.45)
Methomyl 300 g a.i./ha	5.88 (2.44)	4.65 (2.25)	4.31 (2.18)	5.80 (2.34)	4.00 (2.11)	5.44 (2.43)	6.03 (2.54)	4.32 (2.18)	4.87 (2.47)	5.59 (2.51)
Methomyl 450 g a.i./ha	6.94 (2.72)	3.20 (1.91)	3.99 (2.08)	4.08 (2.34)	3.24 (1.92)	4.63 (2.26)	5.00 (2.34)	3.22 (1.92)	4.31 (2.33)	4.54 (2.34)
Endosulfan 350 g a.i./ha	6.12 (2.52)	4.15 (2.15)	5.00 (2.31)	5.00 (2.46)	4.36 (2.19)	5.08 (2.35)	5.69 (2.48)	4.61 (2.17)	5.04 (2.36)	5.49 (2.47)
Methomyl 150 g a.i./ha + NPV 250 LE/ha	7.63 (2.82)	5.03 (2.35)	4.95 (2.34)	5.30 (2.40)	4.53 (2.31)	6.23 (2.58)	6.61 (2.65)	4.78 (2.32)	5.59 (2.46)	5.70 (2.52)
Methomyl 300 g a.i./ha + NPV 250 LE/ha	6.08 (2.70)	4.70 (2.27)	5.05 (2.35)	4.80 (2.29)	4.88 (2.33)	5.54 (2.45)	5.70 (2.48)	4.79 (2.30)	5.29 (2.40)	4.80 (2.38)
Methomyl 450 g a.i./ha + NPV 250 LE/ha	8.43 (2.99)	3.56 (2.01)	5.59 (2.80)	4.70 (2.27)	2.70 (1.78)	4.86 (2.30)	5.31 (2.40)	3.13 (1.89)	5.22 (2.55)	6.93 (2.33)
NPV 250 LE/ha	7.52 (2.80)	6.32 (2.60)	7.74 (2.86)	8.56 (3.33)	7.01 (2.73)	8.67 (3.02)	9.34 (3.13)	6.66 (2.67)	8.54 (2.94)	8.95 (3.23)
NPV 500 LE/ha	8.18 (2.93)	7.15 (2.75)	8.07 (2.91)	9.00 (3.13)	7.49 (2.82)	9.13 (3.09)	9.51 (3.16)	7.32 (2.78)	8.79 (3.00)	9.25 (3.14)
Cypermethrin 60 g a.i./ha	6.52 (2.64)	4.10 (2.13)	5.10 (2.43)	5.30 (2.39)	4.03 (2.12)	5.03 (2.64)	5.46 (2.44)	4.06 (2.11)	5.28 (2.53)	5.38 (2.41)
Endosulfan 175 g a.i./ha+ NPV 250 LE/ha	7.00 (2.72)	3.79 (2.05)	4.98 (2.34)	6.01 (2.40)	4.09 (2.14)	5.71 (2.48)	6.03 (2.54)	3.94 (2.09)	5.50 (2.41)	6.02 (2.47)
Untreated (control)	6.40 (2.44)	8.33 (2.95)	9.36 (3.13)	10.49 (3.31)	10.33 (3.28)	11.33 (3.43)	12.30 (3.62)	9.33 (3.12)	10.83 (3.28)	11.39 (3.51)
S.E. ±	0.14	0.10	0.11	0.17	0.06	0.10	0.07	0.06	0.10	0.09
C.D. at 5 %	N.S.	0.29	0.33	0.52	0.18	0.31	0.22	0.17	0.29	0.26

DAS = Days after spray

* Figures in parenthesis are Poison values ($\sqrt{X+0.5}$)



Effect of various insecticides on population of predators. (average of 2 sprays)

77.08, 78.57 and 66.66 toxicity at 8, 7 and 6 days after spray.

4.4 Phytotoxicity studies

Observations on phytotoxicity test of methomyl 40 SP @ 900 g a.i./ha per five plants are presented in Table 12. The first visible symptom appeared mostly on mature leaves. The tip of leaves showed faint brown colour spots, which later on extended along the margins as well as within the leaf lamina. The brown colour soon became blood red and the leaves showed prominent reddening. The tip reddening extended more rapidly towards the base of leaf then it spread towards the midrib from margin. As a result of this, the injuries appeared to be more prominent at the apical region and margins of leaf, but in case of severe injury entire leaf showed complete reddening. These symptoms appeared more prominently from three days after application and extended rapidly within 14 days. It was further observed that the injuries did not show increase after 14 days. The damaged area did not recover. So also the defoliation was light and necrotis or burning of leaves was not observed. The new foliage did not exhibit phytotoxic symptoms. However, the plots treated with methomyl @ 150, 300 and 450 g a.i./ha alone and in combination with NPV did not record phytotoxic symptoms and square and boll counts revealed no methomyl induced decrease in fruiting forms. This phenomenon did not appear to reduce yield, however.

Table 12. Phytotoxicity test of methomyl 40 SP @ 900 g a.i./ha on cotton

Days after spray	% leaf injury/5 plants					% mean	Grade
	1	2	3	4	5		
2	0.0	0.0	0.0	0.0	0.0	0.0	-
3	0.0	0.0	0.0	0.0	0.0	0.0	-
4	3.0	4.0	2.0	3.0	2.0	2.8	I
5	3.0	4.0	3.0	3.0	3.0	3.2	I
6	5.0	7.0	4.0	6.0	4.0	5.2	I
7	11.0	10.0	12.0	10.0	11.0	11.8	II
8	15.0	17.0	19.0	14.0	16.0	16.2	III
9	22.0	25.0	26.0	20.0	25.0	23.6	III
10	22.0	26.0	26.0	21.0	25.0	24.0	III
11	23.0	28.0	28.0	22.0	28.0	25.8	III
12	28.0	30.0	31.0	24.0	30.0	28.6	III
13	34.0	35.0	34.0	28.0	33.0	32.8	IV
14	39.0	38.0	37.0	29.0	37.0	36.0	IV
15	42.0	40.0	40.0	33.0	48.0	40.6	V

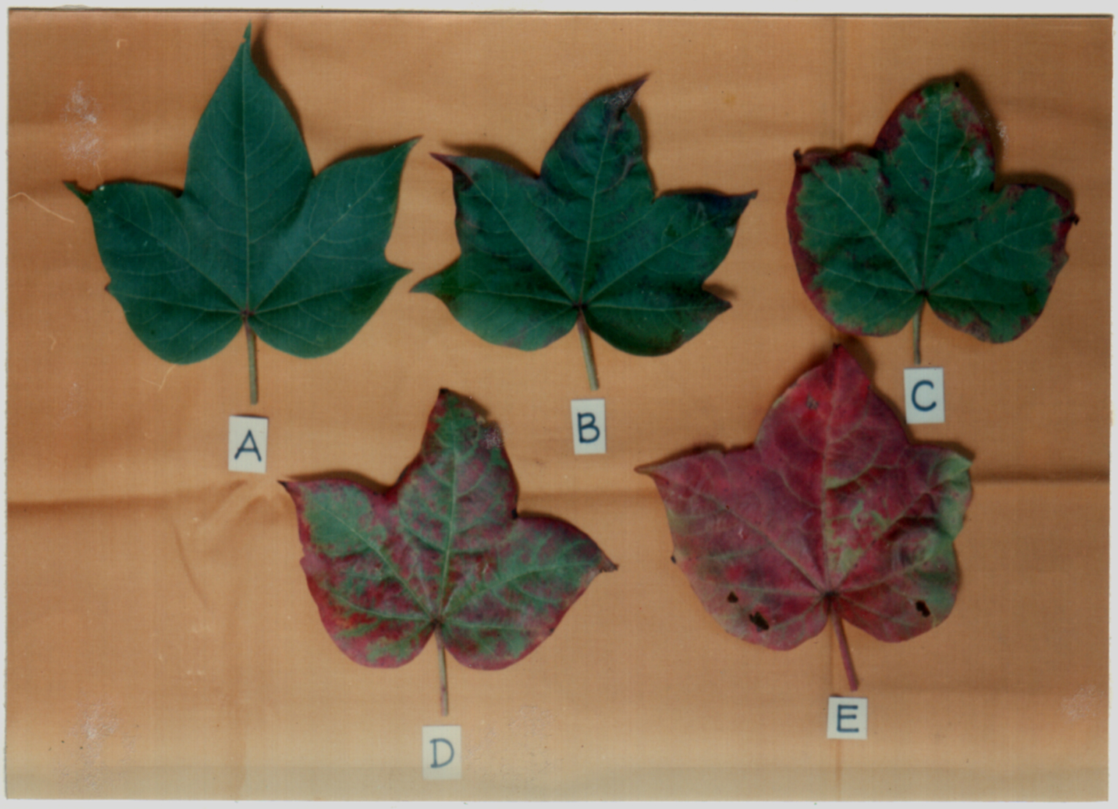


Plate-1 Phytotoxicity symptoms of methomyl 40 SP @ 900 g ai/ha on cotton (Laxmi)

A - Healthy leaf

B - Showing tip burning symptoms (4 DAS)

C - Reddening of leaf extended towards margin (7 DAS)

D - Spreadning of reddening symptom all over leaf lamina (10 DAS)

E - Complete reddening of leaf (15 DAS)

DAS - Days after spray

DuRant (1977) and Luttrell et al. (1979) reported that methomyl treatment caused leaf reddening and was phyto-toxic to cotton which are in carobaration with present investigation.

4.5 Seed cotton yield

The effect of various insecticides on the yield of seed cotton are presented in Table 13. The data indicated that plots treated with various insecticidal treatments produced significantly higher seed cotton yield over untreated control. The treatment with cypermethrin @ 60 g a.i./ha gave the highest yield of seed cotton (15.71 q/ha) as against (7.40 q/ha) in untreated control. It was significantly superior to the rest of the treatments. The second promising treatment was methomyl @ 450 g a.i./ha; it was significantly superior and was at par with methomyl @ 450 g a.i./ha + NPV 250 LE/ha, endosulfan @ 350 g a.i./ha, methomyl @ 300 g a.i./ha and endosulfan @ 175 g a.i./ha + NPV 250 LE/ha. The succeding group of treatments in order of merit were methomyl @ 300 g a.i./ha + NPV 250 LE/ha, methomyl @ 150 g a.i./ha , NPV @ 500 and 250 LE/ha.

The above results are in conformity with DuRant (1977). He reported that methomyl @ 0.75 kg a.i./ha significantly increased the yield. The same was true for 3 consecutive applications of methomyl at 0.50 kg a.i./ha . Luttrell et al. (1979) reported that methomyl @ 70, 140 and 280 g/ha in combination with Elcar 148 g/ha had yield equal to those of Elcar alone. Cypermethrin @ 60 g a.i./ha and 100 g a.i./ha recorded the highest yield (Gandhale et al. 1983, Sharma, 1988).

The results obtained in the present investigation are indicative, the data being of one year only. Hence, additional trials will be needed to arrive at definitive conclusions.

Table 13. Effect of insecticide sprays on yield of seed cotton

Treatment	Yield of seed cotton (kg/plot)				kg/ha
	RI	RII	RIII	Mean	
Methomyl 150 g a.i./ha	1.72	1.91	1.57	1.73	917.00
Methomyl 300 g a.i./ha	1.78	2.27	2.00	2.01	1067.00
Methomyl 450 g a.i./ha	2.61	1.86	2.10	2.19	1158.00
Endosulfan 350 g a.i./ha	2.42	1.76	1.92	2.03	1075.00
Methomyl 150 g a.i./ha + NPV 250 LE/ha	1.45	1.88	1.83	1.72	910.00
Methomyl 300 g a.i./ha + NPV 250 LE/ha	1.61	1.33	2.36	1.76	931.00
Methomyl 450 g a.i./ha + NPV 250 LE/ha	2.54	1.79	2.13	2.15	1137.00
NPV 250 LE/ha	1.32	1.72	1.59	1.54	814.00
NPV 500 LE/ha	1.68	2.06	1.35	1.69	894.00
Cypermethrin 60 g a.i./ha	3.46	3.20	2.26	2.97	1571.00
Endosulfan 175 g a.i./ha + NPV 250 LE/ha	2.14	1.86	1.67	1.89	999.00
Untreated (control)	1.55	1.32	1.35	1.40	740.00
S.E. ±				0.20	105.00
C.D. at 5 %				0.59	312.00

Summary and Conclusion

5. SUMMARY AND CONCLUSIONS

5.1 Summary

Cotton is one of the most important commercial crops playing a key role in the socioeconomic conditions of the farmers in India. It supports a large number of insect and non-insect pest of which the bollworm complex viz., American bollworm (Helicoverpa armigera Hubner), spotted bollworm (Earias vittella Fabricius) and pink bollworm (Pectinophora gossypiella Saunders) play a major role in cotton ecosystem. A new formulation of carbamate insecticide i.e. methomyl 40 SP at different dosages alone and in combination with HaNPV was evaluated for its bioefficacy against bollworms, sucking pests and safety to the predatory lady bird beetle. The formulations included in the present study were methomyl (Lannate 40 SP) @ 150, 300 and 450 g a.i./ha alone and in combination with HaNPV @ 250 LE/ha, cypermethrin (Cyperkil 25 EC) @ 60 g a.i./ha and endosulfan (Thiodan 35 EC) @ 350 g a.i./ha and at half the dose in combination with HaNPV. Baculovirus heliothis @ 250 and 500 LE/ha were also included in the present study. Methomyl at higher dose i.e. @ 900 g a.i./ha was also included in present investigation to study its phytotoxic effects on cotton. Each treatment was evaluated as a schedule of four sprays at an interval of 14 days by initiating the spraying at square formation stage of 'Laxmi' variety of cotton during kharif season of 1993 at the instructional farm, Department of Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri. The results of the experiment are summarised and concluded in this chapter.

Effectiveness of insecticide formulations against bollworms was judged on the basis of different parameters viz., square damage, green boll damage, boll damage, loculi damage, the percentage of bad seed cotton and yield of seed cotton. All the insecticide treatments were quite effective in minimising the damage caused by bollworms and thereby saving the loss in yield of seed cotton. Cypermethrin @ 60 g a.i./ha proved to be the most effective in checking the bollworm complex. The new formulation, methomyl 40 SP was very effective at higher dose, @ 450 g a.i./ha alone and in combination with HaNPV @ 250 LE/ha than the doses at 300 g a.i./ha and 150 g a.i./ha alone and in combination with HaNPV. The conventional insecticide, endosulfan 35 EC @ 350 g a.i./ha alone and at half the dose in combination with HaNPV was also equally effective in controlling the bollworm complex of cotton. However, NPV @ 250 and 500 LE/ha were moderately effective. Maximum yields (15.71 q/ha) were recorded in the crop sprayed with cypermethrin @ 60 g a.i./ha followed by methomyl 40 SP @ 450 g a.i./ha (11.58 q/ha). Nuclear polyhedrosis virus in combination with methomyl @ 450 g a.i./ha recorded (11.37 q/ha) as compared to that of untreated crop (7.40 q/ha).

Efficacy of insecticides against sucking pests viz., aphid, jassid, thrip and their predator lady bird beetle was also judged. Six leaves, two each from top, middle and bottom portion of the foliage were observed for recording the population count. In this manner, the count of each treatment plot was represented by a population of concerned sucking pests on six leaves/plant of five randomly selected plants. All the insecticides were effective in reducing the population of sucking pests, except in respect of aphid population from the crop treated with cypermethrin @ 60 g a.i./ha. Maximum reduction in the aphid population was noticed due to sprays of methomyl 40 SP @ 450 g a.i./ha, followed by methomyl @ 300 g a.i./ha both alone and in combination with HaNPV. As far as the efficacy of insecticides against jassids and thrips is concerned cypermethrin @ 60 g.i./ha and methomyl @ 450 g a.i./ha alone and in combination with HaNPV @ 250 LE/ha were most effective in reducing the population of jassids and thrips. Methomyl @ 300, 150 g a.i./ha and endosulfan @ 350 g a.i./ha and at half dose in combination with HaNPV were also effective in reducing the sucking pest population. In case of predator all the insecticides were toxic to lady bird beetle except the treatment with NPV @ 250 LE and 500 LE/ha. The untreated plots recorded the highest population of predator followed by NPV 250 LE/ha and NPV 500 LE/ha.

Methomyl 40 SP @ 900 g a.i./ha proved to be toxic to the cotton plant. Reddening of the foilage was observed from 3rd day onwards upto 14th day after spray. Burning of leaves or necrosis was not observed. However, reduction in the fruiting boll forms and yield was not observed.

5.2 Conclusions

(1) A schedule of four sprays at 60, 75, 90 and 105 DAS of methomyl (Lannate 40 SP) @ 450 g a.i./ha or in combination with HaNPV @ 250 LE/ha or cypermethrin 25 EC @ 60 g a.i./ha or endosulfan 35 EC @ 350 g a.i./ha or at half dose in combination with HaNPV @ 250 LE/ha was effective against bollworms of cotton and increasing the yield of seed cotton. The Baculovirus heliothis alone was not sufficient to suppress moderate to high bollworm populations, a viable alternative may be the application of virus in combination with low doses of chemical insecticides.

(2) Spraying of all the above treatments were found to be effective for the control of cotton jassids and thrips.

(3) However, cypermethrin 25 EC @ 60 g a.i./ha reported resurgence of aphid population. Methomyl 40 SP @ 450 or 300 g a.i./ha or in combination with HaNPV @ 250 LE/ha or endosulfan @ 350 g a.i./ha and at half dose with HaNPV reported effective control of aphid population.

(4) Spraying with HaNPV @ 250 and 500 LE/ha were less hazardous than that of methomyl 40 SP, cypermethrin

25 EC and endosulfan 35 EC to the population of lady bird bettles, but the predator did not control the aphids on virus sprayed plots.

(5) Methomyl 40 SP at higher dose @ 900 g a.i./ha reported phytotoxic symptoms on cotton plant.

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6. LITERATURE CITED

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* Original not seen.

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