EFFICACY OF INSECTICIDES ON PESTS OF MULBERRY AND THEIR INFLUENCE ON THE BIOLOGY AND SILK YIELDS OF MULBERRY SILKWORM *Bombyx mori* L. (LEPIDOPTERA : BOMBYCIDAE)

By

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B.Sc (Ag.)

THESIS SUBMITTED TO THE
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CERTIFICATE

Mr.M.RAMAIAH has satisfactorily prosecuted the course of research and that the thesis entitled **EFFICACY OF INSECTICIDES ON PESTS OF MULBERRY AND THEIR INFLUENCE ON THE BIOLOGY AND SILK YIELDS OF MULBERRY SILKWORM *Bombyx mori* L. (LEPIDOPTERA : BOMBYCIDAE)** 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 him for a degree of any University.

24/10/98

(Dr.P.RAJENDRA PRASAD)
Major Advisor

Date : 24-10-98

Place : Tirupati

CERTIFICATE

This is to certify that the thesis entitled **EFFICACY OF INSECTICIDES ON PESTS OF MULBERRY AND THEIR INFLUENCE ON THE BIOLOGY AND SILK YIELDS OF MULBERRY SILKWORM *Bombyx mori* L. (LEPIDOPTERA : BOMBYCIDAE)** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the Acharya N.G.Ranga Agricultural University, Hyderabad, is a record of the bonafied research work carried out by **Mr.M.RAMAIAH** 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 or has been published. The published part has been fully acknowledged. All the assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

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DECLARATION

I, **Mr.M.RAMAIAH** hereby declare that the thesis entitled **EFFICACY OF INSECTICIDES ON PESTS OF MULBERRY AND THEIR INFLUENCE ON THE BIOLOGY AND SILK YIELDS OF MULBERRY SILKWORM *Bombyx mori* L. (LIPIDOPTERA : BOMBYCIDAE)** submitted to Acharya N.G.Ranga Agricultural University for the degree of **'MASTER OF SCIENCE IN AGRICULTURE'** is the result of the original work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

M. Ramaiah

Date : 24/10/98

(M.RAMAIAH)

Place : Tirupati

LIST OF ABBREVIATIONS

^{o}c	:	Degree celsius
DAS	:	Days after spraying
mm	:	millimeter
m^2	:	square meter
%	:	per cent
RBD	:	Randomized Block Design

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ABSTRACT

The present studies were undertaken at Tirupati, during 1996-97 to study the faunal composition and seasonal incidence of mulberry pests, in addition to evaluation of few insecticides for their efficacy against mulberry pests and toxicity against silkworm larvae. The experimental material comprised of M-5 cultivar of mulberry, raised in a garden of 25 cents.

The results revealed infestation of mulberry by nine insect pests, belonging to seven orders and 12 families. Among these, peak infestation of mites, thrips, aphids and bugs was observed during summer months, while the peak population of leaf hoppers, caterpillars and grasshoppers was observed during the month of January, when the minimum temperatures were quite low. However, maximum population of mealy bugs was observed during rainy season.

Studies on relative efficacy of the insecticides against mulberry pests was undertaken in a randomized block design with three replications and seven

treatments, including control. Results revealed the effectiveness of Phosalone (0.05%) and Dimethioate (0.1%) against the sucking pests; and DDVP (0.05%) and Endosulfan (0.05%) against the defoliators. Nemazole (1%) was also observed effective in the management of both sucking and defoliator pest population levels.

Studies on insecticidal toxicity to silkworm larvae revealed relatively shorter waiting periods for DDVP (0.05%) and Nemazole (1%) and long periods for carbaryl (0.1%) and Phosalone (0.05%). Insecticidal treatment of mulberry leaves was also noticed to result in increased larval and pupal durations. Phosalone (0.05%) inspite of its high effectiveness against the insect pests is not recommended for use on mulberry due to high residual toxicity and unfavourable effects on the larval, pupal, cocoon and shell weights, in addition to silk shell ratio and length of reeled silk. Carbaryl (0.1%) had also, in general recorded similar effects, while DDVP (0.05%), Dimethioate (0.1%) and Endosulfan (0.05%) had mostly recorded effects on par with control. In contrast, Nemazole (1%) recorded shorter waiting period, satisfactory control of different mulberry pests and favourable effects on the economic characters of silkworm viz., cocoon weight, shell weight, and length and weight of reeled silk. It is therefore recommended for extensive use in sericulture.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Silk has played an important role in the economic life of man ever since its discovery more than 4000 years ago. India ranks third in the silk production world wide and accounts for more than 12 per cent of the world's production. In India, Karnataka ranks first, in terms of silk production, while the state of Andhra Pradesh, occupies the second position. Silk production in the state is around 2361 tonnes with a reeling cocoon production of 21,722 tonnes. The total area under mulberry cultivation, the only natural food of silkworm (*Bombyx mori* L.), in the state, is around 35,546 ha. (Survey of Indian Agriculture, 1997), concentrated in the districts of Anantapur, Chittoor, Cuddapah and Kurnool, owing to the existence of favourable soil and climatic conditions.

The cocoon yields and quality of the state are however low, compared to the neighboring states of Karnataka and Tamil Nadu. Pest infestations of the mulberry plant constitute an important factor in influencing the production levels and quality of silk. Silkworm larvae fed on pest infested leaves were reported to yield cocoons much inferior in quantity and quality, compared to those reared on healthy leaves (Kariappa and Narsimhanna, 1978).

Around 200 insect pests are known to attack the mulberry crop (Suhas and Devaiah, 1985). Further, the chances of buildup of pest populations are high in the crop, since it remains in the field for longer periods, compared to other field crops. At times, the foliage-feeding herbivores invade and inflict injury to the mulberry crop resulting in a resource constraint.

The emerging concept of pest management in the recent years embodies the idea that knowledge of pest ecology is essential for appropriate control strategies. Hence, a knowledge of the faunal composition and seasonal incidence of the insect pests of mulberry at different stages of crop growth, in addition to their relation to the weather parameters would be of great help in the adoption of appropriate control methods.

Despite considerable social concern on the use of pesticides, most of the proponents of integrated pest management endorse the view that the wise and timely use of appropriate pesticides is an essential component of pest management technology. In sericulture, where a number of pests occur, insecticides are an effective answer. The application of pesticides for effective control of mulberry pests between silkworm crops, was suggested by Rangaswami *et al.* (1976). However, the spraying of highly effective and persistent insecticides, like sulphur (0.4%), against defoliators was reported to be toxic to the silkworm larvae, even after several days of application (Alvis *et al.*, 1965), while relatively safer and less persistent insecticides were ineffective in the control of insect pests for longer periods. The growers also seldom resort to chemical means of insect control, since the mulberry leaf is fed directly to the silkworms, and as the worms are highly fragile. As such the mulberry system warrants, adoption of relatively safer insecticides.

The use of botanical insecticides with minimum toxicity to the non-target organisms, is presently being focussed as an effective alternate solution to the synthetic pesticides. The insecticides of neem origin, in particular, have generated world wide interest and have been demonstrated to possess high potential in the management of different insect species (Singh *et al.*, 1993). Hence, there is a need to screen the traditional insecticides along with the unconventional insecticides for selection of suitable, effective and safer compounds for control of insect pests in mulberry. In this direction, the present study was undertaken with the following objectives :

1. To record the different insect pests in mulberry.
2. To study the relative efficacy of different insecticides on the control of mulberry pests.
3. To find out the influence of insecticides on the life cycle of silkworm.
4. To study the effect of insecticides on the cocoon and silk yields.

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REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

The relevant literature pertaining to "Efficacy of insecticides on the pests of mulberry and their influence on the biology and silk yields of mulberry silk worm (*Bombyx mori* L.)" is presented hereunder :

2.1 FAUNAL COMPOSITION

A large number of insects infest mulberry plants. Over 325 different species of insects have been reported to feed and breed on mulberry from different mulberry growing countries of t he world (Nangia *et al.*,1990). Aruga (1994) also reported over 210 insect species belonging to 50 families and 10 orders, to cause damage to mulberry. The degree of damage caused by these insects, however, varied depending on the type of the insect.

Several workers have reviewed the insect fauna of mulberry. Maiki (1916) listed 87 insect and six non-insect species injurious to mulberry crop in taiwan, while Umeya and Omi (1935) reported 118 insect pests of mulberry in Korea. Chu (1936) mentioned 126 insect species that infest mulberry in china along with their distribution, plant parts attacked and the degree of injury, while Kikuchi (1976) reported 200 insect species infesting mulberry in Japan. Further, Xu and Qu (1990) reported 38 species of insect pests on mulberry in china.

In India, the number of insect pests recorded on mulberry varies from 9 to 62. Sidhu (1966) reported 13 insect species on mulberry, while Rangaswamy *et al* . (1976) listed 30 insect species infesting mulberry. Puttarudrian (1977) mentioned 23 insect and two non-insect species on mulberry, while Kotikal (1982) reported 62 insect and four non-insect pests on mulberry. Sharma and Tara (1985) also reported nine insect species on mulberry from Jammu and Kashmir. Singh *et al.* (1992) also reported nine insect species infesting mulberry in Assam. Among these, the giant African Snail, thrips and Bihar hairy caterpillar were found to be the major pests, while the three species of weevils identified on mulberry were observed to be minor pests, causing sporadic damage. The defoliators, namely, Bihar hairy caterpillar, tobacco caterpillar and tussock caterpillars, were reported to be seasonal pests, while thrips were noticed to be noxious pests.

2.2 SEASONAL INCIDENCE

A knowledge of seasonal incidence of the different mulberry pests at different growth stages of the crop and their relation to the weather parameters would be of great help in planning and adoption of appropriate control strategies. In this direction, the relevant literature on the seasonal incidence of different sucking pests and defoliators noticed in the present investigation is presented hereunder:

2.2.1 Sucking pests

A large number of sucking pests attack mulberry. Among these, mites, thrips, hoppers, mealy bugs, aphids and bugs were noticed to be important, affecting the leaf quality and thereby the silk yield and quality.

2.2.1.1 *Mites*

Among the sucking pests attacking the mulberry, mites constitute an important group. 15 species of mites belonging to the families, Tetranychidae and Eriophyidae have been reported to be the key pests of mulberry (Narayanaswamy *et al.*, 1996). Among these, *Tetranychus ludeni*, *Tetranychus equatorius* and *Aceria mori* were noticed to cause considerable damage (5-10 %) to mulberry in India, while *Tetranychus kanzawai* was found to be a major pest in China and Japan.

Both the adult and nymphal stages desap the plant causing speckling symptoms, and when severe, crinkling and distortion of the leaves is noticed. Eight species of mites have been listed on mulberry (Sadana, 1985). Among these, the red spider mites, *Tetranychus telarius* (Linn) and *Tetranychus equatorius* (Mc Gr) belonging to the family Tetranychidae are known to cause considerable damage to the crop (Knot and Patel, 1956; Sidhu *et al.*, 1969 and Krishnaswami and Pillai, 1980). Among the two, heavy leaf damage was reported from the attack of *Tetranychus equatorius* (Mc Gr), the populations of which were greatest during the months of March and April, and decreased gradually until they reached a minimum in December. Rangaswami *et al.* (1976) reported completion of one generation of *Tetranychus equatorius* (Mc Gr) and *Tetranychus telarius* L. usually within 18 to 40 days though several overlapping generations were common. Heavy infestations were usually noticed during dry and hot seasons.

Pillai *et al.* (1980) recorded the occurrence of *Tetranychus equatorius* during January and February months. The mite population was low during these months and increased during March, April and May, with the peak during the month of April. Further, from June to August, the pest population showed a considerable reduction. However, there was a slight increase during September, but it reduced subsequently and remained at low levels in October, November and December.

Kotikal (1982) observed heavy infestation of *Tetranychus neocaledonicus* Andre during December. However, it was low in May and absent during February, March and

April months. *Tetranychus bimaculatus* Harv. was reported to be one of the most serious and injurious pests to mulberry in tropical regions of South-east Asia. These mites attack tapioca and many other vegetables and are serious during the dry season (Anonymous, 1975). Sinchaisri and Isarangkul (1973), however, reported a tremendous increase in the population of *Tetranychus truncatus* Ehara attacking mulberry at the end of the season. *Tetranychus cinnabarinus* was also reported to be an important pest of mulberry in Zhajiang, China. Maximum damage was noticed in the months of August when the temperature was most favorable for its development. Outbreaks of the pest were closely related to rainfall. Large populations were noticed in the years when the monthly rainfall was less than 50 mm, indicating the important role of dry weather for its multiplication.

2.2.1.2 *Thrips*

Thrips also constitute an important group among the sucking pest complex infesting mulberry crop. Both adults and nymphs suck sap resulting in streaks near the midrib and veins. Further, their feeding hardens the young leaves (Sinchaisri and Israngakul, 1973) and such leaves become unsuitable for feeding to silkworms.

Thrips occur round the year in the mulberry field and often multiply into a high density, as several overlapping generations are passed by this pest in one year. Five species of thrips namely, *Pseudodendrothrips mori* Nawa, *Taeniothrips claratris* Shumsher, *Taeniothrips glycines* Okamato, *Haplothrips coloratus* (Trybom) and *Taeniothrips melanicornis* Shumsher have been reported to occur on mulberry in India (Rangaswami *et al.*, 1976). However, Kotikal (1982) reported six species of thrips on mulberry, namely, *Anapothrips sudanensis* (Trybom), *Caliothrips indicus* Bagnall, *Dendrothrips mori* Linnaeus, *Haplothrips sp.*, *Scirtothrips dorsalis* Hood and *Thrips flavus* Schrank. Two species of thrips, namely, *Pseudodendrothrips mori* Nawa and *Bathrips melanicornis* Shumsher were noticed on mulberry in Assam (Singh *et al.*, 1992). These pests were reported to occur throughout the year with the peak infestations during January to May. High incidence of damage by *Pseudodendrothrips mori* Nawa was also reported during summer months (Sharma, 1989). Further, *Ballothrips mori* Niwa, *Pseudodendrothrips mori* Nawa and *Pseudodendrothrips orantissimus* Shmutz, have been reported serious on young bush mulberry (Anonymous, 1975). Thrips infestation is very sever in rainfed gardens as compared to irrigated gardens (Rangaswami *et al.*, 1976; Ullal and Narasimhanna, 1981). The attack is negligible where whole shoot harvest is practiced and more frequent during the summer (February to June) (Rangaswami *et al.*, 1976). Kariappa and Narasimhanna (1978) also noticed the occurrence of same species on mulberry in Karnataka state.

Observations on vertical distribution of thrips on mulberry plants showed that majority of them were confined to tender portions. The thrips nymphs confine themselves to top tender leaves. The population of thrips per leaf was maximum (24.2) during I week of April and minimum (1.33) during August and there was a significant positive correlation with temperature and negative correlation with rainfall and non correlation with relative humidity. Further, Kotikal (1982) observed persistence of thrips through out to the year, except during II week of August to Ist week of September. The population of *Pseudodendrothrips mori* (Nawa) at Mysore reached a maximum under high temperature from March-April, July-August and November-December and rainfall reduced their population (Pillai and Krishnaswami, 1980). An economic threshold of 18-20 thrips per leaf was suggested for the pest during Summer (Cappellozza and Miotto, 1987).

Sahakundu (1994) studied the effect of weather factors on the population buildup and variation of mulberry thrips in West Bengal. The thrips, namely, *Pseudodendrothrips orantissima*, *Bathrips melonicornis*, *Haplothrips tenuipennis* and *Megalaurothrips distalis* were studied for a period of three years. Highest population of the thrips per leaf was reported in the Summer months of April and May.

2.2.1.3 *Hoppers*

Among the sucking pests attacking mulberry, leaf hoppers constitute an important group. Both the adult and nymphal stages of the hoppers desap the plant causing speckling symptom and under severe levels of infestation, cause crinkling and distortion of leafs. Among the leaf hoppers, *Empoasca flavescens* (Fabricus) is the important species attacking mulberry, causing "Hopper burn" to the tune of 40 per cent (Kariappa and Narasimhanna, 1978). Rangaswami *et al.* (1976) and Ullal and Narasimhanna (1981) reported severe occurrence of *Empoasca flavescens* from October to May. Sharma (1989) also reported similar observations. Kotikal (1982) reported the species to be active on mulberry during October-November. In addition, *Kolla sp.* and *Nisia nervosa* (Motschulsky) were prevalent during November. Further, the studies of Reddy *et al.* (1989) revealed the hoppers, *Neodartus acocephaloides* Melichar and *Batracomorphus angustatus* (Osborn) to be predominant in number, among the various Cicadellids observed on mulberry at Bangalore. These species were found feeding on mulberry from July to January.

2.2.1.4 *Mealy bugs*

The mealy bug, *Maconellicoccus hirsutus* (Green) has become quite a serious pest on mulberry in the recent years (Ali, 1995). The affected apical shoot shows retarded growth and flattening popularly known as "Tukra" causing reduction in yield and quality of leaf as the insect sucks the sap from the plant (Rangaswami *et al.*, 1976). A decrease to the tune of 25-30 per cent has been noticed under severe levels of infestation. Ali and Ahmed (1990)reported 3 to 11 and 15 to 30 per cent of the new and established plantations to be infested by the pest in Banghladesh. The infested leaves are depleted of nutrients and hence, are less suitable for feeding.

Mealy bug is found on mulberry throughout the year. The population of the pest starts building up from March and the incidence is more during April and May with its peak during July and August, causing maximum damage to the mulberry. This may be due to the optimum temperatures of 25°c to 28°c in these months in addition to cloudy weather conditions which are most favorable for the growth and multiplication of the insects. The incidence again comes down from September to February (Winter period). Shriharan *et al.* (1979) noticed the egg laying by Maconellicoccus hirsutus to be poorer in the colder months, namely, November, December and January and high during February, July and August. Correspondingly, the hatching percentage was low during cooler months. Rao *et al.* (1993) also reported greater levels of infestation during Summer and monsoon period, when the temperature was above 30°c and the relative humidity was above 70 per cent.

Mealy bug infestation is found at all stages of mulberry growth. The insect is found surviving on pruned plants in the crevices of the bark and on certain weeds found around the mulberry garden. As soon as sprouting of the auxiliary buds of mulberry occurs, they crawl up, and start sucking sap from the sprouting buds. As a result, these buds are malformed and do not grow into shoots. However, when the infestation occurs at an early stage of growth about one month after pruning, tip of the shoot is malformed and lower leaves on the shoot turn coarse, making them less suitable for use as feed for silkworms.

The leaf yield also decreases drastically, as growth is arrested. Further, the infested mulberry plants are mostly stunted in growth with their young leaves curled and deformed (Sinchaisri and Isarangkul, 1973; Ullal and Narsimhanna, 1981; Sharma, 1989).

The pest has been reported to prefer young shoots, leaves, buds and tips of the shoots (Sinchaisri and Isarangkul, 1973), in addition to succulent branches. Mulberry is prone to maximum attack when the growth of the shoots is prolonged. Though there is a little reduction in leaf yield when grown up shoots are attacked, quality of the leaf suffers.

2.2.1.5 ***Aphids***

Aphids also constitute an important group of the sucking pests, infesting mulberry. Three different species, namely, *Tuberculatus indicus*, *Cervaphis quercus*, *Eutrichosiphum pasaniae* and *Lachnus tropicalis* have been reported on Oak (*Quercus sp.*) by several workers (Rao and Prasad, 1993; Bidyapati *et al.*, 1994). They cause leaf curling, yellowing and also act as carriers of different pathogenic organisms.

Cervaphis quercus Takahashi infests the underside of young leafs, leaf stocks, shoot apices and feeds along the midrib near the petiole the aphids are yellow colored and have branched projection at the posterior end of the abdomen, each branch of which bears an apical seta, except for the terminal process and is 1.6-2.08 mm long. The leaves become yellowish and distort due to feeding. The aphid is found through out the year (Bidyapati *et al* 1994).

Tuberculatus indicus is pale green to yellow aphid. It attacks old leaves and turns the adaxial surface to rusty brown with black powdery patches. Heavy populations of the aphid occur during November-January (Bidyapati *et al.*, 1994).

Lachnus tropicalis (Vander Goot) attacks the buds and young shoots during February to March. The aphid is black in color and 3.18 mm long. Infestation of the aphids effects the delayed sprouting (Bidyapati *et al.*, 1994).

2.2.1.6 *Bugs*

The pentatomid bug, *Platia stali* Scott was reported to infest mulberry, though it is mostly a pest of fruits in Japan (Fukuda and Fujiie, 1988). The minimum threshold temperature for its development was reported to be 12.7°c, while the effective accumulated temperature for its emergence from egg to adult stage was 430 day degree celsius. The critical photoperiod for development of the ovaries was between 14 : 10 and 13.5 : 10.5. Further, adults were mostly seen after mid september in the field. The pest was also reported on other host plants, namely, Cherries and Japanese Cypress.

2.2.2 Defoliators

Mulberry is subjected to severe attack by several defoliators. Among these the caterpillars of lepidoptera are the major pests during the crop growth period followed by grass hoppers and weevils.

2.2.2.1 *Caterpillars*

Six important lepidopterous pests, namely, the black headed hairy caterpillar, *Spilosoma obliqua* walker (Family:Arctidae), tussock caterpillars (Family:Lymantridae), the tobacco caterpillar, *Spodoptera litura* Fabricius (Family : Noctuidae), the Geometrid *Hyposidra talaca* Walker (Family: Geomatridae) and the leaf eating syntomid, *Amata* *passalis* Fabricius (Family : Syntomidae) have been reported as defoliators of mulberry (Kotikal, 1982).

***Euproctis fraterna* Moore**

Many workers have reported the occurrence of the tussock caterpillar, *Euproctis fraterna* Moore on a variety of field crops and tree hosts and from different localities within and outside the country (Beeson, 1941 and Rangaswami *et al.*, 1976).

Srivastava (1964) mentioned the tussock caterpillar to cause enormous losses to castor. Pillai (1968) reported it as a new pest of mulberry crop. It was reported common on many of the food crops, including mulberry, grown in the tropical countries (Rangaswami *et al.*, 1976).

The incidence of caterpillars of *Euproctis fraterna* was observed from March to May and June till August at Mysore (Pillai, 1968), July to August at Bangalore (Vishwanath and Gowda, 1976), March to August (Rangaswami *et al.*, 1976), October to February at Dharwad (Govindan *et al.*, 1980 and Kotikal, 1982) and July to September at Assam (Singh *et al.*, 1993).

Srivastava (1964) reported caterpillars of *E. fraterna* to be a polyphagous pest. Various host records include castor and fodder crops (Pruthi, 1969), banana leaves (Vishwanath and Gowda, 1976), Acacia (Puttarudriah, 1977) and mulberry (Pillai, 1968; Rangaswami *et al.*, 1976; Puttarudriah, 1977 and Kotikal, 1982).

Black headed hairy caterpillar

The black headed hairy caterpillar, *Spilosòma obliqua* Walker is a major defoliator, the incidence of which on mulberry has been reported by several workers (Djou, 1938; Rangaswami *et al.*, 1976; Puttarudriah, 1977; Basavaraja, 1976 and Kotikal, 1982). It has been reported to be a polyphagous pest by many workers within and outside the country, including mulberry in Taiwan (Maki, 1916), China (Djou, 1938) and India (Rangaswami *et al.*, 1976 and Puttarudrain, 1977). Lefroy (1907) noticed this species to undergo hibernation in pupal stage from November to February. The species occurred in cold weather from October to January on castor and ragi in Mysore (Kunhikannan, 1919). Iyer (1921) noted its appearance on castor, lab-lab and horsegram during cold season from October to December. Generally, it occurred during August to December on ragi at Bangalore/Mysore and Hassan (Anonymous, 1945).

Chakravarthi (1945) observed maximum population during August and December. Trehan and Bagal (1958) recorded its activity throughout the year on one or the other crop in Maharashtra state. The insect was abundant during August and October on medicinal plants in Jammu (Mathur, 1962). Rangaswami *et al.* (1976), Puttarudriah (1977), Ullal and Narasimhanna (1981) noticed its frequent incidence from November to January. Sethi *et al.* (1979) observed a sharp increase in the population of *Spilosoma obliqua* in March at Delhi and further peak by third week of March. Kotikal (1982) noticed its incidence during last week of August to the second week of October on mulberry. However, Singh *et al.* (1993) reported the pest on mulberry in Assam from April to November, with its peak from May to August.

Tobacco Caterpillar

The tobacco caterpillar, *Spodoptera litura* (Fabricius) has been reported as a pest of mulbberry (Jones, 1913; Endrozo, 1918 and Puttarudraiah, 1977). The caterpillars are nocturnal in habit and are reported to act as defoliators (Puttarudraiah, 1977). Kotikal (1982) noticed the larvae from first week of September to last week of October. Sharma and Tara (1985) mentioned it as a serious insect, widely distributed and very common between May to September, while Singh *et al.* (1993) reported the frequent occurrence of the pest on mulberry in Assam between November to February.

Glyphodes pyloalis

It is also one of the important defoliators causing serious damage to the mulberry plants during August to October in north India. The first and second instar larvae eat away the parenchymatous tissues of leaves, while the later instar larvae devour entire leaf, except midrib and stouter side veins (Beenson, 1941).

2.2.2.2 *Grass Hoppers*

The wingless grasshopper, *Neo-orthacris acuticeps nilgriensis* Uvarov is a sporadic pest, but because of its polyphagous nature, it has been reported as a serious pest of mulberry in rainfed areas of Karnataka (Sharma, 1989). Kariappa and Narasimhanna (1981) also noticed the wingless grasshopper nymphs, *Neo-orthacris acuticeps nilgiriensis* Uvarov to emerge from soil during late May, till late July, depending upon the first (Summer) rain. They also stated that the eggs under went aestivation in summer months and completed two generations in the field.

Rao (1921) reported damage by the long-horned grasshopper, *Tettigonia albifrons* Fabricius on mulberry in Mesopotamia, Iraq; *Holochlora brevifissa* Brunner damaging mulberry in Japan (Tomizawa, 1925) and India (Butani, 1978).

Sidhu *et al.* (1966) reported the occurrence of *Cyrtacanthacris ranacea* Stoll popularly termed as Madras locust throughout the year on mulberry, specially from March to August and October to January. Puttarudriah (1977) stated the same locust grasshopper to attack mulberry crop.

Kotikal (1982) recorded two long horned and four short horned species of grasshoppers. Of the former, *Letana inflata* Brunner and *Phenetoptera gracilis* Burmeister damaged mulberry from May till the end of September, while among the latter, *Aiolopus simulatrix sumulatrix* (Walker) was prevalent during January. The cotton grasshopper, *Cyrtacanthacris ranacea* Stoll damaged mulberry crop during second fortnight of September, while the tobacco grasshopper, *Attractomorpha crenulata* Fabricius was active during April and May. The Deccan wingless grasshopper, *Colemanis sphenerioida* Bolivar was noticed during September and October, from Dharwad.

2.2.2.3 *Weevils*

In a survey on the species of weevils on mulberry trees in Sichuan, China, eight species were reported, including, *Phytoscaphus sp.*, *Episomus Kwanhsiensis*, *Lepropus flaviottatus* and *Baris deplanta* (Zhou and Zhou, 1994). In India, Singh *et al.* (1993) reported three species of weevils, namely, *Myllocerus undecimpustulatus maculosus* Desb., *Myllocerus discolor* D. and *Myllocerus viridanesus* Boh, on mulberry in Assam during February to October. The peak density of population was noticed during post spring

(March-May). The weevils generally feed on medium leaves and tender buds. Irregular and sporadic serration of leaf margins are generally observed when the population density of the weevils is at its peak in the mulberry field. Further, Siddappaji (1976) noticed 14 species of *Myllocerus* weevils under different agroclimatic conditions in Karnataka. Adults of both *Myllocerus discolor* var. *variegata* Boheman and *Myllocerus subfasciatus* Guer. were found to be present throughout the year, while *Myllocerus discolor* bred on field crops (cereals) migrated to perennial shrubs and on to trees during the colder and summer months, respectively, from October to April and thereafter adults were observed to undergo diapause. *M. undecimpustulatus* Faust., *Myllocerus sp*. and *Apion ampulum* Fabricius were reported from October till December (Kotikal, 1982). Five species of *Myllocerus* weevils on mulberry were recorded by Rangaswami *et al.* (1976), of which, *Myllocerus viridanus* (Fabricius) was observed to be in abundance. Many other species have also been also reported on mulberry namely, *Myllocerus postfasciatus* M., *M. discolor* D., *M. subfaciatus* G and *M. viridanus* F. (Rangaswami *et al.*, 1976).

2.3 CHEMICAL CONTROL OF MULBERRY PESTS

In sericulture, where a number of pests occur, the use of insecticides is a necessity. However, in spite of being quite effective on the target organisms, the chemicals used, must be quite safe to the silkworms, as the leaves are directly fed to silkworms. Botanical pesticides, in particular, insecticides of neem origin are hence being considered as a suitable option. The relevant literature on the chemical control of mulberry pests, including botanical pesticides, is presented hereunder :

2.3.1 Sucking pests

Mites

The control of plant infesting mites requires repeated application of a higher dosage of pesticides (Nelson and Shaw, 1975; Wyatt and Maitleu, 1976; Navvaband and Zare, 1978; Reed and Moremo 1978; Wymann *et al.*, 1979; Dhoonia and Mann, 1980; Marsden and Allen, 1980; Remesh Gera, 1980; and Prasad and Singh, 1981). However, a repeated application of pesticides on mulberry leaf was reported to leaf to deleterious effects on the feeding quality, in addition to long range residual effects, thus rendering the leaf unfit for silkworm feeding and hence, is undesirable. Hence, several pesticides were evaluated for their effectiveness against the pests in addition to their non-toxicity against silkworms.

Dicofol has been widely used for the control of a wide variety of mite pests on agricultural and ornamental plants (Kirby and Tew, 1952; March, 1958; Herne and Chant, 1965; Gupta *et al* 1972; Jagadish, 1979). Bindra and Varma (1966) also reported the efficacy of dicofol (0.025%) for the control of *Tetranychus telarius* L. on cotton. Similarly, Krishnaiah and Tandon (1975) also reported the effectiveness of dicofol among other pesticides for the control of *Tetranychus cucurbitae* (Rahman and Sapra) on Okra. Further, Jagadish and Channabasavanna (1986) reported that dicofol from 0.03-0.002% and sulphur from 0.13 to 0.09% were toxic to *Tetranychus ludeni* on Beans. Bindra and Verma (1968) also reported 0.2 per cent of sulphur to be effective in the control of in the control of *Eutetranychus hirsuti* Pritchard and Baker. Similarly, Singh *et al.* (1975) reported 0.05 per cent sulphur to be effective against the pest. An effective control of oriental red mites, *Eutetranychus orientalis* (Klein), was reported with dicofol applied at the rate of 0.05 per cent (Singh *et al.*, 1977).

Pillai and Jolly (1986) evaluated five pesticides, namely, endosulfan, phosalone, dicofol, quinolpllos and anthio at two concentrations (0.05 and 0.1%). They reported a higher efficiency of phosalone against the mites, followed by endosulfan.

Studies by Nangia *et al.* (1990) on the effectiveness of seven pesticides, namely, dicofol, sulphur, tedion, anthio, metasystox, nuvon and phosalone for the control of *Tetranychus ludeni* and *Eutetranychus suginamensis* revealed the effectiveness of dicofol and tedion at 0.025% and sulpher at 0.13 per cent. Hence, these insecticides were concluded to be more effective for the control of spider mites in mulberry.

Thrips

Cappellozza and Miotto (1987) reported the control of thrips with summer sprays of dimethioate and the hibernating adults with a combination of mineral oil and parathion based products in the winter. Further, Sharma (1989) reported a spray of 0.02% Nuvon to be very effective against the mulberry thrips.

The efficacy of seven insecticides against *Caliothrips indicus* was studied by Singh and Singh (1991). They concluded that the spraying of Sumicidin(fenvalenate 0.01%) or triazophos (0.04%) or Ripcord(Cypermethrin 0.005%), between the second week of September and the first weeks of October was effective in the control of the pests. Further, Singh *et al* (1992) reported the control of mulberry thrips by spraying of Rogor(Dimethioate 0.1%) concentration.

Leaf Hoppers

Yiem *et al* (1988) reported the application of sumithian (Fenitrothion), Elsam (Phenthoate), Dursban (Chlorpyrifos) and Ripcard (Cypermethrin), 8 to 10 times at an interval of 10-15 days, from early June onwards, to be effective in the control of the leaf hopper, *Hishimonus sellatus*. Further, Sharma (1989) reported a spray of 0.1% Rogor and 0.02% Nuvon to be highly effective against the jassids. The effectiveness of neem based compounds in the control of jassids was reported by Rao *et al.* (1991). Similar results were reported in sunflower (Anonymous, 1989).

Melay bugs

This is a hard to kill pest and at present there is no efficient control measure for eliminating the melay bug population. However, Sharma (1989) reported spraying of 0.01 per cent of parathion to be effective in the control of mealy bugs, while Beevi *et al.* (1992) reported minimum hatching in eggs treated with neem oil, followed by those treated with monocrotophos, demeto-methyl, fish oil and resin soap in combination of dichlorovos. Further, 0.2% solution of DDVP with 0.5% soap solution has been recommended for spray on pruned and harvested plants, in two doses, at 10 days interval, to check the incidence during sprouting of the auxiliary buds. However, it has been reported to be difficult to control this pest with contact insecticides, when the incidence is found at later stages, because, nymphs present inside the growing apical buds and in leaf folds, escape contact with insecticides and go on multiplying. Systemic insecticides, though fairly effective, were reported to affect the silkworms adversely (Ali, 1995).

Aphids

Rao and Prasad (1993) reported encouraging results with nuvon (0.05%) in the control of aphids on oak, while Bidyapati *et al.* (1994) recommended the spraying of

0.03% Demecron, a systemic insecticide, for the control of aphids on oak (*Quercus serrata*).

2.3.2 Defoliators

Caterpillars

The plantations of *Morus alba* have been reported to be defoliated by at least 12 species of lepidoptera. *Glyphodes pyloalis* is one of the important defoiator, causing serious damage to the plants (Gupta and Veer, 1986). Application of insecticides have often been recommended for control of this insect pest. 19 conventional contact insecticides were tested against the third instar larvae of *Glyphodes pyloalis* in the laboratory, by Gupta Veer (1986). The descending order of toxicity of the insecticides was Chlordimeform > Formothion > Quinalphos> Monocrotophos > Toxaphene > Carbaryl >Fenitrothion> Malathion (Premium grade) > Methyl parathion > Endosulfan > DDT > Dimethioate > Pyrethrum > Chlordane > gamma BHC. Monocrotophos, formothion and chlordimeform were 27-32 times more toxic than DDT. The study also revealed a variation in the degree of toxicity of the chemicals with a variation in the defoliator species, thus requiring application of different doses of different contact insecticides, for different species of defoliators of *Morus alba.*

The black headed hairy caterpillar, *Spilosoma obliqua*, another major defoliator of mulberry was reported to be effectively controlled with the sprays of endosulfan 0.1%., Dichlorovos 0.1%, monocrotophos 0.1%, carbaryl 0.1%, permethrin 50 ppm and cypermethrin 25 ppm. The insecticides were found to be effective against all instars of the pest (Kotikal Devaiah, 1988). Further, Sharma (1989) reported a spray of 0.02% Nuvon to be very effective against the bihar hairy caterpillar.

The efficacy of neem compounds in the control of lepidopterous larvae was reported by several workers. Joshi *et al.* (1984) reported that spraying of tobacco crop with the neem seed kernel suspension, at 0.5 to 1.0 per cent concentrations offered protection against Spodoptera litura for seven days, with no adverse effect on the yield and quality of tobacco leaves. Similarly, Siddapaji *et al.* (1986) reported application of neem seed kernel extracts (5%) to result in least pod damage by *Heliothes armigera*, on par with the chemicals, Phenthoate (0.05%) and Chloropyriphos (0.05%). Further, Badaya and Das (1987) reported application of neem seed kernel extract at 5 per cent to be most effective and economical against *Heliothes armigera* on gram. Similarly, Joshi *et al.* (1990) and Obulapathi (1994) reported the effectiveness of neem based chemicals in control of the tobacco caterpillar, *Spodoptera litura.* Arya *et al.* (1995) also reported the effectiveness of Neemguard (1%) in reduction of the population levels of *Heliothes armigera* on sunflower.

Grass hoppers

The wingless grass hopper, *Neorthacris acuteceps nilgirensis*, a serious pest on mulberry was fist reported to be controlled by poison baiting (Ballard, 1921). Kariappa and Narasimhamma (1981) tested BHC 50% wp and DDVP 100 EC for their comparative toxicity on the adult hoppers and found both BHC 50% wp at 0.25% concentration and DDVP at 0.1% concentration to be equally effective in the control of the pest.

Weevils

Zhen *et al.* (1990) reported an effective control of the curculionid pest of mulberry, *Baris deplanta* with a combined spraying of Fenitrothion and methamidophos, while Bidyapati *et al.* (1994) recomonded a spraying of 0.03% Demecron or 0.05% Nuvon for control of the curculionid shoot borer, *Auletobius demostus*.

2.4 EFFECT OF INSECTICIDE SPAYED MULBERRY LEAVES ON BIOLOGY AND LIFE-CYCLE OF SILK WORM

A large number of insect species cause damage to the mulberry plantations. Among these, leaf eating caterpillars, jassids, thrips, mealy bugs and scales are known to cause severe damage (Ullal and Narasimhanna, 1978). An outbreak of leaf eating caterpillars (*Diacrisa obliqua*) in the Dharwad area, resulted in the spraying of Ekalux EC 25 against these caterpillars by a few sericulturists of the area. It was discovered later that the silkworms grown on the sprayed mulberry leaves, showed reduced growth, mortality and a reduction in the cocoon weight (Bhosale *et al.*, 1988).

Residual toxicity of insecticides on non-target organisms including beneficial insects is well known. In recent years, however, it has been suggested that insecticides also disrupt the normal functioning of other tissues including fat body (Granett and Leeling, 1972; Orr and Downer, 1982; Yadwad, 1986), which plays an important role in the growth, development and reproduction of *Bombyx mori* (Tazima, 1978). The relevant literature pertaining to residual toxicity of the insecticides applied on mulberry, their safe periods and effect of feeding silkworms with the sprayed leaves on its biology and life-cycle is presented hereunder.

Alves *et al.* (1965) reported that endrin 0.05 per cent and sulphur 0.4 per cent when used on mulberry were toxic to silkworms for 60 and 30 days respectively, after application. However, leaves from mulberry plants sprayed with Dichlorovos at 0.016 per cent concentration were found safe for feeding silkworms after 20 hours (Kuwana *et al.*, 1980). Kariappa and Narsimhanna (1978) also reported the efficacy of DDVP and Rogor against mulberry thrips and recommended a safe period of 1 and 5 days, respectively, before feeding of the treated leaves to the silkworms. Similar results on the safe period of dimethioate were observed by Ullal and Narasimhanna (1978). The economic characters such as cocoon weight and shell weight were also reported to be superior in silkworms reared on the treated leaves, compared to those reared on thrips infested leaves and inferior to those reared on normal healthy leaves (Kariappa and Narsimhanna, 1978).

Radha *et al.* (1978) also recommended a waiting period of 12 days before feeding of leaves treated with monocrotophos 0.025 per cent and dimethoate 0.1 per cent, applied for the control of thrips and scales of mulberry, to silkworms. Similarly, Rai and Nageshchandra (1978) reported a waiting period of 5 days to feed the silkworm larvae with Malathion 0.2 per cent sprayed mulberry leaves. Kuawana *et al.* (1980) also reported that, leaves from mulberry plants sprayed with Dichlorvos @ 0.016 per cent were safe for feeding silkworms 20 hours after spraying. Further, Sugiyama and Emori (1980) reported a slight reduction in the cocoon weight of the silkworm larvae reared on mulberry leaves treated with Fenitrothion and fenthion insecticides.

In the studies on chemical control of the wingless grass hopper on mulberry, Kariappa and Narsimhanna (1981) reported a waiting period of 7 days for BHC and 1 hour for DDVP with no harmful effects on the growth and survival rate of silkworm. Suhas and

Devaiah (1985) observed a safe period of 12 days for feeding of silkworm with Endosulfan (1 kg a.i./ha) treated mulberry leaves.

Pillai and Jolly (1986) tested endosulfan, phosolone, dicofol, quinalphos and anthio at 0.05 per cent concentration, against red spidermite and reported that, leaf picking after 15th day was safe for silkworm feeding. Further, endosulfan, phosphamidon, carbaryl, permethrin and cypermethrin when applied at 1.00,0.50, 1.00, 0.05 and 0.025 kg a.i per hectare were found safe 12, 6, 8, 30 and 30 days after spraying, respectively. The effect on larval weight due to feeding with treated leaves after the waiting period was found to be maximum, after first moult in case of demeton-methyl (16.73mg); after second (82.83 mg), third (102.20 mg), fourth moult (383.13 mg) and in mature worms (2.33 g), in case of carbaryl. The mature larval weight, in case of control, demeton-methyl and dichlorovos treated leaves was 2.273, 2.249 and 2.232 g, respectively. Maximum pupation was noticed in the case of dichlorovos treated leaves. Further, with regards to cocoon, single shell and pupal weight, carbaryl, demeton-methyl, phosphomidon and dichlorovos were found to be on par with control.

Ferrari and Trevisan (1987) reported leaves treated with delta-methrin to cause mortality in silkworm, even after 30 days, while Malathion and dimethioate recorded a repellant effect on the silkworm larvae, resulting in their death due to starvation. The products containing Dichlorovos or Mevinphos were reported to be most satisfactory, since treated leaves could be consumed by silkworms after 10 days with no adverse effects.

Bhosale *et al.* (1988) reported that use of Ekalux Ec-25 (Quinalphos 25% W/V) sprayed leaves, 15 days after spraying as feed for silkworm larvae, resulted in reduced growth, mortality and reduction in cocoon weight. Further, residual toxicity of Ekalux was reported to be most evident in the fifth instar larvae. owing to greater ingestion of the insecticide along with the food.

Sharma (1989) reported that mulberry leaves sprayed with 0.1 per cent Rogor for the control of jassids can be used for silkworm rearing after 10 days, while those sprayed with 0.02 per cent Nuvon can be fed to silkworms after three days. Similarly, the waiting period for 0.05 per cent Nuvacron or Malathion treated leaves was reported to be 20 days and 10 days for 0.01 per cent parathion. Sharma *et al.* (1989) also reported residual toxicity of Rogor 0.1 per cent upto seven days. Further, Srinivas and Rao (1989) reported third and fourth instar larvae of *Bombyx mori* to be more susceptible to phosphomidon, 24 hours after application, compared to fifth instar larvae.

Samsijah (1989) reported an increase in the larval periods in silkworms fed with mulberry leaves, treated with insecticides, namely, Demecron 50 SCW (Phosphomidon) at 2g per litre, Nuvacron 250 ULV (250 g/litre), Azodrin 15 WSC (150 g/litre) and Agrolene 26 WP (26% Indane) at 2 g per litre. A safe period of 16 days was suggested for these insecticides.

Reddy *et al.* (1989) reported a considerable reduction in the cocoon, pupal and shell weights and other cocoon parameters, in addition to deterioration in quantity (reelability) and quality of silk thread in *Bombyx mori*, due to carbaryl treatment. Further, carbaryl was also reported to result in a reduction in the growth of the larvae, in addition to an adverse effect on the fibronin content and the haemolymph. An increase in larval duration to carbaryl treatment was also noticed.

Nangia *et al.* (1990) reported it desirable to harvest the mulberry leaves after 15 days of spray with either sulphur, phosalone or dicofol, for feeding of the silkworms, since the pesticides are non-toxic to the worms after the waiting period. However, in case of leaves sprayed with tedion, anthio, metasystox and nuvon, the waiting period was reported to be longer than 15 days, due to the prevalence of residual toxicity.

Ye (1990) reported a decrease in the developmental rate of the larvae following, feeding on the leaves treated with the insecticides, Shachong shuang (Thio-sulfuric acid 5,5'-[2-(dimethyl amino)-1, 3-propanediyl] ester disodium salt) and fenvalarate. These larvae had poor vitality at higher doses. However, the chemicals did not influence the synthesis of silk. In contrast, metamidophos affected the growth, rate and weight of the larvae, in addition to synthesis of silk.

Ali (1995) also reported an adverse affect on the silkworm larvae reared on mulberry leaves sprayed with systemic insecticides, even after the safe period. Insecticidal poisoning of silkworms when fed with leaves sprayed with 0.05 per cent monocrotophos (Nuvacron) was reported even after 40 days of spraying, though the established safe period is only 13 days. Hence, systemic insecticides which degenerate quickly and are less persistent in the plant system were suggested for use on mulberry.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled "Efficacy of Insecticides on Pests of Mulberry and their Influence on the Biology and Silk Yields of Mulberry Silk Worms (*Bombyx mori* L.)" was undertaken at Patakalva, Peruru, Tirupati, during 1996-97 to study the seasonal incidence of various mulberry pests and evaluation of few insecticides for their efficacy against these insect pests in addition to the study of toxicity of these chemicals on the silk worm larvae, cocoon characteristics and the silk quality.

3.1 HOST

M-5 cultivar of mulberry, raised in a mulberry garden of 0·1 hectare following row system under irrigated condition, at Patakalva, Peruru, Tirupati, comprised the experimental material for the present investigation. The plot was pruned, manured and maintained throughout the course of study, adopting recommended package of practices.

3.2 INCIDENCE AND ASSESSMENT OF PESTS

The incidence of different insect pests of mulberry was studied during a period of one year, starting from the Ist week of August 1996 to the last week of July 1997. The pest incidence was observed regularly at fortnightly intervals, during the entire period of study, using suitable techniques as mentioned below.

3.2.1 Mites, Hoppers and Thrips

The population level of these insect pests was recorded on 10 random plants in the control plot. Nymphal and adult population was recorded from the top, middle and bottom leaves of the selected plants. Thus, a total of 30 leaves from 10 randomly selected plants, were observed at fortnightly intervals. The average population per leaf was calculated and recorded. A total of 24 observations were thus recorded during the entire crop growth period.

3.2.2 Aphids and Mealy bugs

Incidence of aphids and mealy bugs was estimated on 20 randomly selected plants in the control plot of the mulberry field and the average population per plant was recorded.

3.2.3 Bugs, Grasshoppers and Weevils

These were collected by net sweeping at five randomly selected spots in the control plot of the mulberry field. The total number of insects, including adult and immature stages, were counted and recorded separately for each pest.

3.2.4 Caterpillars

The larval counts of caterpillars were recorded in one square meter area of the control plot, in the mulberry field. Insects found feeding on the mulberry plant were hand picked and identified in the laboratory. Further, the caterpillars found in the field were brought to the laboratory and reared until the emergence of adults for identification and confirmation of the species.

3.3 METEOROLOGICAL DATA

Data on weather parameters viz., temperature, relative humidity, number of sunshine hours and rainfall during the experimental period, was recorded from the meteorological observatory located at Regional Agricultural Research Station, Tirupati. This data was utilized to study the influence of abiotic factors on the incidence of insect pests of mulberry.

3.4 CHEMICAL CONTROL

An experiment was also conducted at Patakalva, Peruru, Tirupati, during 1996-97, to evaluate the efficacy of few insecticides, against the pests of mulberry.

3.4.1 Lay out

The experiment was conducted in a randomized block design (RBD) with three replications and seven treatments, including control (Fig. 1). The details of the treatments are as follows:

T_1 : Application of DDVP @ 0.05%

T_2 : Application of Endosulfan @ 0.05%

T_3 : Application of Dimethioate @ 0.1%

T_4 : Application of Carbaryl @ 0.1%

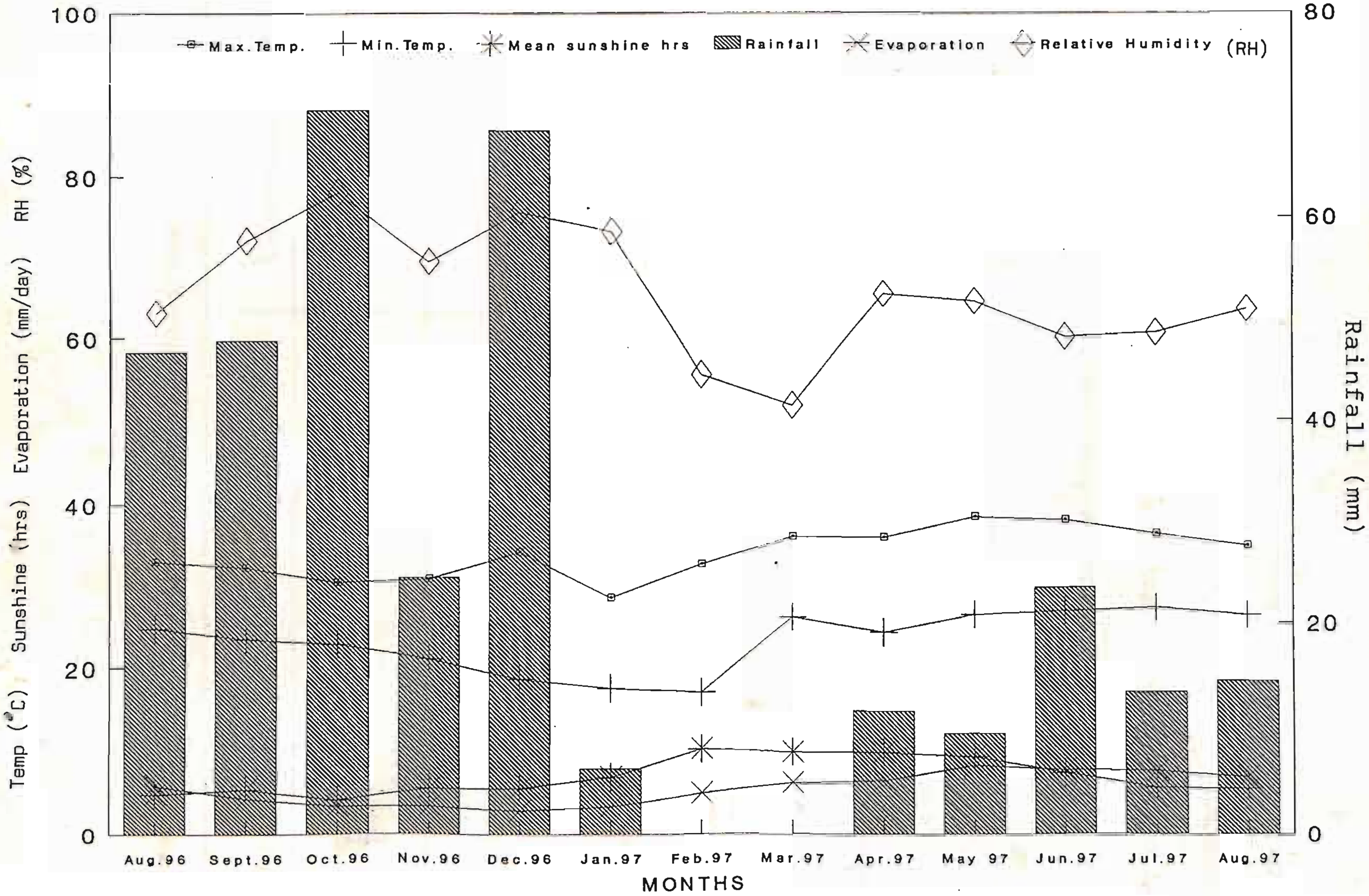

Fig.2 Weather conditions during the period of study (Aug 1996 to July 1997)

Fig. 1: Layout of the experimental field

T1 DDVP @ 0.05%	T5 Nemazol @ 1%	T3 Dimethioate @ 0.1%
T3 Dimethioate @ 0.1%	T4 Carbaryl @ 0.1%	T2 Endosulfan @ 0.05%
T2 Endosulfan @ 0.05%	T6 T6 Phosalone @ 0.05%	T4 Carbaryl @ 0.1%
T6 Phosalone @ 0.05%	T3 Dimethioate @ 0.1%	T5 Nemazol @ 0.1%
T4 Carbaryl @ 0.1%	T7 Control	T1 DDVP @ 0.05%
T5 Nemazol @ 1%	T1 DDVP @ 0.05%	T6 Phosalone @ 0.05%
T7 Control	T2 Endosulfon @ 0.05%	T7 Control

Design : Randomized block design

Replications : Three

Treatments : Seven

Gross plot size : 5 x 3 m^2

T_5 : Application of Nemazol @ 1%

T_6 : Application of Phosalone @ 0.05%

T_7 : Untreated control

The particulars of insecticides used in the experiment along with their sources are presented in Table 1. The insecticides were applied as foliar sprays, during evening hours and due care was taken to prevent the drift of spray fluid to adjacent plots. Further, the plants in each plot were thoroughly sprayed with the insecticide. Observations with regards to pest incidence were recorded, one day before spraying and thereafter, the counts were taken after one, third, seventh and fourteenth day after spraying, in all the treatments. Efficacy of the insecticides was evaluated in two seasons, each season consisting of six months duration starting from August 1996.

3.5 LABORATORY STUDIES

The effect of insecticides studied in the present investigation on silk worm larvae, silk yield and quality was examined in the laboratory.

3.5.1 Effect of insecticides on mortality and larval duration of silkworm larvae (*Bombyx mori* L.)

The experiment was conducted at the Department of Entomology insectary, S.V. Agriculture College, Tirupati. The effect of insecticides on the mortality percentage and larval duration of silk worm larvae (Race PM X NB_4D_2) at different instars was studied by

Table 1. Particulars of the insecticides with their source

Common Name	Group	Chemical Name	Trade Name and Strength	Source
Dichlorovos (DDVP)	Organophosphates	2,2-Dichlorovinyl dimethyl phosphate	Nuvon 76 EC	Hindustan Ciba-Gei Ltd.
Endosulfon	Organochlorines	6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a hexahydro-6,9-methano-2,4,3-benzo(e)dioxothiepin-3-oxide	Endosel 35 EC	Excel Industries Ltd
Phosalone	Organophosphates	5-(6-Chloro-2-oxobenzoxazolin-3-yl)-methyl-0,0-diethylphosphorodithioate	Zolone 35 EC	Rhone Poulenc Agrochemicals Indi:
Carbaryl	Carbamates	1-Naphthyl methyl carbamate	Sevin 50% WDP	Bhopal Pesticides P Ltd.
Dimethioate	Organophosphates	0,0-dimethyl-s-(Methyl carbamoyl methyl) phosphorodithioate.	Rogor 30 EC	Rallis India Ltd.
Nemazol	Botanical	Azadirachtin	Neoneem 1500 ppm	Nishant Ecotechnol Ltd.

feeding leaves collected from the plants sprayed with the insecticides, after every 24 hours, up to 15 days after spraying. A minimum of 50 disease free larvae were maintained in each treatment, for each replication, of each instar, at each day of study and observations were recorded on the mortality percentage, calculated as follows:

$$\text{Mortality (\%)} = \frac{\text{Total - surviving}}{\text{Total}} \times 100$$

Further, weight of the 4th and 5th instar larvae was also measured. The initial and final weight of the larva at the beginning and at the end of each instar was recorded and the difference in weight was taken as weight gain in that larval instar. The number of instar was also fixed by the presence of exuviae. In addition, the percentage of cocoons formed in each treatment was also calculated from the total worms taken at the beginning of each treatment.

3.5.2 Effect of insecticides on cocoon characteristics, silk yield and quality

The experiment was also conducted at the Department of Entomology Insectary, S.V. Agriculture College, Tirupati. Silk worm larvae of each instar, fed with mulberry leaves, treated with different insecticides, were studied for characteristics viz., cocoon weight and silk shell weight for which the cocoons were harvested on the fifith day after mounting on Chandrika and a random sample of ten cocoons was drawn from each replication. Later, the cocoons were weighed accurately and the mean weight of cocoon was claculated for each treatment. However, for arriving at the silk shell weight, the cocoons were cut open with the help of a sharp blade and the shell weight was recorded, after removal of the pupae. The silk shell weight percentage was calculated on the basis of cocoon and silk shell weight using the following formula:

$$\text{Silk shell percentage} = \frac{\text{Weight of the silk shell}}{\text{Weight of cocoon}} \times 100$$

For measuring of silk filament length and denier, a random sample of ten cocoons was taken from each replication, in each treatment and stiffled in hot air at 90-95°C for three hours and air dried to remove any moisture content in the cocoon. After storing for three days, the cocoons were placed in boiling water, for three to four minutes to soften the sericin content. Later, the cocoons were reeled out on an epprouvette. The length of the silk filament from each cocoon was obtained by multiplying the number of revolutions (R) with circumference of the epprouvette (1.125 m) i.e., L = R X 1.125, as outlined by Krishnaswami *et al.* (1972), where L = length of bave in meters per cocoon

The raw silk filament, thus obtained was dried at 70-80°C in an oven and later weighed. Denier was computed according to the following formula (Krishnaswami *et al.*, 1972).

$$D = W/L \times 9000$$

where, D = Denier

W = weight of single cocoon reeled silk

L = Total length (m) of single cocoon filament and 9000 being the constant value.

3.6 STATISTICAL ANALYSIS

Simple correlation co-efficients (Snedecor and Cochran, 1968) were computed in addition to regression analysis to determine the influence of weather factors on the pest populations. Further, the efficacy of various insecticides, with regards to control of the different insect pests was determined through RBD analysis (Panse and Sukhatme, 1978), in comparison to the untreated control. The percentage reduction of the insect pests, over control was calculated using modified Abbot's formula (Fleming and Retnakaran, 1985).

$$\text{Percentage population reduction over control} = \left[1 - \frac{\text{Post-treatment population}}{\text{Pre-treatment population}} \times \frac{\text{Pre-treatment population in control}}{\text{Post-treatment population in control}}\right] \times 100$$

The resultant percentage values were transformed into angular values and then subjected to statistical analysis. The figures 0 and 100 per cent were substituted (Gomez and Gomez, 1984) as follows :

0 = 1/4n

100 = 90 - 1/4n

where, n = number of units

Completely randomized design was adopted for the lab experiments in the present study, to conclude regarding the effects of insecticides on mortality, larval duration, larval length and weight, in addition to the cocoon characteristics. Observations on mortality and silk shell percentage were also subjected to angular transformation, prior to statistical analysis.

RESULTS

CHAPTER IV

RESULTS

Results of the present investigations on "Efficacy of insecticides on pests of mulberry and their influence on the biology and silk yields of mulberry silk worm (*Bombyx mori* L.)" are presented hereunder.

4.1 SEASONAL INCIDENCE OF INSECT PESTS

The insect pests recorded during the period of study (August 1996 - July 1997) are presented in Table 2, while their population levels on mulberry are presented in Table 3. Further, observations on association of the pest population levels with the weather parameters viz., temperature, relative humidity and rainfall are presented in Table 4 and Fig. 2-10. Nine insect pests viz., mites, thrips, hoppers, mealy bugs, aphids, bugs, caterpillars, grasshoppers and weevils were observed on mulberry during the study period.

4.1.1 Mites

Three species of spider mites viz., *Tetranychus telanrius* Linnaeus, *Tetranychus eqatorius* Mc Gr, *Tetranychus neocaledonicus* Andre were found to occur on mulberry canopy at varying intensities throughout the study (Table 2). They were found usually on under surface of mulberry leaves but, when infestation was severe, they were found all over the leaf. Both nymphs and adults fed on sap from lower epidermis of the leaves. The infested leaves showed fine silken thread spun across on the lower surface which caught dust particles. Such leaves

Table 2: Faunal composition of mulberry pests observed during 1996-97 at Patakalva, Peruru, Tirupati, Andhra Pradesh

Insect Pest	Species	Order	Family
Mites	*Tetranychus telarius* Linnaeus	Acarina	Tetranychidae
	Tetranychus equatorius Mc Gr	Acarina	Tetranychidae
	Tetranychus neocaledonicus Andre	Acarina	Tetranychidae
Thrips	*Baliothrips minutus* Vanderventes	Thysanoptera	Thripidae
	Pseudodendrothrips mori Nawa	Thysanoptera	Thripidae
Hoppers	*Empoasca flavescens* Fabricius	Homoptera	Cicadellidae
Mealy bugs	*Maconellicoccus hirsutus* Green	Homoptera	Pseudococcidae
Aphids	*Dactynotus compositae* Theobald	Homoptera	Aphididae
Bugs	*Nezara viridula* Linnaeus	Hemiptera	Pentatomidae
	Menida histrio Fabricious	Hemiptera	Pentatomidae
	Leptocentrus sps.	Hemiptera	Membracidae
Caterpillars	*Spilosoma obliqua* Walker	Lepidoptera	Arctiidae
	Glyphodes pyloalis Kuwana	Lepidoptera	Pyralidae
Grass hopper			
Long horned	*Latana inflata* Brunner	Orthoptera	Tettigonidae
Short-horned	*Oxya nitidula* Walker	Orthoptera	Acrididae
	Cantantops pinguis innotabilis Walker	Orthoptera	Acrididae
	Cyrtacanthacris tatarica Linnaeus	Orthoptera	Acrididae
Weevils	*Myllocerus vividanus* Fabricius	Coleoptera	Curculionidae

developed yellowish speckles/spots on the upper surface which later coalesced and entire leaf became yellowish. Deformation of new flushes and leaves of the mulberry plants was also observed (Plate 1).

The mite population ranged from 8.30 to 12.72 per leaf during the period of study with an average density of 10.76 per leaf (Table 3). Minimum density (8.30) was recorded during the first fortnight of December, while maximum population (12.72) was recorded during the second fortnight of March. Further, positive and significant correlation between mite population on mulberry (Table-4 and fig-3) and maximum temperature (0.711**) was observed and negatively correlated with relative humidity (-0.705**) and rainfall (-0.680**). The weather parameters together accounted for 69 per cent of the pest population on mulberry (Table 5).

4.1.2 Thrips

Two species of thrips viz., *Baliothrips minutus* Vanderventer and *Pseudodendrothrips mori* Nawa were encountered on mulberry (Table 2) inflicting injury to buds, leaves and tender shoots. They were found through out the year at varying intensities, mostly on the lower surface of leaves. Feeding by both adults and nymphs resulted in crinkling and curling of the leaves.

The population ranged from 2.03 to 6.30 with an average of 4.18 thrips per leaf (Table 3). It was minimum during the first fortnight of October and maximum during the second fortnight of May. Further, the pest population on mulberry was observed to be positively and significantly correlated (Table 4 and Fig. 4) with

Plate 1: Symptoms of mite infestation

Table 3: Seasonal incidence of mulberry pests during 1996-97 at Patakalava, Peruru, Tirupati, Andhra Pradesh

Insect Pest	August 1996		September '96		October,'96		November '96		December '96		January '97		February '97		March '97		April '97		May '97		June '97		July '97	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Sucking pests																								
* Mites	9.76	10.20	10.80	10.45	10.08	9.97	9.47	9.08	8.30	8.65	9.60	10.25	10.86	11.53	12.23	12.72	9.74	11.94	11.81	12.03	12.07	12.13	12.15	12.45
* Thrips	2.44	2.99	2.99	2.52	2.03	2.99	3.30	3.15	2.15	3.81	4.03	4.30	4.68	5.18	5.28	5.46	5.61	5.21	5.25	6.30	6.07	5.05	4.71	4.92
* Hoppers	6.84	6.00	5.93	6.22	7.57	6.93	7.17	7.12	7.43	5.85	5.82	4.47	4.66	3.13	3.05	3.21	3.03	2.74	2.21	2.06	1.85	1.54	1.34	1.12
** Mealy bugs	6.43	6.51	5.82	6.01	6.00	5.71	5.35	5.31	5.88	4.23	5.27	5.13	5.19	5.09	5.12	5.07	5.79	5.48	5.67	5.28	5.14	5.73	5.05	5.87
** Aphids	5.31	5.15	2.68	2.92	2.51	5.37	3.92	5.57	3.02	5.76	5.82	6.81	7.03	7.28	7.35	7.13	6.83	7.04	6.81	7.27	6.59	6.71	6.96	7.02
+ Bugs	3.73	3.50	3.31	3.35	3.09	3.82	3.64	3.86	3.47	3.86	3.99	4.46	4.68	4.99	5.15	5.12	4.92	4.50	4.88	4.57	4.61	4.99	4.61	4.54
Defoliators																								
@ Cater-pillars	3.82	3.95	3.77	3.30	4.52	2.70	3.15	2.50	4.22	2.63	2.93	2.44	2.63	2.23	1.99	1.14	1.74	1.07	1.17	1.01	1.41	1.28	1.63	1.35
+ Grass hoppers	4.88	4.85	5.09	5.35	6.27	5.20	5.40	5.75	5.99	5.69	5.24	5.05	4.64	4.95	4.23	4.03	4.00	3.25	3.86	2.78	3.18	3.23	2.57	3.17
+ Weevils	2.51	2.82	3.09	3.50	2.37	3.25	3.30	3.15	2.99	2.70	3.64	4.72	4.23	3.60	3.73	3.36	3.30	2.63	2.63	2.23	2.24	2.44	2.57	1.99

I Observations in first fortnight; II Observations in second fortnight; * Density per leaf; ** Density per plant; + Density per five sweeps; @ Density per sq. meter area

Table 4: Correlation (r) between weather parameters and the seasonal incidence of mulberry pests during 1996-97

Weather Parameter	Correlation (r) Value of Insect Pests								
	Mites	Thrips	Hoppers	Mealy bugs	Aphids	Bugs	Cater-pillars	Gross hoppers	Weevils
Maximum temperature	0.711**	0.750**	-0.684**	0.685**	0.747**	0.718**	-0.528*	-0.466*	-0.249
Minimum temperature	0.234	0.336	0.212	0.250	0.265	0.251	-0.121	-0.452*	-0.660**
Relative humidity	-0.705**	-0.505*	+0.636**	0.658**	-0.666**	-0.695**	0.428*	+0.645**	-0.251
Rainfall	-0.680**	-0.553**	+0.549**	0.506*	-0.675**	-0.618**	0.418*	+0.456*	-0.250

*, ** Significant at 5 and 1 per cent levels

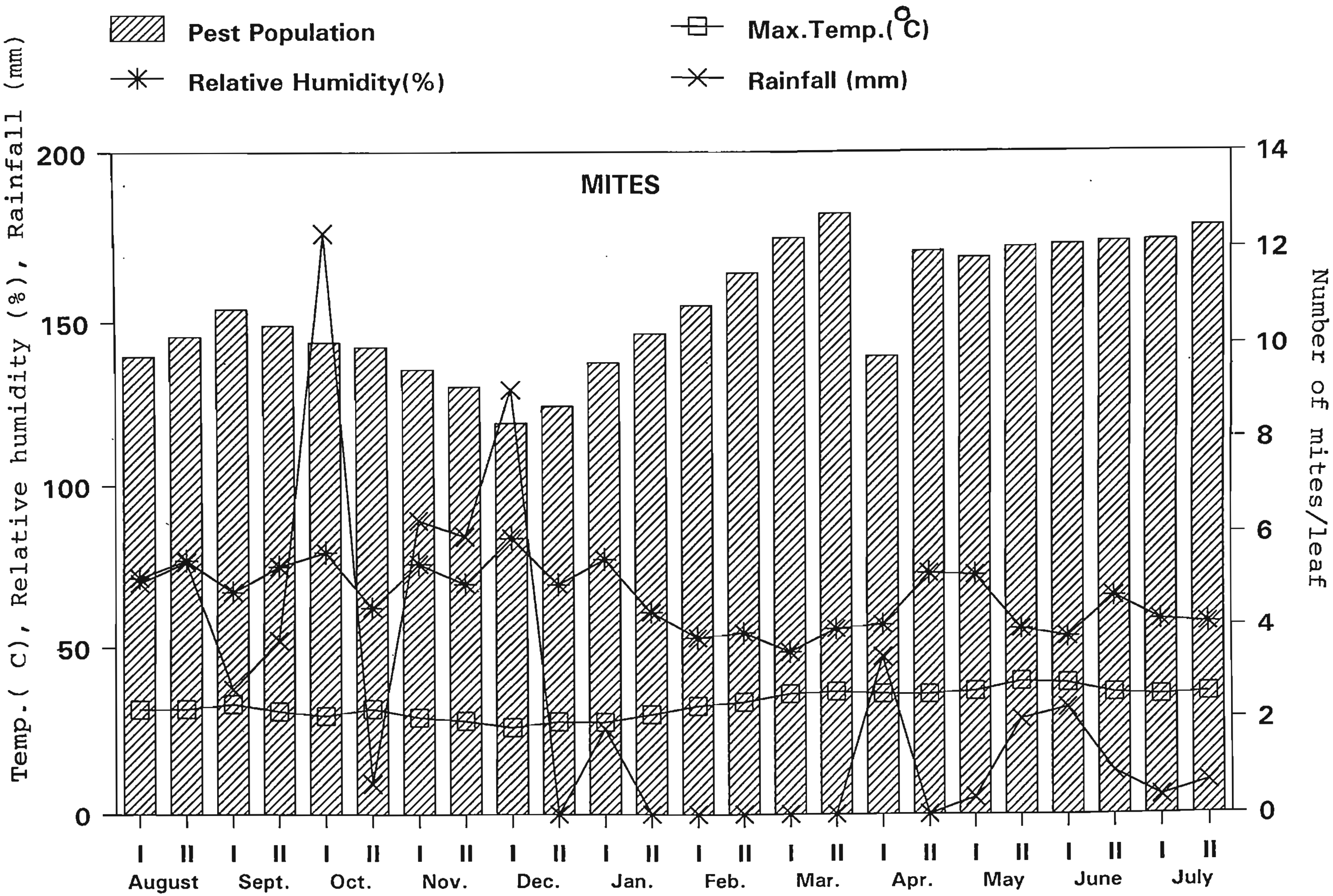

Fig. 3: Relationship between weather parameters and mite population levels on mulberry

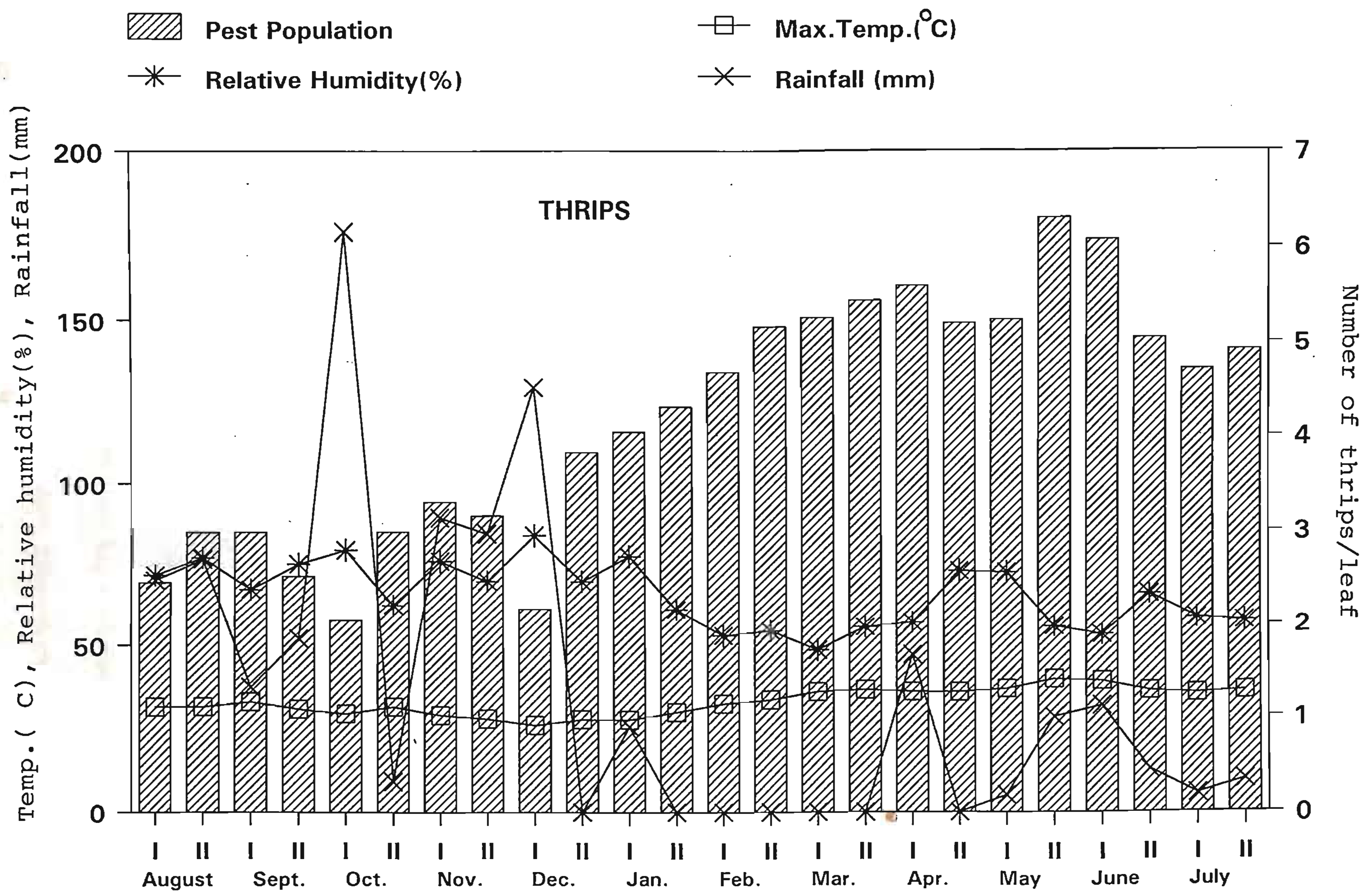

Fig. 4: Relationship between weather parameters and thrip populations on mulberry

maximum temperature (0.75**) and negatively correlated with relative humidity (-0.505*) and rainfall (-0.553**). These weather parameters together accounted for 72 per cent of the variability in the pest population (Table 5).

4.1.3 Hoppers

The study revealed infestation of mulberry with *Empoasca flavescens* Fabbricius leaf hopper. Both adults and nymphs were observed sucking sap from leaves and tender flushes, causing crinkling and distortion of leaves.

The population ranged from 1.12 to 7.57 with an average of 4.47 hoppers per leaf (Table 3). It was minimum during the second fortnight of July and maximum during the first fortnight of October. Further, the pest population on mulberry was observed to be positively and significantly correlated (Table 4 and Fig. 5) with relative humidity (0.636**) and rainfall (0.549**) and negatively correlated with maximum temperature (-0.684**). These weather parameters together accounted for 54 per cent of the variability in the pest population (Table 5).

4.1.4 Mealy bugs

The mealy bug, *Maconellicoccus hirsutus* was noticed in clutches at the terminal shoot and leaf buds of mulberry (Plate 2). The nymphs, called crawlers were observed to be tiny, pinkish and gregarious (Plate 3). Both nymphs and adults (sedentary forms) were noticed to suck sap continuously and excrete honey dew, in addition to secretion of white powdery filamentous material on their bodies

Plate 2: Infestation of mealy bugs (*Maconellicoccus hirsutus*)

Plate 3: Tiny, pinkish and gregarious crawlers of *Maconellicoccus hirsutus*

Plate 4: Adult of *Maconellicoccus hirsutus*

Table 5: Regression of weather parameters on the seasonal incidence of mulberry pests

Insect pest	Regression equation	R^2
Mites	$Y = 90.27 + 2.85\ X_1 - 4.54\ X_3 - 2.28\ X_4$	0.69
Thrips	$Y = -89.21 + 3.71\ X_1 + 3.88\ X_3 + 1.09\ X_4$	0.72
Hoppers	$Y = -19.37 - 1.98\ X_1 + 5.42\ X_3 + 9.29\ X_4$	0.54
Mealy bugs	$Y = -4.00 + 1.56\ X_1 + 7.36\ X_3 + 4.57\ X_4$	0.59
Aphids	$Y = -29.33 + 3.09\ X_1 - 1.73\ X_3 - 6.23\ X_4$	0.72
Bugs	$Y = 2.20 + 9.54\ X_1 - 8.79\ X_3 - 6.73\ X_4$	0.66
Caterpillars	$Y = 49.14 - 1.67\ X_1 + 0.58\ X_3 + 1.47\ X_4$	0.59
Grasshoppers	$Y = 26.84 - 3.12\ X_1 - 2.17\ X_2 + 2.47\ X_3 + 8.88\ X_4$	0.63
Weevils	$Y = 30.45 - 1.02\ X_2$	0.54

Y = Pest population; X_1 - Maximum temperature;
X_2 - Minimum temperature; X_3 - Relative humidity; X_4 - Rainfall

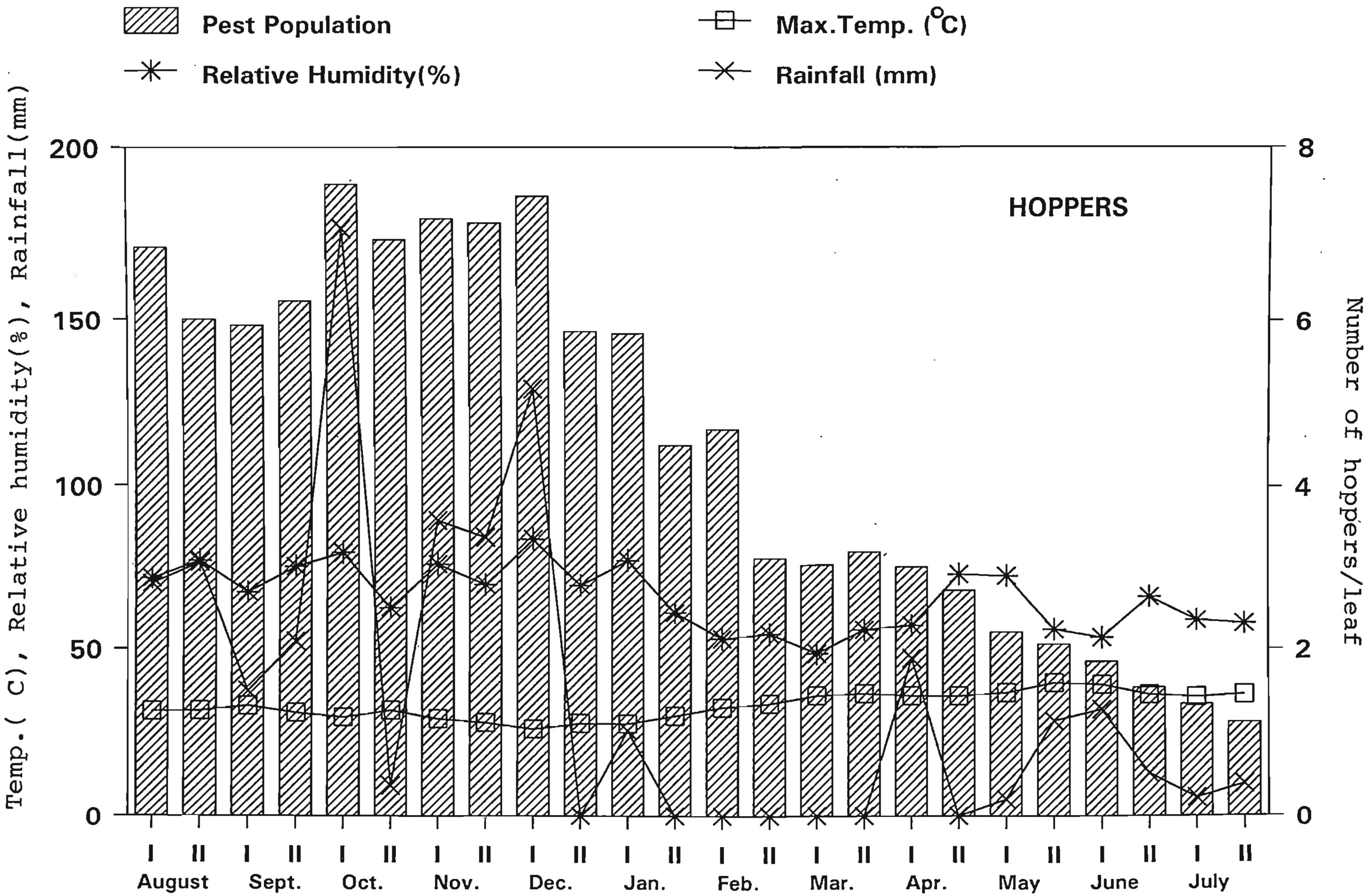

Fig.5: Relationship between weather parameters and leaf hopper population levels on mulberry

and the site of infestation (Plate 4). The infested shoots were distorted and flattened. Further, the new buds were observed to be crinkled and scorched.

The pest population ranged from 4.23 to 6.51 with an average of 5.54 mealy bugs per plant (Table 3). It was minimum during second fortnight of December and maximum during second fortnight of August. Further, the pest population was observed to be positively and significantly correlated (Table 4 and Fig. 6) with maximum temperature (0.685**), relative humidity (0.658**) and rainfall (0.506*). However, no significant association of the pest was noticed with minimum temperature. These weather parameters, together accounted for 59 per cent of the variability in the pest (Table 5).

4.1.5 Aphids

One species of aphid viz., *Dactynotus compositae* Theobald was observed on mulberry canopy at varying intensities throughout the study (Table 2). These were found to suck sap from the mulberry leaves. A late forms of the pest were also found feeding on the tender shoots.

The pest population ranged from 2.68 to 7.35 with an average of 5.78 aphids per plant (Table 3). It was minimum during the first fortnight of September and maximum during first fortnight of March. Further, the pest population was observed to be positively and significantly correlated (Table 4 and Fig. 7) with maximum temperature (0.747**) and negatively correlated with relative humidity (-0.666**) and rainfall (-0.675**). These weather parameters, together accounted for 72 per cent of the variability in the pest (Table 5).

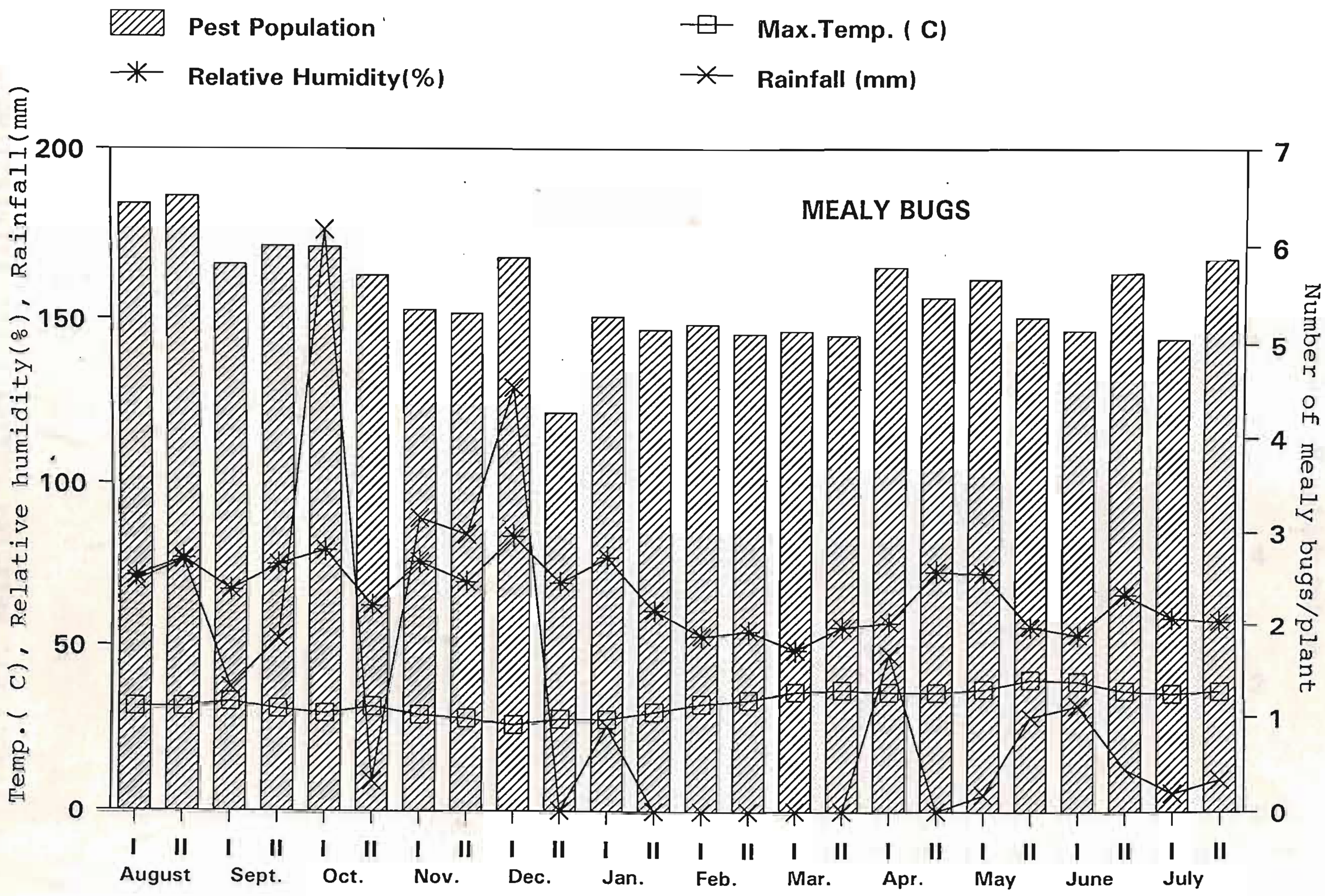

Fig.6: Relationship between weather parameters and mealy bug populations on mulberry

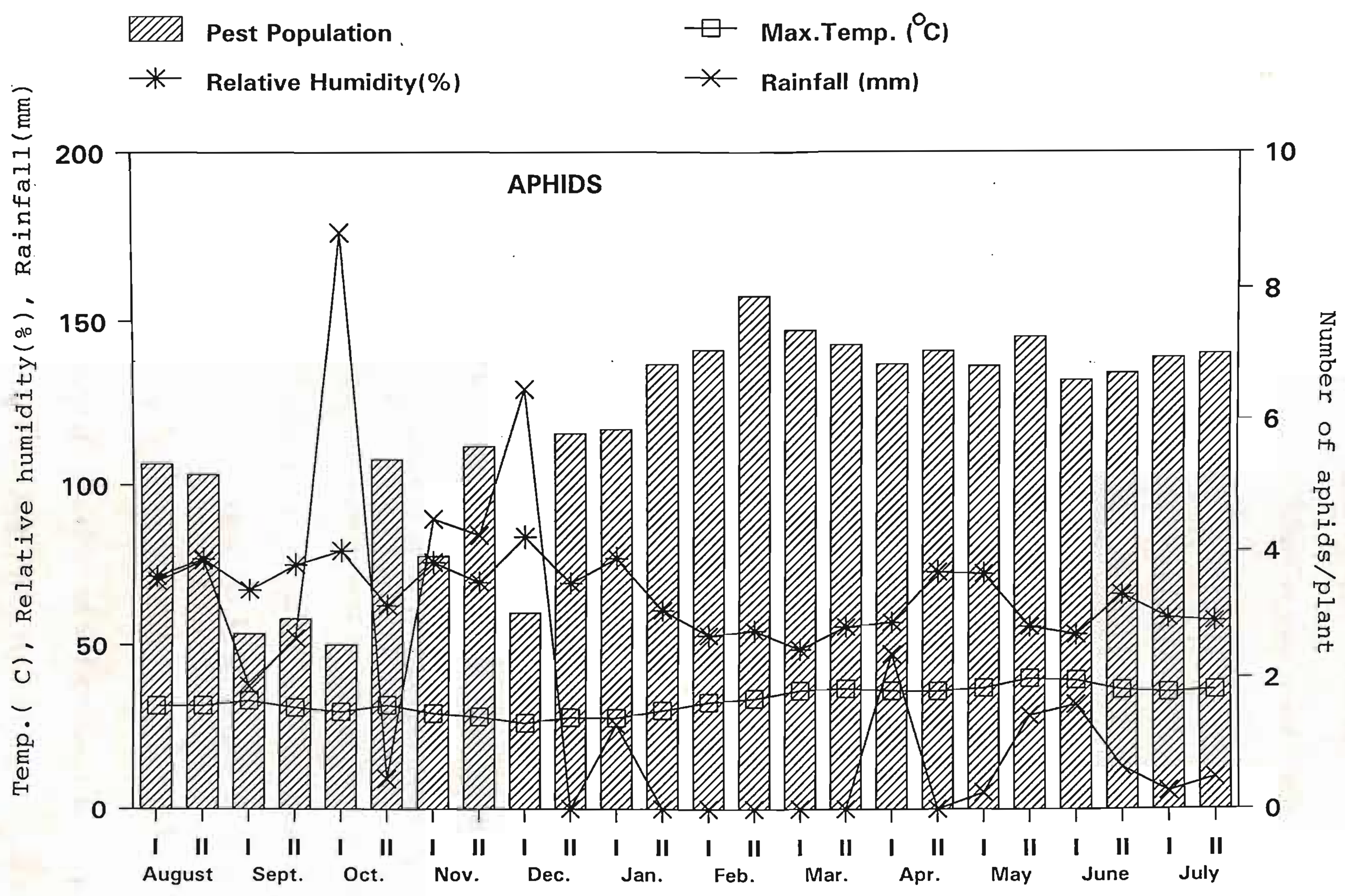

Fig.7: Relationship between weather parameters and aphid population levels on mulberry

4.1.6 Bugs

Three species of bugs viz., *Nezara virudula* Linnaeus, *Menida histrio* Fabricius (Plate 5) and *Leptocentrus sps.* (Plate 6) were found on the mulberry canopy through out the study (Table 2). Among these, the green bug, *Nezara viridula* Linnaeus was found in fairly large numbers, feeding on the sap of mulberry leaves, tender shoots and inflorescence.

The pest population ranged from 3.09 to 5.15 with an average of 4.23 bugs for five sweeps of the net (Table 3). It was minimum during the first fortnight of October and maximum during first fortnight of March. Further, the pest population was observed to be positively and significantly correlated (Table 4 and Fig. 8) with maximum temperature (0.718**) and negatively correlated with relative humidity (-0.695**) and rainfall (-0.618**). These weather parameters, together accounted for 66 per cent of the variability in the pest (Table 5).

4.1.7 Caterpillars

Two species of caterpillars viz., *Spilasoma obliqua* walkes and *Glyphodes pyloalis* Kuwana were observed on mulberry in the present study (Table 2). The first instar larvae of *Spilosana obliqua* were noticed to feed on the chlorophyll content of mulberry leaves, while the grown up larvae feed voraciously on the leaves, leaving midribs and thick veins. These larvae are mostly nocturnal and pupated in debris.

Larvae of *Glyphodes pyloalis* were observed to form fine threads on the abaxial side of the mulberry leaves and kept eating the mesophyll tissue from

Plate 5: Bugs on mulberry (*Mendia histrio* Fabricious)

Plate 6: Bugs on mulberry (*Leptocentrus* sp.)

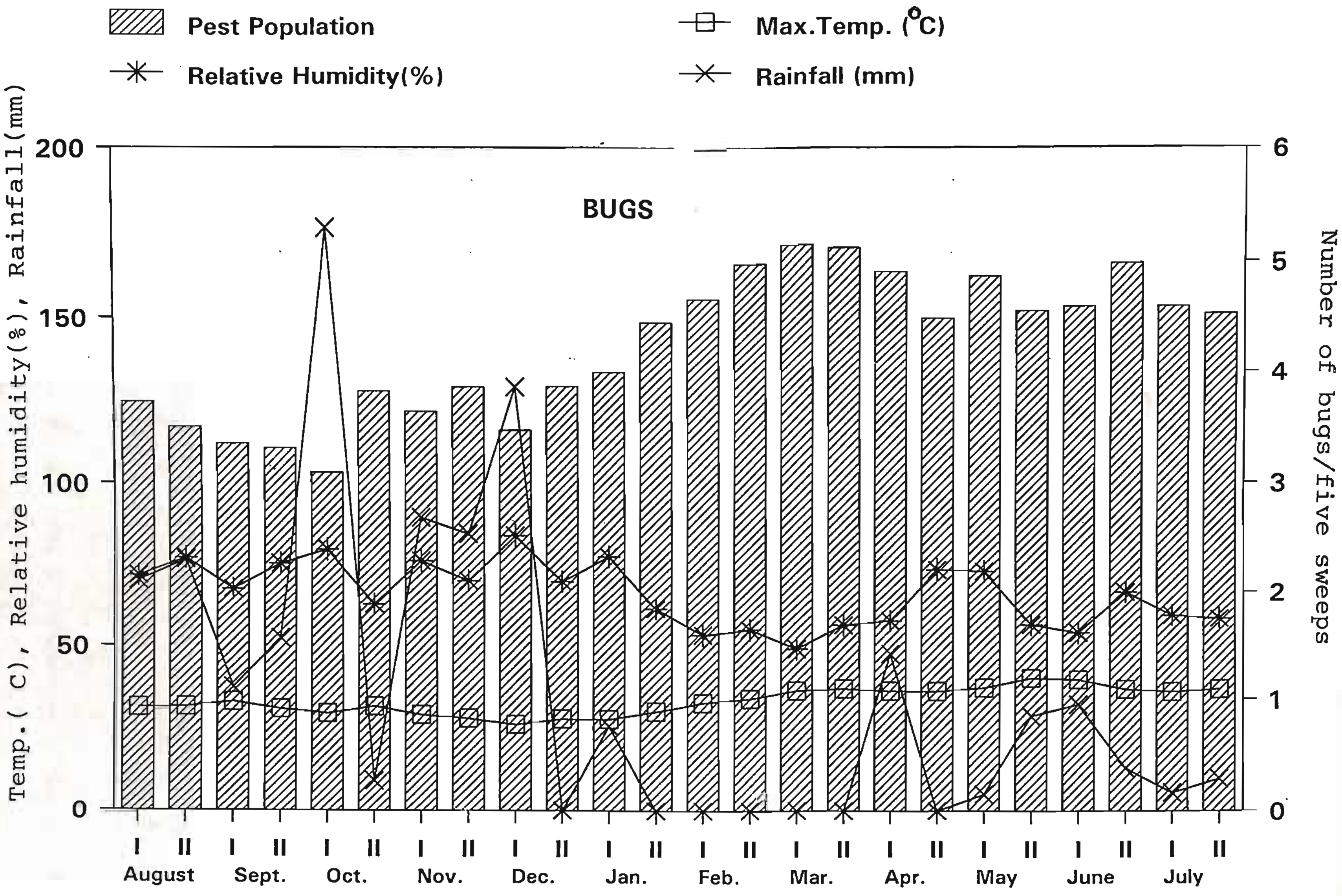

Fig.8: Relationship between weather parameters and bug populations on mulberry

under these threads, leaving a network of epidermis. Further, the damage was observed to be mid during the first and second instars, while it increased drastically during the third and fourth instars.

The pest population ranged from 1.01 to 4.52 with an average of 2.44 caterpillars per sq.m. area (Table 3). Minimum pest population was noticed during the second fortnight of May, while maximum population was recorded during the first fortnight of October. Further, the pest population was observed to be positively and significantly correlated (Table 4 and Fig. 9) with relative humidity (0.428*) and rainfall (0.418*) and negatively correlated with maximum temperature (-0.528*). These weather parameters together accounted for 59 per cent of the variability in the pest (Table 5).

4.1.8 Grass hoppers

Three species of short-horned grasshoppers viz., *Oxya nitidula* walker (Plate 7), *Catantops pinguis innotabilis* walker (Plate 8) and *Cyrtacanthacris tatarica* Linnaeus, in addition to a long horned grasshopper viz., *Letana inflata* Brunner, were observed in the present study on mulberry canopy (Table 2). Both nymphs and adults fed on leaves and tender shoots.

The pest population ranged from 2.57 to 6.27 with an average of 4.94 grasshoppers per five sweeps (Table 3). Minimum pest population was noticed during the first fortnight of July while maximum population was recorded during first fortnight of October. Further, the pest population was observed to be positively and significantly correlated (Table 4 and Fig. 10) with relative humidity

Plate 7: Short-horned grasshopper (*Oxya nitidula* Walker)

Plate 8: Short-horned grasshopper Walker)

(*Catantops pinguis innotabilis*

Plate 9: Weevil on mulberry (*Myllocenus viridanus* Fabricius)

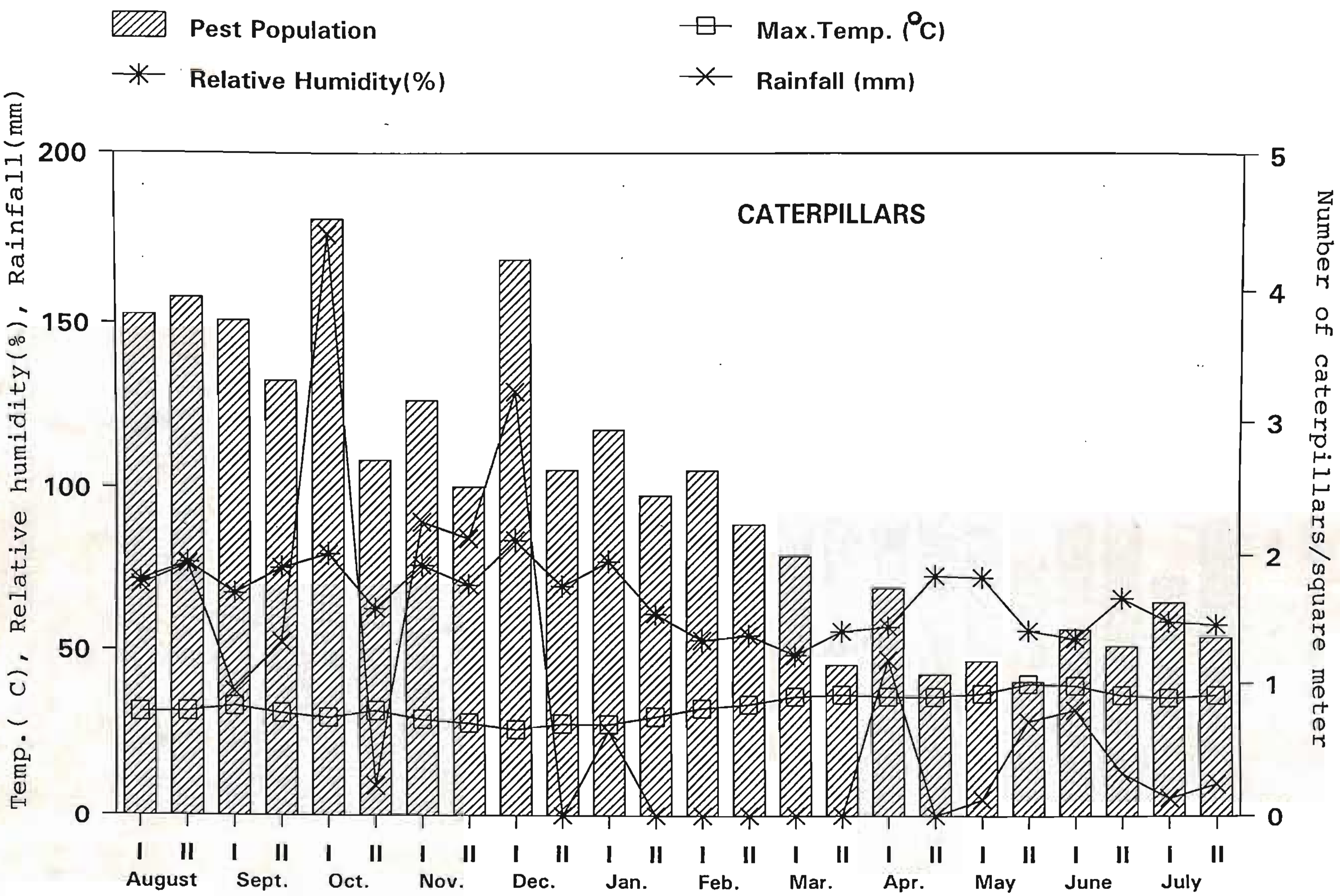

Fig.9: Relationship between weather parameters and density of caterpillars on mulberry

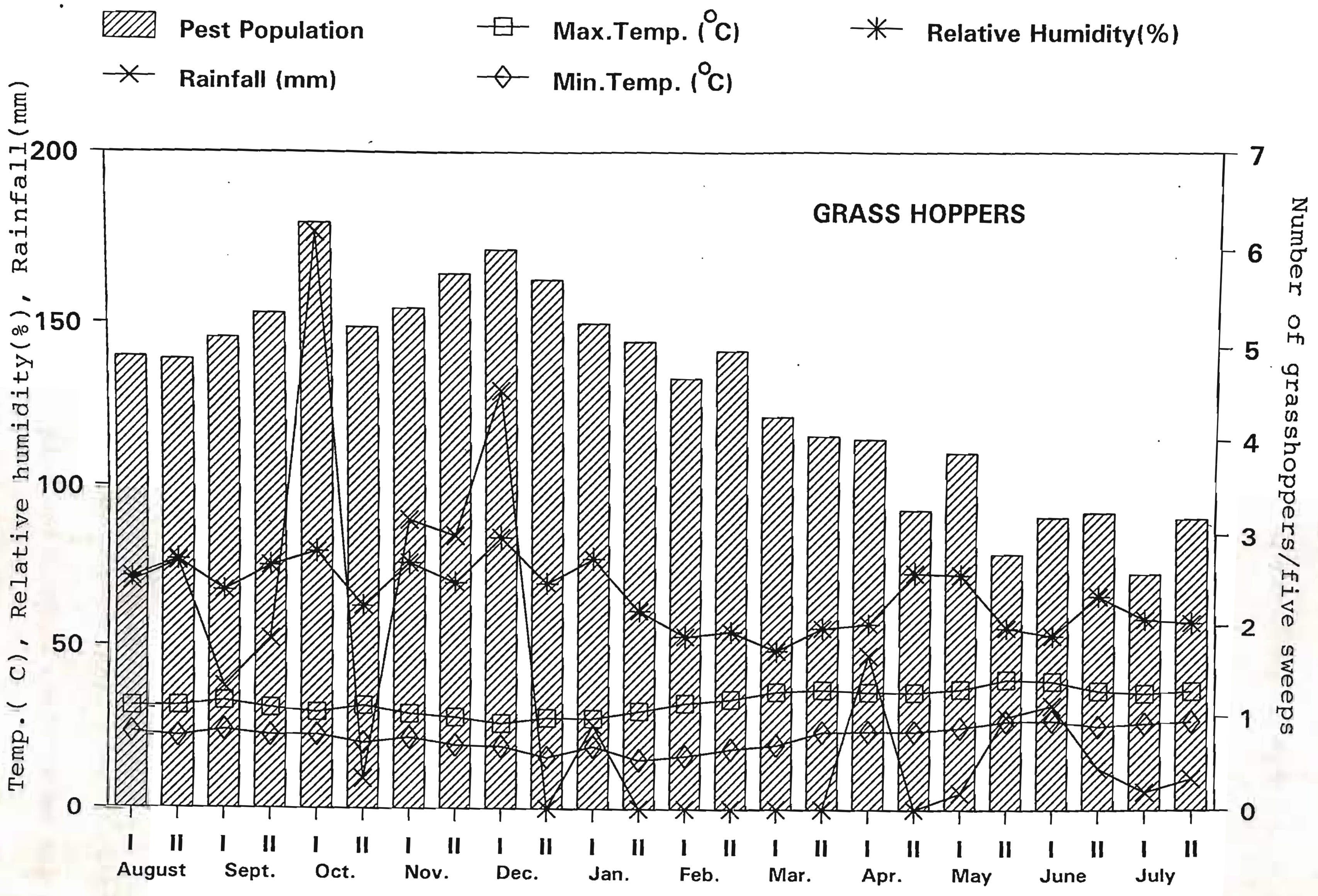

Fig.10: Relationship between weather parameters and grass hopper populations on mulberry

(0.645**) and rainfall (0.456*) and negatively correlated with maximum temperature (-0.466*) and minimum temperature (-0.452*). These weather parameters together had accounted for 6.3 per cent of the variability in the pest population (Table 5).

4.1.9 Weevils

During the pest study, *Myllocerus viridanus* Fabricius species of weevil (Table 2) was observed on the mulberry canopy (Plate 9). The adults made "U" shaped notches on leaf margin and fed from the margin towards centre in zig-zag fashion leaving thick veins and midrib. They were also seen to damage buds hiding at the terminal during bright sunshine.

The incidence of *Myllocerus viridanus* Fabricius was noticed on mulberry through out the year, ranging from 1.99 to 4.72 with an average of 3.04 weevils per five sweeps (Table 3). Maximum incidence was observed during second fortnight of July. Further, a highly significant and negative correlation (Table 4 and Fig. 11) was recorded with minimum temperature (-0.660**), while maximum temperature, relative humidity and rainfall did not record any significant association with the pest population. Minimum temperature accounted for 54 per cent of the variability in the pest population (Table 5).

4.2 EFFICACY OF INSECTICIDAL APPLICATIONS AGAINST MULBERRY PESTS

Results on the relative efficacy of different insecticides viz., DAVP, endosulfan, dimethioate, carbaryl, nemazol and phosalone against various mulberry pests in two seasons of study are presented in Tables 6 - 14.

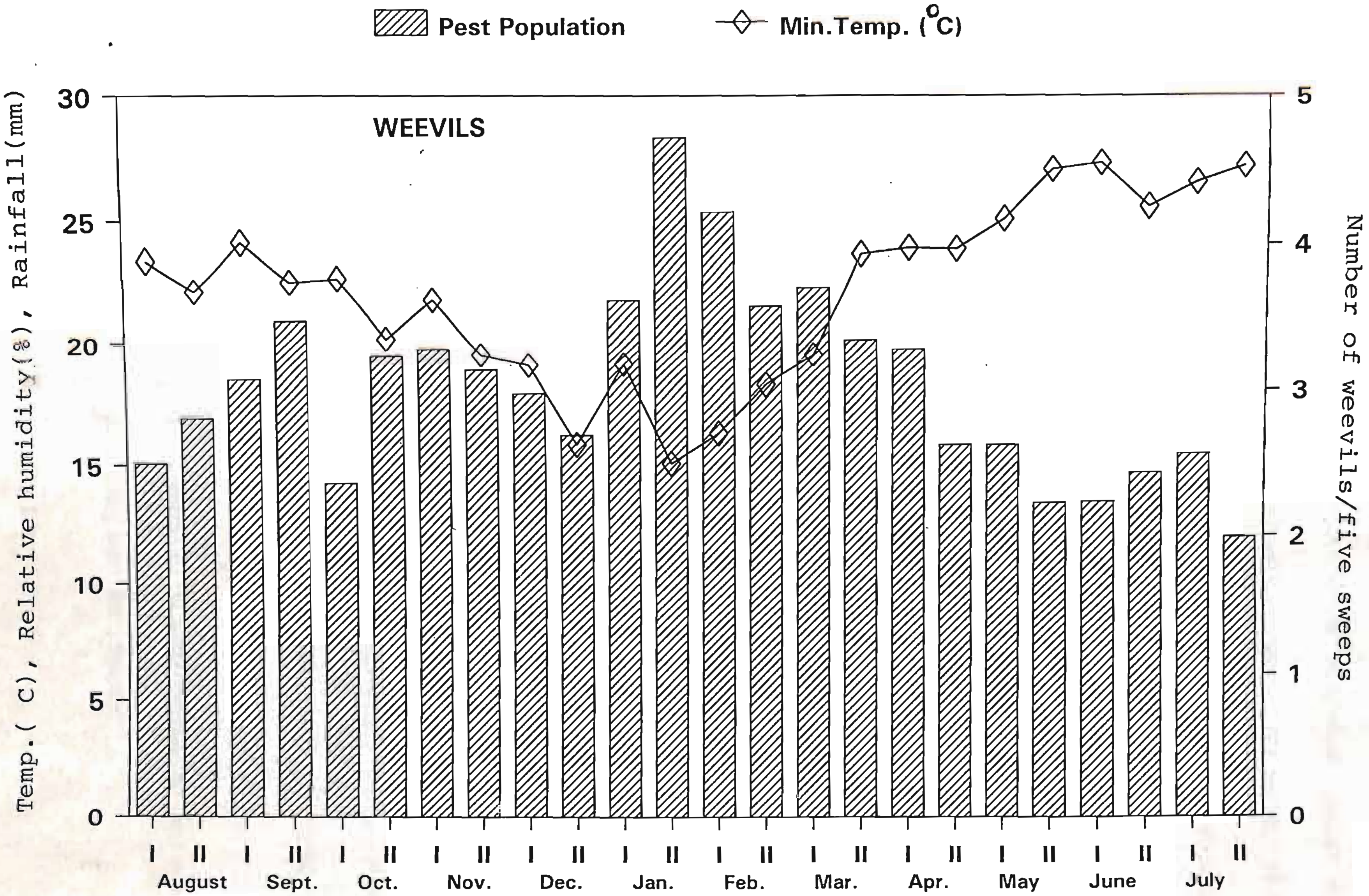

Fig.11 : Relationship between weather parameters and weevil populations on mulberry

4.2.1 Mites

The results are presented in Table 6 and Fig.12. A gradual decrease in the per cent reduction over control was observed with increase in the number of days after spraying. However, more than 39 per cent reduction in the pest population was noticed at 14 DAS, with the insecticidal applications.

Per cent reduction in the pest population over control, 1 DAS ranged from 56.38 to 69.02 during first season and 58.88 to 73.22 during second season. However, at 3 DAS, it ranged from 44.02 to 65.40 during first season and 50.40 to 70.68 during second season, while at 7 DAS per cent reduction in the pest population ranged from 42.88 to 64.72 during first season and 47.11 to 68.62 during second season. At 14 DAS, the per cent reduction ranged from 39.10 to 60.09 during first season and 47.01 to 65.08 during second season.

Maximum reduction was noticed with application of phosalone (0.05%) during both the seasons, at all days after spraying and overall, wherein it had recorded more than 64 per cent control of the pest, Dimethioate (0.1%), Nemazol (1%) and DDVP (0.05%) were also observed to be on par with phosalone (0.05%) during both seasons 1 DAS, while Dimethioate (0.1%) and phosalone (0.05%) were observed to be on par upto 7 DAS during both the seasons. Carbaryl (0.1%) had however recorded minimum per cent reduction of the pest population over control, among the various insecticides studied during both the seasons.

Table 6: Efficacy of insecticides against mulberry mites during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	65.49 (54.02)	67.31 (55.14)	57.10 (49.08)	62.48 (52.20)	54.22 (47.43)	57.78 (49.47)	51.19 (45.68)	54.42 (47.56)	56.75	60.49
Endosulfan (0.05%)	60.82 (51.26)	63.48 (52.81)	47.62 (43.72)	54.20 (47.41)	50.89 (45.50)	48.42 (44.10)	42.30 (40.57)	50.08 (45.04)	50.39	53.99
Dimethioate (0.1%)	67.79 (55.42)	70.02 (56.50)	62.70 (52.36)	67.61 (55.31)	60.88 (51.28)	58.52 (49.91)	54.50 (47.58)	60.50 (51.06)	61.46	64.16
Carbaryl (0.1%)	56.38 (48.66)	58.88 (50.11)	44.02 (41.57)	50.40 (45.23)	42.88 (40.90)	47.11 (43.35)	39.10 (38.70)	47.01 (43.29)	45.59	50.85
Nemazol (1%)	63.42 (52.78)	65.58 (54.07)	52.92 (46.70)	56.62 (48.83)	50.52 (45.30)	54.71 (47.72)	43.38 (41.20)	52.88 (46.64)	52.56	57.44
Phosalone (0.05%)	69.02 (56.20)	73.22 (59.22)	65.40 (53.97)	70.68 (57.20)	64.72 (53.59)	68.62 (55.96)	60.09 (50.81)	65.08 (53.77)	64.80	69.40
S.Em.	1.63	2.32	0.89	1.42	2.05	2.76	1.03	0.70		
C.D. (0.05)	3.64	5.17	2.00	3.16	4.54	6.16	2.31	1.56		

Figures in parenthesis indicate angular transformation values

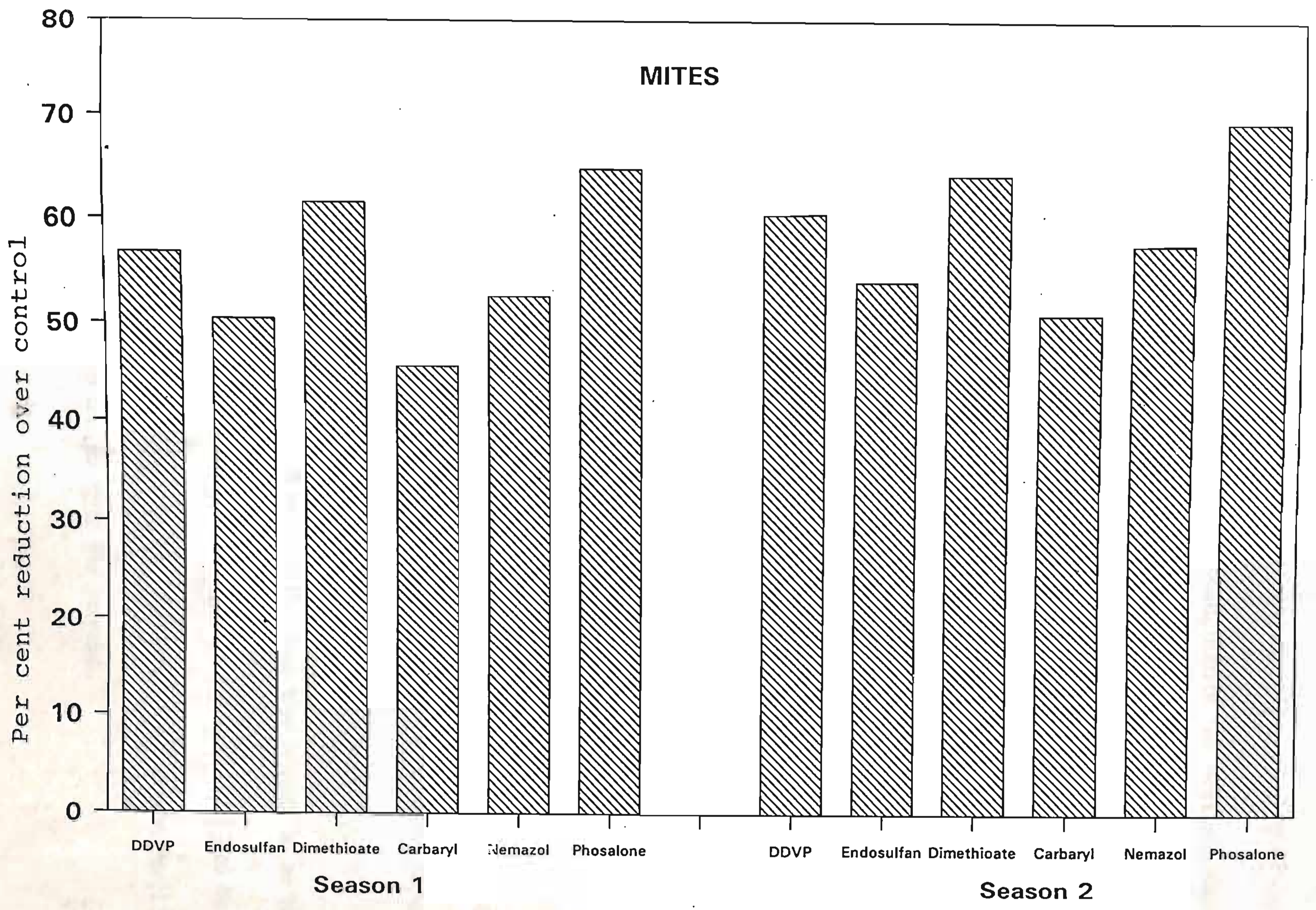

Fig.12: Relative efficacy of insecticides against mulberry mites during two seasons of 1996-97

4.2.2 Thrips

The results are presented in Table 7 and Fig.15. A decrease in the per cent reduction over control was observed with increase in the number of days after spraying. However, more than 34 per cent reduction in the pest population was noticed at 14 DAS with the insecticidal applications.

Per cent reduction in the pest population over control, 1 DAS ranged from 38.48 to 53.38 during first season and 40.98 to 55.68 during second season. However, at 3 DAS, it ranged from 34.18 to 47.28 during first season and 39.92 to 54.90 during second season, while at 7 DAS, per cent reduction in the pest population ranged from 36.09 to 46.17 during first season and 36.79 to 51.98 during second season. At 14 DAS, the per cent reduction ranged from 34.40 to 44.60 during first season and 34.42 to 47.70 during second season.

Greatest reduction in the pest population was noticed with application of phosalone (0.05%) during both the seasons at all days after spraying and overall, wherein it had recorded more than 47 per cent control of the pest population. DDVP (0.05%) was also observed to be on par with phosalone (0.05%), 1 DAS, during both the sesons. Further, dimethioate (0.1%) was also noticed to be effective and on par with phosalone (0.05%), upto 7 DAS. Carbaryl (0.1%) had however, recorded minimum per cent reduction of the pest population over control among the various insecticides studied during both the seasons.

Table 7: Efficacy of insecticides against mulberry thrips during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	48.42 (44.10)	48.80 (44.31)	42.22 (40.52)	46.60 (43.05)	40.41 (39.48)	44.31 (41.74)	38.51 (38.36)	40.41 (39.47)	42.39	45.02
Endosulfan (0.05%)	41.81 (40.29)	43.49 (41.26)	35.58 (36.60)	42.80 (40.86)	37.22 (37.60)	42.48 (40.67)	35.71 (36.70)	36.68 (37.26)	37.58	41.34
Dimethioate (0.1%)	48.32 (44.06)	53.78 (47.16)	45.38 (42.35)	51.58 (45.91)	44.02 (41.59)	47.18 (43.33)	40.82 (39.71)	41.58 (40.15)	44.63	48.53
Carbaryl (0.1%)	38.48 (38.32)	40.98 (39.81)	34.18 (35.77)	39.92 (39.19)	36.09 (36.91)	36.79 (37.34)	34.40 (35.91)	34.42 (35.94)	35.78	38.02
Nemazol (1%)	44.28 (41.70)	46.81 (43.18)	37.52 (37.78)	44.29 (41.72)	38.20 (38.17)	43.42 (41.24)	37.63 (37.85)	40.48 (39.50)	39.40	43.75
Phosalone (0.05%)	53.38 (45.92)	55.68 (48.85)	47.28 (43.43)	54.90 (47.81)	46.17 (43.15)	51.98 (46.12)	44.60 (41.90)	47.70 (43.68)	47.85	52.56
S.Em.	1.86	2.15	1.08	1.03	1.08	1.28	0.92	0.87		
C.D. (0.05)	4.15	4.80	2.40	2.30	2.42	2.85	2.05	1.96		

Figures in parenthesis indicate angular transformation values

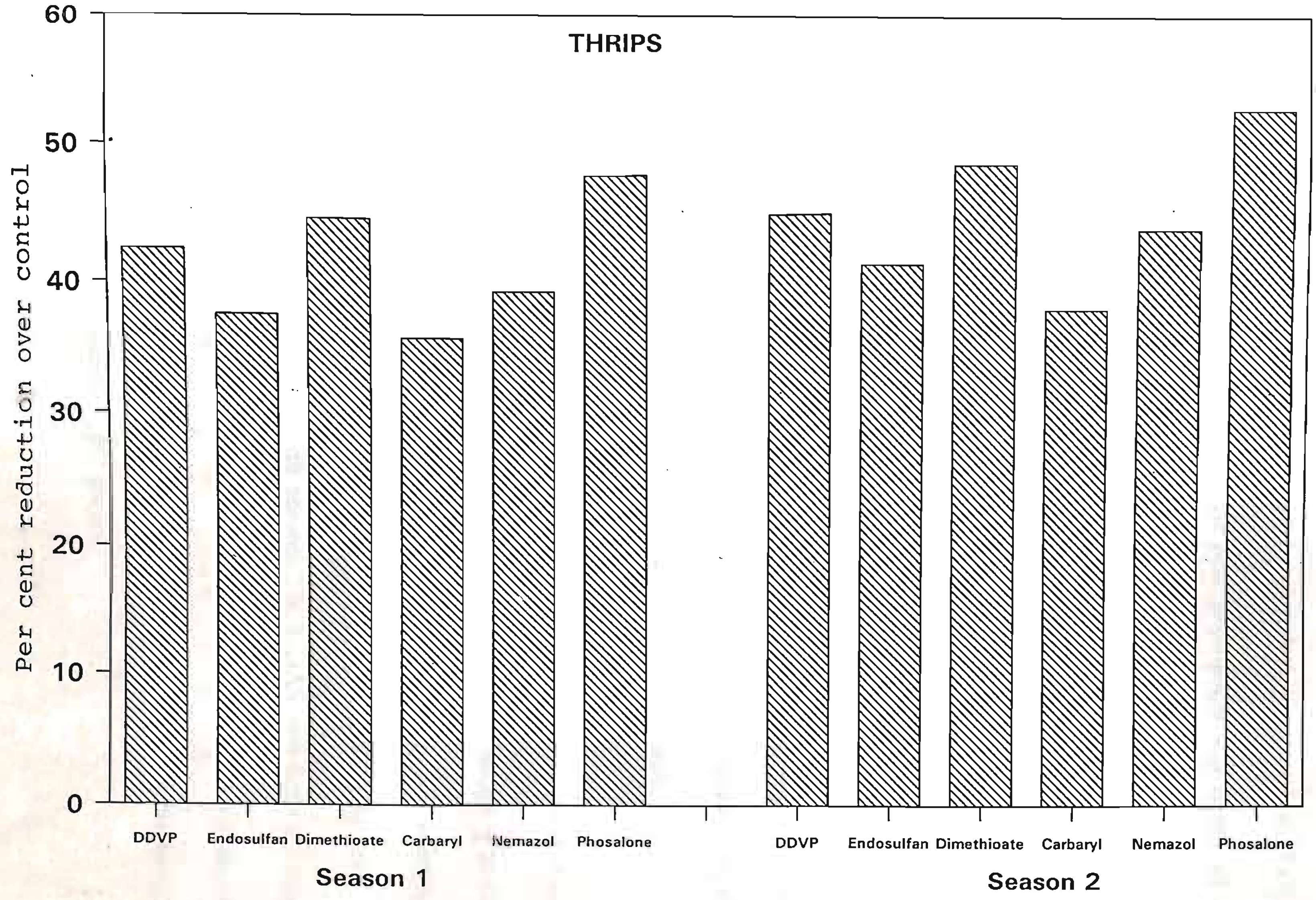

Fig.13: Relative efficacy of insecticides against mulberry thrips during two seasons of 1996-97

4.2.3 Leaf hoppers

Insecticidal applications against leaf hoppers of mulberry had resulted in more than 40 per cent reduction of the pest population over control (Table 8 and Fig.14). Further, a gradual buildup of the pest population was observed with an increase in the number of days after spraying.

The per cent reduction in pest population over control, 1 DAS ranged from 58.06 to 72.68 during first season and 60.42 to 77.42 during second season. However, at 3 DAS it ranged from 50.62 to 69.00 during first season and 54.13 to 75.00 during second seasons, while 7DAS, per cent reduction in the pest population ranged from 42.72 to 66.48 among first season and 48.02 to 70.02 during second season. At 14 DAS, the per cent reduction ranged from 42.62 to 59.21 during first season and 48.41 to 69.02 during second season.

The highest reduction in pest population was noticed with Phosolone (0.05%) application during both the seasons, at all days after spraying and overall, wherein it had recorded more than 66 per cent control of the pest. Application of Dimethioate (0.1%) had also recorded per cent reduction in population over control on par with Phosolone (0.05%) during season 2 at 1 DAS and both the seasons at 3 DAS and 14 DAS. Carbaryl (0.1%) had however, recorded minimum per cent reduction of the pest population over control, among the various insecticides studied, during both the seasons, at all stages.

Table 8: Efficacy of insecticides against leaf hoppers of mulberry during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	67.08 (54.97)	73.38 (58.90)	63.28 (52.70)	68.59 (55.91)	59.42 (50.46)	62.02 (51.96)	54.02 (47.31)	59.10 (50.24)	60.95	65.77
Endosulfan (0.05%)	62.80 (52.42)	62.20 (52.06)	52.72 (46.59)	57.41 (49.28)	49.10 (44.48)	54.62 (47.68)	46.31 (42.89)	48.00 (43.85)	52.73	55.55
Dimethioate (0.1%)	69.07 (56.19)	76.22 (60.21)	66.98 (54.93)	72.32 (58.26)	62.30 (52.12)	66.10 (54.39)	58.01 (49.62)	62.48 (52.23)	64.09	69.28
Carbaryl (0.1%)	58.06 (49.64)	60.42 (51.02)	50.62 (45.35)	54.13 (47.39)	42.72 (40.81)	48.02 (43.89)	42.62 (40.78)	48.41 (44.10)	48.50	52.74
Nemazol (1%)	66.94 (54.31)	70.92 (57.36)	58.94 (50.15)	64.42 (53.40)	47.62 (43.64)	58.90 (50.13)	46.39 (42.93)	52.60 (46.49)	54.97	61.71
Phosalone (0.05%)	72.68 (58.48)	77.42 (61.63)	69.00 (56.17)	75.00 (60.00)	66.48 (54.62)	70.02 (56.83)	59.21 (51.31)	69.02 (56.18)	66.84	72.86
S.Em.	0.96	1.14	1.90	1.75	1.12	1.04	0.88	1.80		
C.D. (0.05)	2.13	2.54	4.24	3.90	2.49	2.32	1.97	4.02		

Figures in parenthesis indicate angular transformation values

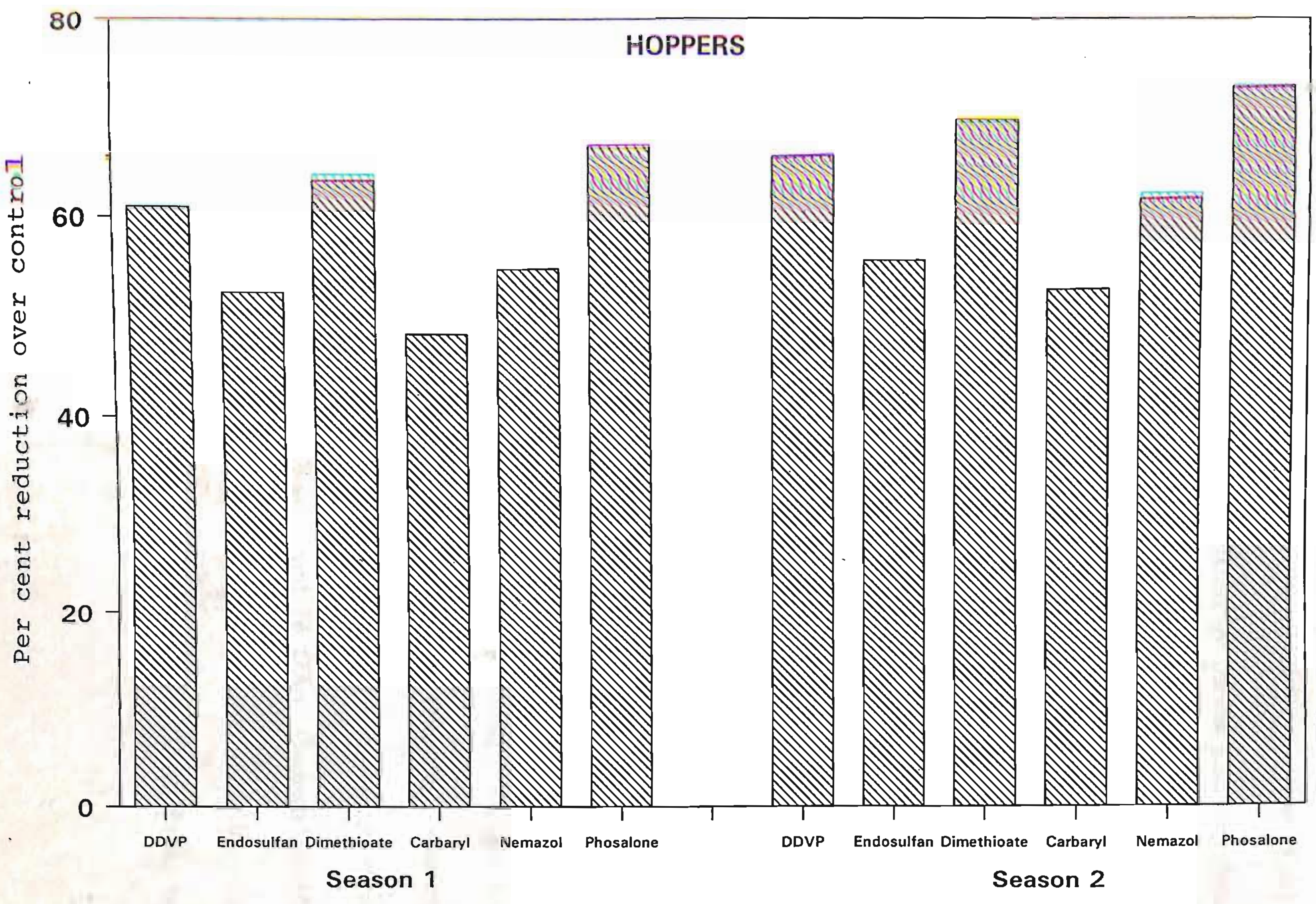

Fig.14: Relative efficacy of insecticides against leaf hoppers on mulberry during two seasons of 1996-97

4.2.4 Mealy bugs

The results are presented in Table 9 and Fig.15. A decrease in the per cent reduction over control was observed with increase in the number of days after spraying. However, more than 20 pr cent reduction in the pest population was noticed at 14 DAS with the insecticides.

Per cent reduction in the pest population over control, 1 DAS ranged from 42.61 to 66.50 during first season and 52.20 to 79.12 during second season. However, at 30 DAS, it ranged from 38.78 to 51.41 during first season and 44.40 to 68.00 during second season, while at 7 DAS, per cent reduction in the pest population ranged from 25.72 to 45.18 during first season and 33.71 to 50.70 during second season. At 14 DAS, the per cent reduction ranged from 20.84 to 36.49 during first season and 23.72 to 35.02 during second season.

Maximum reduction in the pest population was noticed with application of Phosolone (0.05%) during both the seasons at all days after spraing and overall where in it had recorded more than 50 per cent control of the pest. Application of Dimethioate (0.1%) was also observed to be statistically on par during season 1 at 1 DAS and 3 DAS; and season 2 at 7 and 14 DAS. Carbaryl (0.1%) and endosulfan (0.05%) had however, recorded minimum per cent reduction of the pest population over control among the various insecticides studied, during both the seasons, at all stages.

Table 9: Efficacy of insecticides against melay bugs on mulberry fields during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	50.71 (45.41)	65.81 (54.22)	43.00 (40.95)	51.38 (45.78)	35.29 (36.44)	41.52 (40.13)	27.21 (31.45)	26.22 (30.83)	39.05	46.23
Endosulfan (0.05%)	42.62 (40.76)	52.30 (46.32)	38.08 (38.10)	44.40 (41.78)	26.08 (30.70)	33.71 (35.51)	20.92 (27.24)	23.72 (29.17)	31.92	38.53
Dimethioate (0.1%)	65.02 (53.75)	72.11 (58.13)	46.62 (43.08)	58.92 (50.16)	40.22 (39.36)	45.98 (42.70)	20.84 (27.17)	32.12 (34.52)	43.17	52.28
Carbaryl (0.1%)	42.61 (40.75)	52.20 (46.26)	38.78 (38.50)	44.40 (41.78)	25.72 (30.49)	33.71 (35.51)	20.92 (27.24)	23.78 (29.17)	32.00	38.52
Nemazol (1%)	48.58 (44.18)	56.62 (48.81)	40.58 (39.55)	48.82 (44.35)	27.61 (31.70)	37.18 (37.49)	23.31 (28.87)	24.70 (29.80)	35.02	41.83
Phosalone (0.05%)	66.50 (54.63)	79.12 (62.82)	51.41 (45.82)	68.00 (55.55)	45.18 (42.22)	50.70 (45.40)	36.49 (37.16)	35.02 (36.30)	49.89	58.21
S.Em.	0.92	1.47	1.71	0.81	1.27	1.67	0.81	1.55		
C.D. (0.05)	2.05	3.29	3.81	1.80	2.83	3.72	1.81	3.45		

Figures in parenthesis indicate angular transformation values

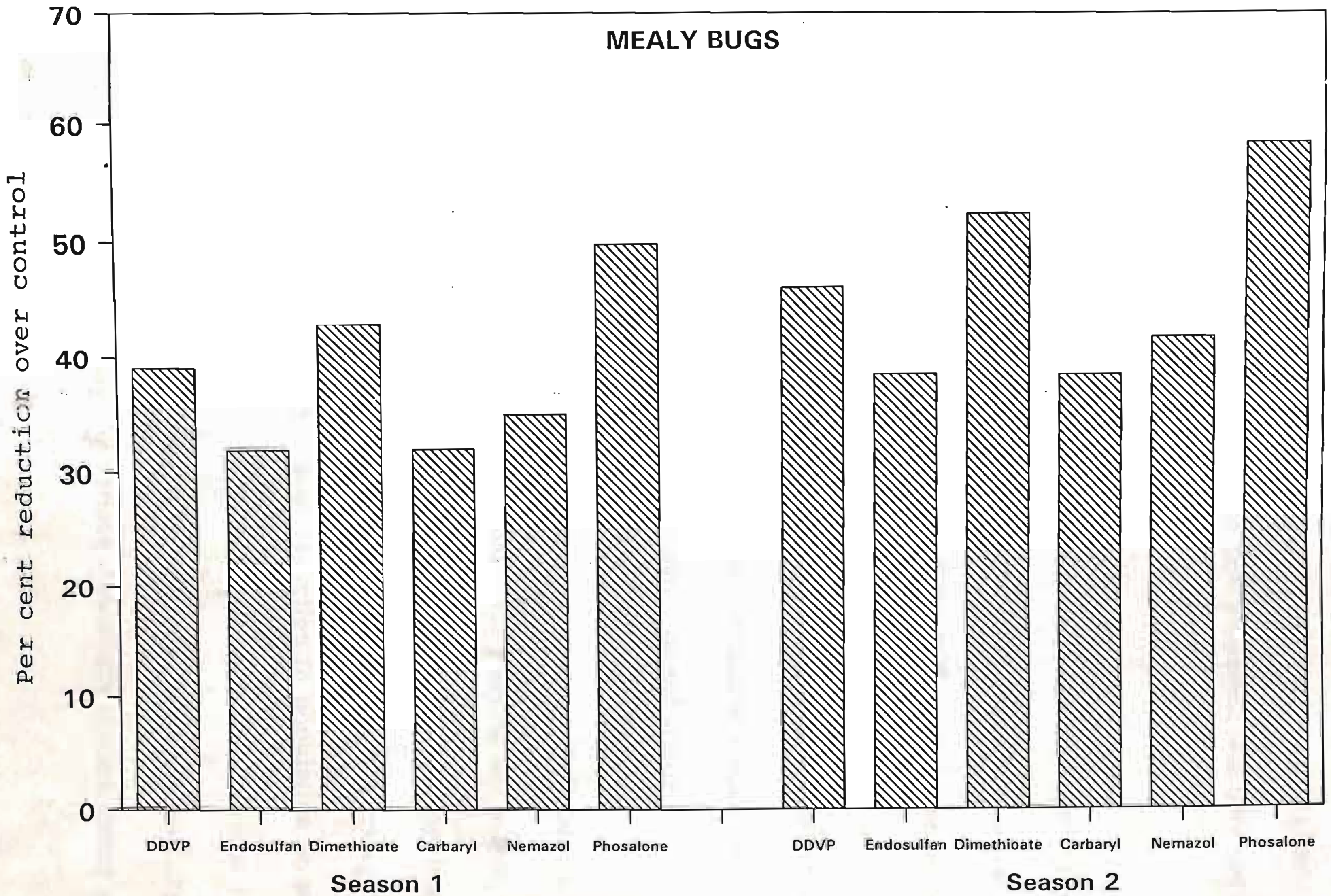

Fig.15: Relative efficacy of insecticides against mealy bugs on mulberry during two seasons of 1996-97

4.2.5 Aphids

Insecticidal applications against aphids of mulberry had resulted in more than 35 per cent reduction of the pest population over control (Table 10 and Fig.16). Further, a gradual build up of the pest population was observed with an increase in the number of days after spraying.

The per cent reduction in pest population over control, 1 DAS ranged from 46.29 to 67.09 during first season and 48.80 to 73.88 during second season. However, at 3 DAS, it ranged from 43.67 to 63.80 during first season and 46.46 to 68.98 during second season, while at 7 DAS per cent reduction in the pest population ranged from 41.19 to 58.07 during first season and 43.68 to 61.20 during second season. At 14 DAS, the per cent reduction ranged from 35.09 to 52.08 during first season and 39.49 to 57.08 during second season.

The highest reduction in pest population was noticed ith Phosolone (0.05%) application during both the seasons, at all days after spraying and overall, wherein it had recorded more than 60 per cent control of the pest. Application of Dimethioate (0.1%) during both the seasons at all days after spraying. Further, DDVP (0.05%) had recorded per cent reduction in population on par with Phosolone (0.05%) during season 1 at 7 DAS and both the seasons at 14 DAS. Carbaryl (0.1%) had however, recorded minimum per cent reduction of the pest population over control, among the various insecticides studied, during both the seasons at all stages.

Table 10: Efficacy of insecticides against mulberry aphids during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	58.47 (49.86)	61.16 (51.42)	55.20 (47.98)	58.18 (49.68)	53.26 (46.84)	55.58 (48.20)	48.29 (44.02)	52.98 (46.70)	53.80	56.97
Endosulfan (0.05%)	50.50 (45.29)	52.58 (46.47)	47.49 (43.56)	49.26 (44.55)	42.10 (40.45)	45.58 (42.45)	39.09 (38.69)	43.39 (44.20)	44.79	47.70
Dimethioate (0.1%)	62.87 (52.44)	69.27 (56.31)	57.68 (49.41)	67.48 (55.21)	56.70 (48.85)	58.80 (50.07)	50.88 (45.51)	54.30 (47.47)	57.03	62.46
Carbaryl (0.1%)	46.29 (42.87)	48.80 (44.31)	43.67 (41.34)	46.46 (42.95)	41.19 (39.92)	43.68 (41.36)	35.09 (36.30)	39.49 (38.93)	41.56	44.60
Nemazol (1%)	55.69 (48.26)	57.90 (49.55)	51.30 (45.74)	54.68 (47.68)	49.28 (44.58)	51.97 (46.11)	41.98 (40.39)	46.48 (42.97)	49.56	52.75
Phosalone (0.05%)	67.09 (54.95)	73.88 (59.26)	63.80 (53.01)	68.98 (56.13)	58.04 (49.62)	61.20 (51.47)	52.08 (46.18)	57.08 (49.04)	60.26	65.28
S.Em.	1.36	1.69	1.65	1.24	1.55	0.97	1.39	1.40		
C.D. (0.05)	3.04	3.78	3.68	2.77	3.46	2.17	3.10	3.13		

Figures in parenthesis indicate angular transformation values

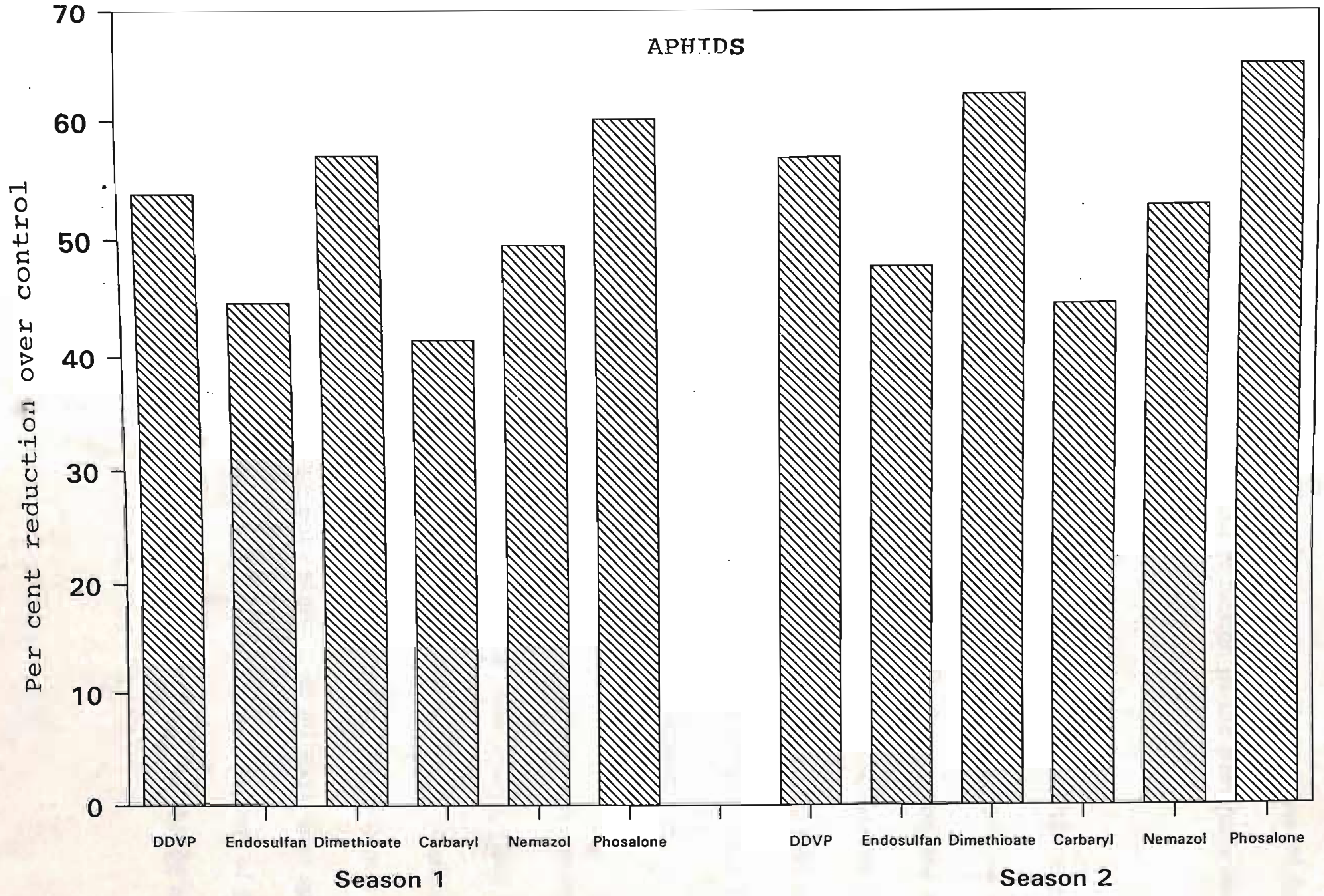

Fig.16: Relative efficacy of insecticides against mulberry aphids during two seasons of 1996-97

4.2.6 Bugs

The results are presented in Table 11 and Fig.17. A decrease in the per cent reduction over control was observed with increase in the number of days after spraying. However, more than 20 per cent reduction in the pest population was noticed at 14 DAS with the insecticides.

Per cent reduction in the pest population over control, 1 DAS ranged from 39.07 to 48.89 during first season and 42.26 to 52.20 during second season. However, at 3 DAS, it ranged from 30.36 to 45.50 during first season and 38.86 to 50.02 during second season, while at 7 DAS, per cent reduction in the pest population ranged from 26.08 to 40.89 during first season and 36.66 to 47.76 during second season. At 14 DAS, the per cent reduction ranged from 22.32 to 38.86 during first season and 31.09 to 45.36 during second season.

Maximum reduction in the pest population was noticed with application of Phosalone (0.05%) during both the seasons, at all days after spraying and overall, wherein it had recorded more than 43 per cent control of the pest. Application of Dimethioate (0.1%) had also recorded per cent reduction in population over control on par with Phosalone (0.05%) during both seasons, at all days after spraying. Carbaryl (0.1%) had however, recorded minimum per cent reduction of the pest population over control, among the various insecticides studied, during both the seasons, at stages.

Table 11: Efficacy of insecticides against bugs during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	44.22 (41.67)	48.86 (44.35)	39.82 (39.11)	44.98 (42.05)	35.66 (36.60)	43.37 (41.18)	34.36 (35.89)	40.38 (39.46)	38.51	44.39
Endosulfan (0.05%)	39.82 (39.10)	44.67 (41.92)	37.16 (37.54)	40.72 (39.63)	29.68 (32.99)	37.88 (37.97)	33.96 (35.64)	36.86 (37.38)	35.15	40.03
Dimethioate (0.1%)	46.60 (43.05)	50.70 (45.40)	42.20 (40.50)	46.78 (43.16)	38.66 (38.42)	45.56 (42.45)	36.66 (37.27)	42.28 (40.53)	41.03	46.33
Carbaryl (0.1%)	39.07 (38.66)	42.26 (40.55)	30.36 (33.42)	38.86 (38.56)	26.08 (30.67)	36.66 (37.26)	22.32 (28.17)	31.09 (33.88)	29.45	37.21
Nemazol (1%)	42.20 (40.50)	46.57 (43.03)	35.58 (36.56)	42.26 (40.53)	32.28 (34.60)	41.09 (39.86)	31.16 (33.92)	38.86 (38.56)	35.30	42.19
Phosalone (0.05%)	48.89 (44.35)	52.20 (46.26)	45.50 (42.41)	50.02 (45.00)	40.89 (39.73)	47.76 (43.70)	38.86 (38.56)	45.56 (42.45)	43.53	48.88
S.Em.	1.59	0.64	1.41	1.04	1.10	1.08	0.60	0.65		
C.D. (0.05)	3.55	1.44	3.15	2.33	2.47	2.41	1.34	2.45		

Figures in parenthesis indicate angular transformation values

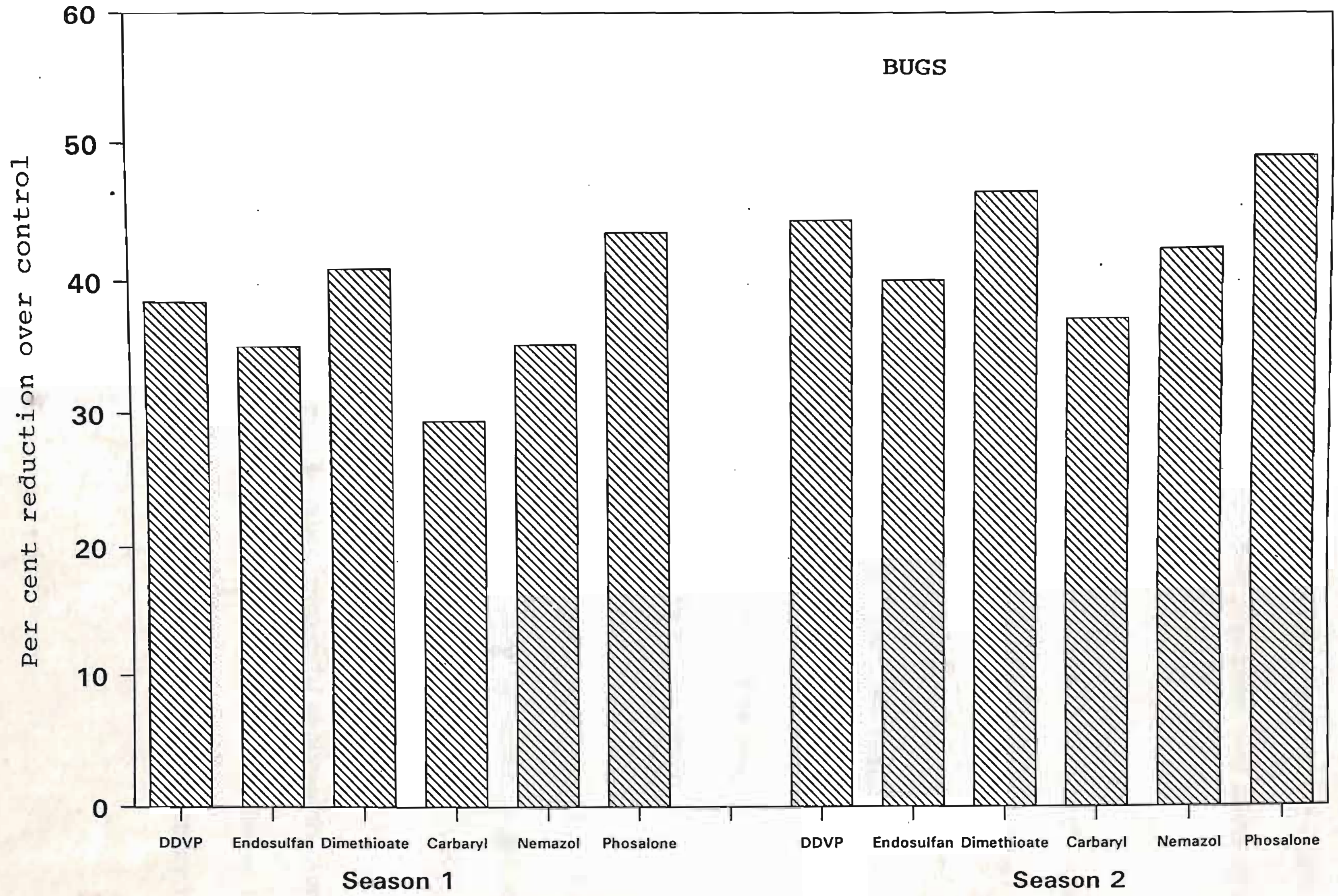

Fig.17: Relative efficacy of insecticides against bugs on mulberry during two seasons of 1996-97

4.2.7 Caterpillars

Insecticidal applications against caterpillars of mulberry had resulted in more than 32 per cent reduction of the pest population over control (Table 12 and Fig.18). Further, a gradual buildup of the pest population was observed with an increase in the number of days after spraying.

The per cent reduction in pest population over control, 1 DAS ranged from 43.19 to 82.78 during first season and 49.08 to 85.18 during second season. However, at 3 DAS, it ranged from 41.28 to 72.56 during first season and 43.20 to 77.28 during second season, while at 7 DAS per cent reduction in the pest population ranged from 35.78 to 62.09 during first season and 38.30 to 67.38 during second season. At 14 DAS, the per cent reduction ranged from 32.96 to 57.69 during first season and 34.88 to 59.19 during second season.

The highest reduction in pest population was noticed with DDVP (0.05%) during both seasons, at one and three days after spraying. Application of endosulfan (0.05%) was also observed to be statistically at par with DDVP (0.05%) during both seasons, 1 DAS and pest season 3 DAS. However, it was further superior at 7 and 14 DAS compared to other insecticidal applications. Application of Dimethioate (0.1%) had recorded minimum per cent reduction of the pest population over control, among the various insecticides studied, during both the seasons at all days after spraying.

Table 12: Efficacy of insecticides against leaf caterpillars on mulberry during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	82.78 (65.46)	85.18 (67.32)	72.76 (58.51)	77.28 (61.54)	55.58 (48.20)	62.88 (52.46)	50.38 (45.19)	56.38 (48.66)	65.37	70.43
Endosulfan (0.05%)	78.16 (62.12)	81.76 (64.70)	66.26 (54.46)	63.38 (52.73)	62.09 (51.97)	67.38 (55.16)	57.69 (49.41)	59.19 (50.29)	66.05	67.92
Dimethioate (0.1%)	43.19 (41.08)	49.08 (44.45)	41.28 (39.97)	43.20 (41.09)	35.78 (36.73)	38.30 (38.23)	32.96 (35.01)	34.88 (36.17)	38.30	41.36
Carbaryl (0.1%)	51.46 (45.32)	67.09 (54.97)	49.68 (44.80)	55.30 (48.04)	46.60 (43.05)	51.00 (45.57)	41.26 (39.94)	46.26 (42.85)	47.25	54.91
Nemazol (1%)	76.76 (61.18)	78.96 (62.67)	64.47 (53.39)	59.48 (50.44)	51.10 (45.63)	56.99 (49.00)	46.79 (43.16)	51.50 (45.86)	59.78	61.73
Phosalone (0.05%)	48.10 (43.91)	52.66 (46.51)	47.56 (43.58)	49.58 (44.75)	42.88 (40.89)	48.20 (43.97)	37.46 (37.71)	39.98 (39.20)	40.00	47.60
S.Em.	1.54	1.83	2.04	1.27	1.52	0.97	1.37	0.71		
C.D. (0.05)	3.44	4.09	4.57	2.83	3.39	2.16	3.07	1.60		

Figures in parenthesis indicate angular transformation values

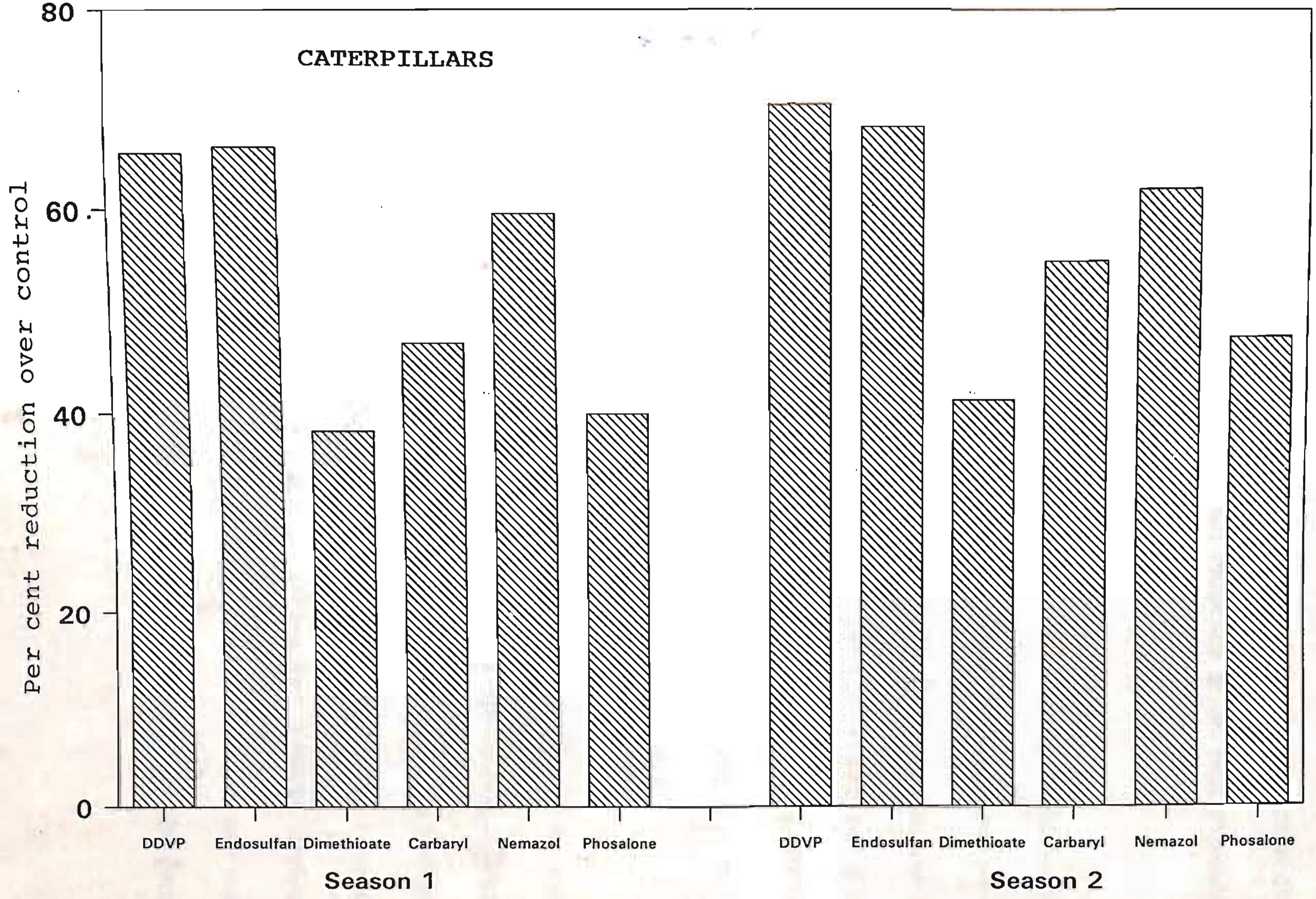

Fig.18: Relative efficacy of insecticides against leaf caterpillars on mulberry during two seasons of 1996-97

4.2.8 Grass hoppers

The results are presented in Table 13 and Fig.13. A decrease in the per cent reduction over control was observed with increase in the number of days after spraying. However, more than 33 per cent reduction in the pest population was noticed at 14 DAS with the insecticides.

Per cent reduction in the pest population over control, 1 DAS ranged from 46.76 to 77.16 during first season and 49.20 to 80.08 during second season. However, at 3 DAS, it ranged from 39.70 to 66.58 during first season and 46.50 to 67.36 during second season, while at 7 DAS, per cent reduction in the pest population ranged from 36.98 to 53.08 during first season and 44.08 to 53.96 during second season. At 14 DAS, the per cent reduction ranged from 33.08 to 42.60 during first season and 36.48 to 51.78 during second season.

Maximum reduction in the pest population was noticed with the application of DDVP (0.05%) at 1 and three days after spraying. Application of Endosulfan (0.05%) was also observed to be statistically at par with DDVP (0.05%) during both seasons, at one and three days after spraying. However, it was superior at 7 and 14 DAS, compared to other insecticidal applications. Further, application of Dimethioate (0.1%) and Phosolone (0.05%) had recorded lower per cent reductions of pest population over control, compared to other insecticides studied during both the seasons at all days after spraying.

Table 13: Efficacy of insecticides against mulberry grass hoppers during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	77.16 (61.47)	80.08 (63.45)	66.58 (54.67)	67.36 (55.13)	47.08 (43.33)	49.46 (44.69)	38.88 (38.58)	44.66 (41.91)	57.42	60.39
Endosulfan (0.05%)	75.48 (60.32)	78.06 (62.04)	60.68 (51.16)	62.76 (52.40)	53.08 (46.76)	53.96 (47.28)	42.60 (40.74)	51.78 (46.01)	57.96	61.64
Dimethioate (0.1%)	46.76 (43.16)	49.20 (44.54)	42.38 (40.62)	48.86 (44.35)	36.98 (37.44)	44.08 (41.59)	33.57 (35.41)	36.66 (37.28)	39.92	44.70
Carbaryl (0.1%)	55.08 (47.92)	56.30 (48.62)	52.08 (46.17)	52.27 (46.28)	42.36 (40.59)	48.26 (43.99)	37.48 (37.74)	42.06 (42.16)	46.75	49.72
Nemazol (1%)	53.38 (46.93)	67.08 (54.99)	47.66 (43.66)	53.06 (46.74)	44.79 (42.01)	47.96 (43.83)	37.98 (38.04)	43.79 (41.43)	45.95	52.97
Phosalone (0.05%)	47.60 (43.62)	52.50 (46.43)	39.70 (39.06)	46.50 (42.99)	38.88 (38.54)	44.96 (42.09)	33.08 (35.10)	36.48 (37.14)	39.81	45.11
S.Em.	0.56	1.81	1.59	1.23	0.92	0.98	0.96	1.47		
C.D. (0.05)	1.26	4.04	3.55	2.75	2.07	2.18	2.16	3.28		

Figures in parenthesis indicate angular transformation values

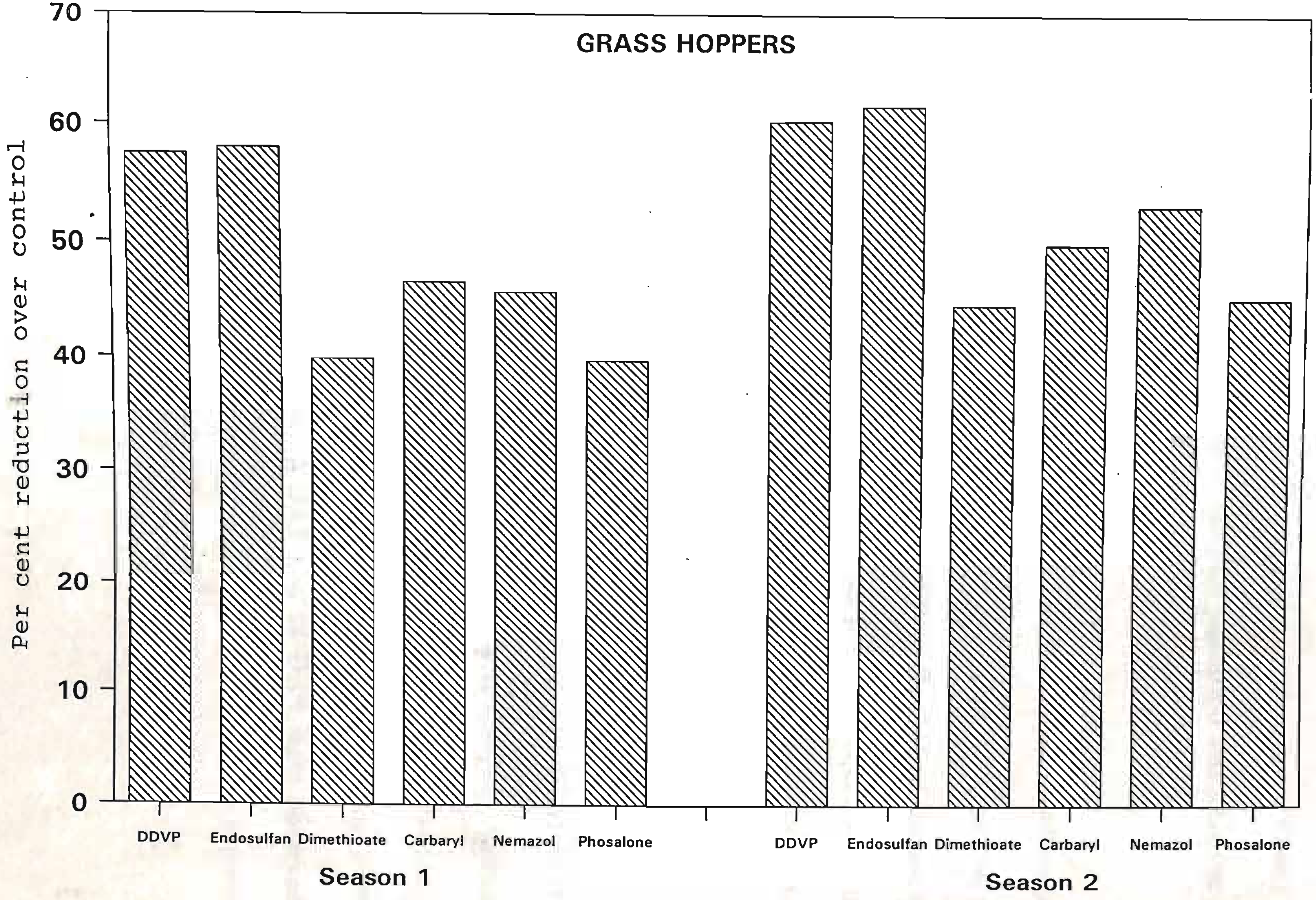

Fig.19: Relative efficacy of insecticides against mulberry grass hoppers during two seasons of 1996-97

4.2.9 Weevils

Insecticidal applications against weevils of mulberry had resulted in more than 39 per cent reduction of the pest population over control (Table 14 and Fig.20). Further, a gradual build up of the pest population was observed with an increase in the number of days after spraying.

The per cent reduction in pest population over control, 1 DAS ranged from 48.90 to 61.68 during first season and 51.00 to 67.66 during second season. However, at 3 DAS, it ranged from 47.08 to 59.20 during first season and 47.30 to 65.10 during second season, while at 7 DAS per cent reduction in the pest population ranged from 44.08 to 57.59 during first season and 46.68 to 63.78 during second season. At 14 DAS, the per cent reduction ranged from 39.29 to 49.36 during first season and 41.96 to 60.88 during second season.

Greatest reduction in pest population was noticed with DDVP (0.05%) and Endosulfan (0.05%) during both seasons at all days after spraying. Application of Dimethioate (0.1%) had however, recorded minimum per cent reduction of the pest population over control, during both seasons at all days after spraying. Further, the effects of Phosolone (0.05%) at 7 DAS and 14 DAS were observed to be statistically at par with Dimethioate (0.1%). Similar effects were observed with insecticidal application of carbaryl (0.1%) at 7 DAS.

Table 14: Efficacy of insecticides against weevils on mulberry during two seasons of 1996-97

Treatments	Per cent reduction over control									
	1 DAS		3 DAS		7 DAS		14 DAS		Overall efficacy	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	61.68 (51.73)	67.66 (55.31)	59.26 (50.31)	65.10 (53.79)	55.58 (48.20)	60.08 (50.80)	45.90 (42.65)	57.28 (49.16)	53.85	62.53
Endosulfan (0.05%)	60.00 (51.35)	64.99 (53.71)	56.19 (48.54)	62.66 (52.32)	57.59 (49.36)	63.78 (52.98)	49.36 (44.61)	60.88 (51.26)	55.78	63.07
Dimethioate (0.1%)	48.90 (44.37)	51.00 (45.57)	47.08 (43.32)	47.30 (43.45)	44.08 (41.57)	46.68 (43.09)	39.29 (38.81)	41.96 (40.35)	44.83	46.73
Carbaryl (0.1%)	58.58 (49.91)	58.09 (49.64)	52.10 (46.20)	54.28 (47.43)	46.36 (42.89)	50.08 (45.04)	43.68 (41.36)	47.60 (43.62)	50.18	52.51
Nemazol (1%)	57.66 (49.39)	60.26 (50.91)	52.38 (46.34)	56.37 (48.64)	49.50 (44.71)	54.70 (47.70)	43.98 (41.54)	52.58 (46.47)	50.88	55.97
Phosalone (0.05%)	53.88 (47.21)	55.78 (48.29)	50.46 (45.25)	52.29 (46.31)	45.26 (42.26)	49.60 (44.77)	41.99 (40.39)	44.57 (41.87)	47.89	50.56
S.Em.	0.48	1.41	1.63	0.92	1.09	1.61	1.11	1.38		
C.D. (0.05)	1.07	3.14	3.64	2.05	2.43	3.59	2.49	3.08		

Figures in parenthesis indicate angular transformation values

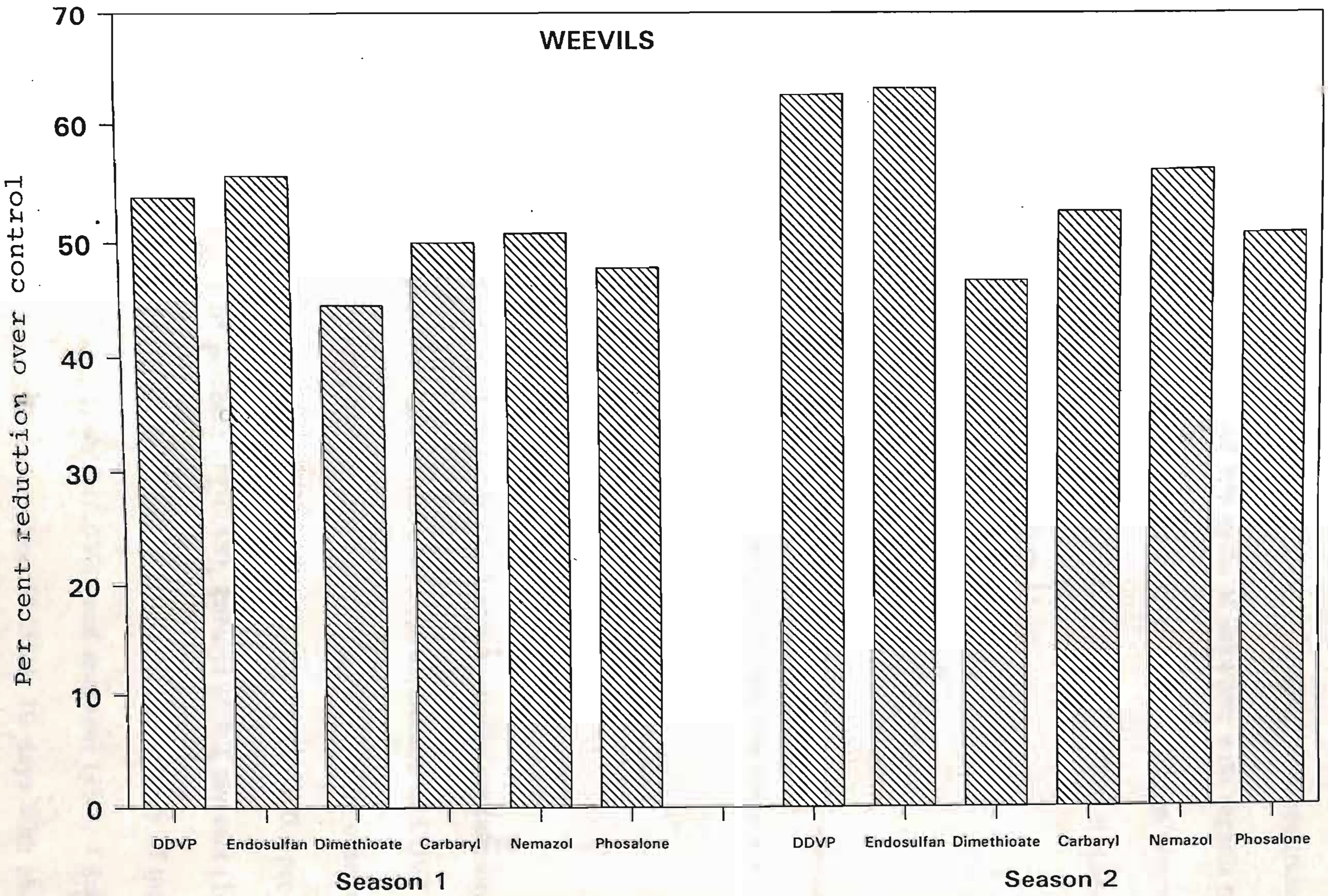

Fig.20: Relative efficacy of insecticides against weevils on mulberry during two seasons of 1996-97

4.3 EFFECT OF INSECTICIDAL APPLICATIONS ON BIOLOGY AND LIFE CYCLE OF SILKWORM

Studies were made on the effect of feeding mulberry leaves treated with different insecticides on biology and life cycle of silkworm with regards to larval mortality, duration and weight, pupal duration and weight, cocoon weight, shell weight and ratio, length and weight of reeled silk and denier during two seasons of 1996-97 and the results are presented in Tables 15-29.

4.3.1 Larval mortality

The effect of feeding mulberry leaves treated with various insecticides on the larval mortality of different instars of silkworm during two seasons of 1996-97 are presented in Tables 15-19.

4.3.1.1 First instar larvae

The results are presented in Table 15. Larval mortality considerably higher than control was observed for a short period with the application of DDVP @ 0.05 per cent (4 DAS) and Nemazol @ 1 per cent (2 DAS), while it was observed for a considerably long period with the application of Dimethioate @ 0.1 per cent (9 DAS), endosulfan @ 0.05 per cent (11 DAS), carbaryl @ 0.1 per cent (14 DAS) and phosalone @ 0.05 per cent (14 DAS). 100 per cent mortality of the larvae was observed for 1 day with DDVP (0.05%) and nemazol (1%), 4 days with dimethioate (0.1%), 5 days with endosulfon (0.05%), 10 days with phosalone

.e 15: Insecticidal toxicity with regards to mortality per cent of silkworm first instar larvae during two seasons of 1996-97

	Days after spraying															
	1		2		3		4		5		6		7		8	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
)VP (0.05%)	100.00	100.00	47.33	58.66	22.66	37.33	15.33	20.33	3.33	6.33	5.00	4.00	5.33	4.66	8.66	3.66
ndosulfan (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	89.33	96.66	77.66	85.00	70.00	82.00
)imethioate (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.00	94.66	81.33	86.33	70.33	75.33	60.66	65.66
Carbaryl (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nemazol (1%)	100.00	100.00	37.66	42.00	3.66	4.66	2.66	2.33	4.33	4.00	6.00	3.33	2.66	4.66	3.66	5.66
Phosalone (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Control	3.66	2.00	6.33	6.33	5.00	4.66	3.33	3.00	6.66	5.33	8.66	2.66	4.00	4.00	2.33	2.66

	Days after spraying													
	9		10		11		12		13		14		15	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
)VP (0.05%)	3.00	3.66	7.33	4.33	2.66	3.66	4.33	5.00	3.33	9.66	3.00	7.66	3.66	3.
ndosulfan (0.05%)	68.66	76.33	52.66	65.66	39.66	46.33	2.33	4.00	8.66	4.00	2.33	4.00	7.00	3.6
)imethioate (0.1%)	50.33	59.33	6.66	3.66	5.33	8.66	5.33	3.33	2.00	4.00	5.33	4.00	8.66	4.0
Carbaryl (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	79.33	87.33	68.66	62.66	54.66	44.33	2.00	3.0
Nemazol (1%)	4.00	5.00	8.66	7.66	6.33	7.33	4.33	3.66	8.66	3.66	4.00	3.00	5.33	6.6
Phosalone (0.05%)	100.00	100.00	100.00	100.00	90.33	89.00	82.00	72.66	70.00	65.35	55.00	47.00	0.00	0.0
Control	5.66	3.66	7.00	6.00	3.33	5.33	6.00	2.66	5.66	5.00	4.33	3.66	6.66	6.3

S_1 - Season 1 (August 1996 - January 1997); S_2 - Season 2 (February 1997 - July 1997)

(0.05%) and 11 days with carbaryl (0.1%). Further, a drastic reduction in the mortality per cent was observed with DDVP (0.05%) and nemazol (1%) application from the second day onwards, while a gradual decrease in the mortality per cent was observed after several days with other insecticidal applications. Mortality of less than 10 per cent was also observed in the control through out the period of study.

4.3.1.2 Second instar larvae

The results are presented in Table 16. Larval mortality considerably higher than control was observed for a short period with the application of nemazol @ 1 per cent (2 DAS) and DDVP @ 0.05 per cent (4 DAS), while it was observed for a considerably long period with the application of dimethioate @ 0.1 per cent (9 DAS), endosulfon @ 0.05 per cent (11 DAS), carbaryl @ 0.1 per cent (14 DAS) and phosalone @ 0.05 per cent (14 DAS). 100 per cent mortality of the larvae was observed for 1 day with DDVP (0.05%) and nemazol (1%), 4 days with dimethioate (0.1%), 5 days with endosulfon (0.05%), 10 days with phosalone (0.05%) and 11 days with carbaryl (0.1%). Further, a drastic reduction in the mortality per cent was observed with DDVP (0.05%) and nemazol (1%) application from the second day onwards, while a gradual decrease in the mortality per cent was observed after several days with other insecticidal applications. Mortality of less than 10 per cent was also observed in the control through out the period of study.

Table 16: Insecticidal toxicity with regards to mortality per cent of silkworm second instar larvae during two seasons of 1996-97

	Days after spraying																													
	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
DDVP (0.05%)	100.00	100.00	49.00	52.00	28.00	31.00	16.00	18.66	6.33	2.66	4.33	2.66	4.66	4.00	4.33	5.00	3.66	4.33	5.66	4.00	3.66	8.66	5.00	8.00	4.00	3.66	4.66	3.66	4.33	5.3
Endosulfan (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.00	92.66	73.66	79.33	70.00	76.00	67.66	71.00	55.00	60.66	39.66	40.33	6.66	6.00	2.33	4.00	7.66	3.66	4.00	7.0
Dimethioate (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	87.66	90.33	78.00	82.66	65.66	70.00	57.00	61.00	48.66	52.00	6.66	2.66	3.33	5.00	4.66	6.66	5.33	3.33	4.00	3.66	2.33	3.6
Carbaryl (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	78.66	82.00	62.00	67.66	47.00	59.00	6.66	2.6
Nemazol (1%)	100.00	100.00	32.93	37.66	3.66	4.44	3.00	2.66	4.66	5.66	5.33	6.00	4.00	5.33	7.00	6.66	4.33	6.66	7.66	2.66	4.00	5.33	5.00	4.66	6.66	4.33	5.33	3.66	3.33	5.0
Phosalone (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	82.00	88.66	76.66	81.33	69.66	73.66	51.33	58.66	6.66	8.0
Control	5.33	6.33	2.66	3.66	7.66	7.66	3.66	3.66	6.33	2.33	4.00	6.33	3.66	3.66	6.33	8.33	2.66	5.66	3.33	4.33	8.66	5.66	4.33	6.00	7.66	4.66	3.33	8.00	5.33	5.6

S_1 - Season 1 (August 1996 - January 1997); S_2 - Season 2 (February 1997 - July 1997)

4.3.1.3 Third instar larvae

The results are presented in Table 17. Larval mortality considerably higher than control was observed for a relatively short period with the application of nemazol @ 1 per cent (2 DAS) and DDVP @ 0.05 per cent (4 DAS), while it was observed for a considerably long period with the application of dimethioate @ 0.1 per cent (6 DAS), endosulfon @ 0.05 per cent (7 DAS), carbaryl @ 0.1 per cent (11 DAS) and phosalone @ 0.05 per cent (11 DAS). 100 per cent mortality of the larvae was observed for 1 day with DDVP (0.05%) and nemazol (1%), 3 days with endosulfon (0.05%) and dimethioate (0.1%), and 8 days with carbaryl (0.1%) and phosalone (0.05%). Further, a drastic reduction in the mortality per cent was observed with DDVP (0.05%) and nemazol (1%) application from the second day onwards, while a gradual decrease in the mortality per cent was observed after several days with other insecticidal applications. Mortality per cent of less than 10 was also observed in the control throughout the period of study.

4.3.1.4 Fourth instar larvae

The results are presented in Table 18. Larval mortality considerably higher than control was observed for a short period with the application of nemazol @ 1 per cent (2 DAS) and DDVP @ 0.05 per cent (4 DAS), while it was observed for a considerably long period with the application of dimethioate @ 0.1 per cent (6 DAS), endosulfon @ 0.05 per cent (7 DAS), carbaryl @ 0.1 per cent (11 DAS) and phosalone @ 0.05 per cent (11 DAS). 100 per cent mortality of the larvae

Table 17: Insecticidal toxicity with regards to mortality per cent of silkworm third instar larvae during two seasons of 1996-97

Days after spraying

	1		2		3		4		5		6		7		8	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
DDVP (0.05%)	100.00	100.00	46.00	48.00	22.00	27.00	13.00	15.33	3.33	2.66	6.00	5.33	2.66	3.33	6.00	4.00
Endosulfan (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	88.66	92.66	79.33	84.33	67.66	78.33	55.33	60.66	4.33	3.66
Dimethioate (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	81.33	89.66	70.66	78.66	57.66	65.33	3.66	2.66	4.00	2.66
Carbaryl (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nemazol (1%)	100.00	100.00	30.66	33.66	4.66	2.66	6.00	5.00	5.66	2.00	2.66	7.00	6.66	4.00	5.33	6.00
Phosalone (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Control	8.66	6.00	4.00	4.66	3.33	8.33	6.00	5.66	8.33	2.00	2.66	7.66	5.00	5.33	7.66	6.00

	9		10		11		12		13		14		15	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
DDVP (0.05%)	3.66	4.00	2.66	4.66	6.00	4.00	5.00	3.33	2.33	3.66	8.66	4.00	3.00	5.3
Endosulfan (0.05%)	7.33	4.66	5.66	3.66	3.00	4.33	5.00	3.66	4.66	4.00	7.00	6.33	3.66	3.0
Dimethioate (0.1%)	7.33	4.66	6.00	2.66	5.33	8.66	3.33	4.66	4.33	5.33	3.66	6.00	3.33	4.0
Carbaryl (0.1%)	86.33	91.33	77.66	82.66	68.33	76.33	6.66	3.00	5.00	4.66	4.00	6.00	4.33	2.0
Nemazol (1%)	4.66	7.33	2.00	7.33	4.33	3.33	8.66	5.00	2.66	3.00	6.66	8.66	4.00	5.0
Phosalone (0.05%)	89.66	94.33	72.33	80.68	62.66	72.00	4.00	3.66	5.00	4.66	8.66	7.33	5.00	2.6
Control	3.33	3.66	5.66	6.00	7.33	5.33	3.66	8.66	6.33	4.00	8.66	3.66	4.33	5.3

S_1 - Season 1 (August 1996 - January 1997); S_2 - Season 2 (February 1997 - July 1997)

Table 18: Insecticidal toxicity with regards to mortality per cent of silkworm fourth instar larvae during two seasons of 1996-97

	Days after spraying																													
	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
DDVP (0.05%)	100.00	100.00	39.66	42.00	17.00	22.00	10.00	12.00	3.33	4.00	3.33	8.66	5.00	6.66	3.66	4.00	2.66	6.00	4.00	4.66	4.00	4.33	3.00	4.66	7.00	3.33	2.00	2.66	4.00	3.
Endosulfan (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	82.66	88.00	76.66	81.66	66.33	73.66	47.66	54.33	2.66	8.66	2.00	3.66	8.66	4.33	8.00	7.66	6.66	5.00	6.00	4.00	5.00	4.00	4.33	2.
Dimethioate (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	76.66	80.66	62.66	70.33	54.33	60.33	9.66	3.66	8.66	7.66	4.66	5.33	6.00	3.66	2.66	4.00	8.66	4.66	5.66	4.33	4.66	3.66	4.00	5.
Carbaryl (0.1%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.00	95.33	79.66	83.66	71.66	78.33	60.33	67.33	56.66	62.66	3.66	2.66	4.00	5.33	5.00	2.66	3.66	2.
Nemazol (1%)	100.00	100.00	27.66	30.66	2.66	8.00	3.33	8.66	4.33	7.00	5.33	4.66	4.00	4.33	5.33	5.00	5.33	5.00	2.00	4.66	8.66	6.33	3.33	3.66	4.00	5.33	2.66	5.66	3.66	7.
Phosalone (0.05%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.66	92.66	81.33	87.00	76.00	82.66	72.66	78.33	63.33	70.66	6.60	5.66	3.66	4.33	3.33	6.00	4.00	3.
Control	3.00	7.33	5.00	3.68	8.00	4.66	2.00	6.66	7.00	3.33	5.00	5.66	2.00	4.33	4.00	3.00	6.00	2.66	8.00	3.66	3.00	7.00	5.00	8.66	4.00	5.33	6.00	4.66	8.00	3.

S_1 - Season 1 (August 1996 - January 1997); S_2 - Season 2 (February 1997 - July 1997)

was observed for 1 day with DDVP (0.05%) and nemazol (1%), 3 days with endosulfon (0.05%) and dimethioate (0.1%) and 6 days with carbaryl (0.1%) and phosalone (0.05%). Further, a drastic reduction in the mortality per cent was observed with DDVP (0.05%) and nemazol (1%) application from the second day onwards, while a gradual decrease in the mortality per cent was observed after several days with other insecticidal applications. Mortality of less than 10 per cent was also observed in the control throughout the period of study.

4.3.1.5 Fifth instar larvae

The results are presented in Table 19. Larval mortality considerably higher than control was observed for a relatively short period (2 DAS) with the application of nemazol (1%) and DDVP (0.05%), while it was observed for a considerably long period with the application of dimethioate @ 0.1 per cent (3 DAS), endosulfon @ 0.05 per cent (4 DAS), carbaryl @ 0.1 per cent (8 DAS) and phosalone @ 0.05 per cent (8 DAS). 100 per cent mortality of the larvae was observed for 1 day with DDVP (0.05%) and nemazol (1%), 2 days with dimethioate (0.1%), 3 days with endosulfon (0.05%), 5 days with phosalone (0.05%) and 6 days with carbaryl (0.1%). Further, a drastic reduction in the mortality per cent was observed with DDVP (0.05%) and nemazol (1%) application from the second day onwards, while a relatively gradual decrease in the mortality per cent was observed later with other insecticidal applications. Mortality per cent of less than 10 was also observed in the control through out the period of study.

19: Insecticidal toxicity with regards to mortality per cent of silkworm fifth instar larvae during two seasons of 1996-97

	Days after spraying																													
	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
(0.05%)	100.00	100.00	32.00	38.00	2.66	3.00	2.66	4.66	5.33	6.66	8.00	4.00	3.66	2.66	4.00	2.00	3.66	3.00	2.66	3.33	6.66	6.00	6.66	5.00	5.66	4.00	4.66	3.66	4.00	6.00
ulfan %)	100.00	100.00	100.00	100.00	100.00	100.00	40.33	46.33	6.66	3.00	4.00	5.00	8.66	2.66	3.66	4.00	4.66	6.66	2.00	3.66	5.00	4.00	2.66	3.33	2.00	6.66	6.00	5.00	6.60	3.33
hioate)	100.00	100.00	100.00	100.00	48.00	52.66	2.00	3.33	2.66	4.00	5.00	6.66	5.00	2.66	3.33	6.66	8.00	7.00	7.33	6.00	5.66	6.33	5.00	2.00	2.66	5.66	6.66	3.33	5.66	6.66
ryl)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	68.00	72.00	46.66	57.33	2.66	3.00	2.66	3.66	4.00	8.00	3.33	2.00	2.66	5.00	6.66	3.00	5.00	3.33
ol	100.00	100.00	20.66	28.00	3.33	2.00	3.00	6.66	3.00	6.66	5.00	6.66	2.00	3.33	4.00	2.66	4.00	6.66	2.00	3.33	6.00	5.66	4.00	3.33	4.00	6.66	4.33	3.66	3.66	4.00
lone %)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.66	65.00	48.55	52.66	38.66	45.66	2.66	4.33	2.66	3.66	4.00	6.66	3.33	4.00	5.00	6.66	3.00	6.66	4.00	5.66
ol	6.33	3.66	5.00	5.33	4.66	8.66	2.33	6.00	3.33	4.66	5.00	3.66	6.66	2.33	7.33	4.66	5.66	7.33	4.33	6.66	3.66	5.33	5.33	7.66	3.66	8.33	8.66	3.66	6.33	4.00

Season 1 (August 1996 - January 1997); S_2 - Season 2 (February 1997 - July 1997)

4.3.2 Larval duration

The results are presented in Table 20. Feeding of first instar larvae with insecticide treated leaves was observed to result in an increase of larval duration. Maximum larval duration of 4.66 and 4.33 days during first and second seasons, respectively was recorded with phosalone (0.05%), while DDVP (0.05%), endosulfon (0.05%) and nemazol (1%) recorded low larval duration, compared to other insecticidal treatments.

An increase in larval duration of the second instar larvae was also noticed, upon feeding with insecticide treated leaves. Maximum larval duration of 5.33 and 5.60 days during first and second seasons, respectively was recorded with phosalone (0.05%), while DDVP (0.05%) treatment recorded larval duration, similar to that of control during both the seasons. Nemazol (1%) had also recorded similar larval duration compared to control during season 1.

Feeding of the third instar larvae with insecticide treated leaves also resulted in increased larval duration. Greater increase was noticed for carbaryl (0.1%) and phosalone (0.05%) insecticides, while relatively lower increase was observed with nemazol (0.1%) application.

Increase in the larval duration of fourth instar larvae was also observed with all insecticides studied in the present investigation. Maximum increase was recorded with carbaryl (0.1%) and phosalone (0.05%), while small increases were

Table 20: Effect of insecticidal sprayings on silkworm larval duration during two seasons of 1996-97 (days)

Treatments	Larval duration (days)									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	4.00	3.66	4.33	4.00	5.00	4.66	5.66	5.33	7.33	6.66
Endosulfan (0.05%)	4.00	3.66	4.66	4.33	5.00	4.66	5.33	5.00	7.00	6.66
Dimethioate (0.1%)	4.33	4.00	4.66	4.33	5.00	4.66	5.00	5.33	7.00	6.66
Carbaryl (0.1%)	4.33	4.00	5.06	4.66	6.33	6.00	6.33	6.66	8.33	7.33
Nemazol (1%)	4.00	3.66	4.33	4.66	4.66	4.66	5.33	5.00	6.33	6.00
Phosalone (0.05%)	4.66	4.33	5.33	5.00	6.33	5.66	6.33	6.00	7.66	7.33
Control	3.66	3.33	4.33	4.00	4.66	4.33	5.00	4.66	6.33	6.00

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

recorded with nemazol (1%) endosulfon (0.05%) and dimethioate (0.1%) insecticidal applications.

Feeding of the fifth instar larvae with insecticide treated leaves also resulted in increased larval duration, compared to control. The increase was high with carbaryl (0.1%) treatment, followed by phosalone (0.05%). It was however, relatively low with nemazol (1%).

4.3.3 Larval weights

The results are presented in Table 21. Feeding of fourth and fifth instar larvae with insecticide treated leaves was observed to effect their weights. However, the effect varied with the insecticide. A marginal and non-significant increase in larval weights was observed with DDVP (0.05%) and nemazol (1%) insecticidal applications, during both seasons, for both instars, while a marginal and non-significant reduction in the larval weights was noticed with endosulfon (0.05%) application. However, a significant decrease in the larval weights was recorded with dimethioate (0.1%), carbaryl (0.1%) and phosalone (0.05%) insecticidal applications, during both seasons for both instars.

4.3.4 Pupal duration

The effect of feeding insecticide treated leaves to silkworm larvae of different instars was studied with regards to their pupal duration, during two seasons of 1996-97 and the results are presented in Table 22.

Table 21: Effect of insecticidal sprayings on larval weights of fourth and fifth instar silkworm larvae

Treatments	Subjected Larvae			
	4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	46.15	44.66	123.11	120.00
Endosulfan (0.05%)	43.14	41.18	118.76	113.22
Dimethioate (0.1%)	40.65	37.46	115.33	110.43
Carbaryl (0.1%)	37.50	34.91	113.45	108.44
Nemazol (1%)	48.71	46.98	124.85	122.35
Phosalone (0.05%)	35.88	33.76	109.02	106.80
Control	45.77	43.13	121.54	117.62
S.Em.	1.24	1.26	1.97	1.86
C.D. (0.05)	3.82	3.89	6.07	5.71

Season 1 (August, 1996 - January, 1997);
Season 2 (February, 1997 - July, 1997)

Table 22: Effect of insecticidal sprayings on silkworm pupal duration during two seasons of 1996-97 when different instars fed with treated leaf (days)

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	6.33	5.66	5.66	5.33	5.00	5.33	4.66'	4.33	4.66'	4.33
Endosulfan (0.05%)	6.66	6.00	6.00	5.66	5.33	5.00	5.00	4.66	5.00	4.66
Dimethioate (0.1%)	7.00	6.33	6.33	6.00	5.66	5.33	5.00	4.66	5.66	4.66
Carbaryl (0.1%)	7.33	6.66	6.66	6.33	5.66	5.00	5.66	5.00	6.00	5.66
Nemazol (1%)	6.00'	5.33'	5.66'	5.00'	4.66'	4.33'	4.66'	4.33'	4.66'	4.00'
Phosalone (0.05%)	7.66	7.33	7.00	6.66	6.66	6.00	6.33	5.66	6.66	6.00
Control	5.66	5.00	5.33	4.66	4.33	4.00	4.66	4.00	4.33	4.00

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

An increase in pupal duration was noticed for all instars with all insecticidal applications compared to control during both the seasons. Phosalone (0.05%) recorded maximum pupal duration at all instars during both the seasons studied, while relatively lower pupal duration was recorded with nemazol (1%) insecticidal application, among the various insecticides studied, during both seasons at all instars.

4.3.5 Pupal weights

The effect of feeding insecticide treated leaves to silkworm larvae of different instars was studied with regards to their pupal weights, during two seasons of 1996-97 and the results are presented in Table 23. Feeding of silkworm larvae of different instars with insecticide treated leaves was observed to effect their pupal weights. However, the effect varied with the insecticide and instar involved. Insecticidal application of nemazol (1%) had resulted in a significant increase in the pupal weights of first instar and second instar larvae. However, the effect of feeding nemazol (1%) treated leaves was insignificant on the pupal weights of third, fourth and fifth instar larvae. In contrast, feeding of phosalone (0.05%) treated leaves recorded insignificant effects on pupal weights of first and second instar larvae, while a significant reduction in the pupal weights of third, fourth and fifth instar larvae was observed in the present investigation. Further, the effects of feeding DDVP (0.05%), endosulfon (0.05%), dimethioate (0.1%) and carbaryl (0.1%) treated mulberry leaves was non-significant on the pupal weights of silkworm larvae of different instars, during both the seasons.

Table 23: Effect of insecticidal sprayings on pupal weight (g) of silkworm during two seasons of 1996-97

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	0.98	0.97	1.05	0.93	1.03	0.95	1.06	0.88	1.06	0.95
Endosulfan (0.05%)	0.97	0.80	0.98	0.79	0.99	0.77	0.97	0.78	0.99	0.82
Dimethioate (0.1%)	0.97	0.90	0.99	0.87	1.01	0.88	1.03	0.83	1.01	0.86
Carbaryl (0.1%)	0.93	0.78	0.92	0.79	0.91	0.77	1.10	0.76	0.97	0.72
Nemazol (1%)	1.32	1.15	1.21	1.05	1.12	1.02	1.14	1.00	1.09	0.99
Phosalone (0.05%)	0.80	0.72	0.91	0.78	0.83	0.75	0.86	0.71	0.92	0.76
Control	0.98	0.96	0.99	0.88	1.03	0.90	1.02	0.87	1.02	0.94
S.Em.	0.06	0.07	0.07	0.04	0.03	0.04	0.03	0.04	0.03	0.04
CD (0.05)	0.19	0.17	0.16	0.13	0.11	0.13	0.12	0.13	0.09	0.18

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

4.3.6 Cocoon Weight

The effect of feeding insecticide treated mulberry leaves to silkworm larvae of different instars was studied with regards to their cocoon weight and the results are presented in Table 24. Feeding of insecticide treated leaves had effected cocoon weights of th larvae. However, the effect varied with insecticide, season and larval instars. Nemazol (1%) insecticidal application had resulted in a significant increase in cocoon weight of the larvae, compared to control during first season. However, during second season, the effect of nemazol was observed to be non-significant for all the larval instars studied. Further, a significant reduction in the cocoon weights of first instar larvae with Endosulfan (0.05%), carbaryl (0.1%) and phosalone (0.05%) compared to control. Similar effects of carbaryl (0.1%) and phosalone (0.05%) were also observed during the second season of fourth and fifth instar larvae. Application of phosalone (0.05%) had also recorded a significant reduction in the cocoon weights of the fifth instar larvae during first season, compared to control.

4.3.7 Silk shell weight

The effect of feeding insecticide treated mulberry leaves to silkworm larvae of different instars was studied with regards to their silk shell weight and the results are presented in Table 25. Feeding of insecticide treated leaves had effected the silk shell weights of the larvae. However, the effect varied with insecticide. Nemazol (1%) insecticidal application had resulted in a significant increase in the

Table 24: Effect of insecticidal sprayings on cocoon weight of silkworm during two seasons of 1996-97

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	1.24	1.23	1.27	1.16	1.29	1.19	1.34	1.10	1.35	1.20
Endosulfan (0.05%)	1.19	0.99	1.18	0.98	1.24	0.97	1.23	1.02	1.24	1.08
Dimethioate (0.1%)	1.21	1.12	1.22	1.08	1.27	1.19	1.21	1.02	1.06	1.08
Carbaryl (0.1%)	1.15	0.98	1.16	0.96	1.21	0.99	1.22	0.96	1.19	1.03
Nemazol (1%)	1.63	1.31	1.51	1.13	1.61	1.29	1.41	1.27	1.38	1.24
Phosalone (0.05%)	1.01	0.93	1.14	0.98	1.16	0.97	1.20	0.96	1.14	0.95
Control	1.12	1.19	1.24	1.10	1.28	1.11	1.29	1.20	1.27	1.19
S.Em.	0.06	0.06	0.06	0.06	0.06	0.06	0.03	0.06	0.03	0.03
CD (0.05)	0.19	0.18	0.19	0.19	0.19	0.19	0.10	0.19	0.09	0.10

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

Table 25: Effect of insecticidal sprayings on shell weight (g) of silkworm during two seasons of 1996-97

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	0.23	0.20	0.23	0.20	0.24	0.22	0.25	0.21	0.26	0.23
Endosulfan (0.05%)	0.20	0.16	0.20	0.17	0.21	0.20	0.22	0.19	0.22	0.19
Dimethioate (0.1%)	0.21	0.18	0.21	0.19	0.22	0.20	0.22	0.19	0.24	0.18
Carbaryl (0.1%)	0.18	0.15	0.18	0.16	0.20	0.18	0.21	0.18	0.20	0.16
Nemazol (1%)	0.27	0.22	0.27	0.23	0.27	0.24	0.27	0.24	0.27	0.27
Phosalone (0.05%)	0.17	0.14	0.17	0.15	0.17	0.16	0.20	0.17	0.19	0.16
Control	0.22	0.19	0.22	0.19	0.23	0.21	0.24	0.21	0.24	0.22
S.Em.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.003
CD (0.05)	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.04

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

silk shell weight of the larvae, compared to control during both the seasons, at all instars. In contrast, application of carbaryl (0.1%) and phosalone (0.05%) had recorded a significant decrease in the silk shell weight of the larval instars, compared to control during both the seasons. Further, silk shell weights of the different larval instars with insecticidal applications of DDVP (0.05%), Endosulfan (0.05%) and Dimethioate (0.1%) were observed to be at par with control during both the seasons.

4.3.8 Silk Shell Ratio

The effect of feeding insecticide treated mulberry leaves to silk worm larvae of different instars was studied with regards to their silk shell ratio and the results are presented in Table 26. Feeding of insecticide treated leaves had effected the silk shell ratios of the larvae. However, the effect varied with insecticide. Phosalone (0.05%) insecticidal application had resulted in a significant decrease in the silk shell ratio of the larvae, compared to control during both the seasons, at all instars. In contrast, silk shell ratios of the differnt larval instars with insecticidal application of DDVP (0.05%), Endosulfan (0.05%), Dimethoate (0.1%), Carbaryl (0.1%) and Nemazol (1%) were observed to be at par with control, during both the seasons.

4.3.9 Length of Realed silk

The effect of feeding insecticide treated mulberry leaves to silkworm larvae of different instars was studied with regards to length of reeled silk and the results

Table 26: Effect of insecticidal sprayings on silk shell ratio (%) of silkworm during two seasons of 1996-97

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	17.56	16.32	17.94	17.26	18.76	18.42	19.72	19.42	19.71	19.42
Endosulfan (0.05%)	17.52	15.76	16.80	16.70	17.84	16.50	18.50	18.68	18.50	18.28
Dimethioate (0.1%)	16.22	15.94	17.42	16.92	17.84	17.72	18.92	18.66	18.32	18.66
Carbaryl (0.1%)	16.34	15.54	16.50	16.40	17.60	17.02	18.24	18.76	18.24	18.76
Nemazol (1%)	17.76	16.96	19.06	17.76	19.82	18.76	20.12	19.84	20.00	19.84
Phosalone (0.05%)	15.60	13.42	15.96	15.76	16.72	16.14	17.86	17.00	17.86	17.00
Control	16.92	16.12	17.82	17.16	18.44	18.26	19.32	19.12	19.05	19.12
S.Em.	0.36	0.57	0.47	0.34	0.30	0.57	0.36	0.30	0.03	0.30
CD (0.05)	1.14	1.80	1.49	1.08	0.95	1.80	1.14	0.95	1.01	0.95

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

are presented in Table 27. Feeding of insecticide treated leaves had effected the length of realed silk obtained from the larvae of different instars. However, the effect varied with insecticide. Phosalone (0.05%) insecticidal application had resulted in a significant decrease in the length of reeled silk, compared to control during both the seasons, at all instars. In contrast, Nemazol (1%) insecticidal application had resulted in a significant increase in the length of reeled silk, compared to control, during both seasons for the second, third, fourth and fifth instar larvae. However, the effects were observed to be non-significant during both seasons for the first instar larvae. Further, the length of reeled silk of the different larval instars with insecticidal applications of DDVP (0.05%), Endosulfan (0.05%), Dimethioate (0.1%) and Carbaryl (0.1%) were observed to be at par with control, during both the seasons.

4.3.10 Weight of reeled silk

The effect of feeding insecticide treated mulberry leaves to silkworm larvae of different instars was studied with regards to weight of reeled silk and the results are presented in Table 28. Feeding of insecticides treated leaves had effected the weight of reeled silks obtained from the larvae of different instars. However, the effect varied with insecticide Nemazol (1%) insecticidal application had resulted in a significant increase in the weight of reeled silks, compared to control, during both the seasons, at all instars. In contrast, the weight of reeled silks of the different larval instars with insecticidal application of DDVP (0.05%), Endosulfan

Table 27: Effect of insecticidal sprayings on length of reeled silk during two seasons of 1996-97 (m)

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	699.50	699.67	694.20	701.30	696.65	723.33	695.25	737.25	701.77	539.67
Endosulfan (0.05%)	651.10	683.67	659.35	687.93	668.54	717.33	672.31	727.67	674.72	744.33
Dimethioate (0.1%)	667.75	687.33	675.45	700.00	663.25	717.00	676.36	723.14	671.44	739.33
Carbaryl (0.1%)	648.84	667.00	656.98	689.66	659.45	715.02	667.48	720.45	678.68	725.01
Nemazol (1%)	710.00	699.67	723.32	724.67	730.51	742.00	638.24	744.00	754.28	759.00
Phosalone (0.05%)	629.67	615.30	617.11	679.50	622.97	700.33	642.42	714.00	656.35	710.67
Control	689.89	669.37	675.18	704.51	677.39	722.33	677.11	733.00	684.24	737.33
S.Em.	16.88	6.11	6.27	5.41	6.29	5.31	6.16	5.36	5.96	5.52
CD (0.05)	52.03	38.84	19.33	16.68	19.40	16.39	19.00	16.62	18.40	17.03

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

Table 28: Effect of insecticidal sprayings on Weight (g) of reeled silk during two seasons of 1996-97

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	0.18	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Endosulfan (0.05%)	0.17	0.17	0.18	0.18	0.17	0.17	0.18	0.18	0.18	0.17
Dimethioate (0.1%)	0.17	0.17	0.18	0.18	0.17	0.17	0.18	0.17	0.17	0.15
Carbaryl (0.1%)	0.17	0.17	0.18	0.18	0.18	0.18	0.17	0.17	0.18	0.18
Nemazol (1%)	0.19	0.18	0.19	0.19	0.19	0.19	0.19	0.19	0.20	0.19
Phosalone (0.05%)	0.16	0.15	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.16
Control	0.17	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17
S.Em.	0.003	0.003	0.006	0.003	0.003	0.003	0.003	0.003	0.003	0.003
CD (0.05)	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

(0.05%), Dimethioate (0.1%), Carbaryl (0.1%) and Phosalone (0.05%) was observed to be at par with control during both the seasons.

4.3.11 Denier

The effect of feeding insecticide treated mulberry leaves to silkworm larvae of different instars was studied with regards to denier and the results are presented in Table 29. Non-significant differences were observed among the treatments during both seasons at all larval instars. Insecticidal applications had recorded denier on par with control at all the stages.

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Table 29: Effect of insecticidal sprayings on the denier during two seasons of 1996-97

Treatments	Subjected Larvae									
	1st instar		2nd instar		3rd instar		4th instar		5th instar	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
DDVP (0.05%)	2.31	2.18	2.33	2.30	2.62	2.23	2.33	2.19	2.30	2.19
Endosulfan (0.05%)	2.34	2.33	2.45	2.35	2.28	2.13	2.40	2.22	2.39	2.05
Dimethioate (0.1%)	2.29	2.22	2.39	2.31	2.30	2.13	2.39	2.11	2.27	1.82
Carbaryl (0.1%)	2.35	2.29	2.46	2.34	2.45	2.26	2.29	2.12	2.38	2.23
Nemazol (1%)	2.40	2.31	2.36	2.35	2.34	2.30	2.67	2.22	2.38	2.25
Phosalone (0.05%)	2.28	2.19	2.33	2.11	2.45	2.18	2.38	2.27	2.47	2.15
Control	2.21	2.15	2.13	2.17	2.25	2.11	2.25	2.08	2.23	2.07
S.Em.	0.06	0.09	0.10	0.08	0.12	0.08	0.13	0.08	0.08	0.08
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Season 1 (August 1996 - January 1997); Season 2 (February 1997 - July 1997)

DISCUSSION

CHAPTER V

DISCUSSION

Pest infestations of mulberry constitute an important factor in influencing the production levels and quality of silk. Studies on faunal composition and seasonal incidence of mulberry pests, in addition to their possible chemical control through a wide array of insecticidal applications are therefore necessary. Further, information regarding the effects of insecticidal applications on the larvae and other economic characters of silk worm assumes importance, as the mulberry leaves sprayed with insecticides for the control of pests are fed directly to the highly delicate and fragile silkworm larvae. The present investigation is an attempt in these directions and the results obtained are discussed hereunder.

5.1 FAUNAL COMPOSITION OF MULBERRY PESTS

In the present study, the insect pests consisting of 18 species, belonging to seven orders and 12 families were recorded on mulberry. Among these insect pests, two distinct groups viz., sucking pests and defoliators were observed. The sucking pest complex consisted of six insect pests (mites, thrips, hoppers, mealy bugs, aphids and bugs) of 11 species, belonging to four orders (Acarina, Thysonoptera, Homoptera and Hemiptera) and seven families (Tetranychidae, Thripidae, Cicadellidae, Pseudococcidae, Aphididae, Pentatomidae and Membracidae) while defoliation consisted of three insect pests of seven species, belonging to three orders (Lepidoptera, Orthoptera and Coleoptera) and five families (Arctiidae, Pyralidae, Tettigonidae, Acrididae and Curculionidae).

5.2 SEASONAL INCIDENCE OF MULBERRY PESTS

A knowledge of seasonal incidence of different mulberry pests at different growth stages of the cropand their relation to weather parameters would help in planning and adoption of appropriate control strategies. In the present investigation, peak infestation of mites, thrips, aphids and bugs was observed during summer months, while the peak population of leaf hoppers, caterpillars and grass hoppers was observed during winter months. Peak population levels of weevils was also noticed during the month of January, when the minimum temperatures were quite low (<20°C). However, maximum population of mealy bugs was observed during rainy season. A detailed discussion is presented hereunder.

5.2.1 Mites

Among the sucking pests attaching mulberry, mites constitute an important group. 15 species of mites belonging to the families, Tetranychidae and Eriophyidae have been reported to be key pests of mulberry (Narayanswamy *et al*.., 1996). Among these, *Tetranychus ludeni, Tetranychus equatorius* and *Aceria mori* were noticed to cause considerable damage to mulberry in India, while *Tetranychus kanzawai* was found to be a major pest in China and Japan. In the present investigation, three species of spidermites viz., *Tetranychus telarius, Tetranychus equatorius* and *Tetranychus neocaledonicus* were observed on mulberry. Average mite population of the mites (12.72 per leaf) was observed during second fortnight of March, under conditions of high temperature (36°C), low rainfall (0 mm) and relative humidity (48-56%). Sinchaisri and Isarangkul (1973) and Rangaswami *et al.*. (1976) reported similar heavy infestation of mites during dry and hot seasons. Pillai *et al.* (1980) also reported high levels of mite population from March to May and low levels during October-December. Similar results were observed in the present investigation.

5.2.2 Thrips

Thrips also constitute an important group among the sucking pest complex infesting mulberry crop. They occur round the year in mulberry field and often multiply into a high density, as several overlapping generations are passed by this pest in one year. Two species of thrips viz., *Baliothrips minutus* and *Pseudodendrothrips mori* were encountered on mulberry in the present investigation. Average population of the pest was 4.18 thrips per leaf, during the study period. High levels of the pest were noticed during summer months (March-June) with the peak (6.30 thrips per leaf) during second fortnight of May, under conditions of severe temperatures (>39°C), low relative humidity (56%) and moderate rainfall (28 mm). Several workers (Rangaswami *et al.*., 1976; Pillai and Krishnaswami, 1980; Cappellozza and Miotto, 1987; Sahakundu, 1994) had also reported greater attack of the pest during summer. Further, significant and positive correlation of the pest population with temperature and negative correlation with rainfall was reported by Kotikal (1982), similar to the findings of the present investigation.

5.2.3 Leaf hoppers

Empoasca flavescens, leaf hoppers has been reported to be an important species attacking mulberry, causing "Hopper burn" to the tune of 40 per cent (Kariappa and Narasimhanna, 1978). In the present investigation also, *Empaasca flavescens* was observed on mulberry. Average population of the pest was 4.47 hopper per leaf during the study period. High levels of the pest were noticed during October-November with the peak during first fortnight of October (7.57 hoppers per leaf), under conditions of low temperature (<30°C), high relative humidity (80%) and rainfall (176.40 mm), Rangaswami *et al.*. (1976) and Ullal and Narasimhanna (1981) also reported severe occurrence of *Empoasca flavescens* from October onwards. Further, Kotikal (1982) reported the species to be most active on mulbery during October-November, similar to the findings of the present investigation.

5.2.4 Mealy bugs

The mealy bug, *Maconellicoccus hirsutus* has been reported to be a serious pest on mulberry in the recent years (Ali, 1995). The affected apical shoot shows retarded growth and flattering popularly known as "Tukra" causing reduction in yield and quality of the leaf, as the insect sucks the sap from the plant (Rangaswami *et al.*., 1976). The pest was also noticed in the present investigation on mulberry throughout the year. Average population of the pest was 5.54 mealy bugs per plant, during the study period. High levels of the pest were noticed during August with the peak during second fortnight of August (6.51 mealybugs per plant), under conditions of moderate temperatures (>30°C), high relative humidity (78%) and rainfall (76.95 mm). Optimum temperatures, coupled with cloudy weather conditions have also been reported to be most favourable for the growth and multiplication of the insects (Shriharan *et al.*, 1969). Egg laying was also reported to be high during July and August months for the pest (Shriharan *et al.*, 1979). Further, Rao *et al.* (1993) reported greater levels of infestation during monsoon period, when the temperature was above 30°C and the relative humidity was above 70 per cent, similar to the findings of the present investigation.

5.2.5 Aphids

Aphids also constitute an important group of the sucking pests, infesting mulberry, *Dactynotus compositae* species was observed on the mulberry canopy throughout the year, in the present study. Similar results were reported by Bidyapati *et al.* (1994). Average population of the pest was 5.78 aphids per plant. However, high levels of the pest were noticed during February-March, with the peak (7.35 aphids per plant) during first fortnight of March, under conditions of relatively high temperatures (35-36°C), low relative humidity (53%) and rainfall (0 mm). A strong positive correlation with maximum temperature and negative correlation with relative humidity and rainfall were also observed for the pest population.

5.2.6 Bugs

Three species of bugs viz., *Nezara viridula, Menida histrio* and *Leptocentreo* sp. were found in the present investigation on mulberry. Among these the green bug *Nezara viridula* was found in fairly large numbers, feeding on the sap of mulberry leaves, tender shoots and inflorescence. Average population of the pest was 4.23 bugs per five sweeps of the net. Further, high populations of the pest were noticed during February-March with the peak during first fortnight of March (5.15 bugs per five sweeps), under conditions relatively high temperatures (35-36°C), low relative humidity (53%) and rainfall (0 mm).

5.2.7 Caterpillars

The caterpillars of Lepidoptera are the major defoliators during crop growth period. Two seasons viz., *Spilosoma obliqua* and *Glyphodes pyloalis* were observed on mulberry in the present investigation. Among these, *Spilosoma obliqua* or the black headed hairy caterpillar was found in fairly large numbers. Average population of the pest was 2.44 caterpillars per square meter area. High population levels were noticed during August to December with the peak during first fortnight of October (4.52 caterpillars/m^2), under conditions of low temperature (30°C), high relative humidity (80%) and rainfall (176.40 mm). The findings are in agreement with the reports of earlier workers (Kunhikannan, 1919; Iyer, 1921; Chakravarthi, 1945; Mathur, 1962; Kotikal, 1982).

5.2.8 Grasshoppers

Three species of short-horned grass hoppers viz., *Oxya nitidula, Catantopis pinguis linnotablilis* and *Cyrtacanthacris tatarica*, in addition to a long horned grasshopeer viz., *Latana inflata* were observed on mulberry in the present investigation. Average pest population was 4.94 grasshopper five sweeps, while maximum population was recorded during first fortnight of October (6.27 grasshoppers/five sweeps), under conditions of low temperature (<30°C), high relative humidity (80%) and rainfall (176.40 m). The pest population had also recorded positive associations with relative humidity and rainfall and negative associations with maximum and minimum temperatures. Sidhu *et al.*. (1966) reported the occurence of *Cyrtacanthacris* sp. on mulberry throughout the year, similar to the findings of the present investigation.

5.2.9 Weevils

Eight species of weevils were reported on mulberry in China (Zhou and Zhou, 1994) viz., *Myllocerus undecimpustulatus maculosus, M. discolor* and *M.vividanesus*, while three species were reported in India (Singh *et al.*, 1993). However Rangaswami *et al.* (1976) recorded five species of *Myllocerus* weevils on mulberry of which *Myllocerus viridanus* was observed to be in abundance. *Myllocenus viridanus* was also noticed inthe present investigation, throughout the year. The average pest population was 3.04 weevils per five sweeps. Maximum incidence was observed during second fortnight and January and high populations were noticed during January-February. When the minimum temperatures were lower than 20°C. The findings are in agreement with the reports of Kotikal (1982).

5.3 CHEMICAL CONTROL OF MULBERRY PESTS

A number of pests occur on mulberry. Hence, the use of insecticides is a necessity. In the present investigation, a wide array of chemicals, including botanical pesticides were studied for their relative efficacy with regards to control of mulberry pests. Phosalone (0.05%) and Dimethioate (0.1%) were in general observed to be most effective against sucking pests, while DDVP (0.05%) and Endosulfan (0.05%) were observed effective against the defoliators. Nemazole (1%) was also observed to be effective in the management of both sucking and defoliator pest populations. The results obtained are discussed in detail hereunder.

5.3.1 Mites

The control of plant infesting mites requires repeated application of a higher dosage of pesticides (Nelson and Shaw, 1975; Wyatt and Maitleu, 1976; Navvaband and Zare, 1978; Reed and Moremo, 1978; Wymman *et al.*., 1979; Dhoonia and Mann, 1980; Marsden and Allen, 1980; Ramesh Gera, 1980; Prasad and Singh, 1981). Pillai and Jolly (1986) evaluated five pesticides viz., endosulfan, phosalone, dicofol, quinolphos and anthio at two concentrations (0.05 and 0.1%) and reported a greater control of the mites with phosalone application. Maximum reduction in the mite population (64%) was also noticed in the present investigation with the application of phosalone (0.05%), during both seasons at alldays after spraying. Application of Dimethioate (0.1%) had also recorded more than 60 per cent control of the pest population and hence were effective against mulberry mites.

5.3.2 Thrips

Application of phosalone (0.05%) was found to be most effective (48-53% reduction in pest population) against thrips in the present investigation followed by Dimethioate (0.1%) and DDVP (0.05%) which had also recorded more than 40 per cent control of the pest. The findings are in agreement with the reports of Cappellozza and Miotto (1987) and Sharma (1989).

5.3.3 Leaf Hoppers

Application of phosalone (0.05%) recorded maximum control of the pest >65%), followed by Dimethioate (0.1%). Sharma (1989) had also reported the effectiveness of Dimethioate (0.1%) against leaf hoppers. Further, the effectiveness of neem based compounds in the control of Jassids was reported by Rao *et al.* (1991). Similar reports were observed in the present investigation, wherein Nemazol (1%) application had resulted in more than 50 per cent control of the pest population.

5.3.4 Mealy bugs

These are hard to kill pests and no effective control measures have been reported for eliminating the mealy bug population. However, application of phosalone (0.05%), Dimethioate (0.1%), DDVP (0.05%) and Nemazol (1%) had resulted in more than 35 per cent reduction of the pest population and hence may be adopted for management of the pest population levels. Application of contact insecticides, such as endosulfan (0.05%) and carbaryl (0.1%) were however noticed to yield poor results. The findings are in agreement with the reports of Beevi *et al.* (1992) and Ali (1995).

5.3.5 Aphids

Application of phosalone (0.05%), Dimethoate (0.1%) and DDVP (0.05%) were observed to be effective in reducing the pest population levels by more than 50 per cent. Rao and Prasad (1993) also reported similar encouraging results with Nuvon (0.05%) in the control of aphids.

The efficacy of systemic insecticides in the control of aphids was also indicated by Bidyapati *et al.* (1994) similar to the findings of the present investigation.

5.3.6 Bugs

Application of systemic insecticides viz., Phosalone (0.05%) and Dimethioate (0.1%) had resulted in more than 40 per cent control of the pest population. However, application of relatively safer insecticides such as DDVP and Nemazol were also observed effective in management of the pest population levels (>35%).

5.3.7 Caterpillars

The plantations of mulberry have been reported to be defoliated by atleast 12 species of lepidoptera. Among these, *Glyphodes pyloalis* observed in the present investigation, is an important defoliator, causing serious damage to the plant (Gupta and Veer, 1986). The black headed hairy caterpillar, *Spilosoma obliqua* another major defoliater was also noticed in the present investigation. Application of DDVP (0.05%) and endosulfan (0.05%) were observed to be highly effective in the present investigation, wherein more than 65 per cent control of the pest population was achieved. The findings are in consonance with the reports of Kotikal and Devaiah (1988) and Sharma (1989). Further, the efficacy of neem compounds on the control of lepidopterous larvae was reported by several workers (Joshi *et al.*, 1990; Obulapathi, 1994; Arya *et al.*, 1995). Application of nemazol (1%) had also recorded an effective reduction in the pest population (59-62%) levels in the present investigation.

5.3.8 Grass hoppers

Application of DDVP (0.05%) and Endosulfan (0.05%) were observed to be superior, over other insecticidal applications in the present investigation, with regards to control of grasshoppers. These insecticidal applications had recorded more than 57 per cent control of the pest population. Kariappa and Narasimhanna (1981) had also reported DDVP to be effective against grasshoppers.

5.3.9 Weevils

Application of DDVP (0.05%) and Endosulfan (0.50%) were also observed to be equally effective against weevils compared to other insecticidal applications studied in the present investigation. These insecticidal applications had recorded more than 53 per cent control of the pest population. The findings corroborate with the reports of Bidyapati *et al.* (1994).

5.4 EFFECT OF INSECTICIDAL APPLICATIONS ON BIOLOGY AND LIFE-CYCLE OF SILK WORM

Insecticidal applications on mulberry were reported to have a detrimental effect on the growth, mortality and cocoon weight of the silkworm larvae reared on a diet of insecticide applications (Bhosale *et al.*, 1988). In the recent years, it has also been suggested that insecticides disrupt the normal functioning of tissues including fat body (Granett and Leeling, 1972; Orr and Downer, 1982; Yadwad, 1986), which plays an important role in the growth, development and reproduction of *Bombyx mori* (Tazima, 1978). However, the economic characters such as cocoon weight and shell weight were reported to be superior in silkworms reared on treated leaves after the safe/waiting period, compared to those reared on pest infested leaves. But these were inferior to those reared on normal healthy leaves (Kariappa and Narasimhanna, 1978).

Feeding of insecticide treated leaves, 1 DAS in the present investigation had resulted in 100 per cent mortality of the silkworm larvae of all instars. Further, DDVP (0.05%) and Nemazol (1%) were observed to have relatively shorter waiting period, while carbaryl (0.1%) and phosalone (0.05%) recorded comparatively longer waiting periods, compared to other insecticidal applications. A drastic reduction in the mortality per cent was also noticed from second day onwards, for all larval instars with DDVP (0.05%) and Nemazol (1%) indicating their lower residual effects due to faster degeneration, compared to the highly persistent insecticides viz., carbaryl and phosalone. Several workers had also reported similar waiting periods for DDVP (Sharma, 1989), Dimethioate (Radha *et al.*, 1978; and Sharma, 1989), endosulfan (Suhas and Devaiah, 1985; Pillai and Jolly, 1986) and Phosalone (Nangia *et al.*, 1990).

The waiting period of insecticides also varied with the stage of silkworm larvae and is presented in Table 30. The length of waiting period was noticed to decrease with an increase in the larval instar. This may be attributed to the greater resistance of latter instar larvae to insecticidal residues. Similar results were reported by Srinivas and Rao (1989) in their studies on insecticidal applications to third, fourth and fifth instar silkworm.

An increase in the larval duration of different instars was also observed in the present investigation upon feeding with insecticide treated leaves. However, the increase was noticed to be higher with Phosalone (0.05%) at all instars, while carbaryl (0.1%) had recorded greater increase in larval duration, at later instars (Third instar onwards). Similar increase in the larval periods of silkworms fed with mulberry leaves, treated with insecticides was reported by Samsijah (1989). Reddy

Table 30: Waiting period (days) for insecticide treated mulberry leaves before use as feed for silkworm larvae of different instars

Insecticide	Stage of silk worm larvae				
	1st instar	2nd instar	3rd instar	4th instar	5th instar
DDVP (0.05%)	4	4	4	4	2
Endosulfan (0.05%)	11	11	7	7	4
Dimethioate (0.1%)	9	9	6	6	3
Carbaryl (0.1%)	14	14	11	11	8
Nemazol (1%)	2	2	2	2	2
Phosalone (0.05%)	14	14	11	11	8

et al. (1989) had also reported similar increase in larval decrease due to carbaryl treatment.

A significant decrease in the larval weights, compared to contol, was also observed in the present study for the fourth and fifth instar larvae, upon feeding with Dimethoate (0.1%), Carbaryl (0.1%) and Phosalone (0.05%) treated mulberry leaves. However, feeding of leaves treated with DDVP (0.05%), Nemazol (1%) and Endosulfn (0.05%) had resulted in larval weights on par with control.

Insecticidal treatment of mulberry leaves was observed to result in an increase in pupal durtion. The increase was maximum with Phosalone (0.05%) and minimum with Nemazol (1%). Pupal weight, however recorded an increase with Nemazol (1%) during the first and second instars. However, it was at par with control, for latter instars. In contrast, Phosalone (0.05%) recorded a significant decrease in pupal weight, compared to control from third instar onwards. This may be attributed to the greater ingestion of the insecticide along with greater quantity of food. Similar results were reported by Bhosale *et al.* (1988).

A significant increase inthe coccon weights, shell weight, length of reeled silk and weight of reeled silk was observed in the present study, upon feeding with Nemazol (1%) treated mulberry leaves. In contrast, a significant decrease in the cocoon weights of fifth instar larvae, shell weights, silk shell ratio and length of reeled silk of the different instars was observed upon feeding with phosalone (0.05%). Similar effects were also observed for carbaryl (0.1%) with regards to cocoon weight and shell weight. The findings are in agreement with the reports of Reddy *et al.* (1989). However, DDVP (0.05%), Endosulfan (0.05%) and Dimethioate (0.1%) were observed to be at par with control, with regards to pupal weight, cocoon weight, shell weight, silk shell ratio, length and weight of reeled silk. The results are in broad agreement with the reports of Pillai and Jolly (1986). Further, the insecticidal treatments did not record any significant influence on the denier. Similar results were reported by Ye (1990).

Ali (1995) had reported an adverse effect on the silk worm larvae reared on mulberry leaves sprayed with insecticides, even after the safe period. Hence, insecticides which degrades quickly and are less persistent were suggested for use on mulberry. Such qualities were observed in DDVP and Nemazol insecticides in the present investigation. Nemazol (1%), in addition to satisfactory control of different mulberry pests had recorded favourable effects on the economic characters of silkworm (cocoon weight, shell weight and length and weight of reeled silk) and hence, may be considered for extensive adoption in sericulture.

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SUMMARY

CHAPTER VI

SUMMARY

The present investigation entitled "Efficacy of insecticides on pests of mulberry and thier influence on the biology and silk yields of mulberry silkworm (*Bombyx mori* L.)" was undertaken at Patakalva, Peruru, Tirupati, during 1996-97 to study the faunal composition and seasonal incidence of mulberry pests and evaluation of few insecticides for their efficacy against these pests, in addition to study of toxicity against silkworm larvae. The experimental material comprised of M-5 cultivar of mulberry raised in a mulberry garden of 0.1 hectare.

The incidence of different insect pests of mulberry was studied during a period of one year, starting from the first week of August, 1996 to the last week of July 1997. Pest incidence was observed regularly during this period at fortnightly intervals. The results revealed infestation by nine insect pests, consisting of 18 species, belonging to seven orders and 12 families, belonging to two district groups viz., sucking pests and defoliators. Among these, peak infestation of mites, thrips, aphids and bugs was observed during summer months, under conditions of high temperature (36°C), low rainfall (0 mm) and low relative humidity (48.56%), while the peak population of leaf hoppers, caterpillars and grasshoppers was observed during winter months, under conditions of low temperature (<30°C), high relative humidity (80%) and rainfall (176.40 mm). Peak population levels of weevils was also noticed during the month of January, when the minimum temperatures were quite low (<20°C). However, maximum population of mealy bugs was observed

during rainy season, under conditions of moderate temperatures (>30°C), high relative humidity (78%) and rainfall (76.95 mm).

Studies on relative efficacy of the insecticides against mulberry pests was undertaken in a randomized block design with three replications and seven treatments, including control. Results revealed the effectiveness of Phosalone (0.05%) and Dimethioate (0.1%) for all sucking pests studied in the present investigation, while DDVP (0.05%) and Endosulfan (0.05%) were observed effective against the defoliators. Nemazol (1%) was also observed effective in the management of both sucking and defoliator pest populations.

Studies on insecticidal toxicity to silk worm larvae, revealed 100 per cent mortality in silkworm larvae of all instars, upon feeding with treated mulberry leaves, one DAS. However, a drastic reduction in the mortality per cent was noticed from second day onwards, for all larval instars with DDVP (0.05%) and Nemazol (1%) indicating their lower residual effects, due to faster degradation. These insecticides had also recorded relatively shorter waiting periods, compared to carbaryl (0.1%) and phosalone (0.05%) which had recorded maximum waiting periods. Further, the waiting period of insecticides decreased with an increase in the larval stage. In addition, insecticidal treatment of mulberry leaves was noticed to result in increased larval and pupal durations, while a significant decrease in the larval and pupal weights was noticed upon feeding with Phosalone (0.05%) treated mulberry leaves. A significant decrease in the cocoon weights of fifth instar larvae, shell weight, silk shell ratio and length of reeled silk was also observed upon feeding with Phosalone (0.05%). Similar effects were also observed for carbaryl (0.1%) with regards to larval, cocoon and shell weights. DDVP (0.05%), Endosulfan (0.05%) and Dimethioate (0.1%) were observed to be at par with control for majority of the pupal, cocoon and other economic characters of silkworm studied in the present investigation; for all larval instars during both the seasons.

The use of Nemazole (1%) treated mulberry leaves as feed for silkworm larvae had however, resulted in a significant increase in the cocoon weight, shell weight, and the length and weight of reeled silk. Therefore, Nemazol with its low residual toxicity, satisfactory control of different mulberry pests and favourable effects on the economic characters of silkworm was concluded to be an ideal choice for use in sericulture.

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LITERATURE CITED

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