"STUDIES ON INSECT-PEST COMPLEX OF JASMINE WITH SPECIAL REFERENCE TO LEAF WEBWORM, *Nausinoe geometralis* (Guenee)"

A

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ABSTRACT

"STUDIES ON INSECT-PEST COMPLEX OF JASMINE WITH SPECIAL REFERENCE TO LEAF WEBWORM, *Nausinoe geometralis* (Guenee)"

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ABSTRACT

An investigation on biology, population dynamics, varietal screening and field bio-efficacy of insecticides against leaf webworm, *Nausinoe geometralis* was carried out at Navsari Agricultural University, Navsari, Gujarat during 2006-2007.

Studies on biology of *N. geometralis* revealed that both the sexes passed through four stages *viz.* egg, larva, pupa and adult with five larval instars. Morphology of all the stages, period of immature stages, longevity of adults and reproductive potential of *N. geometralis* were also studied.

Studies on population dynamics of insect pest of jasmine revealed that incidence of leaf webworm was started from the second week of May and reached its peak during first week of October (10.80 larvae/plant) with highest leaf damage (40.35 %). The evaporation had significantly negative influence on leaf webworm population. while non significant negative influence was

found with maximum temperature, sunshine hour and wind velocity. Whereas non significantly positive influence of minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, rainy days and rainfall was found on leaf webworm of jasmine.

The population of thrips was observed during November 2006 to June 2007 and October 2007. During last week of March, its population was at highest level (2.30 thrips/leaf), whereas it was absent during July to September 2007. The thrips population exhibited significant positive correlation with maximum temperature, sunshine hours and evaporation, while significant negative correlation was recorded with minimum temperature, morning relative humidity, evening relative humidity, average relative humidity and rainy days.

Studies on varietal screening of jasmine against *N. geometralis* revealed that Co-2 and Co-1 found resistant. While varieties Local and Motiya found susceptible to *N. geometralis*. The varieties Co-2 and Co-1 also found resistant against thrips, while varieties Local and But Mogra found susceptible to thrips.

The bioefficacy of different insecticides tested under field condition against *N. geometralis* revealed that out of ten insecticides tested, indoxacarb 0.0075 per cent, acetamiprid 0.004 per cent and profenofos 0.075 per cent recorded the lower population of leaf webworm and minimum per cent of leaf damage. Imidacloprid 0.005 per cent, novaluron 0.0075 per cent, spinosad 0.002 per cent, fipronil 0.075 per cent, clothianidin 0.003 per cent and thiamethoxam 0.005 per cent were found moderate effective.

Profenofos and indoxacarb were most economical with 1:14.46 and 1:12.38 net CBR, respectively.

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON INSECT-PEST COMPLEX OF JASMINE WITH SPECIAL REFERENCE TO LEAF WEBWORM, *N. geometralis* (Guenee)"** submitted by **Mr. GAJERA DHARMESH KALUBHAI** in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** to the **NAVSARI AGRICULTURAL UNIVERSITY, NAVSARI** is a record of bonafide research work carried out by him under my guidance and the thesis has not previously framed the basis for the award of any degree, diploma or other similar title.

Place : Navsari

Date : 23rd January, 2009.

(K. A. Patel)

Major Advisor

DECLARATION

This is to declare that the whole of the research work reported in this thesis, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** by the undersigned is the results of investigation done by me under direct guidance and supervision of **Dr. K. A. PATEL,** Senior Acarologist, Dept. of Agricultural Entomology, N. M. College of Agriculture, Navsari Agricultural University, **Navsari** and no part of the work has been submitted for any other degree so far.

Place : Navsari

Date : 23rd January, 2009.

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Place :Navsari
Date :23rd January, 2009

(Gajera D. K.)

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INTRODUCTION

I INTRODUCTION

Jasmine is one of the oldest fragrant flowers to be cultivated by man. The word 'Jasmine' has been derived from the persian word 'Jasminum' meaning fragrance. The genus Jasminum belongs to the olive family oleaceae. It consists about 200 species, which are cultivated for their ornamental value. About 42 Jasmine species are reported to be cultivated in India.

Out of these species, with scented flowers, only three are mostly cultivated for their cut flower and extraction of perfume, these are *Jasminum sambac* Ait, *Jasminum grandiflorum* L. and *Jasminum auriculatum* Vahl.

According to Kolavalli (1988) jasmine is grown in nearly 6,385 hectares in India. An annual production of flowers is estimated worth of Rs. 80-100 million (Muthuswamy and Abdul Khader, 1986). It is estimated that 12,500 kg of flowers of different kinds of Jasmine are sold everyday at important cities (Randhwa and Mukhopadhyay, 1986). In Gujarat, the area under Jasmine cultivation is concentrated in and around Surat, Navsari, Valsad, Baroda and Ahmedabad.

Jasmine flowers are used for making garland-adorning hair by women, religious and ceremonial functions. Different species of jasmines are widely grown in garden as shrubs and climbers. The flowers of Jasmine are highly estimated by the perfume owing industry to the delicacy and sweetness of its odour. A large quantity of some species is also consumed for extraction of essential oil. It gives smoothness and elegance to

the perfume combinations. The international market price of commercially produced Jasmine oil is said to be around Rs. 12,000/Kg. *J. sambac* Ait. contain 0.14 to 0.19 per cent concrets (Muthuswamy and Abdul Khader, 1986).

Some important species of Jasmine *viz. Jasminum arborescens* L., *Jasminum calophylllum* Vahl., *Jasminum flexile* Vahl., *Jasminum humile* L., and *Jasminum pubescens* Willd. are widely used for extraction of oil.

Jasmine plant is attacked by number of insect pests like leaf webworm, budworm, gallery worm, tinged bug, thrips, green plant hopper, jasmine bug, leaf roller, blossom midge and non insect pest like red spider mite and cyclamen mite. Among them, Jasmine leaf-web worm, *Nausinoe geometralis* (Guenee) (Lepidoptera : Pyralidae) is a serious pest of Arabian Jasmine (*Jasminum sambac* Ait.) in India (David, 1958). The caterpillars web the leaves and nibble to make holes in the leaves which are quite often reduced to mere veins. The severely attacked bush present 'burnt appearance' because the damaged and dried leaves remain entrapped in the web. This results in reduced vitality of plant which tells upon the growth of the bush and consequently production of flower buds/flowers reduces in the subsequent year.

Study on pest complex is the essential component for entomological aspect to start with any crop. Information regarding population dynamics, varietal screening, and biology of important pests and chemical control of pest complex in a

long duration crop like jasmine is helpful to the farmers for suppressing the pest population. Above work on jasmine in Gujarat is none, hence attempts have been made to have comprehensive information on the aspects cited below.

The following aspects were studied during the course of present investigation.

1. To study the biology of jasmine leaf web worm.
2. To study the population dynamics of insect pest complex of jasmine in relation to weather parameters.
3. To test the bio-efficacy of newer insecticides against jasmine leaf web worm.
4. To study the screening of jasmine varieties against insect pest complex.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Jasmine is an important commercial flower crop which is grown in tropical and subtropical regions throughout the world. In India, jasmine is cultivated throughout the country in an area of about 8,000 ha. Flowers worth eight to ten crores rupees are produced annually. There are about 50 different insect species belonging to more than eight orders harbouring varied microhabitats of the jasmine plants. Among the various insect pests, leaf-web worm, *N. geometralis* is a serious pest of the jasmine in India (David, 1958). The caterpillars primarily damage the older leaves mainly in the basal region of the bush. Young larvae scape the tissues while 3rd and 5th instar green caterpillars web the leaves to nibble on the foliage gregariously during bush growth in post monsoon months. Severely affected bushes exhibit 'burnt up' appearance due to entrapping of detached leaves in the web. Continued injury affects the vigour of the bush and flowering is reduced in the following years. The jasmine leaf-web worm, *N. geometralis* belongs to family Pyrelidae of the order Lepidoptera. The literature pertaining to *N. geometralis* particularly in relation to the present investigation has been reviewed and presented here as under.

2.1 Biology of jasmine leaf webworm, *N. geometralis* :

David *et al.* (1962) studied the life history and habits of leaf-web worm, *N. geometralis*. The biology of leaf-web worm of jasmine, *N. geometralis* was reported by Hung and Rhuh-houh (1965) in China. Shukla and Sandhu (1988) also studied the

biology of the jasmine leaf-web worm, *N. geometralis* at Ludhiana.

2.1.1 Egg :

The review pertaining to eggs of *N. geometralis* is presented under following heads.

2.1.1.1 Site and pattern of egg laying :

David and Venugopal (1962) reported that hardly distinguishable eggs were laid on the lamina of leaves and the moth did not discriminate between the tender and older leaves as the eggs were found on any portion of the plant. Whereas, Shukla and Sandhu (1988) found that the eggs of *N. geometralis* laid in singly or in small batches of 2-14 eggs (Av. 4 eggs) usually overlapping each other and glued with whitish fluid on the undersurface of leaves and could be seen with difficulty because of the flat translucent appearance of the egg mass. Eggs were also observed on the newly emerged leaf. They observed that the female rarely made specific choices in between various sites available to it. The eggs were also observed on the silken strands of the web usually singly or in batches of 2-3 eggs.

2.1.1.2 Colour, shape and size :

Shukla and Sandhu (1988) reported that the freshly laid eggs of *N. geometralis* were oblong in shape, greenish yellow in colour and there were irregular lines from one side to the other making zig-zag pattern over the surface of the egg shell. As reported by them, the eggs were 0.90 ± 0.10 mm in length and 0.70 ± 0.10 mm in breadth.

2.1.1.3 Incubation period and fecundity :

David and Venugopal (1962) recorded only 15-20 eggs per female in capitivity. Hung and Rhuh-houh (1965) observed that a female laid 201 eggs. Shukla and Sandhu (1988) found that the maximum and minimum incubation period of *N. geometralis* were 5.70 ± 0.60 and 4.10 ± 0.30 days, respectively. According to them, the female laid 53.00 ± 24.70 eggs with a range of 20.50-90.50 eggs per female.

2.1.2 Larva :

According to David and Venugopal (1962) and Shukla and Sandhu (1988), the larvae of *N. geometralis* passed through five instars.

David and Venugopal (1962) reported that the newly hatched larvae had narrower head than the body. There were four rows of grey spots on the body (two on the dorsal surface and each on the lateral side of the body). There were two rows of macro-pairs on the dorsal surface of the body. There were two rows of hairs on the dorsolateral side of the body having one such row of hairs on each side. Prolegs were unjointed, conical and fleshy with crochets arranged on a circle. Whereas, Shukla and Sandhu (1988) reported that the newly hatched larvae measured 5.20 ± 0.40 mm in length and 0.40 ± 0.04 mm in breadth. It was yellowish white with reddish yellow head which was broader than the body and tapered towards anal end.

Shukla and Sandhu (1988) found that second instar larvae measured 8.10 ± 0.70 mm in length and 0.70 ± 0.10 mm in

readth. It was whitish initially and slowly turned yellowish reen with dark grey spots on the body. These spots were faintly isible on the abdominal segment of the body. The spiracles were lear on each segment of the body like a black dot. The macro nd micro-hairs were also present on the body. The hairs on the nal end appeared to be conspicuous.

The third instar larvae measured 10.70 ± 0.10 mm in ength and 1.30 ± 0.10 mm in breadth. The larvae were whitish nitially but turned green fading towards anal end. Head was rown with whitish spots. Black spots were prominent and rranged on 4 rows as reported by them.

They have reported that the fourth instar larvae measured 14.40 ± 0.90 mm in length and 1.60 ± 0.10 mm in breadth. The larvae turned green in colour with dark brown or blackish head with white spots. Black dot like spots were present at the base of the hairs. The brown spots were bolder on thoracic segments and there were two black triangular spots on the prothorax. The spots on the abdominal segments were quite faint. There were more hairs at the anal end.

According to them, the full grown larvae measured 20.10 ± 1.70 mm in length and 1.80 ± 0.10 mm in breadth. The body was green with dark brown, head had whitish spots. The black spots were present on the prothorax. Macro white hairs were present on the body. Spiracles appeared like a black dot. Five pairs of prolegs were palish having circular crochets. The

larvae matured in 9.40-15.80 days with an average of 11.50 ± 0.10 days during July-October.

2.1.3 Prepupa :

Shukla and Sandhu (1988) reported that the prepupal period was 1-1.50 days.

2.1.4 Pupa :

Deol (1974) reported that the pupa of *N. geometralis* was 12 mm long.

Shukla and Sandhu (1988) reported that the pupae measured 11.50 to 15.50 mm in length with an average of 13.70 ± 1.40 mm. It was spindle shaped, broad anteriorly and tapering posteriorly. The compound eyes became prominent on the second day. The wing formation started on the third day. Abdomen was light green, naked and held in position by the pointed end which was attached to the silken threads. On the fourth day the pupae turned yellow and looked like dry leaves or sometimes changed to light brown colour and sometimes changed to light brown colour and remained in this form till adult emergence.

According to them, pupal stage lasted for 4-6 days with an average of 4.90 ± 0.20 days.

2.1.5 Adult :

David and Venugopal (1962) reported that moths generally rested by hanging under the lamina of the leaf with wings held half open at 45° with abdomen facing to the open lighted space.

Shukla and Sandhu (1988) reported that brownish moths were seen flying in between the foliage and settled only on the undersurface. Moths rested by hanging under the leaf lamina and avoided thick bushy shady area and preferred open foliage. Moths were invariably seen during day, flying in zig-zag manner.

According to them, the moths measured 21.50 ± 1.00 mm with wing expanse and 10.10 ± 1.10 mm in body length. The body was palish brown with dorsal and lateral white patches in each segment. It was slightly swollen at the middle and tapered towards anal end. The wings were brown with white spots, there was black wavy line at the apical margin of the wings followed by seven more or less circular small white spots on the apical margin of the wing. There were five large irregular, elongate spots. Out of the five large spots, two spots were mixed together towards the anal margin of the hind wing. The tip of abdomen was yellow with slit like genital aperture in case of females and the abdomen of males was less raised upward as compared to that of slender abdomen was pointed and greyish and much more bent upward. The first pair of leg was small as compared to second and third pair of legs which were quite long and enabled the moths to hold itself in hanging position.

Longevity of female moths was 4-7 days with an average of 5.90 ± 0.70 days. Males died quickly (2.70 ± 0.90 days).

The female longevity when further sub divided into pre-oviposition, oviposition and post-oviposition periods also exhibited similar trend and the corresponding ranges for those were 1-2, 2-5 and 0-2 days with an average of 1.40 ± 0.50, 3.20 ± 0.60 and 1.00 ± 0.60 days respectively. Sex ratio was 1:1.

2.1.6 Total life cycle :

Venugopal (1962) reported that life-cycle at Coimbotore was completed within 22-24 days during July-August while, egg, larval and pupal stages were 3-4, 12-15 and 6-7 days, respectively.

Whereas, Shukla and Sandhu (1988) reported that period from egg to adult was in the range of 24.7 to 36.3 days with an average of 27.00 ± 0.90 days.

2.2 Population dynamics of jasmine leaf webworm, *N. geometralis* :

During the spring of 1956, fields of pikake, *Jasminum sambac* (L) Aitken, in Honolulu were so badly infested (about 90%of the shoots) with cyclamen mite, *Steneotarsonemus pallidus* (Banks) (Frank and Boyle, 1958).

During June-July (1970), jasmine and nerium plants were severely attacked by the grubs of *Holotrichia sp.* at Coimbatore (Perumal *et al.*, 1970)

Ananthakrishnan (1972, 1973) reported *Aclystothrips, Ayyarothrips, Spingothrips, Synergothrips, Liophlaeothrips ablusus, Liothrips digressus, Phorinothrips minusculus* from galls on *Jasminum* and *Bathrips jasminae* Ananthakrishnan,

Pensrothrips jasminum Ramk.and Marg on leaves and *Isothrips orientalis* Bangall, *Thrips florum* Schmutz and *Haplothrips ganalbaueri* Schmutz on flowers of *J. sambac.*

David and Kumaraswami (1975) reported leaf rollers, *Glyphodes celsalis* Wlk. and *Glyphodes unionalis* F. on *J. sambac.*

Ananthakrishnan *et al* (1976) observed *Haplothrips ceylonicus* schm, *Haplothrips venoniae* Priesner on the flowers of *J. sambac.*

Shukla and Sandhu (1988) reported that the population of leaf-web worm was sever in month of June-October on jasmine at Ludhiana.

2.3 Chemical control of leaf webworm of jasmine, *N. geometralis* :

Shukla and Sandhu (1984) found monocrotophos as most effective insecticide against *N. geometralis.*

Dhandapani *et al* (1989) conducted two field experiments for the control of jasmine bud worm, *Hendecasis duplifascialis* (Hmpsn.) and reported that the application of deltamethrin 25 g a.i. / ha or cypermethrin 150 g a.i. / ha reduced the infestation by 90.11 and 90.21 per cent in the first experiment and 87.29 and 86.89 per cent in the second experiment, respectively. Application of FMC 35001, 480 g a.i. / ha or monocrotophos 360 g a.i. / ha were also found equally effective in reducing the budworm damage.

Suganthi *et al* (2006) studied efficacy of λ-cyhalothrin (Kungfu 2.5 EC) @ 10, 20, 30 and 40 g a.i. / ha against budworm, *Hendecasis duplifascialis* Hampson on jasmine and compared with recommended insecticide, monocrotophos 360 g a.i. / ha. Among all these doses, the effect of λ-cyhalothrin at 20 g a.i. / ha was significant and comparable with the standard check monocrotophos.

MATERIALS AND METHODS

III MATERIALS AND METHODS

The investigation on "Studies on insect-pest complex of jasmine with special reference to leaf webworm, *Nausinoe geometralis* (Guenee)" was carried out at College Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during November-2006 to October-2007. The biology of *Nausinoe geometralis* (Guenee) on jasmine cv. Local was studied in the laboratory of Department of Agricultural Entomology, N.M.College of Agriculture, N.A.U., Navsari during November-December, 2006. The materials used and techniques employed for conducting various experiments are presented here.

3.1 Biology of *Nausinoe geometralis* (Guenee) on jasmine cv. local

Biology of *N. geometralis* was studied in the laboratory of Department of Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari at 24.03 ± 1.75 °C average room temperature and average relative humidity 73.90 ± 3.04 per cent recorded during the period of November to December 2006.

The initial culture of jasmine leaf webworm was raised by collecting large number of larvae from the field of jasmine crop from Horticulture farm, ASPEE College of Horticulture and Forestry, N.A.U., Navsari. The larvae were kept in a plastic culture bottle having 20.00 cm height and 16.00 cm

diameter containing jasmine leaves. Rearing bottle was cleaned everyday.

3.1.1 Rearing technique

In the laboratory, larvae were reared separately on jasmine in transparent plastic tubes having 2.50 cm diameter and 7.50 cm length. The open end of plastic tubes was covered with the perforated lids to facilitate aeration. Jasmine leaves were provided as food daily till pre-pupal stage. At the time of pre pupal stage, 1/3 part of each plastic tube was filled with leaves to facilitate pupation. The pupae formed were transferred to jars for emergence of the adults.

To rear the adults, newly emerged male and female moths were transferred in a glass jar (23 cm diameter x 10 cm height). Tender shoots of jasmine plant having leaves on them were cut and cut end of the shoots were dipped in fresh water filled in conical flask (4.50 cm diameter at bottom and 8.0 cm height) to maintain turgidity of leaves. The shoots, thus prepared, were provided to the moths inside the rearing jars for resting and oviposition. The open end of glass jar was covered with fine musline cloth, secured in a position with the help of rubber band. Cotton swabs dipped in five per cent honey solution were placed in rearing jar for food to the moths. The shoots were substituted daily with fresh one. The eggs were collected from the leaves and used for further study.

.1.2 Study on various stages of *N. geometralis*

.1.2.1 Eggs

To study the incubation period and hatching ercentage, freshly laid eggs were picked up with the help of ne moist camel hair brush and counted number of eggs laid in etridishes (10 cm diameter). The eggs were also examined under icroscope for their colour, shape and size. The observations on umber of eggs hatched were recorded daily in the morning till nhatched eggs were shrinked. Incubation period was calculated om date of egg laying to the date of hatching. Hatching per ent was calculated from the number of eggs hatched out of the otal number of eggs kept for hatching. Measurements of eggs vere recorded under microscope with the help of stage and cular micrometer.

.1.2.2 Larvae

With a view to determine the number and duration of ifferent larval instars and total larval periods, the newly atched larvae (first instar) were placed individually with the elp of fine camel hair brush in plastic culture tubes (3.50 cm iameter x 4.00 cm height) and leaves were provided to the arvae. The leaves in each tube were changed daily in the norning.

In order to determine the number of larval instars, the ize of individual larvae was observed daily. Exuvium as well as asted off head capsule were also observed. The moulting was onfirmed by the presence of casted off head capsule of the

larvae of the subsequent instars. The larvae in each instar were studied for their colour and size. Observations on number of instars, durations of instars and total larval period were recorded. Measurement of eggs and immature stages was recorded under microscope with the help of stage and ocular micrometer and mature stages of larva and adults measured with the help of standard scale.

3.1.2.3 Pre-pupa

To record the pre-pupal period, the larvae were observed from the time when it stopped feeding and became sluggish to the time when it turned to pupae.

3.1.2.4 Pupa

Freshly formed pupae were collected and placed individually in plastic tubes (21.50 cm diameter x 7.50 cm height). Observations on pupal duration, colour and size were also recorded.

3.1.2.5 Adult

A male and a female of the same age paired and reared separately in glass jar (23 cm diameter x 10 cm height).They were provided with five per cent honey solution as food and fresh leaves of jasmine were provided to them for resting and oviposition. The material provided for resting and egg laying was replaced daily with fresh one. The observations on adult period as well as colour and size of the adults were also recorded. The length and breadth with their expanded wings were measured directly with the help of standard scale.

3.1.3 Pre-oviposition, oviposition and post-oviposition period, fecundity and longevity

In order to study the pre-oviposition period, oviposition period, post-oviposition period, fecundity and adult longevity, the newly emerged adults of *N. geometralis* were reared separately in rearing cage on jasmine plant.

Pre-oviposition period was calculated from the date of emergence of female adult to the date of starting of egg laying. Date of starting egg laying to ceasing of egg laying were noted as oviposition period. A period between the date of ceasing egg laying and the date of death of female was recorded as post-oviposition period.

Longevity of male and female adult was calculated from the date of emergence and date of death of adult, separately and average longevity was calculated.

To find out the fecundity, numbers of eggs laid by each female were recorded daily till the death of the female and average fecundity was calculated.

3.1.4 Total life cycle

Total life cycle was considered as the period between date of egg laying and the date of adult death.

3.1.5 Sex ratio

In order to determine sex ratio (Male : Female) under laboratory conditions, countered number of pupae were kept in different plastic tubes and observations on emergence of male and female moths were recorded to find out the sex ratio. The

exes were identified by observing the tip of the abdomen of the dults. In case of male the slender abdomen was pointed, grayish nd much more bent upward as compared to the tip of female bdomen with yellow slit like genital aperture identified by the presence of tuft of hairs on the tip of the abdomen of female while it was absent in male.

3.2 Population dynamics of insect pest complex of Jasmine

A study on population dynamics of insect pests of asmine was carried out at College farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during November-2006 to October-2007. The letails of the experiment are given below.

3.2.1 Experimentel details

.	Location	: ASPEE College farm, N.A.U., Navsari
.	Season and year	: November-2006 to October-2007
.	Area of Experimental plot	: 1,053 m^2
.	Crop	: Jasmine
.	Variety	: Local
.	Date of planting	: 5thJune 2005
.	Method of planting	: By Cuttings
.	Spacing	: 1.0 x 1.5 m
.	Type of soil	: Black soil

All the recommended agronomical practices were ollowed. However, the experimental area was kept free from

nsecticidal spray throughout the year in order to record the ncidence of various insect pests.

To find out the incidence of insect pests on jasmine variety Local, 50 plants were randomly selected in zigzag direction and tagged from the entire experimental area. Population of various insect pests was recorded at weekly nterval from tagged plants starting from November-2006 to October-2007.

3.2.3 Method of observations

3.2.2.1 Leaf webworm, *Nausinoe geometralis* (Guenee).

The observations were recorded at weekly interval by thoroughly observing the entire tagged plants and total numbers of larvae of leaf webworm were recorded per plant. Whereas, percentage leaf damage was calculated from total number of damaged and healthy leaves.

3.2.2.3 Thrips

Observations on thrips were recorded at weekly interval. For the purpose, three leaves each one from top, middle and bottom canopies of each tagged plant were observed for recording the number of nymphs and adults of thrips. Mean population of thrips was worked out and the data were statistically analysed.

3.2.3 Population dynamics of insect-pests of jasmine in relation to weather parameters

Data on maximum, minimum and average temperature and morning, evening and average relative humidity, rainfall,

rainy days and sunshine hours recorded at the meteorological observatory, College Farm, N.A.U., Navsari were used to study the effect of weather parameters on population of insect pests viz., leaf webwom and thrips. The simple correlation coefficient was worked out.

3.3 Varietal screening of jasmine against major insect pests

Screening of jasmine varieties for their relative resistance/susceptibility against major insect pests of jasmine, field experiment was conducted during September-2007 to November-2007.The details of screening trial are furnished here under.

3.3.1 Experimental details

1. Location : ASPEE College farm, N.A.U., Navsari
2. Design : RBD
3. No. of replications : 5
4. No. of varieties : 7
5. Season and year : September to December-2007
6. Spacing : 1.0 x 1.5m
7. Method of planting : By cuttings
8. Date of planting : 5th June 2005
9. Type of soil : Black soil

3.3.2 Details of varieties

But Mogra

Local

Motiya

4. Barmasi
5. Co-1
6. Co-2
7. Juhi

3.3.3 Cultural operations

All the cultural operations were followed. However, crop was kept free from insecticidal spray during entire year. Observations were recorded at weekly interval starting from September to December-2007.

3.3.4 Method of observations

The observations were recorded by selecting five plants randomly per plot and tagged and numbers of larvae were recorded. Whereas, percentage leaf damage was worked out from total number of damaged and healthy leaves. For sucking pests, three leaves each from top, middle and lower canopy of each tagged plants were recorded.

3.4 Evaluation of bio-efficacy of newer insecticides against *N. geometralis*

3.4.1 Experimental details

1. Location : ASPEE College farm, N.A.U., Navsari
2. Design : RBD
3. No. of replications : 3
4. No. of treatments : 10
5. Variety : Local
6. Plot Size : Gross plot : 6 x 10 m
   : Net plot : 3 x 8 m

7. Season and year : Rabi 2006-2007
8. Spacing : 1.0 x 1.5m
9. Method of planting : By cuttings
10. Date of planting : 5th June 2005
11. Type of soil : Black soil

3.4.2 Details of insecticidal treatments

Sr.No.	Name of insecticide	Conc. (%)	Dose formulation/10 litre of water
1.	Acetamiprid 20% SP	0.004	2.0 gm
2.	Imidacloprid 17.8% SL	0.005	2.8 ml
3.	Clothianidin 50% WDG	0.003	0.6 gm
4.	Novaluron 10% EC	0.0075	7.5 ml
5.	Spinosad 2.5% SC	0.002	8.0 ml
6.	Thiamethoxam 25% WG	0.005	2.0 gm
7.	Fipronil 5% SC	0.005	10 ml
8.	Profenofos 50% EC	0.075	15.0 ml
9.	Indoxacarb 15% SC	0.015	10.0 ml
10.	Control	-	-

3.4.3 Time and method of application

First spray was done at the initiation of leaf webworm. The treatment emulsions were sprayed on jasmine plants with knapsack sprayer (15 litre capacity) to the extent of slight run off. The sprayer was washed thoroughly prior to the application of each treatment. The subsequent spray was done 15 days after first spray. Two spray applications were carried out.

Table: 1 Details of the insecticides used.

Treatment	Technical name	Trade name	Formulation	Concentration (%)	Manufacture/source
1	Acetamiprid	Pride	20% SP	0.004	DE-NOCIL Crop Protection Pvt. Ltd., Unit no. 1, First floor, Corporate Park V. N. Purav Marg, Chembur, Mumbai, 400 071.
2	Imidacloprid	Confidor	17.8% SL	0.005	Bayer (India) Limited, Bayer House, Central Avonue, Hiranandani Gardens. Powai, Mumbai, 400 078.
3	Clothianidin	Dantop	50% WDG	0.003	Nagarjuna Agrichem Limited , Plot No.- 61, Nagarjuna Hills, Punjgutta, Hydrabad, 500 082.
4	Novaluron	Rimon	10% EC	0.0075	Indofil Chemicals Company, Nirlon House, Dr. Annie Besant Road Woril, Mumbai. 400 071.
5	Spinosad	Success	2.5% SC	0.0020	DE-NOCIL Crop Protection Pvt. Ltd., Unit no. 1, First floor, Corporate Park V. N. Purav Marg, Chembur, Mumbai, 400 071.
6	Thiamethoxam	Actara	25% WG	0.005	Syngenta Inida Ltd. (pesticidal division) Royal estate, Tata road, Churchgate, Mumbai, 400 071.
7	Fipronil	Regent	5% SC	0.005	Bayer Crop Science India Ltd. Aventis House, 54/A, M. V. Road, Chakla, Andheri (E), Mumbai – 400 093
8	Profenofos	Curacron	50% EC	0.075	Syngenta Inida Ltd. (pesticidal division) Royal estate, Tata road, Churchgate, Mumbai, 400 071.
9	Indoxacarb	Avaunt	15% SC	0.0075	E. I. Dupont India Pvt. Ltd. 8 floor, DLF Plaza Tower, DLF Qutab Ennclave phase-1, Gurgoan- 122 022, Haryana.
10	Control	-	-	-	-

3.4.3 Method of observation

From each net plot five plants were randomly selected and tagged. Observations on leaf webworm (larvae) and damaged leaves were recorded a day before treatment (pre treatment) and 1, 3, 5, 7 and 14 days (post treatment) after each application.

3.4.4 Statistical analysis

The data on number of leaf webworm larvae as well as number of damaged leaves obtained were analysed statistically using suitable transformation whenever necessary.

3.4.5 Yield and economics

The flower yield per plot was recorded for each treatment and converted in per hectare.

3.4.6 Benefit to Cost Ratio

Benefit to cost ratio (BCR) was worked out for each treatment. For the purpose, gross realization was worked out for all the treatments including control by deducting the cost of insecticide as well as the cost of labour required for spray from the total income of the marketable flower yield. Net gain over control was calculated by deducting realization of each treatment. At the end, the benefit to cost ratio for each treatment was calculated by dividing the net gain over control by deducting total cost of insecticides including cost of labour for spray.

RESULT AND DISCUSSION

IV RESULTS AND DISCUSSION

An investigation on biology, population dynamics, varietal screening and bio-efficacy of insecticides against major insect pests of jasmine was undertaken at Navsari Agricultural University, Navsari. The results are presented and discussed in this chapter under following headings

4.1 Biology of jasmine leaf webworm.

4.2 Population dynamic of insect pests complex of jasmine in relation to weather parameters.

4.3 Bio-efficacy of insecticides against *Nausinoe geometralis* on jasmine.

4.4 Varietal screening of jasmine against insect pest complex.

4.1 Biology of *Nausinoe geometralis*

The study on biology indicated that *N. geometralis* passed through four stages in their development, i.e. egg, larva, pupa and adult. The study on biology of leaf webworm *N. geometralis* was carried out in the laboratory of Department of Agricultural Entomology, N.M. College of Agriculture, Navsari, during November – December, 2006. The average temperature during study period was 24.03 ± 1.75 ^{0}C and average relative humidity was 53.90 ± 3.04 per cent. The findings are reported here under.

4.1.1 Egg

4.1.1.1 Site of egg laying

In laboratory as well as in field conditions, the females

Plate : 1 Moths confined in oviposition jar for egg laying

Plate : 2 Oviposition jar placed in wooden cage for laboratory rearing of *N. geometralis*

of *N. geometralis* laid eggs singly or in small batches on the lamina of the leaves. (Plate-III). Shukla and Sandhu (1988) reported that the eggs were laid singly or in small batches on the undersurface of leaves. Eggs were also observed on the newly emerged leaf. It was observed that the females rarely made specific choices in between various sites available to it. According to them, the eggs were also observed on the silken strands of the web. While, David and Venugopal (1962) reported that hardly distinguishable eggs were laid on the lamina of the leaves and the moth did not discriminate between the tender and older leaves as the eggs were found on any portion of the plant.

4.1.1.2 Colour, shape and size

The freshly laid eggs were small, flat, oblong and greenish yellow (Plate-III) in colour which became yellow prior to hatching. The present findings are more or less similar to those of Shukla and Sandhu (1988).

The length and breadth of twenty five freshly laid eggs were measured under microscope. The results summarized in Table-2 indicated that the length of freshly laid eggs varied from 0.87 to 1.10 mm with an average of 0.94 ± 0.04 mm and breadth varied from 0.63 mm to 0.76 mm with an average of 0.72 ± 0.02 mm. Shukla and Sandhu (1988) reported that the eggs of *N. geometralis* were 0.90 ± 0.10 mm in length and 0.70 ± 0.10 mm in breadth. Thus, the present finding is almost in confirmation with that of Shukla and Sandhu (1988).

Table 2: **Measurement of eggs of *N. geometralis***

Sr.No.	Length (mm)	Breadth (mm)
1	0.87	0.63
2	0.93	0.65
3	0.88	0.75
4	0.97	0.75
5	0.92	0.71
6	0.93	0.71
7	0.93	0.76
8	0.92	0.75
9	0.92	0.71
10	0.93	0.71
11	0.93	0.71
12	0.93	0.70
13	0.92	0.75
14	0.93	0.75
15	0.95	0.70
16	0.93	0.71
17	1.00	0.70
18	0.99	0.73
19	1.00	0.71
20	1.10	0.73
21	0.95	0.73
22	0.94	0.71
23	0.94	0.73
24	0.95	0.73
25	0.95	0.71
Min.	**0.87**	**0.63**
Max.	**1.10**	**0.76**
Ave. ± SD	**0.94 ± 0.04**	**0.72 ± 0.02**

4.1.1.3 Incubation period

The data presented in Table-3 indicated that the incubation period of eggs varied from 3 to 4 days with an average of 3.88 ± 0.33 days. Earlier, the incubation period of eggs was found to be 4 to 6 days with an average of 5.70 ± 0.60 days (Shukla and Sandhu, 1988) which is not concurrence with the present finding.

4.1.1.4 Hatching percentage

During experiment, total 872 eggs were observed for per cent hatching. Out of these, 824 eggs were hatched. It can be seen from Table-4 that hatching percentage varied from 68.18 to 97.96 with an average of 92.95 ± 7.40. However, Shukla and Sandhu (1988) reported that the hatching percentage of eggs of *N. geometralis* on jasmine was 98.50 per cent.

4.1.2 Larva

In order to study the various larval instars of *N. geometralis*, newly hatched larvae were reared individually on leaves of jasmine till they pupated. The data obtained on duration of different larval instars are presented in Table-3.

4.1.2.1 Number of larval instar

During present study, the larvae of *N. geometralis* moulted four times and thus passed through five larval instars. This observation tally with those reported by David and Venugopal (1962) and Shukla and Sandhu (1988).

Table 3: **Duration of egg period and larval instars of *N. geometralis***

Sr.No.	Egg period	1st instar	2nd instar	3rd instar	4th instar	5th instar	Total larval Period
1	4	3	4	2	2	2	13
2	4	3	4	2	2	2	13
3	4	3	4	2	2	2	13
4	4	3	4	2	2	2	13
5	4	2	4	3	2	3	14
6	4	3	3	3	2	3	14
7	3	3	4	2	2	2	13
8	4	3	4	2	3	2	14
9	4	3	3	2	3	2	13
10	4	2	3	2	2	2	11
11	3	2	3	2	2	3	12
12	3	3	4	2	2	2	13
13	4	3	4	2	2	2	13
14	4	3	4	2	2	2	13
15	4	3	4	2	2	2	13
16	4	3	3	2	2	2	12
17	4	3	3	3	2	3	14
18	4	2	4	2	3	3	14
19	4	3	4	3	2	2	14
20	4	2	4	2	3	2	13
21	4	3	4	2	2	2	13
22	4	3	4	2	2	2	13
23	4	3	4	2	2	3	14
24	4	2	4	3	2	2	13
25	4	3	3	2	3	2	13
Min.	**3**	**2**	**3**	**2**	**2**	**2**	**11**
Max.	**4**	**3**	**4**	**3**	**3**	**3**	**14**
Ave. ± SD	**3.88 ± 0.33**	**2.76 ± 0.44**	**3.72 ± 0.46**	**2.20 ± 0.41**	**2.20 ± 0.41**	**2.24 ± 0.44**	**13.12 ± 0.73**

Table 4: **Hatching percentage of eggs of *N. geometralis***

Sr. No.	Period of study	No of eggs observed	No of eggs hatched	Hatching percentage
1	09/12/2007 to 12/12/2007	66	64	96.97
2	10/12/2007 to 13/12/2007	49	48	97.96
3	11/12/2007 to 14/12/2007	68	65	95.59
4	12/12/2007 to 15/12/2007	77	75	97.40
5	13/12/2007 to 15/12/2007	33	31	93.94
6	13/12/2007 to 16/12/2007	98	94	95.92
7	14/12/2007 to 17/12/2007	22	15	68.18
8	14/12/2008 to 18/12/2007	53	47	88.68
9	15/12/2008 to 18/12/2007	100	96	96.00
10	15/12/2007 to 19/12/2007	34	31	91.18
11	16/12/2007 to 20/12/2007	48	46	95.83
12	17/12/2007 to 21/12/2007	72	68	94.44
13	18/12/2007 to 21/12/2007	29	26	89.66
14	18/12/2007 to 22/12/2007	89	85	95.51
15	19/12/2007 to 23/12/2007	34	33	97.06

Total number of eggs observed : 872
Total number of eggs hatched : 824
Minimum percentage hatching : 68.18
Maximum percentage hatching : 97.96
Average percentage hatching ± SD : 92.95 ± 7.40

Plate : 3 Eggs of *N. geometralis* laid on jasmine leaf

Plate : 4 First instar larva of *N. geometralis*

4.1.2.2 First instar

The freshly emerged larvae (Plate-IV) were yellowish white with reddish yellow head which was broader than the body and tapered towards the anal end. There were four rows of grey spots on the body (two on the dorsal surface and each on the dorsolateral side of the body). There were two rows of macro-pairs on the dorsal surface of the body. There were two rows of hairs on the dorsolateral side of the body having one such row of hairs on each side. These observations are comparable with that of David and Venugopal (1962) except, they reported that the newly hatched larvae had narrower head than the body. Shukla and Sandhu (1988) also reported almost similar description of the first instar larvae.

It can be seen from the Table-5 that the body length of first instar larvae varied from 3.50 to 5.00 mm with an average of 4.03 ± 0.32 mm while, the width varied from 0.30 to 0.40 mm with an average of 0.39 ± 0.03 mm. Shukla and Sandhu (1988) reported that the newly hatched larvae measured 5.20 ± 0.40 mm in length and 0.40 ± 0.04 mm in breadth.

The duration of first instar larva varied from 2 to 3 days with an average of 2.76 ± 0.44 days (Table-3).

4.1.2.3 Second instar

Second instar larvae (Plate-V) were initially whitish and slowly turned yellowish green with dark grey spots on the body. These spots were faintly visible on the abdominal segments. The pattern and the shape of the spots resembled each other on the alternate segment of the body. The spiracles were clear on each

Table 5: **Measurement of first instar larvae of *N. geometralis***

Sr.No.	Length (mm)	Breadth (mm)
1	4.00	0.40
2	4.00	0.40
3	4.00	0.40
4	4.00	0.40
5	4.00	0.40
6	4.00	0.40
7	3.90	0.40
8	4.00	0.40
9	4.00	0.40
10	3.80	0.30
11	4.00	0.40
12	4.00	0.40
13	4.00	0.40
14	4.00	0.40
15	3.50	0.30
16	4.00	0.40
17	4.00	0.40
18	4.00	0.40
19	4.00	0.40
20	5.00	0.40
21	5.00	0.40
22	4.00	0.30
23	4.00	0.40
24	4.00	0.40
25	3.50	0.40
Min.	**3.50**	**0.30**
Max.	**5.00**	**0.40**
Ave. ± SD	**4.03 ± 0.32**	**0.39 ± 0.03**

Plate : 5 Second instar larva of *N. geometralis*

Plate : 6 Third instar larva of *N. geometralis*

segment of the body like a black dot. The macro and micro-hairs were also present on the body. The hairs on the anal end appeared to be conspicuous.

The second instar larvae measured 7.00 to 8.00 mm with an average of 7.67 ± 0.30 mm in length and 0.60 to 0.80 mm with an average of 0.72 ± 0.05 mm in width (Table-6). However, Shukla and Sandhu (1988) reported that the body length of second instar larva was 8.10 ± 0.70 mm in length and 0.70 ± 0.10 mm in breadth which is more or less similar to that of present finding.

The data presented in Table-3 revealed that the duration of second instar larvae varied from 3 to 4 days with an average of 3.72 ± 0.46 days.

4.1.2.4 Third instar

Third instar larvae (Plate-VI) were larger than second instar larvae. The larvae were initially whitish but turned green fading towards anal end. Head was brown with whitish spots. Black spots were prominent and arranged in 4 rows.

It can be seen from the Table-7 that the body length of third instar larvae varied from 10.50 to 11.00 mm with an average of 10.72 ± 0.18 mm while the width of body varied from 1.20 to 1.40 mm with an average of 1.31 ± 0.07 mm. Shukla and Sandhu (1988) revealed that the body length of third instar larvae was 10.70 ± 0.10 mm in length and 1.30 ± 0.10 mm in breadth which is in concurrence with the present findings.

The duration of third instar larvae varied from 2 to 3 days with an average of 2.20 ± 0.41 mm (Table- 3).

Table 6: Measurement of second instar larvae of *N. geometralis*

Sr.No.	Length (mm)	Breadth (mm)
1	7.80	0.70
2	7.20	0.70
3	7.00	0.70
4	8.00	0.70
5	8.00	0.80
6	8.00	0.80
7	8.00	0.80
8	8.00	0.80
9	7.70	0.70
10	7.80	0.70
11	7.50	0.70
12	7.80	0.70
13	7.50	0.70
14	7.80	0.70
15	7.20	0.60
16	7.50	0.70
17	7.30	0.70
18	7.50	0.70
19	8.00	0.80
20	7.50	0.70
21	7.80	0.70
22	8.00	0.80
23	7.50	0.70
24	7.50	0.70
25	7.80	0.70
Min.	**7.00**	**0.60**
Max.	**8.00**	**0.80**
Ave ± SD	**7.67 ± 0.30**	**0.72 ± 0.05**

ble 7: Measurement of third instar larvae of *N. geometralis*

Sr.No.	Length (mm)	Breadth (mm)
1	10.70	1.30
2	10.50	1.20
3	11.00	1.30
4	10.50	1.20
5	10.70	1.30
6	11.00	1.30
7	10.70	1.40
8	10.70	1.30
9	11.00	1.30
10	11.00	1.40
11	10.60	1.30
12	10.50	1.20
13	10.70	1.30
14	10.70	1.30
15	10.80	1.40
16	10.50	1.30
17	10.50	1.40
18	10.50	1.20
19	10.70	1.40
20	10.90	1.40
21	11.00	1.20
22	10.70	1.30
23	10.70	1.40
24	10.80	1.40
25	10.50	1.30
Min.	**10.50**	**1.20**
Max.	**11.00**	**1.40**
Ave. ± SD	**10.72 ± 0.18**	**1.31 ± 0.07**

Plate : 7 Fourth instar larva of *N. geometralis*

Plate : 8 Fifth instar larva of *N. geometralis*

4.1.2.5 Fourth instar

The fourth instar larvae (Plate-VII) turned green in colour with dark brown or blackish head with white spots. Black dot like spots were present at the base of the hairs. The brown spots were bolder on thoracic segments and there were two black triangular spots on the prothorax. The spots on the abdominal segments were quite faint. There were more hairs at the anal end.

The fourth instar larvae measured from 14.90 to 15.30 mm with an average of 15.06 ± 0.12 mm in body length while width varied from 1.60 to 1.70 mm with an average of 1.66 ± 0.05mm (Table-8).

Results summarized in Table-3 revealed that the duration of fourth instar larvae ranged from 2 to 3 days with an average of 2.20 ± 0.41 days.

4.1.2.6 Fifth instar

The body of fifth instar larvae (Plate-VIII) was green with dark brown head having whitish spots. The black spots were present only on thoracic segments. There was a dark longitudinal band present on the prothorax. White micro-hairs were present on the body. Spiracles appeared like a black dots. These most of the observations are in resemblance with that of David and Venugopal (1962) and Shukla and Sandhu (1988).

It can be seen from Table-9 that the body length of fifth instar larvae varied from 19.50 to 20.00 mm with an average of 19.88 ± 0.19 mm while, the width of body varied from 1.80 to 2.00 mm with an average of 1.98 ± 0.05 mm. Shukla and Sandhu (1988)

Table 8: **Measurement of fourth instar larvae of *N. geometralis***

Sr.No.	Length (mm)	Breadth (mm)
1	15.00	1.70
2	15.20	1.70
3	15.30	1.60
4	15.00	1.70
5	15.00	1.60
6	15.20	1.70
7	14.90	1.70
8	15.00	1.70
9	15.20	1.60
10	15.10	1.60
11	15.00	1.70
12	15.00	1.70
13	14.90	1.70
14	15.00	1.70
15	15.00	1.70
16	15.00	1.60
17	15.30	1.60
18	15.10	1.70
19	15.10	1.60
20	15.00	1.70
21	14.90	1.60
22	15.00	1.70
23	15.00	1.60
24	15.10	1.70
25	15.20	1.60
Min.	**14.90**	**1.60**
Max.	**15.30**	**1.70**
Ave. ± SD	**15.06 ± 0.12**	**1.66 ± 0.05**

ble 9: Measurement of fifth instar larvae of *N. geometralis*

Sr.No.	Length (mm)	Breadth (mm)
1	20.00	2.00
2	19.50	2.00
3	19.50	2.00
4	20.00	2.00
5	20.00	2.00
6	20.00	1.90
7	20.00	2.00
8	19.80	2.00
9	19.70	1.80
10	20.00	1.90
11	20.00	2.00
12	19.80	2.00
13	20.00	2.00
14	19.60	2.00
15	20.00	2.00
16	20.00	2.00
17	20.00	2.00
18	20.00	2.00
19	20.00	2.00
20	20.00	2.00
21	20.00	2.00
22	20.00	2.00
23	19.50	2.00
24	19.60	2.00
25	20.00	2.00
Min.	**19.50**	**1.80**
Max.	**20.00**	**2.00**
Ave. ± SD	**19.88 ± 0.19**	**1.98 ± 0.05**

recorded length of the fifth instar larva as 20.10 ± 1.70 mm and width as 1.80 ± 0.10 mm, which is in agreement with the present finding.

The duration of fifth instar larvae ranged from 2 to 3 days with an average 2.24 ± 0.44 days (Table-3).

4.1.2.7 Total larval period

The data on total larval period (Table-3) indicated that the larval period ranged from 11 to 14 days with an average of 13.12 ± 0.73 days. Shukla and Sandhu (1988) recorded total larval period as 9.80 to 10.40 days with an average of 10.10 ± 0.20 days. Thus the present investigation is more or less similar with the observations recorded by the above workers.

4.1.3 Prepupa

After completion of development, larvae ceased feeding and searched for a suitable site for pupation. In the prepupal stage, the full grown larvae of fifth instar became sluggish and suspended feeding and movement. The colour of the full grown larvae was greenish (Plate-IX) and later on it turned to yellowish green before formation of pupae. The larvae contracted its length and appendages and became quiescent and than the pupal formation took place (Plate -X).

The length of prepupae varied from 14.00 to 16.00 mm with an average of 14.98 ± 0.44 mm while the width of the body varied from 1.70 to 2.00 mm with an average of 1.86 ± 0.09 mm (Table-10).

The duration of prepupae ranged from 1 to 2 days with

Table 10: Measurement of pre-pupae and pupae of *N. geometralis*

Sr.No.	Pre-pupae		Pupae	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1	14.00	1.80	13.50	2.00
2	16.00	1.90	13.00	2.00
3	15.00	1.80	13.00	2.00
4	15.00	2.00	13.50	2.20
5	16.00	2.00	13.00	2.00
6	15.00	1.80	13.00	2.00
7	15.00	1.90	13.50	2.30
8	15.00	1.80	13.50	2.00
9	15.00	1.80	13.50	2.20
10	15.00	1.80	13.00	2.00
11	14.50	1.90	13.00	2.00
12	15.00	1.80	13.50	2.00
13	15.00	2.00	13.00	2.00
14	14.50	1.80	13.50	2.00
15	14.00	2.00	13.00	2.00
16	15.00	2.00	13.50	2.00
17	15.00	1.80	13.50	2.00
18	15.00	1.80	13.50	2.00
19	15.50	1.90	13.00	2.00
20	15.00	1.80	13.00	2.00
21	15.00	1.70	13.50	2.30
22	15.00	1.80	13.50	2.20
23	15.00	1.90	13.50	2.20
24	15.00	1.90	13.00	2.00
25	15.00	1.90	13.50	2.00
Min.	**14.00**	**1.70**	**13.00**	**2.00**
Max.	**16.00**	**2.00**	**13.50**	**2.30**
Ave. ± SD	**14.98 ± 0.44**	**1.86 ± 0.09**	**13.28 ± 0.25**	**2.06 ± 0.10**

Table 11: Duration of pre-pupae and pupae of *N. geometralis*

Sr.No.	Prepupal Duration (days)	Pupal Duration (days)
1	1	8
2	1	8
3	1	8
4	1	8
5	1	8
6	1	8
7	1	7
8	1	8
9	1	8
10	2	8
11	1	8
12	1	8
13	1	7
14	1	8
15	1	8
16	1	8
17	1	8
18	1	8
19	1	8
20	1	7
21	1	7
22	1	8
23	1	8
24	1	8
25	1	8
Min.	**1**	**7**
Max.	**2**	**8**
Ave. ± SD	**1.04 ± 0.20**	**7.84 ± 0.37**

Plate : 9 Prepupa of *N. geometralis*

Plate : 10 Pupa of *N. geometralis*

Plate : 11 Old pupa of *N. geometralis*

an average of 1.04 ± 0.20 days (Table-11). Shukla and Sandhu (1988) revealed that the pre-pupal stage lasted for 1.00 to 1.50 days. Thus, the present findings are more or less in conformity with the observations reported by above workers.

4.1.4 Pupa

The pupae were spindle shaped, broad anteriorly and tapering posteriorly (Plate-X). The compound eyes became prominent on the second day. The wing formation started on the third day. Abdomen was marked with distinct segments. Freshly formed pupae were light green, naked and held in position by the pointed end which was attached to the silken threads. On the fourth day the pupae turned yellow and looked like dry leaves or sometimes changed to light brown colour and remained in this form till adult emergence (Plate-XI). Similar observations were reported by David and Venugopal (1962) and Shukla and Sandhu (1988).

It can be seen from the Table-10 that the length of pupae ranged between 13.00 to 13.50 mm with an average of 13.28 ± 0.25 mm while, the width of pupae varied from 2.00 to 2.30 mm with an average of 2.06 ± 0.10 mm. Deol (1974) reported that the pupa was 12 mm long. Shukla and Sandhu (1988) reported that the pupae measured as 11.50 to 15.50 mm in length with an average of 13.70 ± 1.40 mm. Thus, the present findings are more or less accordance with the observations reported by above workers.

The duration of pupal stage lasted for 7 to 8 days with an average 7.84 ± 0.37 days (Table-11). Earlier Shukla and Sandhu

(1988) reported that the pupal period lasted for 5.00 to 5.20 days with an average of 5.00 ± 0.10 days.

4.1.5 Adult

The moths of *N. geometralis* were medium in size. The body was palish brown with dorsal and lateral white patches on each segment (Plate-XII). It was slightly swollen at the middle and tapered towards anal end. The wings were brown with white spots. There was a black wavy line at the apical margin of the wing. There were five large irregular, elongated spots. Out of them, one spot was kidney shaped and four were small circular spots on fore wing while, the hind wing had five large spots and one small spot. Out of the five large spots, two spots were mixed together towards the anal margin of the hind wing. The tip of abdomen was yellow with slit like genital aperture in case of females and the abdomen was less raised upward as compared to that of male moths. In case of male moths the tip of slender abdomen was pointed and greyish and much more bent upward. Similar observations were reported by David and Venugopal (1962) and Shukla and Sandhu (1988).

The measurement of body length and width across the expanded wings of male and female of *N. geometralis* are presented in Table-12.

Measurement of female revealed that the length varied from 10.00 to 10.70 mm with an average of 10.19 ± 0.25 mm while, width across the expanded wings varied from 21.00 to 22.50 mm. with an average of 21.96 ± 0.29 mm. In case of male the length varied from 9.00 to 9.70 mm with an average of 9.20 ± 0.24

Table 12: **Measurement of adults of *N. geometralis***

Sr.No.	Female		Male	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)
1	10.00	21.50	9.00	20.00
2	10.00	22.00	9.10	20.30
3	10.00	22.00	9.00	20.00
4	10.50	22.00	9.00	20.00
5	10.60	22.00	9.40	21.00
6	10.70	22.00	9.70	21.60
7	10.30	22.00	9.50	21.00
8	10.40	21.50	9.60	21.20
9	10.50	22.00	9.00	20.00
10	10.00	22.00	9.20	20.50
11	10.00	22.00	9.20	20.60
12	10.00	22.00	9.00	20.10
13	10.30	22.00	9.00	20.00
14	10.40	22.00	9.00	20.00
15	10.00	21.00	9.60	21.50
16	10.00	22.00	9.40	20.80
17	10.00	22.50	9.00	20.00
18	10.00	22.00	9.00	20.00
19	10.50	22.00	9.10	20.00
20	10.60	22.00	9.40	20.90
21	10.00	22.00	9.00	20.00
22	10.00	22.00	9.00	20.00
23	10.00	22.00	9.00	20.10
24	10.00	22.00	9.50	21.00
25	10.00	22.50	9.20	20.50
Min.	**10.00**	**21.00**	**9.00**	**20.00**
Max.	**10.70**	**22.50**	**9.70**	**21.60**
Ave. ± SD	**10.19 ± 0.25**	**21.96 ± 0.29**	**9.20 ± 0.24**	**20.44 ± 0.53**

Male

Female

Plate : 12 Male and female of *N. geometralis*

Plate : 13 Adults of *N. geometralis*

mm while, the width varied between 20.00 to 21.60 mm with an average of 20.44 ± 0.53 mm. Thus, female moths were slightly bigger in size than the male moths. More or less similar trend of measurements was observed by Shukla and Sandhu (1988) who reported that the moths measured 21.50 ± 1.00 mm with wing expanse and 10.10 ± 1.10 mm in body length.

4.1.6 Pre - oviposition, oviposition and post – oviposition

The adult female of *N. geometralis* deposited eggs singly or in small batches on the lamina of leaves.

4.1.6.1 Pre-oviposition period

Pre-oviposition period varied from 1 to 2 days with an average of 1.60 ± 0.50 days (Table-13).

4.1.6.2 Oviposition period

The oviposition period was found to vary from 3 to 4 days with an average of 3.44 ± 0.51 days (Table-13).

4.1.6.3 Post oviposition period

The post-oviposition period was observed to vary between 1 to 2 days with an average 1.12 ± 0.33 days (Table-13).

Shukla and Sandhu (1988) reported that pre-oviposition, oviposition and post-oviposition period of *N. geometralis* was 1 to 2 days (Ave. 1.20 ± 0.40 days), 2 to 4 days (Ave. 3.20 ±0.50 days) and 0 to 2.00 days (Ave. 1.10 ± 0.60 days), respectively which is almost in confirmation with the present findings.

4.1.7 Fecundity of female

The results on fecundity (Table-14) revealed that the egg laying capacity of the female varied from 21 to 133 eggs with

mm while, the width varied between 20.00 to 21.60 mm with an average of 20.44 ± 0.53 mm. Thus, female moths were slightly bigger in size than the male moths. More or less similar trend of measurements was observed by Shukla and Sandhu (1988) who reported that the moths measured 21.50 ± 1.00 mm with wing expanse and 10.10 ± 1.10 mm in body length.

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able 13: Pre-oviposition, oviposition and post-oviposition period of *N. geometralis*

Sr.No.	Pre-oviposition Period (days)	Oviposition Period (days)	Post-oviposition Period (days)
1	2	3	1
2	2	3	1
3	1	3	2
4	2	3	1
5	1	4	1
6	2	4	1
7	2	3	1
8	2	3	1
9	1	4	2
10	2	4	1
11	1	4	1
12	2	3	1
13	1	4	1
14	2	4	1
15	1	4	1
16	2	3	1
17	1	4	1
18	1	4	1
19	1	4	1
20	2	3	1
21	2	3	1
22	2	3	1
23	2	3	1
24	2	3	1
25	1	3	2
Min.	**1**	**3**	**1**
Max.	**2**	**4**	**2**
Ave. ± SD	**1.6 0± 0.50**	**3.44 ± 0.51**	**1.12 ± 0.33**

ıble 14: Fecundity of *N. geometralis*

Sr. No.	No. of eggs laid (days after release)							Total
	1	2	3	4	5	6	7	
1	-	-	21	19	11	3	-	54
2	-	-	22	16	7	6	-	51
3	-	-	18	11	8	-	-	37
4	-	-	12	6	3	-	-	21
5	-	-	17	7	4	-	-	28
6	-	-	18	9	7	3	-	37
7	-	54	39	18	16	6	-	133
8	-	-	23	17	11	6	-	57
9	-	-	29	3	1	-	-	33
10	-	-	19	11	8	-	-	38
11	-	-	18	10	6	-	-	34
12	-	--	30	12	9	7	-	58
13	-	-	32	18	7	4	-	61
14	-	-	28	17	9	5	-	59
15	-	-	29	13	10	6	-	58
16	-	-	23	18	9	4	-	54
17	-	57	19	16	6	4	-	102
18	-	-	17	19	4	-	-	40
19	-	-	16	15	11	6	-	48
20	-	-	20	12	8	4	-	44
Min.	-	-	-	-	-	-	-	**21**
Max.	-	-	-	-	-	-	-	**133**
Ave. ± SD	-	-	-	-	-	-	-	**52.35 ± 25.53**

an average of 52.35 ± 25.53 eggs. David and Venugopal (1962) recorded only 15-20 eggs per female in capitivity. Hung Rhuh-houh (1965) from China observed that a female of laid 201 eggs. Shukla and Sandhu (1988) observed it to be 20.50 to 90.50 eggs with an average of 53 ± 24.70 eggs which is in conformity with the present findings. The variation in fecundity mentioned above might be due to different ecological conditions at various locations.

4.1.8 Longetivity of adult

The results summarized (Table-15) revealed that the longevity of female was varied from 6 to 7 days with an average of 6.16 ± 0.37 days, whereas in case of male, it was varied from 3 to 5 days with an average of 3.88 ± 0.83 days. Thus, the females lived longer than the males.

David and Venugopal (1962) revealed that the longevity of females varied from 4 to 7 days with an average of 5.60 ± 0.7 days, while males died quickly (2.70 ± 0.90 days). While, Shukla and Sandhu (1988) reported that the longevity of females varied from 5 to 7 days with an average of 5.50 ± 0.60 days, whereas in case of male, it was varied from 2.0 to 4.0 days with an average 2.70 ± 0.70 days. These reports are accordance with the present results.

4.1.9 Total life cycle

The total life period of *N. geometralis* (egg to death of adults) recorded on jasmine in laboratory are presented in Table-16.

Table 15: Longevity of adults of *N. geometralis*

Sr.No.	Longevity (days)	
	Female	Male
1	6	3
2	6	5
3	6	3
4	6	3
5	6	4
6	7	4
7	6	5
8	6	3
9	7	3
10	7	5
11	6	3
12	6	4
13	6	3
14	7	4
15	6	5
16	6	3
17	6	3
18	6	4
19	6	5
20	6	5
21	6	4
22	6	4
23	6	4
24	6	5
25	6	3
Min.	**6**	**3**
Max.	**7**	**5**
Ave. ± SD	**6.16 ± 0.37**	**3.88 ± 0.83**

Table 16: Details of life cycle of *N. geometralis* on jasmine

Sr. No.	Particulars	Period (days)		
		Minimum	Maximum	Average ± SD
1.	**Egg period**	3	4	3.88 ± 0.33
2.	**Hatching percentage**	68.18	97.96	92.95 ± 7.40
3.	**Larval period**			
	First instar	2	3	2.76 ± 0.33
	Second instar	3	4	3.72 ± 0.46
	Third instar	2	3	2.20 ± 0.41
	Fourth instar	2	3	2.20 ± 0.41
	Fifth instar	2	3	2.24 ± 0.44
	Total	8	12	9.98 ± 0.84
4.	**Pre-pupal period**	1	2	1.04 ± 0.20
5.	**Pupal period**	7	8	7.84 ± 0.37
6.	**Adult period**			
	Pre-oviposition	1	2	1.60 ± 0.50
	Oviposition	3	4	3.44 ± 0.51
	Post-oviposition	1	2	1.12 ± 0.33
	Longevity:			
	Female	6	7	6.16 ± 0.37
	Male	3	5	3.88 ± 0.83
7.	**Total life cycle:**			
	Female	25	33	28.90 ± 2.11
	Male	22	31	26.62 ± 2.57
8.	**Egg laying capacity (number)**	21	133	52.35 ± 25.53
		Male	**Female**	**M:F**
9.	**Sex ratio**	36	34	1:0.94

Total life cycle of males ranged from 22 to 31 days with an average of 26.62 ± 2.57 days and in case of female it was 25 to 33 days with an average of 28.90 ± 2.11 days. Thus, the duration of life cycle of female was longer than male (Table - 16).

David and Venugopal (1962) recorded total life-cycle of *N. geometrlis* in Coimbtore which was completed in 22 to 24 days. According to Shukla and Sandhu (1988) the period required for the completion of one generation ranged from 24.70 to 36.30 days with an average of 27.00 ± 0.90 days. So, the present findings of total life cycle of *N. geometralis* are almost in confirmation with the observations recorded by earlier workers.

4.1.10 Sex ratio

Adults emerged from laboratory reared pupae were observed separately to study their sexes. The results obtained are presented in Table-16.

The sex ratio of male : female recorded in laboratory was 1 : 0.94.

Shukla and Sandhu (1988) reported that the sex ratio (male : female) was 1 : 1 for laboratory reared adults which is in accordance with the present finding.

4.1.11 Nature of damage

The nature of damage caused by the larvae of *N. geometralis* was studied by extensive observation in the field of jasmine. The caterpillars scraped the leaves and produced 'papery parchment' while matured caterpillars webbed the leaves and nibbled to make holes in the leaves which were quite often reduced

to mere veins or veinlets. The severely attacked bush present 'burnt appearance' because the damaged and dried leaves remain entrapped in the web. This resulted in reduced vitality of plant which tells upon the growth of the bush and consequently production of flowers reduces in the subsequent year.

4.2 Population dynamics of insect pests of jasmine

Leaf webworm (*N. geometralis*)

The data presented in Table-17 and graphically depicted in Fig.-1 revealed that the population of leaf webworm, *N. geometralis* was found during particular period in the year on jasmine. The population of leaf webworm reached the peak level (10.80 larvae/plant) at first week of October. Thereafter pest population steadily declined and reached to a low level up to 0.02 larva/plant at last week of February. During 1st week of March to 1st week of May no larval population was recorded on jasmine. After that the population was more or less constant from 2nd week of May to last week of September.

Percentage leaves damage:

It is evident from the data (Table-17 and Fig.-1) that the percentage leaves damaged by leaf webworm was found higher (40.35 % leaves damage) during first week of October and the minimum 2.80 per cent leaves damage was found during first week of May.

Thrips

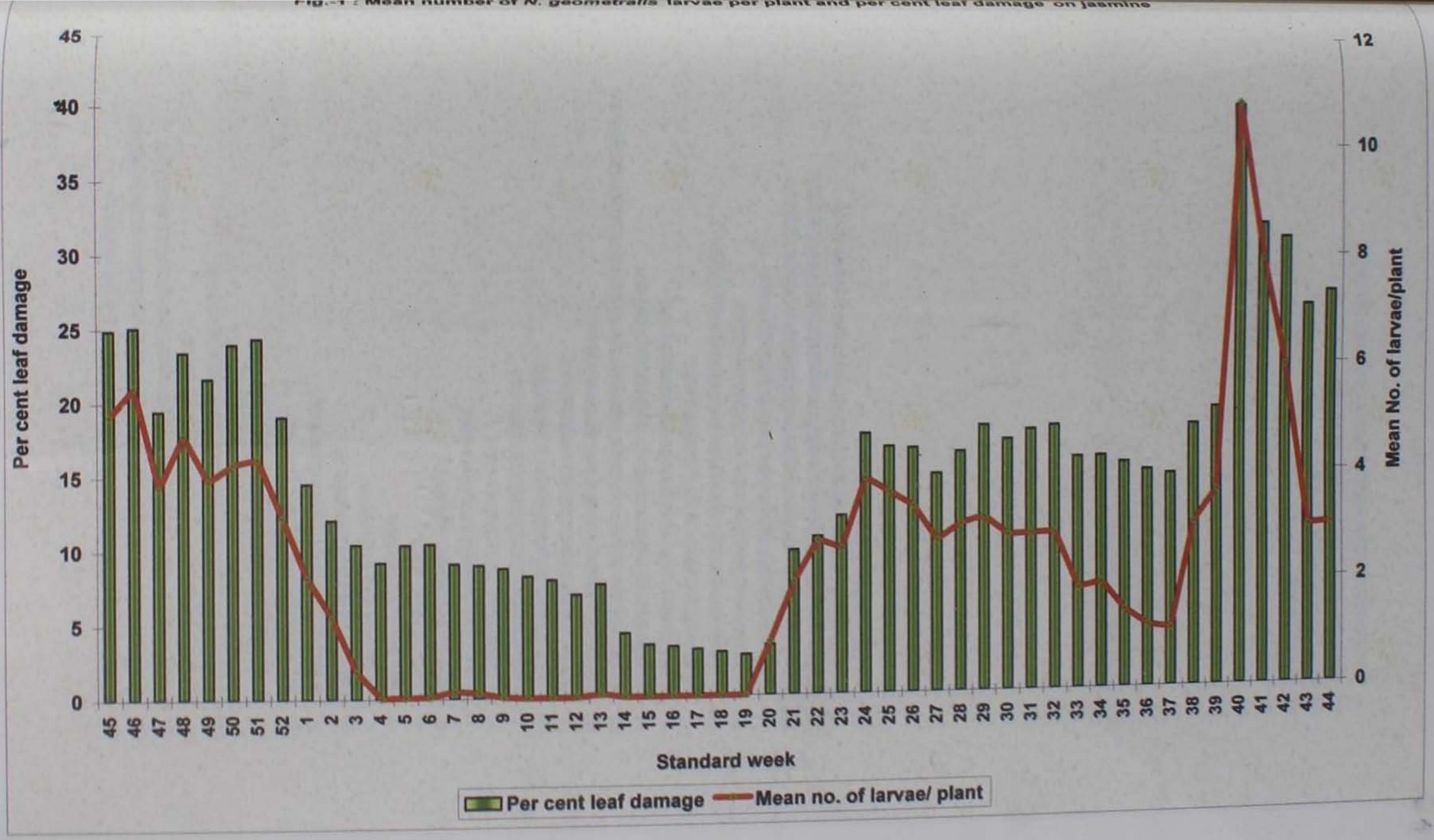
The data presented in Table-17 and depicted in figure-2 revealed that the thrips population was observed during November

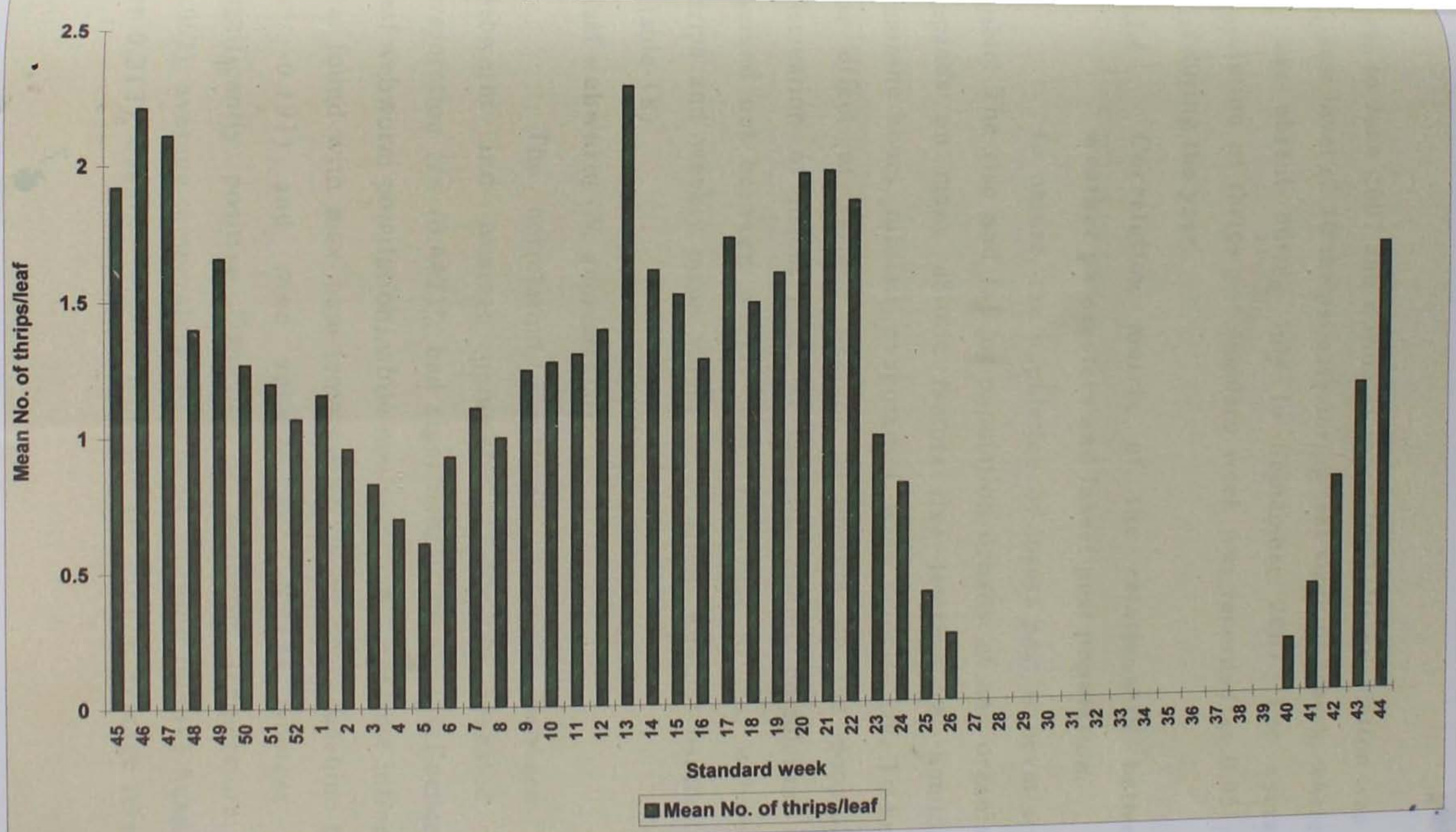
ble 17: Mean number of insect-pest/plant and per cent leaf damage of *N. geometralis* on jasmine

Met. Week	Date	Per cent damaged leaves by Jasmine leaf webworm	Mean no of webworm larvae / plant	Mean no of Thrips / leaf
45	05-11-2006	24.90	5.10	1.92
46	12-11-2006	25.10	5.62	2.21
47	19-11-2006	19.46	3.82	2.11
48	26-11-2006	23.46	4.76	1.40
49	03-12-2006	21.68	3.94	1.66
50	10-12-2006	24.01	4.24	1.27
51	17-12-2006	24.40	4.34	1.20
52	24-12-2006	19.10	3.28	1.07
1	01-01-2007	14.58	2.20	1.16
2	08-01-2007	12.12	1.48	0.96
3	15-01-2007	10.47	0.50	0.83
4	22-01-2007	9.24	0.02	0.70
5	29-01-2007	10.43	0.03	0.61
6	05-02-2007	10.50	0.10	0.93
7	12-02-2007	9.14	0.14	1.11
8	19-02-2007	9.04	0.10	1.00
9	26-02-2007	8.80	0.02	1.25
10	05-03-2007	8.27	0.00	1.28
11	12-03-2007	8.01	0.00	1.31
12	19-03-2007	7.00	0.00	1.40
13	26-03-2007	6.70	0.00	2.30
14	02-04-2007	5.34	0.00	1.62
15	09-04-2007	3.54	0.00	1.53
16	16-04-2007	3.41	0.00	1.29
17	23-04-2007	3.20	0.00	1.74

18	30-04-2007	3.01	0.00	1.50
19	07-05-2007	2.80	0.00	1.61
20	14-05-2007	3.45	0.98	1.98
21	21-05-2007	9.90	2.06	1.99
22	28-05-2007	10.80	2.82	1.88
23	04-06-2007	12.20	2.66	1.00
24	11-06-2007	17.80	3.94	0.82
25	18-06-2007	16.90	3.68	0.41
26	25-06-2007	16.80	3.42	0.25
27	02-07-2007	15.00	2.78	0.00
28	09-07-2007	16.50	3.08	0.00
29	16-07-2007	18.30	3.20	0.00
30	23-07-2007	17.32	2.86	0.00
31	30-07-2007	17.98	2.88	0.00
32	06-08-2007	18.24	2.90	0.00
33	13-08-2007	16.05	1.86	0.00
34	20-08-2007	16.10	1.96	0.00
35	27-08-2007	15.65	1.44	0.00
36	03-09-2007	15.10	1.14	0.00
37	10-09-2007	14.80	1.08	0.00
38	17-09-2007	18.23	3.04	0.00
39	24-09-2007	19.40	3.64	0.00
40	01-10-2007	40.35	10.80	0.20
41	08-10-2007	32.16	7.94	0.41
42	15-10-2007	31.20	5.96	0.82
43	22-10-2007	26.50	2.96	1.18
44	29-10-2007	27.45	3.00	1.72

Fig.-1 : Mean number of *N. geometralis* larvae per plant and per cent leaf damage on jasmine




2.5
2
1.5
1
0.5
0
Mean No. of thrips/leaf
45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Standard week
Mean No. of thrips/leaf

2006 to June 2007 and during October 2007. Its population was at highest level (2.30 thrips/leaf) during last week of March, whereas it was absent during July to September 2007. The average population of thrips per standard week was recorded as 0.95 per leaf during the year.

4.2.1 Correlation matrix of the relationship between weather parameters and insect pest population.

In nature, the population of insect pest is never truly stable. The rise and fall of population density of any organisms depends on many abiotic factors like temperature, humidity, sunshine hours, rainfall, evaporation, wind velocity etc. To know the effect of various weather parameters on the population fluctuation of insect pests of jasmine, simple correlation was worked out between weekly mean incidence of leaf webworm, thrips and weekly mean values of different weather parameters. (Table-18)

Leaf webworm (*N. geometralis*)

The correlation coefficient observed between leaf webworm and weather parameter (Table-18) revealed that evaporation (r= -0.442)*, had significantly negative influence on leaf webworm population, while non significant negative influence was found with maximum temperature (r= -0.084), sunshine hour (r= -0.191) and wind velocity (r= -0.113) whereas non significantly positive influence of minimum temperature (r= 0.082), average temperature (r= 0.028), morning relative humidity (r= 0.213), evening relative humidity (r= 0.237), average relative

Table 18: Correlation matrix of relationship between weather parameters and population of insect pest of jasmine during November 2006 -October 2007

Sr. No.	Weather parameter	*N. geometralis*	Thrips
	Minimum Temperature ^{0}C	0.08291	-0.30349*
	Maximum Temperature^{0}C	-0.08419	0.59634*
	Average Temperature^{0}C	0.02869	0.03430
	Morning Relative Humidity (%)	0.21316	-0.64448*
	Evening Relative Humidity (%)	0.23707	-0.59702*
	Average Relative Humidity (%)	0.24244	-0.64116*
	Sunshine (hours/day)	-0.19155	0.70565*
	Evaporation (mm)	-0.44216*	0.55943*
	Wind velocity (km/hr)	-0.11314	-0.24402
0	Rainy days	0.08982	-0.71206*
1	Rainfall (mm)	0.06115	-0.59223*

Significant at 5 per cent level (r = ± 0.27296)

umidity (r= 0.242), rainy days (r= 0.089) and rain fall (r= 0.061) vas found on leaf webworm of jasmine.

hrips

The results (Table-18) indicated that the thrips population exhibited significant positive correlation with maximum temperature (r= 0.596), sunshine hours (r=0.706) and evaporation (r= 0.559), while significant negative correlation was recorded with minimum temperature (r= -0.303), morning relative humidity (r= -0.644), evening relative humidity (r= -0.597), average relative humidity (r= -0.641), rainy days (r= -0.712) and rainfall (r= -0.592), while wind velocity (r= - 0.244) was negative non significant.

4.3 Varietal screening of jasmine against insect pests.

4.3.1 Larval population

The data presented in Table-19 and graphically depicted in Fig-3 indicated that none of the varieties were found to be free from attack of *N. geometralis*. However, variety Co-2 recorded the lowest population of *N. geometrlis* (0.85 larva/plant) which was at par with Co-1 (1.09 larva/plant) followed by Juhi, Barmasi, But mogra and Local which recorded 6.49, 6.61, 7.20 and 9.60 larvae/plant, respectively. The highest population of leaf webworm (11.10 larvae/plant) was found on variety Motiya.

The results presented in Table-19 by using mean value of incidence of pest which was intermediate to the cut off value. The jasmine leaf webworm population varied from 0.85 to 11.10 larvae per plant. The jasmine leaf webworm population was

Table 19: Mean number of leaf webworm, *N. geometralis* on different varieties of jasmine

Sr. No.	Varieties	Overall mean of 17 week observations of *N. geometralis*/plant
1	But Mogra	**7.20**
2	Local	**9.60**
3	Motiya	**11.10**
4	Barmasi	**6.61**
5	Co-1	**1.09**
6	Co-2	**0.85**
7	Juhi	**6.49**
	SE. m ±	**0.11**
	C.D. at 5%	**0.32**
	C.V.%	**9.80**

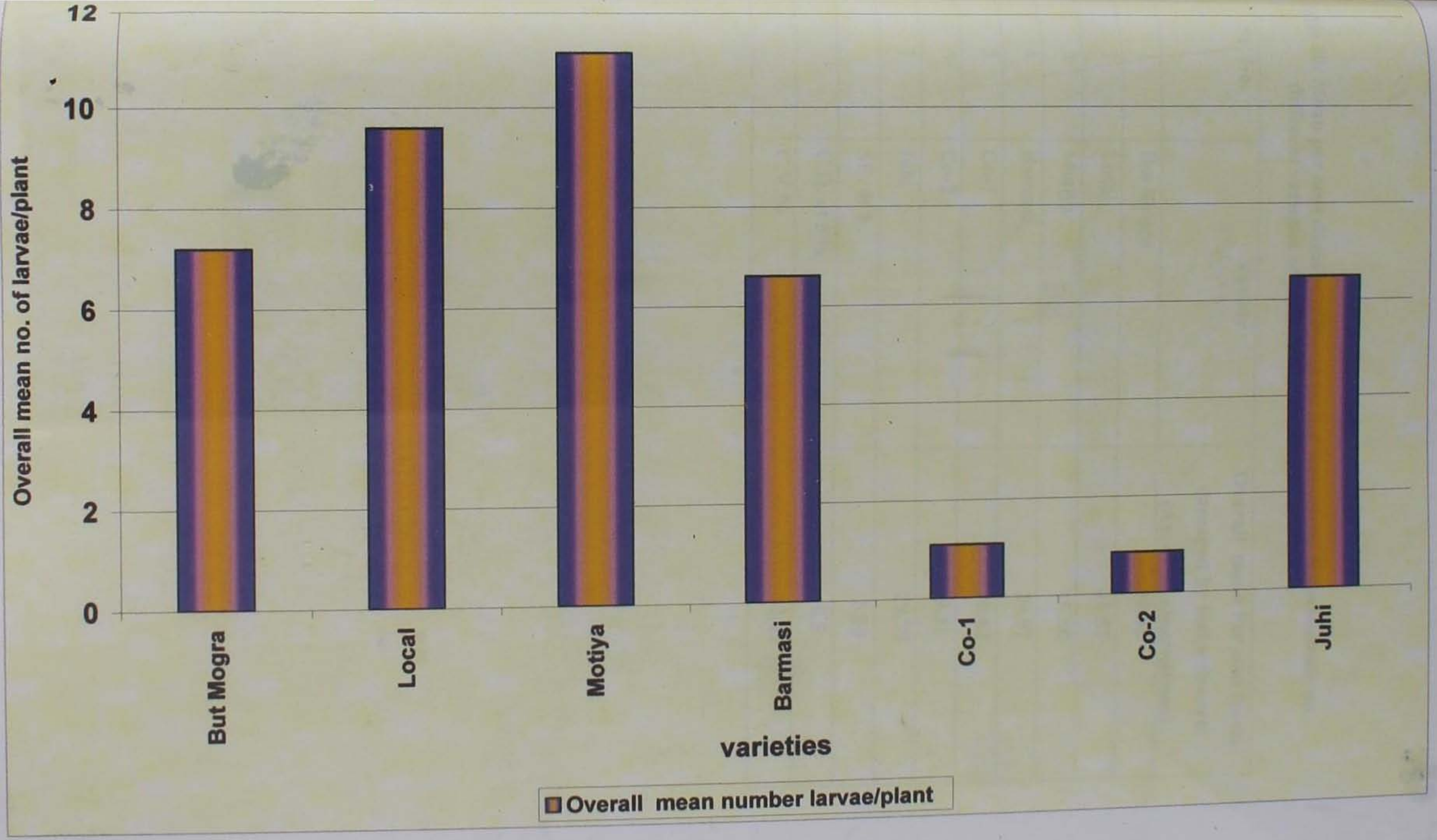
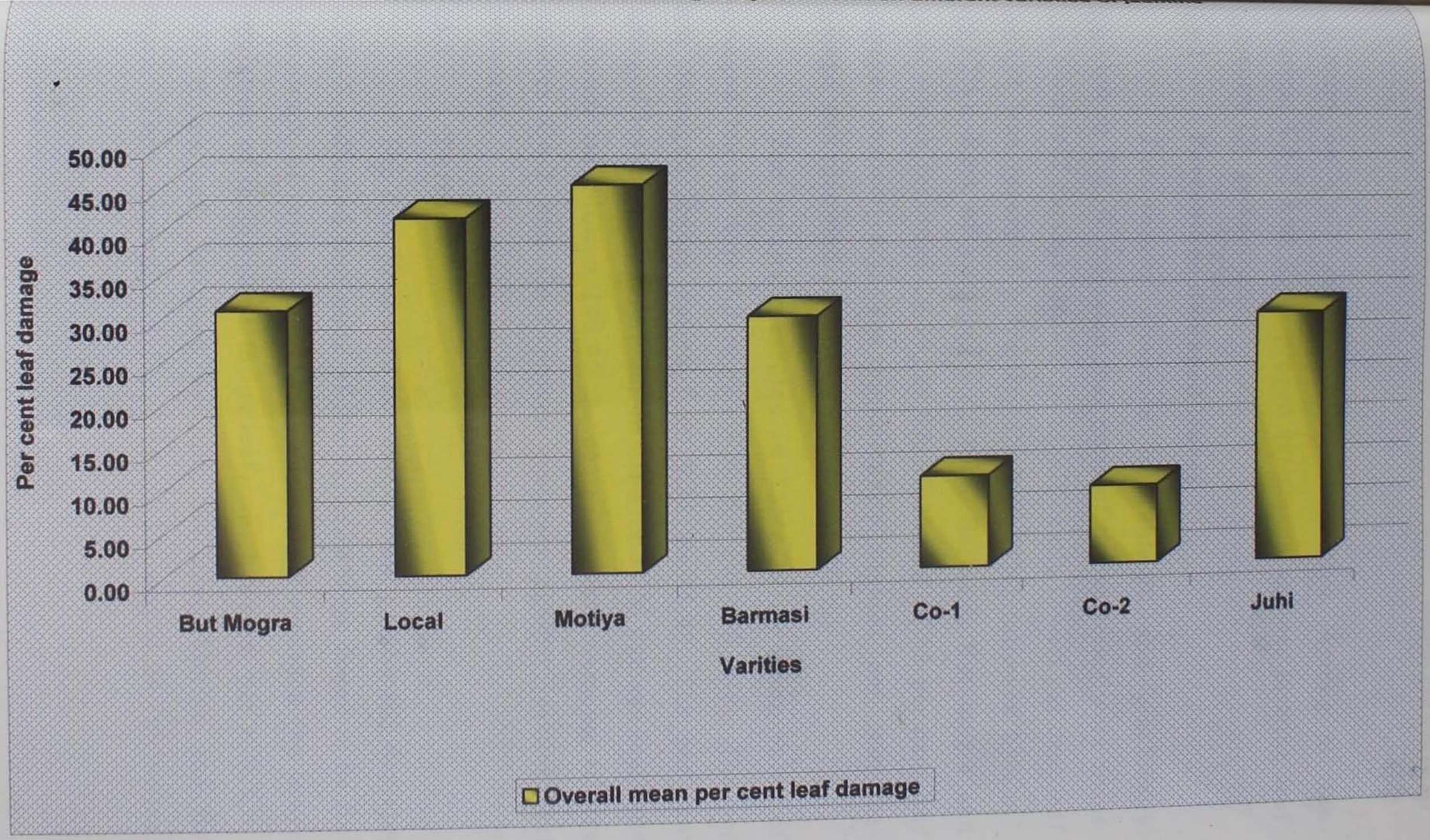

12
10
8
6
4
2
0
Overall mean no. of larvae/plant
But Mogra
Local
Motiya
Barmasi
Co-1
Co-2
Juhi
varieties
Overall mean number larvae/plant

Table 20: Mean per cent damage of leaves by leaf webworm, *N. geometralis* on different varieties of jasmine

Sr. No.	Variety	Overall mean Per cent leaves damaged by leaf webworm (Av. of 17 observations)
1	But Mogra	**30.88**
2	Local	**41.52**
3	Motiya	**45.40**
4	Barmasi	**29.97**
5	Co-1	**10.82**
6	Co-2	**9.31**
7	Juhi	**29.79**
	SE. m ±	**2.80**
	C.D. at 5%	**8.5**
	C.V.%	**12.42**


50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Per cent leaf damage
But Mogra
Local
Motiya
Barmasi
Co-1
Co-2
Juhi
Varities
Overall mean per cent leaf damage

minimum on Co-2 and maximum on Motiya. Among all the varieties, Co-2 and Co-1 proved resistance against jasmine leaf webworm (*N. geometralis*).

4.3.2 Percentage damaged leaves

The results presented in Table-20 and graphically depicted in Fig.-4 indicated that none of the varieties were found free from leaf damage. However, significantly lowest per cent leaf damage was recorded in variety Co-2 (9.31%) followed by Co-1 (10.82%). Rest of varieties *viz*., Juhi, Barmasi, But mogra and Local which recorded 29.79, 29.97, 30.88 and 41.52 per cent leaf damage, respectively. The significantly highest per cent leaf damage was recorded on Motiya variety (45.40 %)

The results presented in Table-20 by using value of damaged leaves were intermediate to the cut off value. The per cent damaged leaves varied from 9.31 to 45.40. The per cent damaged leaves were minimum on Co-2 (9.31 % damage leaf) and maximum on Motiya (45.40 % damaged leaf). Among all the varieties Co-2 and Co-1 proved resistant against jasmine leaf webworm.

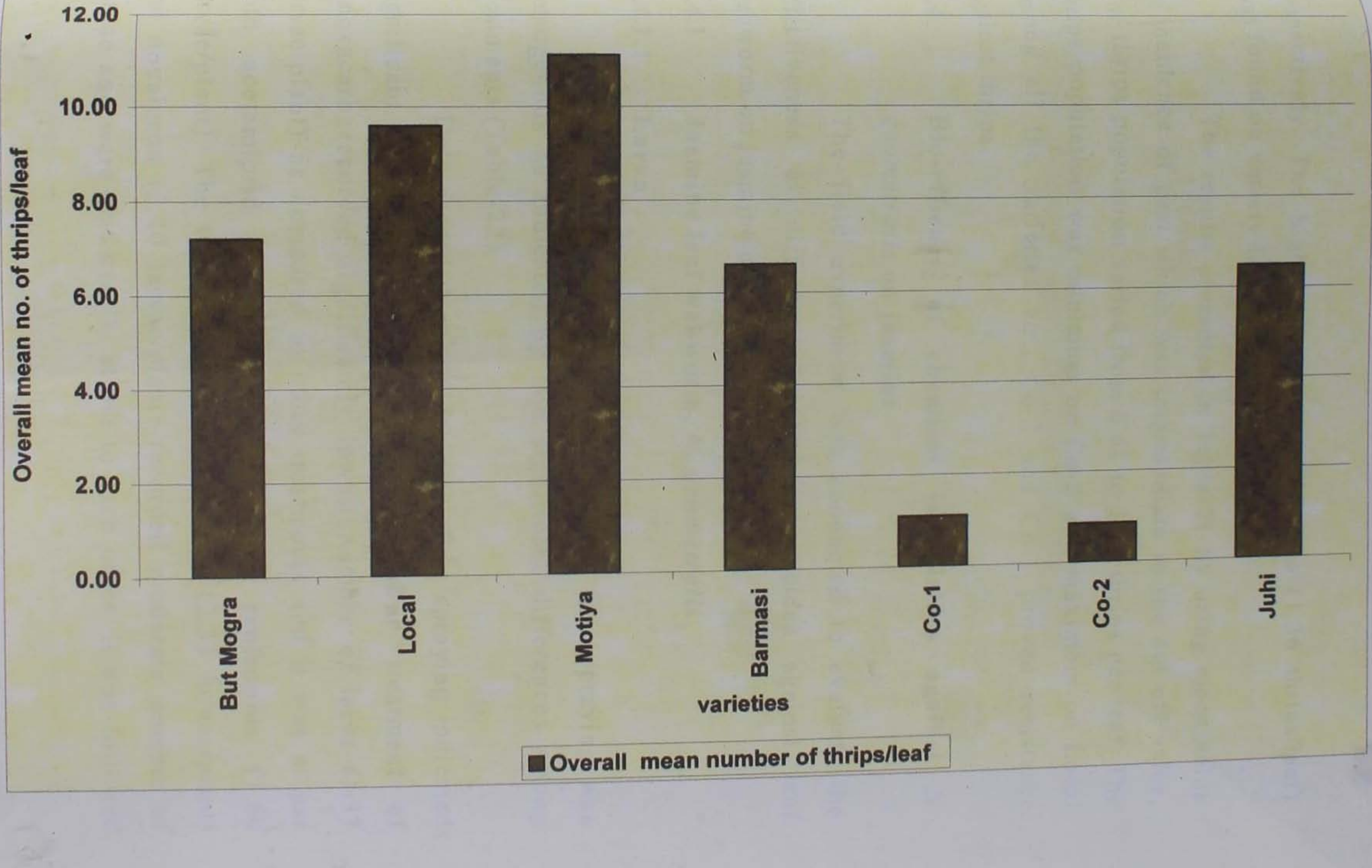
4.3.3 Thrips

The data presented in Table-21 and graphically depicted in Fig-5 indicated that none of the varieties were found to be free from attack of thrips. However, variety Co-2 recorded the lowest population of thrips (0.61 thrips/leaf) which was at par with Co-1 (0.83 thrips/leaf) followed by Juhi, Barmasi, Motiya and But mogra. They recorded 1.17, 1.18, 1.21 and 1.24 thrips/leaf,

Table 21: **Mean number of thrips on different varieties of jasmine**

Sr. No.	Variety	Overall mean of 17 week observations of thrips/leaf
1	But Mogra	**1.24**
2	Local	**1.36**
3	Motiya	**1.21**
4	Barmasi	**1.18**
5	Co-1	**0.83**
6	Co-2	**0.61**
7	Juhi	**1.17**
	SE. m ±	**0.05**
	C.D. at 5%	**0.15**
	C.V.%	**8.62**

Fig.-5 : Overall mean number of thrips on different varieties of jasmine



respectively. The highest population of thrips (1.36 thrips/leaf) was found on variety Local.

The results presented in Table-21 by using mean value of incidence of pest which was intermediate to the cut off value, The thrips population varied from 0.61 to 1.36 thrips per leaf. The thrips population was minimum on Co-2 and maximum on Local among all the varieties *viz.*, Co-2 and Co-1 proved resistance against thrips.

4.4 Bio-efficacy of chemical insecticides against *N. geometralis* on jasmine

The field experiment was conducted to evaluate the effectiveness of different chemical insecticides against leaf webworm on jasmine during year 2007.

4.4.1 Jasmine leaf webworm, *N. geometralis*

4.4.1.1 Larva

Larval population recorded before first spraying was homogenous as indicated by non significant differences among treatments (Table-22).

Data recorded at one day after first spraying indicated significant differences among treatments. The treatment of indoxacarb recorded significantly lowest number of larva (1.37 larvae/plant) as compared to other treatments and it was at par with acetamiprid (1.50 larvae/plant) and profenofos (1.60 larvae/plant). The treatments of imidacloprid (2.33 larvae/plant) and novaluron (2.40 larvae/plant) recorded moderate number of larvae and were statistically at par to each other. It was followed

Table 22: Mean population of *N. geometralis* larvae on jasmine (first spray)

Sr. No.	Treatment	Concentration (%)	Mean No. of *N. geometralis* larvae/plant						
			Before Spray	1 DAS	3DAS	5DAS	7DAS	14DAS	Pooled data over period
1	Acetamiprid 20% SP	0.004	2.04 (3.67)*	1.41 (1.50)*	1.34 (1.30)*	1.27 (1.13)*	1.22 (1.00)*	1.14 (0.80)*	1.43 (1.57)*
2	Imidacloprid 17.8% SL	0.005	2.09 (3.93)	1.68 (2.33)	1.62 (2.13)	1.60 (2.07)	1.57 (1.97)	1.55 (1.90)	1.69 (2.39)
3	Clothianidin 50% WDG	0.003	2.26 (4.67)	1.87 (3.00)	1.82 (2.83)	1.79 (2.70)	1.74 (2.53)	1.79 (2.73)	1.89 (3.08)
4	Novaluron 10% EC	0.0075	2.13 (4.07)	1.70 (2.40)	1.62 (2.13)	1.57 (1.97)	1.54 (1.87)	1.56 (1.93)	1.70 (2.39)
5	Spinosad 2.5% SC	0.0020	2.05 (3.73)	1.85 (3.00)	1.80 (2.77)	1.72 (2.47)	1.68 (2.33)	1.76 (2.60)	1.81 (2.82)
6	Thiamethoxam 25% WG	0.005	2.16 (4.20)	1.99 (3.47)	1.90 (3.13)	1.84 (2.90)	1.80 (2.73)	1.84 (2.90)	1.93 (3.22)
7	Fipronil 5% SC	0.005	2.08 (3.87)	1.90 (3.13)	1.83 (2.87)	1.78 (2.70)	1.75 (2.60)	1.78 (2.70)	1.86 (2.98)
8	Profenofos 50% EC	0.075	2.11 (3.97)	1.45 (1.60)	1.35 (1.33)	1.29 (1.17)	1.24 (1.03)	1.17 (0.87)	1.47 (1.66)
9	Indoxacarb 15% SC	0.0075	2.10 (3.93)	1.36 (1.37)	1.27 (1.13)	1.19 (0.93)	1.15 (0.83)	1.06 (0.63)	1.40 (1.47)
10	Control	-	1.95 (3.33)	2.10 (3.93)	2.14 (4.10)	2.22 (4.43)	2.27 (4.67)	2.30 (4.80)	2.16 (4.21)
	SE..m ±		**0.12**	**0.10**	**0.09**	**0.08**	**0.09**	**0.08**	**0.09**
	C.D. at 5%		**NS**	**0.30**	**0.27**	**0.26**	**0.26**	**0.26**	**0.26**
	C.V.%		**10.18**	**10.06**	**9.10**	**9.01**	**9.25**	**9.13**	**8.63**

* Data in the parentheses are original value, while those out side are square root ($\sqrt{X + 0.5}$) transformed values
DAS = Days After Spraying

by the treatment of clothianidin (3.00 larvae/plant), spinosad (3.00 larvae/plant) and fipronil (3.13 larvae/plant) which were statistically at par to each other. The treatment thiamethoxam (3.47 larvae/plant) found less effective, whereas the highest larvae were recorded in control (3.93 larvae/plant).

The perusal of data recorded at third day after first spraying revealed that all the insecticidal treatments were found significantly superior in reducing larval population over untreated control (4.10 larvae/plant). Indoxacarb maintained its superiority by recording the minimum larval population (1.13 larvae/plant). The next better treatment was acetamiprid (1.30 larvae/plant) followed by profenofos (1.33 larvae/plant) and they were statistically at par with indoxacarb. Further, the treatment of imidaclorid (2.13 larvae/plant) and novaluron (2.13 larvae/plant) found moderately effective in reducing larval population and were at par to each other. Rest of the treatments found less effective which were spinosad (2.77 larvae/plant), clothianidin (2.83 larvae/plant), fipronil (2.87 larvae/plant) and thiamethoxam (3.13 larvae/plant) and among these spinosad, clothianidin and fipronil were found statically at par with each other.

Data recorded on the fifth day after first spraying indicated that larval population was decreased in all the treatments and more or less similar trend was observed.

Data recorded on the seventh day after first spraying indicated that significantly lowest larval population was recorded in the treatment of indoxacarb (0.83 larva/plant) and it was at par with acetamiprid (1.00 larvae/plant) and profenofos (1.03 larvae

/plant). Imidacloprid (1.97 larvae/plant) and novaluron (1.87 larvae/plant) were statistically at par to each other. Remaining treatments *viz*., clothianidin (2.53 larvae/plant), spinosad (2.33 larvae/plant), fipronil (2.60 larvae/plant) and thiamethoxam (2.73 larvae/plant) recorded higher number of larvae. However, significantly lower than untreated control (4.67 larvae/plant).

Data recorded at fourteen days after first spraying revealed that indoxacarb maintained its superiority by recording minimum number of larvae (0.63 larva/plant) than all other treatments and it was at par with acetamiprid (0.80 larva/plant) and profenofos (0.87 larva/plant). The treatments of imidacloprid (1.90 larvae/plant) and novaluron (1.93 larvae/plant) recorded moderate number of larvae and were statistically at par to each other. The order of remaining treatments in effectiveness was clothianidin (2.73 larvae/plant), spinosad (2.60 larvae/plant), fipronil (2.70 larvae/plant) and thiamethoxam (2.90 larvae/plant). The highest numbers of larvae were recorded in untreated control (4.80 larvae/plant).

The pooled data on larval population recorded at different period of observations clearly indicated that all the insecticides recorded significantly lower larval population over untreated control. However, there was wide variation in the effectiveness due to insecticidal treatments. The treatment of indoxacarb recorded significantly lower number of larvae (1.47 larvae/plant). Acetamiprid (1.57 larvae/plant) and profenofos (1.66 larvae/plant) were at par with indoxacarb. The treatments of imidacloprid and novaluron (2.39 larvae/plant) recorded moderate

number of larvae. The order of less effective treatments was spinosad (2.82 larvae/plant), fipronil (2.98 larvae/plant), clothianidin (3.08 larvae/plant) and thiamethoxam (3.22 larvae/plant).

Data (Table-23) recorded at one day after second spraying revealed that significantly minimum larval population was recorded in the treatment of indoxacarb (1.23 larvae/plant) and it was at par with acetamiprid (1.37 larvae/plant) and profenofos (1.40 larvae/plant). The treatments of imidacloprid (2.23 larvae/plant) and novaluron (2.27 larvae/plant) were moderately effective and were at par with each other. The treatments of spinosad (2.73 larvae/plant), clothianidin (2.77 larvae/plant) and fipronil (2.90 larvae/plant) were less effective and were at par with each other. Thiamethoxam (3.20 larvae/plant) recorded higher number of larvae but significantly lower as compared to untreated control (3.77 larva/plant).

On the third day of second spraying, significantly minimum larval population was noticed in treatment of indoxacarb (1.10 larvae/plant), which was statistically at par with treatments of acetamiprid (1.23 larvae/plant) and profenofos (1.30 larvae/plant). The treatments of imidacloprid (2.13 larvae/plant) and novaluron (2.17 larvae/plant) recorded moderate number of larvae and were statistically at par to each other. Further, the treatment of spinosad (2.53 larvae/plant), clothianidin (2.67 larvae/plant) and fipronil (2.77 larvae/plant) recorded higher number of larvae and were statistically at par to each other, whereas the highest number of larvae were recorded in the

treatment of thiamethoxam (3.03 larvae/plant) but significantly lower than untreated control (4.00 larvae/plant).

Data recorded on the fifth day after second spraying indicated that larval population was decreased in all the treatments and more or less similar trend was observed.

On the seventh day after second spraying, indoxacarb maintained its superiority by recording the significantly minimum larval population (0.80 larva/plant) than all other treatments and it was at par with acetamiprid (0.90 larva/plant) and profenofos (0.97 larva/plant). The treatments of imidacloprid (1.90 larvae/plant) which and novaluron (1.93 larvae/plant) were moderately effective and were at par with each other. The order of remaining treatments in effectiveness was spinosad (2.30 larvae/plant), clothianidin and fipronil (2.50 larvae/plant) which were statistically at par to each other. Thiamethoxam (2.77 larvae/plant) recorded higher number of larvae.

Data recorded at fourteen days after second spraying revealed that indoxacarb maintained its superiority by recording significantly minimum number of larvae (0.63 larva/plant) among all the treatments. Acetamiprid (0.80 larva/plant) and profenofos (0.83 larva/plant) were at par with indoxacarb. The treatments of imidacloprid (1.80 larvae/plant) and novaluron (1.83 larvae/plant) recorded lower number of larvae and were statistically at par to each other. The treatment of spinosad (2.20 larvae/plant) recorded moderate number of larvae. The treatments of fipronil (2.60 larvae/plant), clothianidin (2.63 larvae/plant) and thiamethoxam (2.83 larvae/plant) recorded higher number of larvae however,

significantly lower than untreated control (4.60 larvae/plant).

The pooled data of different observations on larval population clearly indicated that all the insecticides recorded significantly lower larval population over untreated control. The treatment of indoxacarb stood first by recording significantly minimum larval population (1.43 larvae/plant) which was at par with acetamiprid (1.45 larva/plant) and profenofos (1.58 larvae/plant). The treatments of imidacloprid (2.31 larvae/plant) and novaluron (2.38 larvae/plant) found moderately effective in reducing larval population and were at par to each other. The order of less effective treatments was spinosad (2.63 larvae/plant), fipronil (2.84 larvae/plant), clothianidin (2.91 larvae/plant) and thiamethoxam (3.13 larvae/plant).

Data on population of larvae pooled over two sprayings of observations indicated that all the insecticidal treatments were significantly superior over untreated control (4.15 larvae/plant). However, significantly lower larval population was recorded in the treatment of indoxacarb (1.45 larvae/plant), which was at par with acetamiprid (1.51 larvae/plant) and profenofos (1.62 larvae/plant). The treatments of imidacloprid (2.35 larvae/plant) and novaluron (2.39 larvae/plant) recorded moderate number of larvae and were statistically at par to each other. Rest of the treatments *viz.*, spinosad (2.73 larvae/plant), fipronil (2.91 larvae/plant), clothianidin (2.99 larvae/plant) and thiamethoxam (3.18 larvae/plant) were less effective (Table-23).

Table 23: **Mean population of *N. geometralis* larvae on jasmine (second spray)**

Sr. No.	Treatment	Concentration (%)	Mean No. of *N. geometralis* larvae/plant							
			Before spray	1 DAS	3DAS	5DAS	7DAS	14DAS	Pooled data over period	Overall pooled mean of two sprayings
1	Acetamiprid 20% SP	0.004	1.95 (3.30)*	1.36 (1.37)*	1.32 (1.23)*	1.26 (1.10)*	1.18 (0.90)*	1.14 (0.80)*	1.40 (1.45)*	1.41 (1.51)*
2	Imidacloprid 17.8% SL	0.005	2.05 (3.77)	1.65 (2.23)	1.62 (2.13)	1.59 (2.03)	1.54 (1.90)	1.51 (1.80)	1.67 (2.31)	1.68 (2.35)
3	Clothianidin 50% WDG	0.003	2.17 (4.27)	1.80 (2.77)	1.78 (2.67)	1.76 (2.60)	1.73 (2.50)	1.77 (2.63)	1.84 (2.91)	1.87 (2.99)
4	Novaluron 10% EC	0.0075	2.12 (4.00)	1.66 (2.27)	1.63 (2.17)	1.60 (2.07)	1.56 (1.93)	1.53 (1.83)	1.70 (2.38)	1.70 (2.39)
5	Spinosad 2.5% SC	0.0020	2.01 (3.60)	1.78 (2.73)	1.72 (2.53)	1.69 (2.43)	1.66 (2.30)	1.63 (2.20)	1.75 (2.63)	1.78 (2.73)
6	Thiamethoxam 25% WG	0.005	2.13 (4.03)	1.92 (3.20)	1.87 (3.03)	1.84 (2.90)	1.80 (2.77)	1.83 (2.87)	1.90 (3.13)	1.91 (3.18)
7	Fipronil 5% SC	0.005	2.04 (3.67)	1.83 (2.90)	1.80 (2.77)	1.76 (2.63)	1.72 (2.50)	1.75 (2.60)	1.82 (2.84)	1.84 (2.91)
8	Profenofos 50% EC	0.075	2.08 (3.87)	1.38 (1.40)	1.34 (1.30)	1.28 (1.13)	1.21 (0.97)	1.15 (0.83)	1.44 (1.58)	1.46 (1.62)
9	Indoxacarb 15% SC	0.0075	2.08 (3.83)	1.31 (1.23)	1.26 (1.10)	1.21 (0.97)	1.14 (0.80)	1.06 (0.63)	1.39 (1.43)	1.40 (1.45)
10	Control	-	1.97 (3.40)	2.06 (3.77)	2.12 (4.00)	2.18 (4.27)	2.23 (4.47)	2.26 (4.60)	2.14 (4.08)	2.15 (4.15)
SE..m ±			**0.12**	**0.10**	**0.10**	**0.09**	**0.08**	**0.09**	**0.09**	**0.08**
C.D. at 5%			**NS**	**0.29**	**0.29**	**0.29**	**0.26**	**0.26**	**0.26**	**0.25**
C.V.%			**10.07**	**9.97**	**10.10**	**10.12**	**9.25**	**9.46**	**8.89**	**8.27**

* Data in the parentheses are original value, while those out side are square root ($\sqrt{X + 0.5}$) transformed values

DAS = Days After Spraying

Fig.-8 : Mean number of N. geometrella larvae [illegible]

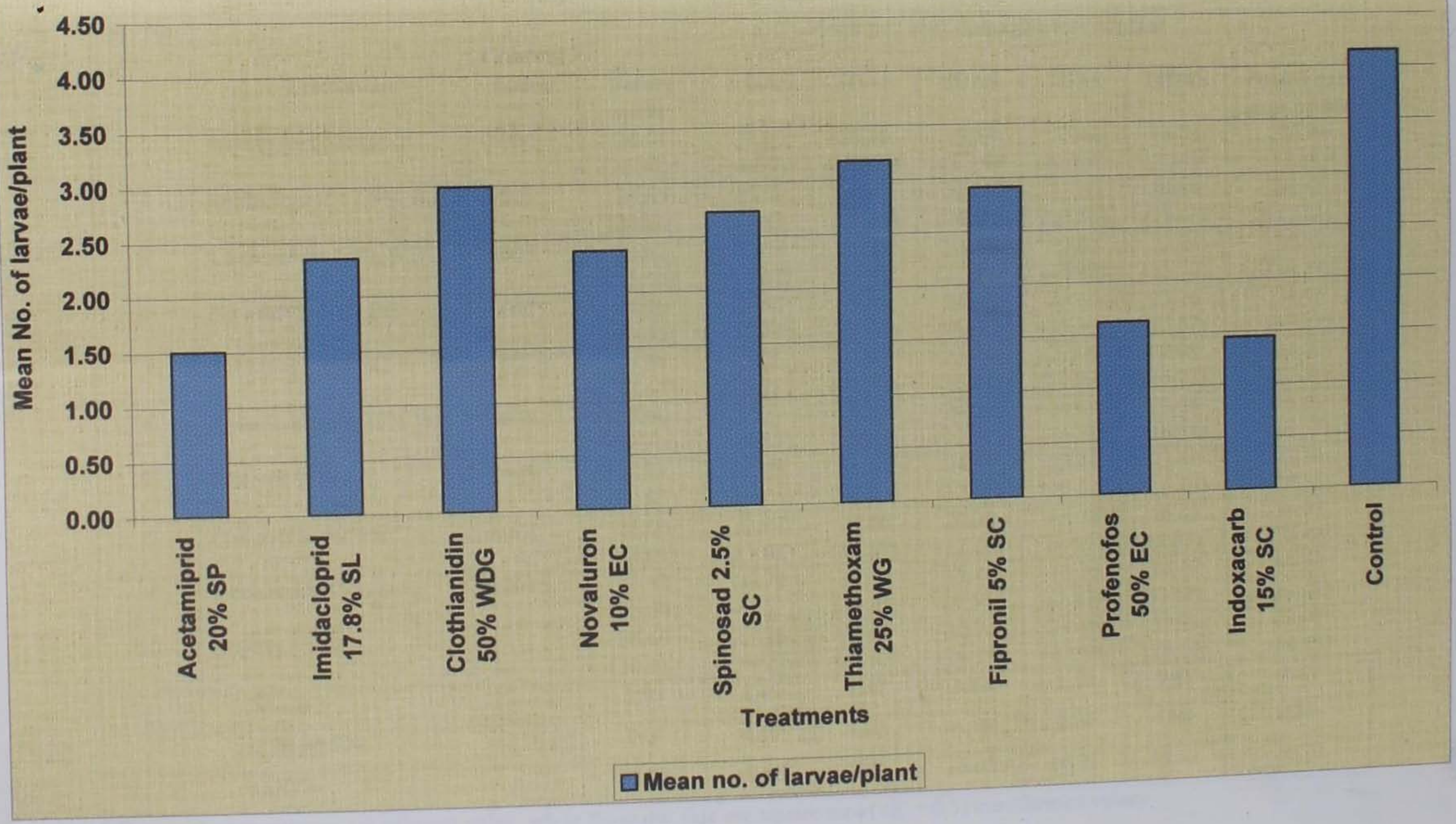


Table 24 : Effect of different insecticides on leaf damage caused by *N. geometralis* on jasmine (first spray)

Sr. No.	Treatment	Concentration (%)	Mean per cent damaged leaves/plant						
			Before spray	1 DAS	3DAS	5DAS	7DAS	14DAS	Pooled data over period
1	Acetamiprid 20% SP	0.004	26.71 (20.30)*	22.43 (14.57)*	21.40 (13.32)*	19.53 (11.18)*	17.46 (9.02)*	15.74 (7.38)*	20.79 (12.63)*
2	Imidacloprid 17.8% SL	0.005	26.85 (20.73)	25.59 (18.82)	24.99 (18.03)	23.46 (16.02)	22.65 (15.00)	22.69 (15.05)	24.41 (17.28)
3	Clothianidin 50% WDG	0.003	28.62 (23.10)	26.58 (20.17)	25.37 (18.52)	24.53 (17.38)	23.07 (15.48)	23.26 (15.70)	25.29 (18.39)
4	Novaluron 10% EC	0.0075	26.15 (19.55)	25.53 (18.63)	24.78 (17.63)	24.02 (16.63)	23.06 (15.40)	23.26 (15.67)	24.49 (17.25)
5	Spinosad 2.5% SC	0.0020	27.66 (21.65)	25.26 (18.22)	24.57 (17.30)	23.74 (16.22)	22.95 (15.22)	22.98 (15.27)	24.57 (17.31)
6	Thiamethoxam 25% WG	0.005	28.00 (22.12)	26.27 (19.67)	25.55 (18.68)	24.75 (17.62)	24.03 (16.67)	23.94 (16.57)	25.45 (18.55)
7	Fipronil 5% SC	0.005	27.77 (21.85)	26.28 (19.75)	25.61 (18.83)	24.75 (17.70)	23.44 (16.02)	23.48 (16.10)	25.26 (18.38)
8	Profenofos 50% EC	0.075	25.80 (19.03)	22.77 (15.02)	21.66 (13.67)	20.32 (12.10)	18.24 (9.85)	16.43 (8.07)	21.05 (12.96)
9	Indoxacarb 15% SC	0.0075	27.58 (21.50)	20.70 (12.52)	19.58 (11.25)	18.40 (9.98)	16.26 (7.87)	14.49 (6.28)	19.86 (11.57)
10	Control	-	26.69 (20.28)	28.76 (23.22)	29.64 (24.52)	30.74 (26.18)	31.41 (27.20)	32.04 (28.18)	29.92 (24.93)
SE..m ±			**1.92**	**1.45**	**1.47**	**1.44**	**1.38**	**1.41**	**1.49**
C.D. at 5%			**NS**	**4.40**	**4.60**	**4.40**	**4.20**	**4.30**	**4.50**
C.V.%			**12.24**	**10.05**	**10.47**	**10.63**	**10.71**	**11.17**	**10.70**

* Data in the parentheses are original value, while those out side are square root ($\sqrt{X + 0.5}$) transformed values
DAS = Days After Spraying

4.4.1.2 Percentage Leaf Damage

The data on percentage damage of leaves recorded before spraying was found to be nonsignificant among different treatments, which indicated that the percentage of leaf damage was homogenous.

Data recorded at one day after first spraying indicated significant difference among treatments. The minimum leaf damage was recorded in the treatment of indoxacarb (12.52 %), which was at par with the treatments of acetamiprid (14.57 %) and profenofos (15.02 %). Spinosad (18.22 %) and novaluron (18.63 %) recorded moderate per cent of leaf damage and were statistically at par to each other. Imidacloprid (18.82 %), thiamethoxam (19.67 %), fipronil (19.75 %) and clothianidin (20.17 %) recorded higher per cent of leaf damage, which were statistically at par with untreated control (23.22 %).

The perusal of data recorded at third day after first spraying revealed that all the insecticidal treatments were found significantly superior in reducing leaf damage over untreated control (24.52 %). Indoxacarb maintained its superiority by recording the minimum leaf damage (11.25 %) which was at par with the treatments of acetamiprid (13.32 %) and profenofos (13.67 %). Remaining treatments *viz.*, Spinosad (17.30 %), novaluron (17.63 %), imidaclopried (18.03 %), clothianidin (18.52 %), thiamethoxam (18.68 %) and fipronil (18.83 %) found less effective.

After fifth day of first spraying similar trend of various

insecticidal treatments in respect of their efficacy against leaf damage was observed.

Data recorded on the seventh day after first spraying indicated that leaf damage was decreased in all the insecticidal treatments. Significantly lowest leaf damaged was recorded in the treatment of indoxacarb (7.87 %) than all other treatments and it was at par with acetamiprid (9.02 %) and profenofos (9.85 %). The remaining treatments *viz.*, imidacloprid (15.00 %), spinosad (15.22 %), novaluron (15.40 %), clothianidin (15.48 %), fipronil (16.02 %) and thiamethoxam (16.67 %) found moderately effective in reducing leaf damage.

At fourteen days after first spraying, the treatment of indoxacarb recorded significantly lowest per cent of leaf damage (6.28 %) and it was at par with acetamiprid (7.38 %) and profenofos (8.07 %). The order of effectiveness of rest of treatments was imidacloprid (15.05 %), spinosad (15.27 %), novaluron (15.67 %), clothianidin (15.70 %), fipronil (16.10 %) and thiomethoxam (16.57 %).

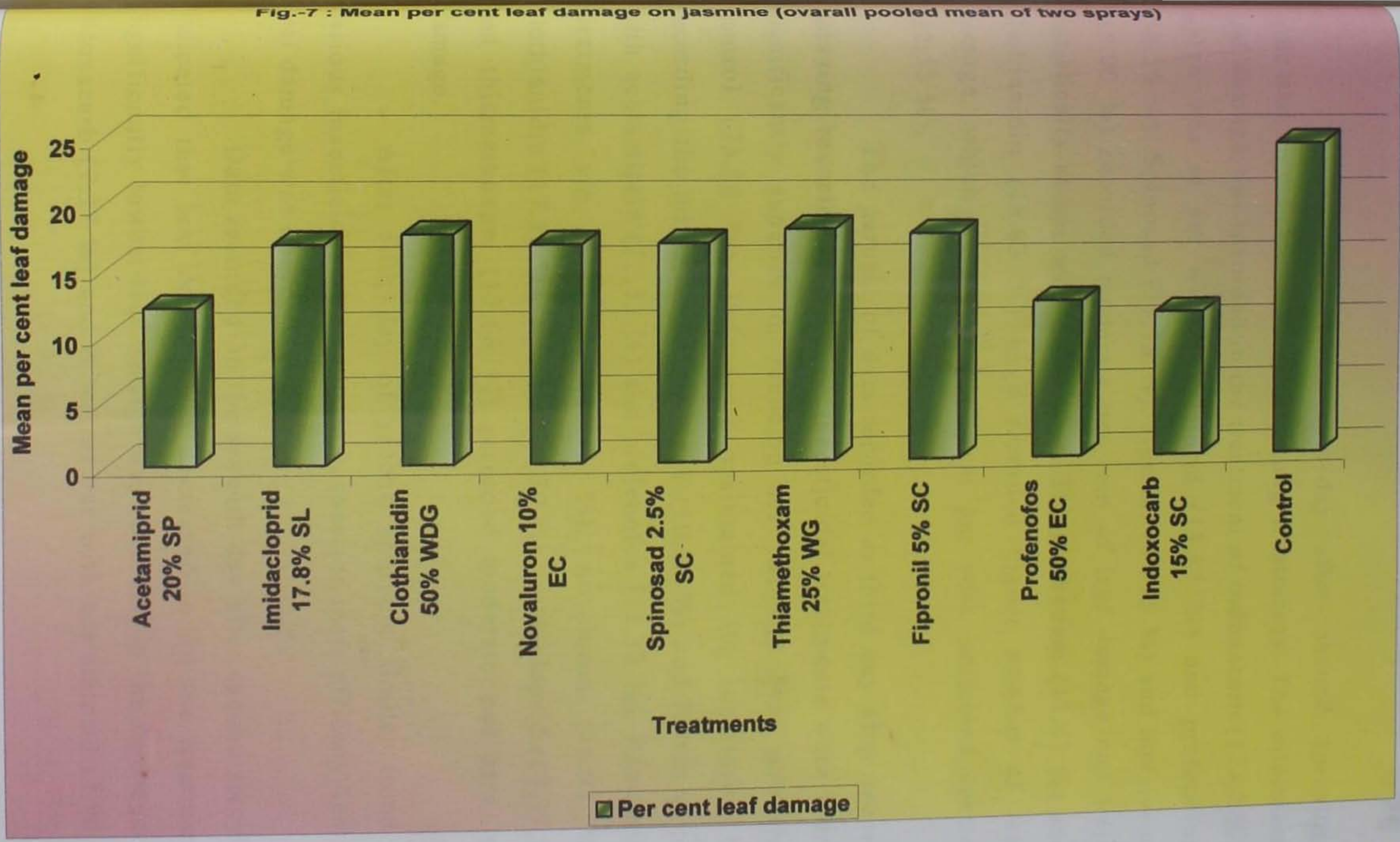
The results of pooled data over periods revealed that indoxacarb recorded lower per cent of leaf damage (11.57 %) which was at par with acetamiprid (12.63 %) and profenofos (12.96 %). The least effective treatments were novaluron (17.25 %), imidacloprid (17.28 %), spinosad (17.31 %), clothianidin (18.39 %) and thiamethoxam (18.55 %), respectively. The maximum per cent of damaged leaf (24.93 %) was recorded in untreated control.

Table 25: Effect of different insecticides on leaf damage caused by N. geometralis on jasmine (second spray)

Sr. No.	Treatment	Concentration (%)	Mean per cent damaged leaves/plant							
			Before spray	1 DAS	3DAS	5DAS	7DAS	14DAS	Pooled data over period	Overall pooled mean of two sprayings
1	Acetamiprid 20% SP	0.004	26.00 (19.30)*	21.61 (13.57)*	20.54 (12.32)*	18.48 (10.05)*	16.32 (7.90)*	14.44 (6.22)*	19.87 (11.56)*	20.34 (12.09)*
2	Imidacloprid 17.8% SL	0.005	26.42 (20.07)	25.13 (18.15)	24.52 (17.37)	22.97 (15.35)	22.15 (14.33)	22.19 (14.38)	23.94 (16.61)	24.18 (16.94)
3	Clothianidin 50% WDG	0.003	27.48 (21.43)	25.62 (18.83)	24.37 (17.18)	23.50 (16.05)	22.00 (14.15)	22.38 (14.62)	24.28 (17.04)	24.78 (17.72)
4	Novaluron 10% EC	0.0075	25.92 (19.22)	25.05 (18.00)	24.25 (16.93)	23.23 (15.60)	22.53 (14.73)	22.70 (14.97)	23.97 (16.58)	24.23 (16.91)
5	Spinosad 2.5% SC	0.0020	26.40 (19.85)	24.92 (17.78)	24.20 (16.83)	23.17 (15.50)	22.63 (14.83)	22.70 (14.93)	24.03 (16.62)	24.30 (16.97)
6	Thiamethoxam 25% WG	0.005	27.31 (21.12)	25.55 (18.67)	24.82 (17.68)	24.00 (16.62)	22.98 (15.33)	23.17 (15.57)	24.67 (17.50)	25.06 (18.03)
7	Fipronil 5% SC	0.005	26.86 (20.52)	24.96 (17.95)	24.48 (17.30)	23.62 (16.20)	22.27 (14.52)	22.37 (14.67)	24.14 (16.86)	24.70 (17.62)
8	Profenofos 50% EC	0.075	24.35 (17.03)	22.35 (14.55)	20.55 (12.33)	18.84 (10.43)	16.95 (8.52)	15.02 (6.73)	19.89 (11.60)	20.48 (12.28)
9	Indoxacarb 15% SC	0.0075	27.23 (21.00)	20.27 (12.02)	19.17 (10.80)	17.93 (9.48)	15.73 (7.37)	13.90 (5.78)	19.42 (11.08)	19.64 (11.32)
10	Control	-	26.21 (19.62)	28.31 (22.55)	29.20 (23.85)	30.31 (25.52)	30.98 (26.53)	13.62 (27.52)	29.48 (24.26)	29.70 (24.60)
SE..m ±			**1.69**	**1.41**	**1.33**	**1.27**	**1.24**	**1.27**	**1.34**	**1.41**
C.D. at 5%			**NS**	**4.30**	**4.05**	**3.8**	**3.70**	**3.90**	**4.06**	**4.28**
C.V.%			**11.11**	**10.00**	**9.79**	**9.72**	**9.99**	**10.46**	**9.92**	**10.30**

* Data in the parentheses are original value. while those out side are square root ($\sqrt{X + 0.5}$) transformed values
DAS = Days After Spraying

Fig.-7 : Mean per cent leaf damage on jasmine (ovarall pooled mean of two sprays)



Data recorded at one day after second spraying indicated significant difference among treatments. The minimum leaf damage was recorded in the treatment of indoxacarb (12.02 %) which was at par with acetamiprid (13.57 %) and profenofos (14.55 %). Spinosad (17.78 %), fipronil (17.95 %) and novaluron (18.00 %) recorded moderate per cent of leaf damage and were statistically at par with each other. Thiamethoxam (18.67 %) and clothianidin (18.83 %) have recorded higher number of leaf damage, which were statistically at par with untreated control (22.55 %).

The perusal of data recorded at third day after second spraying revealed that all the insecticidal treatments were found significantly superior in reducing leaf damage over untreated control (23.85 %). Indoxacarb maintained its superiority by recording the minimum leaf damage (10.80 %) and it was at par with acetamiprid (12.32 %) and profenofos (12.33 %). Remaining treatments *viz.,* spinosad (16.83 %), novaluron (16.93 %), clothianidin (17.18 %), fipronil (17.30 %), imidacloprid (17.37 %) and thiamethoxam (17.68 %) recorded moderate per cent leaf damage.

After fifth day of second spraying similar trend of various insecticidal treatments in respect of their efficacy against leaf damage was observed.

Data recorded on the seventh day after second spraying indicated that leaf damage was decreased in all the treatments. Significantly lowest leaf damage was recorded in the treatment of indoxacarb (7.37 %) and it was at par with acetamiprid (7.90 %)

and profenofos (8.52 %). The next better treatment was clothianidin (14.15 %) followed by imidacloprid (14.33 %), fipronil (14.52 %), novaluron (14.73 %), spinosad (14.83 %) and thiamethoxam (15.33 %) found moderately effective in reducing leaf damage.

At the fourteen days after second spraying, the treatment of indoxacarb recorded significantly lowest leaf damage (5.78 %) and it was at par with acetamiprid (6.22 %) and profenofos (6.73 %). The order of effectiveness of rest of the treatments was imidacloprid (14.38 %), clothianidin (14.62 %) fipronil (14.52 %), spinosad (14.93 %), novaluron (14.97 %) and thiamethoxam (15.57 %).

The pooled results of the data over periods revealed that lower per cent of leaf damage was recorded in the treatment of indoxacarb (11.08 %) and it was at par with acetamiprid (11.56 %) and profenofos (11.60 %). The order of less effective treatment was novaluron (16.58 %), spinosad (16.62 %), fipronil (16.86 %), clothianidin (17.04 %) and thiamethoxam (17.50 %) respectively. The maximum per cent of damaged leaf (24.26 %) was recorded in untreated control.

Data on per cent leaf damage pooled over for two sprayings indicated that all the insecticidal treatments were significantly superior over untreated control (24.60 %). However, significantly lowest per cent leaf damage was recorded in the treatment of indoxacarb (11.32 %) and it was at par with acetamiprid (12.09 %) and profenofos (12.28 %). It was followed by the treatments of novaluron (16.91 %), imidacloprid (16.94 %),

spinosad (16.97 %), fipronil (17.62 %), clothianidin (17.72 %) and thiamethoxam (18.03 %), which were found less effective.

4.4.3 Yield and economics of different chemical insecticidal treatments

The results revealed that the gross realization (Rs/ha) over untreated control was highest in the plots treated with indoxacarb (Rs.72450 ha^{-1}), followed by acetamiprid (Rs. 67206 ha^{-1}), profenofos (Rs. 66309 ha^{-1}), imidacloprid (Rs. 63388 ha^{-1}), novaluron (Rs. 62399 ha^{-1}), clothianidin (Rs. 60743 ha^{-1}), spinosad (Rs. 60398 ha^{-1}), fipronil (Rs. 59271 ha^{-1}) and thiamethoxam (Rs. 57500 ha^{-1}). The corresponding figures for net profit obtained over control were 18009, 11875, 11147, 8255, 5779, 5390, 4896, 3940 and 2324 Rs./ha, respectively.

Looking to net BCR, profenofos stood first (1:14.46), followed by indoxacarb (1:12.38). The order of net BCR of rest of the treatments was acetamiprid (1:12.34), imidacloprid (1:10.93), clothianidin (1:4.91), spinosad (1:3.61), fipronil (1:3.43), thiamethoxam (1:2.16) and novaluron (1:1.65).

It can be concluded from the present results that profenophos and indoxacarb were most economical with net BCR of 1:14.46 and 1:12.38 respectively and gave effective control of *N. geometralis*.

Table: 2: Economics of different insecticidal treatments

Treatments	Total sprays	Quantity of insecticide (L or kg/ha)	Cost of insecticide (Rs/ha)	Labour Cost (Rs/ha)	Total cost of plant protection (Rs/ha)	Yield (Kg./ha)	Gross income (Rs/ha)	Net gain (Rs/ha)	Net profit over control	CBR	
										Gross	Net
Acetamiprid 20% SP	2	0.138	690	200	890	2922	67206	66316	11875	1:13.34	1:12.34
Imidacloprid 17.8% SL	2	0.194	492	200	692	2756	63388	62696	8255	1:11.93	1:10.93
Clothianidin 50% WDG	2	0.047	712	200	912	2641	60743	59831	5390	1:5.91	1:4.91
Novaluron 10% EC	2	0.521	1979	200	2179	2713	62399	60220	5779	1:2.65	1:1.65
Spinosad 2.5% SC	2	0.556	861	200	1061	2626	60398	59337	4896	1:4.61	1:3.61
Thiamethoxam 25% WG	2	0.139	535	200	735	2500	57500	56765	2324	1:3.16	1:2.16
Fipronil 5% SC	2	0.690	690	200	890	2577	59271	58381	3940	1:4.43	1:3.43
Profenofos 50% EC	2	1.042	521	200	721	2883	66309	65588	11147	1:15.46	1:14.46
Indoxacarb 15% SC	2	0.347	1145	200	1345	3150	72450	71105	18009	1:13.38	1:12.38
Control	0	0	0	0	0	2367	54441	-	-	-	-

Price : **Cost of insecticides :**

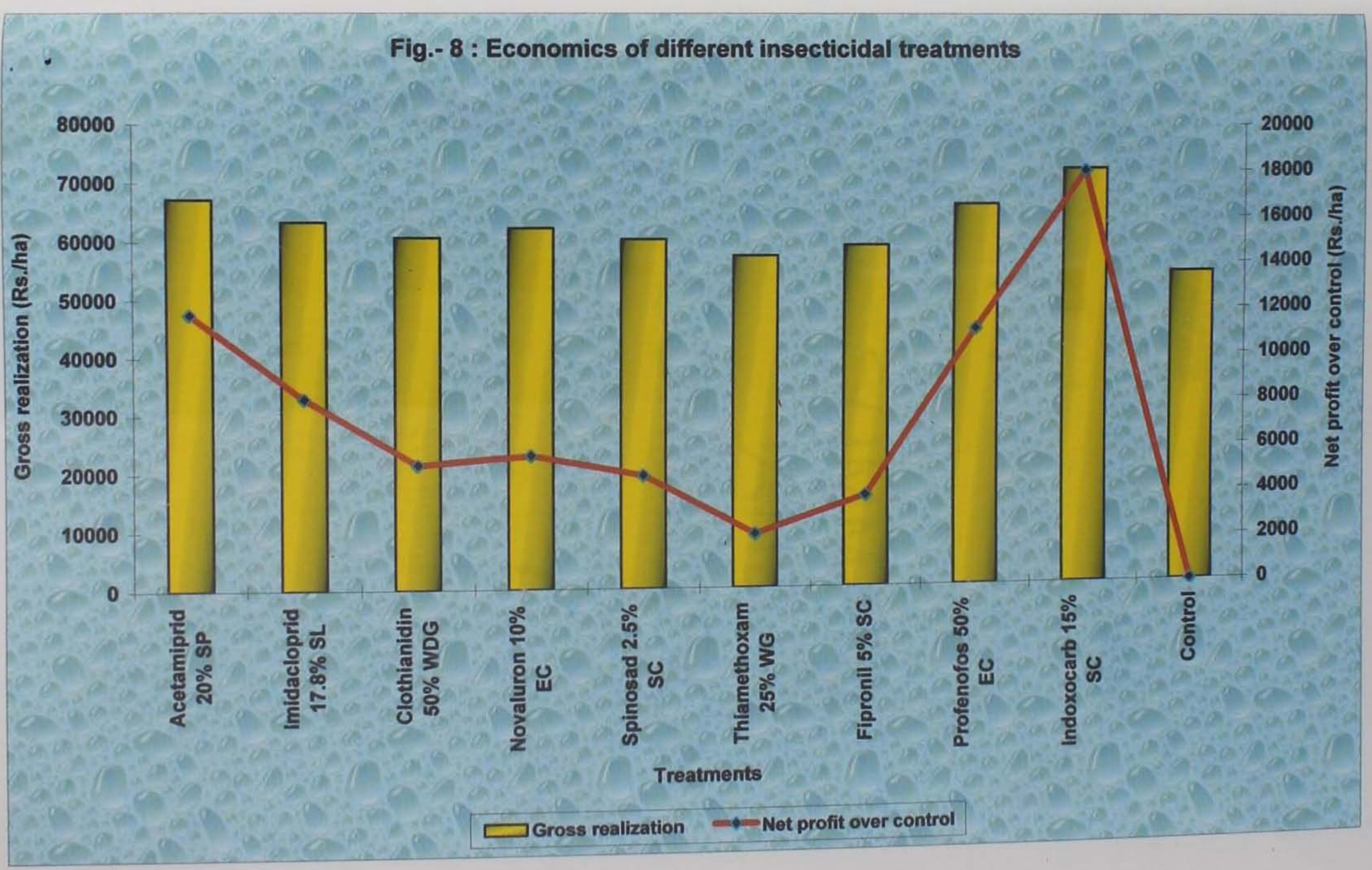
*prevailing market price of flower : Rs. 23/Kg

*Labour charge = 100 Rs/spray

*Cost of insecticides (Rs./L or kg)

Imidacloprid : 1050 Rs/lit
Novaluron : 3800 Rs/lit
Acetamapride : 5000 Rs/kg
Spinosad : 1550 Rs/lit
Clothianidin : 15166 Rs/lit
Thiamethoxam : 3850 Rs/kg
Fipronil : 1000 Rs/lit
Profenofos : 500 Rs/lit
Indoxacarb : 3300 Rs/lit

Fig.- 8 : Economics of different insecticidal treatments



SUMMARY AND CONCLUSION

V SUMMARY AND CONCLUSION

Jasmine is one of the important flower crops of India. It is attacked by several insect pests. Among the various insect pests, leaf webworm (*N. geometralis*) is potential pest causing considerable damage to the plant by attacking on the leaf. Efforts were therefore, made to study the biology, population dynamics, varietal screening and bio-efficacy of insecticides against *N.geometralis* at Navsari Agricultural University, Navsari. The important findings emerged out from these investigations are summarized and concluded below.

5.1 Biology of leaf webworm , *N. geometralis* on jasmine

5.1.1. Eggs

Eggs of *N.geometralis* were small, flat, oblong and greenish in colour. Egg period on jasmine ranged from 3 to 4 days with an average of 3.88 ± 0.33 days.

Length and width of eggs ranged from 0.87 to 1.10 mm with an average of 0.94 ± 0.04 mm and 0.63 to 0.76 mm with an average of 0.72 ± 0.02 mm. Hatching percentage was varied from 68.18 to 97.06 with an average of 92.95 ± 7.40.

5.1.2 Larvae

The freshly emerged larvae were yellowish white with reddish yellow head which was broader than the body and tapered towards the anal end. There were four rows of grey spots on the body (two on the dorsal surface and each on the dorsolateral side of the body). Total larval period was 11 to 14 days with an average of 13.12 ± 0.73 days with five instars. Larval period (I, II, III, IV

and V instars) of *N. geometralis* was varied from 2 to 3 days (I instar), 3 to 4 days (II instar), 2 to 3 days (III instar), 2 to 3 days (IV instar) and 2 to 3 days (V instar) with an average of 2.76 ± 0.44, 3.72 ± 0.46 days, 2.20 ± 0.41, 2.20 ± 0.41 and 2.24 ± 0.44 days, respectively.

First, second, third, fourth and fifth instar larvae measured in length and width as 3.50 to 5.00 mm and 0.30 to 0.40 mm (I instars), 7.00 to 8.00 mm and 0.60 to 0.80 mm (II instars), 10.50 to 11.00 mm and 1.20 to 1.40 mm (III instars), 14.90 to 15.30 mm and 1.60 to 1.70 mm (IV instar), 19.50 to 20.00 mm and 1.80 to 2.00 mm (V instars) with an average of 4.03 ± 0.32 and 0.39 ± 0.03 (I instars), 7.67 ± 0.30 and 0.72 ± 0.05 (II instars), 10.72 ± 0.18 and 1.31 ± 0.07 (III instars), 15.06 ± 0.12 and 1.66 ± 0.05 (IV instar), 19.88 ± 0.19 and 1.98 ± 0.05 (V instars) respectively.

5.1.3 Pupa

Pupation took place on the leaves with average pre pupal period as 1.04 ± 0.20 days. The newly formed pupae were light green in colour. Later, it turned to light brown before emergence of adult. It measured on an average of 13.28 ± 0.25 mm in length and 2.06 ± 0.10 mm in width. The pupal period lasted for 7.84 ± 0.37 days.

5.1.4 Adult

Adult longevity of male and female of *N. geometralis* on jasmine varied from 3 to 5 days (male), 6 to 7 days (Female),

with an average of 3.88 ± 0.83 days (male), and 6.16 ± 0.37 days (female).

The length and width of male and female ranged from 10.00 to 10.70 mm and 21.00 to 22.50 mm (female) and 9.00 to 9.70 mm and 20.00 to 21.60 mm (male) with an average of 10.19 ± 0.25 and 21.96 ± 0.29 mm (female) and 9.20 ± 0.24 and 20.44 ± 0.53 mm (male).

5.1.5 Total life cycle

Total life cycle of male and female of *N. geometralis* on jasmine ranged from 22 to 31 days (male) and 25 to 33 days (female), with an average of 26.62 ± 2.57 (male) and 28.90 ± 2.11 days (female).

5.1.6 Pre-oviposition, oviposition and post-oviposition

Pre-oviposition, oviposition and post-oviposition period of *N. geometralis* on jasmine varied from 1 to 2 days (pre-oviposition), 3 to 4 days (oviposition) and 1 to 2 days (post-oviposition) with an average of 1.60 ± 0.50, 3.44 ± 0.51 and 1.12 ± 0.33 days, respectively.

5.1.7 Fecundity

Fecundity of *N. geometralis* on jasmine ranged from 21 to 133 with an average of 52.35 ± 25.53.

5.1.8 Hatching percentage

Hatching percentage of *N. geometralis* eggs was varied from 68.18 to 97.96.

5.1.9 Sex ratio

The sex ratio of male : female of *N. geometralis* recorded in laboratory was 1 : 0.94.

5.2 Population dynamics of insect pests of jasmine.

Leaf webworm (*N. geometralis*)

The population of leaf webworm reached the peak level (10.8 larvae/plant) during first week of October. Thereafter pest population steadily declined and reached to a low level up to 0.02 larva/plant during last week of February. During 1st week of March to 1st week of May no larval population was recorded on jasmine. After that the population was more or less constant from 2nd week of May to last week of September.

The percentage of damaged leaves by leaf webworm was found higher (40.35 %) during first week of October and the minimum percentage leaf damage (2.80 %) was recorded during first week of May.

Evaporation (r= -0.442), had significantly negative influence on leaf webworm population, while non significant negative influence was found with maximum temperature (r= -0.084), sunshine hour (r= -0.191) and wind velocity (r= -0.113) where as non significantly positive influence of minimum temperature (r= 0.082), average temperature (r= 0.028), morning relative humidity (r= 0.213), evening relative humidity (r= 0.237), average relative humidity (r= 0.242), rainy days (r= 0.089) and rain fall (r= 0.061) was found on leaf webworm of jasmine.

Thrips

The thrips was observed during November to June 2006 and October 2007. During last week of March, population was at highest level (2.30 thrips/leaf), whereas population of thrips was absent during July to September 2007. The average population of thrips per standard week was recorded as 0.95 per leaf during the year.

The thrips population exhibited significant positive correlation with maximum temperature (r= 0.596), sunshine hours (r=0.706) and evaporation (r= 0.559), while significant negative correlation was recorded with maximum temperature (r= -0.303), morning relative humidity (r= -0.644), evening relative humidity (r= -0.597), average relative humidity (r= -0.592), rainy days (r= -0.712) and rain fall (r= -0.592) was positive non significant, while wind velocity (r= - 0.244) was negative non significant.

5.2 Varietal screening of jasmine against *N. geometralis*

5.2.1 Leaf webworm

Among all the varieties, Co-2 recorded the lowest population of *N. geometrlis* (0.85 larva/plant) which was at par with Co-1 (1.09 larva/plant), followed by Juhi, Barmasi, But mogra and Local which recorded 6.49, 6.61, 7.20 and 9.60 larvae/plant, respectively. The highest population of *N. geometrlis* (11.10 larvae/plant) was found on variety Motiya.

Among the varieties the leaf webworm population varied from 0.85 to 11.10 larvae/plant. Among all the varieties Co-

2 and Co-1 found relatively resistant against jasmine leaf webworm.

5.2.2 Percentage damaged leaf

Among all the varieties of jasmine, lowest per cent leaf damage was recorded in variety Co-2 (9.31%) and second lowest per cent leaf damage was observed in Co-1 (10.82%). Rest of varieties *viz*., Juhi, Barmasi, But mogra and Local which recorded 29.79, 29.97, 30.88 and 41.52 per cent leaf damage, respectively. The significantly highest per cent leaf damage was recorded on Motiya variety (45.40 %)

Among the varieties per cent damaged leaves varied from 9.31 to 45.40 per cent. Among all the varieties Co-2 and Co-1 found relatively resistant against jasmine leaf webworm.

5.2.3 Thrips

Among all the varieties of jasmine, Co-2 recorded the lowest population of thrips (0.61 thrip/leaf) which was at par with Co-1 (0.83 thrips/leaf), followed by Juhi, Barmasi, Motiya and But mogra which recorded 1.17, 1.18, 1.21 and 1.24 thrips/leaf, respectively. The highest population of thrips (1.36 thrips/leaf) was found on variety Local.

5.3 Bio-efficacy of different insecticides against *N. geometralis*

The insecticides tested for their bioefficacy against *N. geometralis* under field conditions revealed that all the insecticidal treatments were significantly superior to untreated control in checking the *N. geometralis* population under field conditions.

Among different insecticidal treatments, indoxocarb checked the *N. geometralis* population effectively over all other treatments and given consistent performance. It was followed by the treatment of acetamiprid and profenofos which were statistically at par with indoxocarb. The order of remaining treatments in effectiveness was imidacloprid (2.35 larvae/plant and 16.94 % leaf damage), novaluron (2.39 larvae/plant and 16.91 % leaf damage), spinosad (2.73 larvae/plant and 16.97 % leaf damage), fipronil (2.91 larvae/plant and 17.62 % leaf damage), clothianidin (2.99 larvae/plant and 17.72 % leaf damage) and thiamethoxam (3.18 larvae/plant and 18.03 % leaf damage).

Profenofos and indoxacarb were most economic with 1:14.46 and 1:12.38 net CBR, respectively.

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APPENDIX

Appendix – I : Meteorological data recorded during the course of investigation (weekly mean) year 2008-09

Month	Std. week	Temperature (^{0}C)			Relative humidity (%)			Rainfall (mm)	Rainy days	Sunshine (hrs/day)	Wind Velocity (km/hr)	Evaporati -on Rate (mm)
		Max.	Min.	Ave.	Morning	Evening	Ave.					
1	2	3	4	5	6	7	8	9	10	11	12	13
November	45	34.20	21.60	27.90	85.00	44.00	64.50	0.00	0.00	9.00	4.00	3.00
	46	33.80	19.70	26.75	80.00	44.00	62.00	0.00	0.00	9.00	3.40	3.00
	47	31.70	18.90	25.30	83.00	53.00	68.00	3.00	1.00	7.40	3.60	3.00
	48	31.40	16.30	23.85	84.00	58.00	71.00	0.00	0.00	8.60	3.60	3.50
December	49	31.30	17.20	24.25	85.00	66.00	75.50	0.00	0.00	8.40	3.70	3.60
	50	30.60	15.00	22.80	85.00	65.00	75.00	0.00	0.00	8.90	3.20	3.60
	51	31.50	14.30	22.90	75.00	40.00	57.50	0.00	0.00	9.30	3.60	3.20
	52	30.90	15.40	23.15	83.00	37.00	60.00	0.00	0.00	8.50	3.60	3.10
January	1	28.70	13.20	20.95	86.00	39.00	62.50	0.00	0.00	8.90	3.60	3.10
	2	30.00	14.20	22.10	75.00	36.00	55.50	0.00	0.00	7.90	4.40	3.40
	3	30.40	13.00	21.70	77.00	31.00	54.00	0.00	0.00	9.50	3.60	3.60
	4	31.90	15.80	23.85	75.00	29.00	52.00	0.00	0.00	8.80	3.20	3.70
	5	31.70	16.50	24.10	77.00	36.00	56.50	0.00	0.00	7.70	3.90	4.20
February	6	30.20	17.70	23.95	91.00	47.00	69.00	0.00	0.00	9.20	4.00	3.20
	7	28.10	16.80	22.45	87.00	38.00	62.50	0.00	0.00	8.80	4.70	3.60
	8	34.40	18.90	26.65	71.00	29.00	50.00	0.00	0.00	9.70	4.00	5.30
	9	31.70	17.60	24.65	86.00	34.00	60.00	0.00	0.00	9.50	4.40	5.00
March	10	34.10	16.70	25.40	71.00	24.00	47.50	0.00	0.00	9.20	4.10	6.70
	11	34.40	19.10	26.75	74.00	29.00	51.50	0.00	0.00	9.20	5.30	6.10
	12	35.00	19.10	27.05	84.00	30.00	57.00	0.00	0.00	8.70	4.90	5.90
	13	39.00	20.80	29.90	75.00	26.00	50.50	0.00	0.00	8.70	4.40	7.20

Contd.. Appendix-I

Month	Std. week	Temperature (^{0}C)			Relative humidity (%)			Rainfall (mm)	Rainy days	Sunshine (hrs/day)	Wind Velocity (km/hr)	Evaporati -on Rate (mm)
		Max.	Min.	Ave.	Morning	Evening	Ave.					
1	2	3	4	5	6	7	8	9	1	2	3	4
April	14	38.60	20.80	29.70	74.00	24.00	49.00	0.00	0.00	9.10	5.10	7.00
	15	35.90	22.40	29.15	84.00	36.00	60.00	0.00	0.00	9.80	5.70	6.30
	16	33.30	24.70	29.00	86.00	57.00	71.50	0.00	0.00	9.70	7.00	6.20
	17	34.80	22.90	28.85	83.00	46.00	64.50	0.00	0.00	10.40	6.10	5.50
	18	36.90	24.50	30.70	83.00	43.00	63.00	0.00	0.00	10.40	6.30	7.00
May	19	33.10	26.40	29.75	78.00	59.00	68.50	0.00	0.00	10.10	9.90	6.70
	20	32.20	27.00	29.60	76.00	57.00	66.50	0.00	0.00	9.20	10.10	7.30
	21	33.30	28.00	30.65	75.00	58.00	66.50	0.00	0.00	10.60	10.40	7.00
	22	36.90	26.90	31.90	75.00	54.00	64.50	3.00	1.00	8.60	7.90	6.90
June	23	33.70	27.70	30.70	84.00	62.00	73.00	20.00	1.00	8.40	8.50	5.70
	24	33.60	27.90	30.75	79.00	63.00	71.00	10.00	1.00	7.00	9.30	6.60
	25	33.70	25.60	29.65	87.00	68.00	77.50	49.00	4.00	5.80	8.00	5.90
	26	29.70	25.30	27.50	92.00	82.00	87.00	174.80	6.00	3.20	9.00	3.30
July	27	30.00	26.90	28.45	85.00	81.00	83.00	140.40	4.00	0.40	15.50	3.40
	28	30.00	26.50	28.25	89.00	80.00	84.50	51.80	4.00	3.00	10.20	3.30
	29	30.80	25.90	28.35	90.00	72.00	81.00	23.50	3.00	9.60	10.70	3.50
	30	31.20	25.50	28.35	92.00	76.00	84.00	195.10	3.00	6.50	5.10	3.10
	31	29.50	24.80	27.15	94.00	81.00	87.50	290.00	4.00	3.30	6.00	2.20

Contd.. Appendix-I

Month	Std. week	Temperature (^{0}C)			Relative humidity (%)			Rainfall (mm)	Rainy days	Sunshine (hrs/day)	Wind Velocity (km/hr)	Evaporati -on Rate (mm)
		Max.	Min.	Ave.	Morning	Evening	Ave.					
1	2	3	4	5	6	7	8	9	10	11	12	13
August	32	28.10	25.00	26.55	94.00	88.00	91.00	249.00	6.00	1.10	9.90	1.90
	33	29.80	25.70	27.75	88.00	77.00	82.50	28.90	4.00	2.90	12.10	2.80
	34	30.90	25.40	28.15	91.00	71.00	81.00	11.90	1.00	7.50	5.60	4.10
	35	29.40	25.00	27.20	97.00	89.00	93.00	286.20	6.00	1.50	5.80	2.50
September	36	29.30	25.30	27.30	93.00	80.00	86.50	100.00	6.00	3.40	5.40	3.00
	37	32.00	24.80	28.40	91.00	62.00	76.50	22.00	2.00	8.30	4.00	3.70
	38	31.40	24.30	27.85	96.00	72.00	84.00	157.00	5.00	4.10	4.00	2.90
	39	29.50	25.10	27.30	95.00	80.00	87.50	36.00	3.00	3.00	5.30	2.30
October	40	33.40	22.50	27.95	90.00	48.00	69.00	0.00	0.00	7.40	3.20	3.60
	41	34.00	23.20	28.60	83.00	46.00	64.50	0.00	0.00	7.70	3.40	3.10
	42	35.00	18.50	26.75	77.00	25.00	51.00	0.00	0.00	9.60	3.50	3.80
	43	35.10	19.10	27.10	70.00	27.00	48.50	0.00	0.00	9.70	3.30	3.70
	44	34.90	21.80	28.35	80.00	49.00	64.50	7.00	1.00	8.50	3.40	3.70

C E R T I F I C A T E

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(Gajera D.K.)