

**MANAGEMENT OF PESTS INFESTING ROSES UNDER
POLYHOUSE CONDITION**

A thesis Submitted to

**MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI
DIST. AHMEDNAGAR (M.S), INDIA**

in partial fulfillment of the requirement for the degree

of

DOCTOR OF PHILOSOPHY

In

AGRICULTURAL ENTOMOLOGY

By

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M.Sc.(Agri.) First class with distinction

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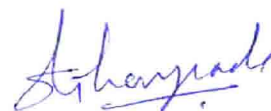
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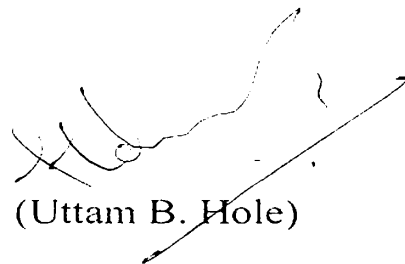
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CANDIDATE'S DECLARATION

I hereby declare that the thesis entitled, "MANAGEMENT OF PESTS INFESTING ROSES UNDER POLYHOUSE CONDITION" or part thereof, has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma.

Place: Rahuri. ,

Date: 15 JUN 2007



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C E R T I F I C A T E

This is to certify that the thesis entitled, **“MANAGEMENT OF PESTS INFESTING ROSES UNDER POLYHOUSE CONDITION,”** submitted to the Faculty of Agriculture, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, District: Ahmednagar, Maharashtra State, in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in AGRICULTURAL ENTOMOLOGY, embodies the results of a piece of bonafide research work carried out by **Shri. U. B. Hole**, under my guidance and supervision and that no part of the thesis has been submitted for any other diploma, degree or publication in any other form.

The assistance and the help received during the course of this investigation and sources of literature referred to have been duly acknowledged.



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A C K N O W L W D G E M E N T S

I consider myself to be extremely fortunate for the opportunity I had of working under the guidance of Dr. A. G. Chandele, my Chairman and Research Guide and Head, Department of Entomology, PGI, MPKV, Rahuri, District: Ahmednagar, (M.S.), India. I have great pleasure in recording my heartfelt feelings of gratification and indebtedness for his scholastic guidance, timely suggestions, constructive criticism and generous treatment. The successful completion of this work is due to his counsel.

It is indeed difficult to put down on paper my heartfelt gratitude towards those innumerable people who have aided me in the completion of my thesis. I would, however, like to avail this opportunity to express my sincere thanks to Dr. M. D. Dethé, Ex. Head, Department of Entomology, MPKV, Rahuri, Dr. S. A. Ghorpade, Ex. Entomologist, All India Coordinated research Project on Biological Control (AICRP-BC), College of Agriculture, Pune and Dr. M. T. Patil, Floriculturist and Associate Director of Research, Zonal Agricultural Research Station, Ganeshkhind, Pune, for being the members of my advisory committee and for their valuable counsel and sensible criticism during the course of investigation.

I am also indebted to Dr. A. S. Jadhav, Dean, Faculty of Agriculture and Director of Instructions, MPKV, Rahuri, Dr. C. B. Gaikwad, Associate Dean, PGI, MPKV, Rahuri, Dr. D. M. Sawant, Associate Dean, College of Agriculture, Kolhapur, Dr. S. S. Jadhav, Professor of Entomology, College of Agriculture, Kolhapur, Dr. V. S. Teli, Associate Professor of Entomology, College of Agriculture, Kolhapur, Dr. J. R. Kadam, Associate Professor of Entomology, MPKV, Rahuri, Prof. J. S. Ambekar, Associate Professor of Entomology, Dr. D. S. Pokharkar, Associate Professor of Entomology, College of Agriculture, Pune, Prof. S. S. Salunkhe, Associate Professor of Physics (CASAM) College of Agriculture, Pune, Dr. C. A. Nimbalkar, Statistician, ZARS, Ganeshkhind, Pune and Shri. H. P. Sonawane, who have made their distinctive presence felt during each and every aspect of my research work and it would indeed have been difficult for me to complete my work satisfactorily without their relentless efforts and constructive criticism.

I would like to express my deep sense of appreciation and gratitude to Prof. A. A Chougule, Manager, Hi-Tech Floriculture and Vegetable Project, College of Agriculture, Pune, Dr. Suresh Dhumal, Director, Horticulture Training Centre (HTC), Talegaon Dhabhade, Tal: Maval, Dist: Pune, Shri. Balasaheb Raskar, Manager and Incharge, Century International Polyhouse Ltd., Shirgaon, Tal: Maval, Dist: Pune, Dr. Santosh Kulkarni, Manager and Dr. Avinash Dhandekar, Incharge, Division of Plant Protection, Deccan Florabase Ltd., Jambhul, Tal: Maval, Dist: Pune, for providing facilities of polyhouses with established plot of roses and other help during the present investigations without which I would not have this much of ease in completing the investigation.

I gratefully acknowledge the help rendered by Dr. S. G. Eswara Reddy, Head, Department of Entomology, Indian Institute of Horticultural Research (IIHR), Hessraghatta, Bagalore, Dr. B. Jhansi Rani, Principal Entomologist, IIHR, Bangalore, Dr. V. Sridhar, Sr. Scientist, IIHR, Bangalore, Dr. P. L. Tandon Sr. Scientist, Project Directorate of Biological Control (PDBC), Bangalore, Dr. S. K. Jalali, Sr. Scientist, PDBC, Bangalore, Dr. B. Ramanujam, Sr. Scientist, PDBC, Bangalore and Dr. Ramani, Sr. Scientist for identification of pest, providing culture of biagents, biopesticides, laboratory as well as instrument facility and timely co-operation during my research programme.

I sincerely extend my gratitude to the librarians MPKV, Rahuri, Dist. Ahmednagar, College of Agriculture, Pune-5, Indian Council of Agricultural Research (ICAR), New Delhi, PDBC, Bangalore, IIHR, Hessraghatta, Bagalore, Tamil Nadu Agricultural University (TNAU), Coimbatore, National Institute of Virology (NIV), Pune-1, National Chemical Laboratory (NCL), Pune-8 and Jaykar Library of Poona University, Pune-7, for library facility and for their help during the investigation.

Completion of this thesis would have been difficult without the close co-operation and efficient endeavors of many faculty and staff members. Special appreciation is extended to Dr. B. S. Shewale, Prof. Kharbade, Dr. V. D. Kale, Dr. Sudam Patil, Dr. P. B. Mohite, Dr. C. S. Patil, Dr. R. V. Nakat,

Dr. G. R. Lolage, Dr. V. K. Mandhare, Dr. L. L. Mhase, Prof. M. S. Shirke, Prof. S. R. Kulkarni, Prof. D. B. Kadam, Shri. B.L. Lande, Shri. Kadam (Photographer, Agril. College, Pune) and Shri. Koli.

I wish to acknowledge kind co-operation of the staff members of Agril Entomology Section, Prof. D. B. Jadhav, Prof. C. S. Choudhari, Dr. R. L. Naik, Dr. V. M. Khaire, Prof. S. S. Shelke for their keen interest and invaluable suggestions during the present course of the investigation. I am highly grateful to the non-teaching staff of Agril. Entomology Section, Shri Rajabhau, Shri. Laxman, Shri. Gajanan, Shri. Shrinivas, Shri. Pandurang. I am also grateful to the staff of Hi-Tech Floriculture and Vegetable Project, College of Agriculture, Pune, for their advice and necessary help.

I am deeply obliged to all the authors whose literature has been cited. I am also thankful to Authorities of MPKV, Rahuri for awarding me two years study leave during the course of degree programme.

I feel inadequacy of my diction to express my hearty feelings and affections to my wife Sou. Maya and son, Hrishikesh for their inexhaustible care and moral support during the course of my study. I can not separate the inspiration, love and help given by my late father-Anna, mother-late Smt. Subhadrabai, my sisters, Manda, Meena and relatives; who always shared weal and woe with me. At last but not least, all my own goes to them all.

I would like to remember all those gentle people who are directly or indirectly concerned with these studies.

Place: Rahuri.

Date: 15 JUN 2007



(Uttam B. Hole).

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LIST OF ABBREVIATIONS

Abbreviations	Denotation
a.i.	active ingredient
CFU	Colony forming unit
C.D.	Critical Difference
cm	centimeter (s)
DAS	Days after spraying
DC	Dispersible concentrate
EC	Emusifiable concentrate
<i>et al.</i>	<i>et alli</i> (and others)
etc.	et cetera (and others)
FORS	Fish oil rosin soap
G	Granule
g	gram (s)
ha ⁻¹	per hectare
hrs	hours
ICBR	Incremental cost benefit ratio
IPM	Integrated pest management
i.e.	id est (that is)
kg	Kilogram
klux	Kilolux
l	Litre
LI	Light intensity
Ltd.	limited
ml	mililitre
M/s.	Messors
MSW	Meteorological standard weeks
No.	Number
N.S.	Non Significant
pp	Pertaining page (s)

POBs	Polyhedral occlusion bodies
q	Quintal
r	Correlation coefficient
RH-I	Relative humidity (morning hours)
RH-II	Relative humidity (afternoon hours)
S.C.	Soluble concentration
S.E.	Standard Error
S.L.	Soluble liquid
S.P.	Soluble powder
Sr.	Serial
T _{max}	Maximum temperature
T _{min}	Minimum temperature
<i>Viz.</i> ,	Videlicet (namely)
Crh-I	Crop canopy morning humidity
Crh-II	Crop canopy afternoon humidity
Ct _{max}	Crop canopy morning temperature
Ct _{min}	crop canopy afternoon temperature
WG	Wettable granules
WP	Wettable Powder
W.S.C.	Water soluble concentrate
°C	Degree Celsius
1r	1/100 hectare
%	Per cent
@	at the rate of
/	per (and or)
>	greater than
<	less than
-	negative

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by

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2007

Research Guide : **Dr. A. G. Chandele**
Department : **Agricultural Entomology**

ABSTRACT

The present investigations on seasonal incidence, varietal reaction, bioefficacy of various components of IPM against the pests infesting roses under polyhouse condition were carried out at Hi-Tech Floriculture and Vegetable Project, College of Agriculture, Pune and Horticulture Training Center (Talegaon Dhabhade); Century International Polyhouse Ltd. (Shirgaon); Deccan Florabase Ltd. (Jambhul gaon) at Maval during 2004-05 and 2005-06.

In the studies carried out on seasonal incidence of thrips, *Frankliniella schultzei*, the incidence was observed twice in a year from July to January and March-April at Pune and Maval. The maximum population of thrips (23.43 and 26.14 per flower) was noticed in October and November at Maval and Pune, respectively. Correlation analysis of thrip incidence with meteorological parameters revealed positive correlation with LI and negative correlation with humidity. Aphid population noticed in 4th and 5th MW was 63.70 and 86.96 aphids per shoot, which was negatively correlated with temperature and humidity at Pune as well as Maval. The meteorological parameters T_{max} , T_{min} , RH-I, RH-II and LI (32.5°C, 13.3°C, 70%, 50% and 64.9 klux) and Ct_{min} , Ct_{max} , Crh-I, and Crh-II (14.7°C, 28°C, 75% and 53%) prevailed during January-February appeared to be congenial for the multiplication of rose aphid.

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The whitefly, *Trialeurodes vaporariorum* population reached its peak in 36 MW, which was positively correlated with $T_{\min}$, humidity and negatively correlated with $T_{\max}$. LL Mealy bugs population was maximum (144.28 per twig) in 12 MW, which was negatively correlated with canopy temperature. Seasonal incidence of *Tetranychus urticae* was observed throughout the year except in severe winter and mid-monsoon, probably due to low temperature and high humidity. The average mite population per leaf ranged from 0.58 to 162.28 and 0.66 to 117.62 at Pune and Maval, respectively. The positive correlation with $T_{\min}$, $T_{\max}$ and negative correlation with morning humidity was observed in relation to mite population.

The incidence of *Helicoverpa armigera* was started by first week of November and reached its peak in second fortnight of February. The pest showed negative correlation with $T_{\max}$ and $Ct_{\max}$. Very high incidence of *Spodoptera litura* was recorded at Maval than Pune. The larval population increased from May and reached its peak during July (4.60 larvae per plant, Maval) and August (4.45 larvae per plant, Pune). The minimum temperature and morning humidity exhibited positive correlation with *S. litura* population at both the places.

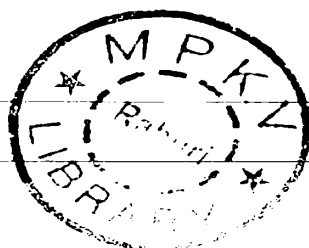
The number of adult moths trapped at weekly interval indicated that *H. armigera* population reached their peaks in January-February and *S. litura* in August-September. The peak occurrence of aphids, whiteflies and thrips were in January, September and October-November, respectively. The mealy bugs incidence was present round the year at Maval and the maximum mealy bug crawlers were trapped in the month of March. The plants grown in sole cocopeat medium recorded less pest population, which were significantly differing from soil grown medium.

Amongst the thirty-five commercial rose cultivars evaluated under polyhouse condition, the cultivar Temptation, Saphir, Merilan, Naranga, Teneki, Texas and Passion were found to be the most promising and recorded the lowest population of thrips, aphids, whiteflies, mealy bugs, *H. armigera*,

S.litura and mites, respectively. While the cultivars Mikado, Suela, Golden gate, Pink Noblesse, Grandgala, Passion and Teneki were most susceptible to these respective pests.

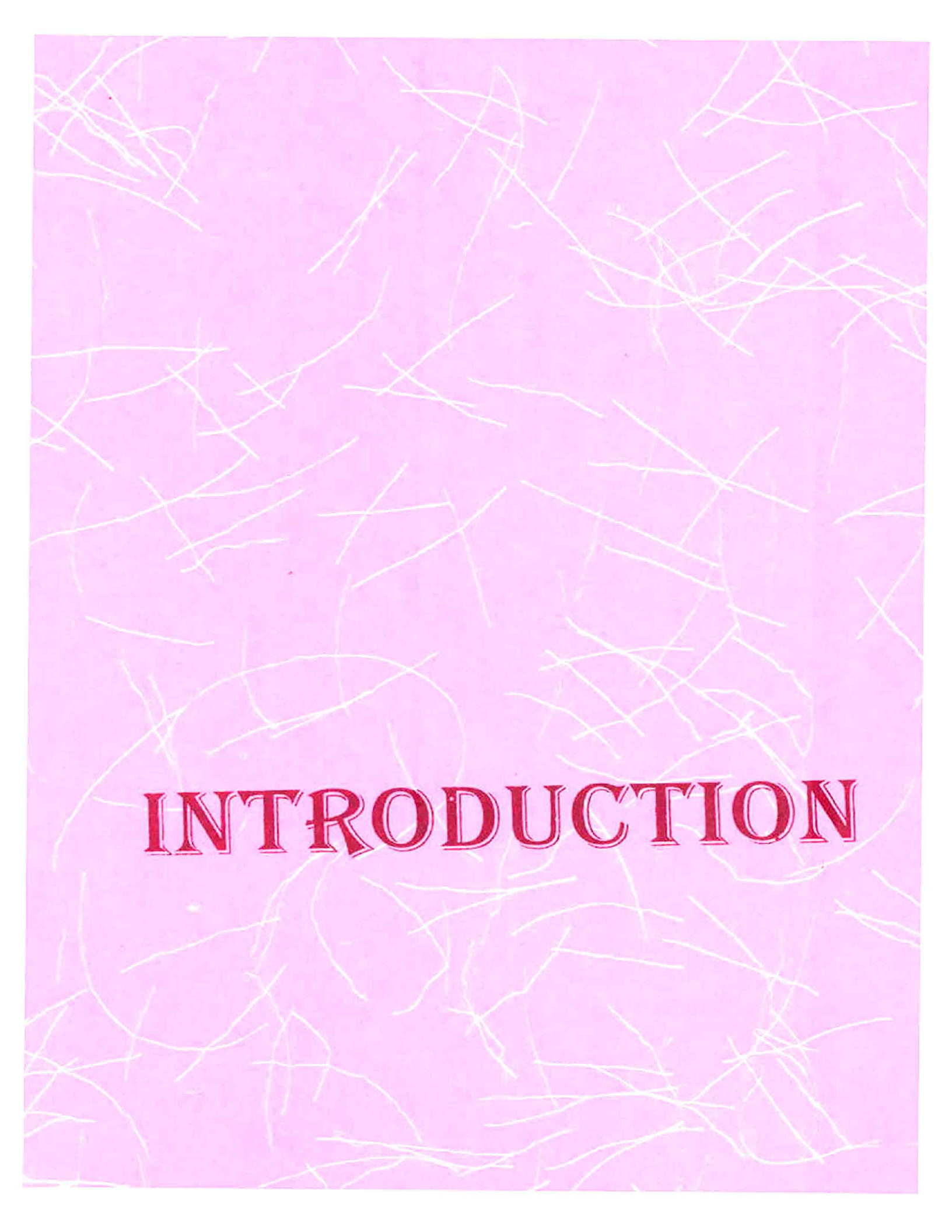
Of the different synthetic pesticides tested against pest infesting rose, spinosad 0.015% (thrips), imidacloprid 0.005% (aphids, mealy bugs), buprofezin 0.06% (whiteflies), indoxacarb 0.02% (*H.armigera*, *S.litura*) and abamectin 0.005% (mites) were significantly superior in reducing pest population. These treatments appeared to be the most economical and recorded maximum flower yield. Among the bio-agents, *Trichogramma chilonis*, *Chrysoperla carnea* and *Cryptolaemus montrouzieri* and bio-pesticides, *Bacillus thuringiensis*, *Verticillium lecanii*, *Nomuraea rileyi*, HaNPV (*Helicoverpa armigera* nuclear polyhedrosis virus) and SiNPV (*Spodoptera litura* nuclear polyhedrosis virus) were also effective in reducing pest population over control. In case of rose cultivars, the highest parasitisation of 52.59% (First red) was observed on eggs of *H.armigera* by *T.chilonis*.

Studies were conducted to evaluate the relative efficacy of various IPM components against pests infesting roses revealed the superiority of IPM technology in reducing pest population over untreated control. The plot receiving IPM technology recorded the lowest incidence of pests with CBR of 1:7.31.



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1 to 180 Pages

The background of the entire page is a solid pink color. Overlaid on this background are numerous thin, white, irregular lines that resemble scratches or marbled paper patterns. These lines are scattered across the entire surface, creating a textured effect.

INTRODUCTION

1. INTRODUCTION

The flowers symbolize beauty, purity, honesty and divinity. There are several references on flowers in ancient Indian literature glorifying their importance. The flowers have become integral part of our civilization, culture and inseparable in any sphere of our activities. On any occasion, either happiness or sorrow, flowers are considered as the finest and dignified form of expression. With the changing life styles and increased urban affluence, floriculture at present has assumed a definite commercial status in India. Due to globalization of market, more emphasis is now being given to export the floriculture produce. This has led to the establishment of export oriented commercial floriculture projects in the states like Maharashtra, Karnataka, Andhra Pradesh, Delhi and Haryana where high quality flowers are grown under protective polyhouse conditions.

In India total area under flower production is around 70,000 hectares with a total production of 7,35,000 tonnes of loose flowers and 2,060 million cut flowers. The international trade in cut flowers is increasing and 11 per cent increase was registered between 1995 and 2000 (Anonymous, 2005). There is an ever-increasing demand for floriculture products in which cut flowers contribute nearly 60 per cent of total floricultural product in global market. In the developing countries, consumers spirit become more romantic, cheerful with flowers, fragrances and flavours. The concept of commercial floriculture in polyhouse is now a recent development in India. More over due to popularity of foreign television channels and thrust on Tourism and Hotel industry, Indians are being more inclined to western style. This resulted into increasing demand for cut flowers for social function and day-to-day interior decoration.

Floriculture trade is lucrative business and more so the cut flower trade. The cut flower industry is a multimillion-dollar business involving 140 countries. The international trade in cut flower is increasing. The main importing countries for cut flowers are Germany, USA, UK, France and Netherlands. Consumption of flowers in world varies from country to country.

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In European countries, 50 per cent flowers purchased are used as gifts and 30 per cent are used for self-consumption. In Japan, the flowers are used for business purpose also. The demand for cut flowers to the extent of 60 per cent is reported in East Germany for self-use only. In France, about 44 per cent demand for flowers is in the form of bouquets (HTC, 2005). Thus, floriculture contributed 6.5 per cent of total export worth Rs. 166 crores in the year 2003-04 (IHD, 2004).

In India, major cut flowers of commercial importance are rose, gladiolus, tuberose, carnation, chrysanthemum, gerbera, lily and marigold. At present, in India Hi-tech floriculture constitute to the extent of 80 per cent by Rose and rest by Gerbera, Carnation, Orchid, Anthurium, etc. for export and domestic market.

In Maharashtra, the regions of mid-western and south-western comprising the districts of Pune, Satara, Nasik, Ahmednagar and Kolhapur and parts of Thane and Nagpur are the major areas of growing floricultural crops. The large commercial floriculture units at present are flourishing in areas around Pune, which thereby is considered as the district of "Corporate Hi-Tech Floriculture". The adjoining districts viz. Satara, Sangli and Kolhapur are the areas where large numbers of small farmers managed Hi-Tech floriculture units are seen. During the year 2002-03, the area under flower crops was 8,522 hectares with a production of 47 thousand tonnes of flowers in Maharashtra. Rose alone accounts for about one-third area under open flower cultivation with a production of about 5,400 tonnes of loose flowers. The cultivation of flower crops under protection is a recent development and the total area under protected cultivation of flowers is about 106.4 hectares comprising more than 1000 production units. Rose alone constitutes nearly 50 per cent of the area under protected conditions producing 750 lakh flowers. The total cut flower production in the state of Maharashtra was estimated to about 1350 lakh flowers annually (Gurav *et al.*, 2003).

Rose (*Rosa* spp.) belonging to the family Rosaceae is one of the important components of modern life, leading a great attraction to our-

domestic, leisure and working environment. It has a great demand in domestic as well as international market. It occupies first position among the top ten cut flowers (Singh, 2002/03). Different species of roses have different places of origin; but the first Bourbone rose is believed to have arisen during the year 1817 from a natural cross between the Parson's pink china rose (*Rosa chinensis*) and the Autumn Damask rose (*Rosa damaascenabifera*); while they were growing in the island of Bourbon (now Reunion) in the Southern Indian Ocean (Bose and Yadav, 1989).

Among the various factors affecting production and quality of flowers, pests and diseases are of prime importance. The uniform environmental conditions in polyhouses throughout the year favour the multiplication of insect pests around the year and are an ideal for the rapid proliferation of unwanted pathogens and insects, which constitute an ever-present threat to the quality of flowers. More than 50 insect and related pest species were recorded infesting polyhouse roses in Maharashtra (Chandele, 2002). The most commonly associated pests with rose are thrips, *Frankliniella schultzei* (Pergande) (Thysanoptera : Thripidae); aphids, *Macrosiphum rosae* (Linnaeus) (Hemiptera : Aphididae); whiteflies, *Trialeurodes vaporariorum* (Westwood) (Hemiptera : Aleyrodidae); mealy bugs, *Planococcus citri* (Risso) (Hemiptera : Pseudococcidae); foliage feeders and bud borers, *Helicoverpa armigera* (Hubner); *Spodoptera litura* (Fabricius) (Lepidoptera : Noctuidae) and mites, *Tetranychus urticae* Koch (Acarina : Tetranychidae) (Dreistadt, 2001; Rajkumar and Gour, 2004).

In Maharashtra, these pests have posed a serious threat to the rose cultivation and damage caused by these pests is the major hindrance in the production of good quality rose flowers. The present control strategies adopted by the growers are mostly based on the use of conventional chemical pesticides. However, sole dependence on them has led to several problems like toxic residues, environmental pollution, decline in population of natural enemies and insect resistance to insecticides (Singh *et al.*, 1990). Among these problems, the development of resistance to insecticides is of prime concern

under polyhouse condition because of calendar based preventive applications of insecticides as well as chances of migration of susceptible individuals in polyhouse are meager as compared to open condition.

Thus, in the light of scanty work on the management of pests infesting roses in polyhouses in the recent past and severe losses continue to be caused by different pests, it was felt necessary to undertake detailed study on seasonal incidence of pests with a view to evolve suitable package of practices for management of these pests infesting roses in polyhouses. Incidentally, it was also felt necessary to make use of several techniques such as use of resistant / tolerant rose cultivars alongwith suitable management practices. Pest management practices are based on carefully structured and monitored combination of biological control, plant genetics, cultural practices and use of chemicals only as a last resort (Jensen and Malter, 1995).

In the development of the pest management strategies the knowledge of the ecology of the pest is of paramount importance and unfortunately information on ecology of pests infesting roses in polyhouses is very scanty. Hence, it was thought necessary to undertake the study on ecological aspects of pests infesting roses with a view to utilize it in developing rose pests management strategy in polyhouses.

As pest population varies depending on the biotic and abiotic environmental factors, it is necessary to study the pests in relation to its biotic and abiotic requirements with an objective to suppress its build up. Thus, in the light of above, the present studies were undertaken to evolve safe, handy, effective and economical rose pest management programme in polyhouses during the year 2004 to 2006 with following objectives.

1. Seasonal incidence of pests infesting rose and its relationship with abiotic factors.
2. Reaction of various rose cultivars to pests.
3. Bio-efficacy of various components of IPM against pests of rose.
4. Formulation of IPM module.

REVIEW OF
LITERATURE

2. REVIEW OF LITERATURE

Rose is being a perennial crop, provides all the year round food and protection to pests. The literature pertaining to thrips, aphids, whiteflies, mealy bugs, leaf feeders/bud borers and mites infesting roses under polyhouse condition in respect of seasonal incidence, varietal screening, evaluation of various components of IPM and formulation of IPM module were reviewed and presented in this chapter.

2.1 Seasonal Incidence

2.1.1 Thrips

Alford (1991) reported that adult thrips, *Frankliniella schultzei* Pergande are narrow, less than 2 mm long and most often yellow to brownish yellow, antennae eight-segmented. Adults have long fringes on the margins of their wings. Females insert tiny eggs into plants, commonly into leaves or buds. The elongate larvae are translucent white to yellowish. The pale pre-pupae and pupae occur mostly in the soil. Breeding is continuous under polyhouse condition, the complete life cycle (including egg, two nymphal and two pseudo-pupal stages) occupying about 2 to 3 weeks at temperature of 20 to 30°C.

According to Nelson (1998), *Frankliniella occidentalis* build up in large number outdoors and swarm into green houses during the warm months. Many of them carried on air currents. Thrips feed on a broad range of crops. They are commonly found in buds, on flower petals and on axils of leaves. The adults are visible to the unaided eye but are usually hidden in buds or flowers. They can be detected by tapping buds or flowers over a sheet of white or black paper. Thrips will fall onto the paper and can be seen. Author opined, thrips is the most serious pest problem of greenhouses today. It transmits impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV). These viruses infect a large number of greenhouse crops, destroy them and have no cure. The only control is thorough elimination of thrips in the greenhouse.

Ananthakrishnan and Jagadish (1968) recorded the severe infestation of thrips which occurred from February to May. The increase in temperature during summer season favoured the development and multiplication of the thrips and this may be the reason for the increased population with increase in temperature. The population declined from June with the onset of rains, but the activity again resumed in November. Under greenhouse condition generations follow each other throughout the year, the total time required for each generation being from 20 to 35 days at 26.7°C depending on the climatic conditions and the species of thrips. Effective temperatures for development of thrips were from 10 to 32°C (Metcalf and Flint, 1979).

Infestation of thrips on green house chrysanthemum, gerbera and rose has been studied in laboratory by Bene *et al.*, (1990). The studies revealed that life cycle of *Thrips palmi* was completed in 12.1 days at 25°C, 26.7 days at 18°C and 56.9 days at 12°C. Jadhav and Bhujbal (1990) studied the population build up in rainy season and found that the population of thrips reached its peak during the first week of October when average maximum and minimum temperatures were 31.6°C and 15.2°C, respectively with the relative humidity of 49.5%.

Valui *et al.*, (1999) noted that thrips was the most consistent and serious pest of rose and that could be found throughout the year. The infestation of *Scirtothrips dorsalis* Hood on rose was found to occur round the year except in the month of July-September in polyhouse leading to severe yield losses both in terms quality and quantity (Onkarappa and Mallik, 1998 and Murugan, 2000).

Thrips have several generations per year; the development time depends on the temperatures. The lower threshold temperature was found to be 11°C and the generation time of *F. occidentalis* was 13 days (Dreistadt, 2001). Duraimurugan and Jagadish (2004) studied the seasonal incidence of *S. dorsalis* in an unsprayed rose garden at Thirunahalli (Karnataka) on the local red rose variety during September, 1999 to June, 2000. They observed that thrips

prevailed throughout the flowering period and attained its peak during the second fortnight of April (43.71 thrips per flower).

Correlation between weather and the thrips :

Ananthakrishnan and Jagadish (1968) reported the incidence of *S.dorsalis* on rose and found significantly positive correlation with the maximum temperature ($r = 0.5570$) and significantly negative correlation with an average relative humidity ($r = -0.6894$).

Bagale (1993) studied seasonal fluctuations of thrips, *S.dorsalis* in pomegranate and results obtained showed that the population was abundant during June to August. He found prolonged dry spell after rains favoured the population of thrips. The weekly minimum, maximum temperatures and relative humidity with correlation coefficient values were 0.65, 0.52 and 0.41, respectively.

2.1.2 Aphids

According to Alford (1991), the adult apterous females of *Macrosiphum rosae* (Linnaeus) are 1.7 – 3.6 mm long, green to pink or reddish-brown, spindle shaped with long antennae and legs; siphunculi long, pale and tapered, cauda pale and elongate. Alate are 2.2 to 3.4 mm long, green to pinkish-brown, distinctly marked with black along the sides of abdomen. Over-wintered eggs often occurred on rose, although adult aphids found survive the winter if conditions favoured. Substantial colonies were noticed during the spring and summer and infested shoots often becoming smothered. In summer, winged forms spread infestation to other rose plants and these plants remain liable to invasion throughout the summer months and new colonies were often present through the autumn until their development was curtailed by the onset of cold weather.

The prevalence of sexuales of the rose aphid (*M.rosae*) only at higher altitudes (1180 to 2350 MSL) characterized by low atmospheric temperature, short photoperiod and higher intensity of light, indicated that subtropical and temperate climate favoured the appearance of sexuales. The occurrence of

sexuales at higher altitudes had also been reported by Lees (1966), Dixon (1973), Blackman (1975), Ghosh and Raychaudhari (1981).

Jamwal and Kandoria (1990) observed appearance of cotton aphid on brinjal from first week of August to fourth week of November. Chattopadhyay *et al.*, (1996) reported the importance of cloudiness in aphid population during the first generation. In 33rd MW when the mean temperature drops below 25°C may cause sharp rise in aphid population. The pest usually appeared around 30th MW (23 to 30 July) and remains active upto 4th MW (28th Jan. to. 3 Feb.).

The effects of meteorological parameters on population of aphid on rose were reported by Hole *et al.*, (1997). The pests build up started in third week of January and peaked (149.25 aphids/shoot) during the fourth week of February. Maximum temperatures 30.3 to 31.5°C and minimum temperatures 9.7 to 11.7°C with relative humidity 85 to 91 per cent in the morning and 28 to 31 per cent in the afternoon in February appeared to be congenial for multiplication of aphids.

Syed *et al.*, (1999) recorded three species of aphids infesting roses. They noted average population of 11.89 aphids per flower during December to March. Bisht *et al.*, (2001) found that the oviposition occurred during the severe cold months from late November to early January when atmospheric temperatures varied from – 3 to 20°C. The eggs were laid in a scattered manner or in group of 2 to 4, preferably on the abaxial surface of leaves. The incubation period of eggs was found to vary from 39 to 81 days at atmospheric temperature ranging between 8 to 22°C.

Dreistadt (2001) recorded a generation period of 6 to 7 days only during warm days. Further, he reported many generations per year and rapid increase in population, especially when temperatures were moderate. Extreme temperatures found to retard aphid growth and reproduction. Most of the aphids were females that reproduce without mating. Throughout year, adult aphids (winged or wingless) gave birth to live youngones. Aphids produced over wintering eggs outdoors in locations with cold winters.

2.1.3 Whiteflies

Whiteflies, *Trialeurodes vaporariorum* (Westwood) eggs usually laid on the underside of leaves. Eggs are oblong, tiny and have a short stalk inserted into leaf tissue. Eggs are white to yellowish when laid and uniformly darken before hatching.

Eggs hatch in about nine days at glasshouse temperature of 21°C. The tiny crawlers (mobile first instar nymphs) emerge from eggs and crawl over the leaf surface upto several hours but soon settle down to feed, inserting their mouthparts into the leaf tissue and remaining completely immobile throughout the rest of their development. After the first moult, the semitransparent nymphs become flattened pale green and oval resembling tiny scale insect. They pass through three feeding stages and a non-feeding pupal stage, before the new adults appear about 18 days later. Pupa is oval and whitish with relatively short marginal wax processes and several pairs of long waxen dorsal tubes. Breeding continues under favourable conditions, with several overlapping generations annually and is mainly parthenogenetic. The pest commonly survives between crops on glasshouse weeds or on outdoor plants in the near vicinity. Adults may also hibernate throughout the winter on outdoor weeds but they are unable to survive if weather conditions are severe (Alford, 1991).

Glasshouse whitefly, *T.vaporariorum*, is a polyphagous pest of many herbaceous crops and is becoming an increasingly important pest in many diverse agricultural systems, especially under protective cultivation (Kim *et al.*, 1986). Hulspas *et al.*, (1989) studied population growth rates of *T.vaporariorum* under greenhouse conditions on eggplant, cucumber, sweet pepper and gerbera. During experimentation the mean minimum and maximum temperatures were 21.2 and 35.7°C and the corresponding levels of mean relative humidity were 73.0 and 78.0 per cent. Experimental results showed that population growth on different hosts were in the descending order as on aubergine, cucumber, gerbera, tomato and sweet pepper. Further, it was

concluded that population growth was strongly influenced by duration of development, oviposition frequency and sex ratio.

Reddy *et al.*, (1989) observed that cotton whitefly multiplied rapidly at a temperature range of 29 to 33°C on cotton. The population of whitefly was found increased from August and reached its peak in December and thereafter gradually decreased (Patel and Jhala; 1992). The most favourable period for reproduction and survival of *Bemisia tabaci* Genn. was November to January.

Population dynamics of *B.tabaci* was studied in fields of Gujarat on mustard, soybean, bottle gourd and cowpea by Patel and Jhala (1992). Studies indicated that the population increased from August and reached at it's peak in December and thereafter declined gradually. The incidence of whitefly was not noticed during May to July. The most favourable period for reproduction and survival of *B.tabaci* was found to be November to January.

Sutterlin and Lamour (1994) studied dispersal and dynamics of *T.vaporariorum* on gerbera under greenhouse condition. Population dynamics of *T.vaporariorum* was followed with and without parasitoid (*Encarsia formosa* Gahan) releases in two greenhouses. When no parasitoids were released, the population level of aleyrodid was 100 times higher at the end of 11th week of observation period.

Yellow sticky cards were used to monitor population of *B.tabaci* on cucumber by Abdel *et al.*, (1993). It was found that the type of sticker used and position of the traps were important factors in trapping the adult whiteflies. The highest numbers of *B.tabaci* were noticed in traps placed at 0.5 m above the ground level. Studies on population dynamics of *B.argentifolii* were conducted by Tappertzhofen (1996) using yellow sticky traps during 1993-94 and it was concluded that population dynamics in the field depends upon proliferation and mortality of *B.argentifolii*.

Effect of temperature on development and reproduction of silver leaf whitefly was studied by Wang and Tsai (1996). They reported that the development time from egg to adult varied from 105 days at 15°C to 14 days at 30°C. Population dynamics of *B.tabaci* and its parasitoids were monitored in Lower Rio Grande valley, Texas by Legaspi *et al.*, (1997). Studies revealed that there was no correlation between adult whitefly estimates using sticky traps and those directly counted on the leaves.

Wood *et al.*, (1997) conducted experiment during 1994 to 1996 to look at *B.argentifolii* population using three inches yellow sticky cards. During 1996, they recorded higher population than that of 1994 and 1995. Population was least in 1995. It was concluded that cooler, wetter climate and influence of high density of other pest might be the cause of lower population of *B.argentifolii* during 1995.

Prasad and Kumar (2000) recorded the life cycle period of *T.vaporariorum* of 32 days in spring and 23 days in summer. Chickweed, a common greenhouse weed, found to harbour the pest over winter in all stages of the life cycle. The time required to complete a single generation was found to vary from one to several months, depending on host plants and especially on temperature. A single generation was found completed in 18 days when temperature was 28°C (Dreistadt, 2001).

Correlation between weather and the whiteflies :

Several workers have agreed to weather factors as one amongst the major contributing factors to the outbreak of whitefly. Across the country, various workers have described the relationship of ecological factors with the whitefly population on the location-specific trials (Rote and Puri, 1991; Simwat and Gill, 1992; Raghupsti Rao and Chari, 1993 and Kundu, 1996).

Prasad and Logiswaran (1997) have undertaken multiple correlation studies at Agricultural College and Research Institute, Madurai on MDU-1 cultivar of brinjal in winter 1991 and summer 1992. In winter 1991 the population of whitefly (*B.tabaci*) showed significantly positive association with

maximum temperature and relative humidity; while during summer 1992 a significantly negative association was observed with rainfall. The population of cotton aphid *Aphis gossypi* revealed a positive association with maximum temperature during winter 1991 and summer 1992 seasons, respectively.

The conventional approach of Empirical Damage Function (EDF) was followed by Gupta *et al.*, (1998) in assessing the impact of abiotic factors on the population dynamics of cotton whitefly, *B.tabaci* in upland cotton. Amongst six weather parameters taken for study, minimum temperature and evening relative humidity were significantly correlated with the whitefly populations over time. Multiple regression equations were constructed for each and every year (1991-1998) and discussed for their combined effect on the population build up of the concerned cohort. It has been observed that the effect of abiotic factors could explain the variation in the population dynamics of whitefly, which was in the range of 39 per cent to 75 per cent over years. Singh and Butter (1998) carried out the field studies indicated that greatest population build up of *B.tabaci* on cotton was positively correlated with temperature and rainfall and negatively with relative humidity.

2.1.4 Mealy bugs

Adult female mealy bugs, *Planococcus citri* (Risso) are wingless, soft bodied, pinkish insects about 3 to 4 mm long. They are elongate, segmented and covered with whitish or cottony wax. The peripheral and caudal waxen processes are characteristically short and stout. Male mealy bugs are tiny and delicate, their bodies are commonly yellow or red.

A female deposits from 300 to 600 yellow eggs in a cottony mass of wax secreted from their bodies. The egg hatch in 8 to 10 days. The young nymph remains in the egg case for a short time. Mealy bug nymphs are oblong, reddish and may or may not be covered with wax. Both nymphs and adults crawl slowly over the plants. Shortly after they begin feeding, a white waxy material begins exuding from their bodies and forms a covering over the insect and about 36 prominent leg-like filaments, which radiate from the margin of the

body on all sides. They do not remain fixed but move about to some extent over the plant, although they are always very sluggish. The female passes through three nymphal instars before transforming to adults; while the male after three nymphal instars passes through a pupal stage in as slimy cocoon before becoming an adult. The adult males have two wings; the females are wingless throughout life. The pest over-winters as eggs or females or in all stages. They have several generations each year, requiring several weeks to several months to develop from egg to adult, depending on temperatures (Metcalf and Flint, 1979; Alford, 1991 and Deristadt, 2001).

Prasad and Kumar (2000) reported that the *P.citri*, being a tropical species, it developed most quickly in high temperatures and humidities as it completed a life cycle within about twenty-two days at 30°C. Lakra *et al.*, (1980) and Dwivedi *et al.*, (2003) observed that the population of mealy bug, *Drosicha mangiferae* Green was found maximum (84.6) at the base of tree trunk in February and minimum (0.58) on the tree trunk in the month of December. The population range was found from 15.1 to 84.6, 4.9 to 44.1 and 0.58 to 31.8 in different months at the base of tree trunk and on the terminal twigs or inflorescence, respectively. The activity of *D.mangiferae* was observed from December to May.

2.1.5 *Helicoverpa armigera* (Hubner)

The moths are nocturnal and often attracted into greenhouses if night lighting is used. The moths have a wing expanse of about 25 to 38 mm. The wing colouration varies from light yellow to brown with irregular lines and dark area near the tips on the forewings near the margins. During the warm evenings, female deposit cream coloured hemispherical and ridged eggs singly on new foliage and young buds on which the larvae feed.

The egg hatch in 2 to 10 days. Larvae vary from pale green to dark brown with alternating light and dark longitudinal stripes that run the length of the body. Fully developed larvae crawl down to the ground into which they burrow and excavate a small smooth walled brown cell, where they pupate. The

insect passes the winter in the form of brown pupa at 3 to 10 cm below the surface of soil.

Bilapate *et al.*, (1997) and Fitt (1989) have undertaken the studies on the effect of high temperature on growth and multiplication of *H.armigera*. Tripathi and Sharma (1985) recorded five generations on various crops in Uttar Pradesh during December to March. Patel and Koshiya (1997) studied the seasonal abundance of *H.armigera* and observed the pest activity during November to January-February with its peak during December on chickpea.

Kalariya *et al.*, (1997) studied the incidence of *H.armigera* on pigeon pea in North Gujarat and reported the November-December as active period of pest with its peak in December. Ravi and Verma (1997) conducted the field experiment at IARI, New Delhi, on seasonal incidence of *H.armigera*. The incidence was started by first week of January and reached at its peak by March on chickpea sown on 12th October, 1993 and 8th November, 1993.

Chaudhari *et al.*, (1999) installed the pheromone traps for capture of cotton bollworm, *H.armigera* moths at Anand during 1994 to December 1996 to study the effect of weather on activity of *H.armigera* in middle Gujarat agro-climatic condition. More catches were recorded from October to March. The number of insect trapped at weekly interval indicated that *H.armigera* population reached their peaks between the standard meteorological weeks of 6 to 14 and 40 to 44, these peaks correspond to the periods when weekly mean temperature and relative humidity ranged between 20 to 30°C and 50 to 65%, respectively; which seems to be optimum for their multiplication. The number of moths trapped indicated higher values during the months of January and October to December. The population was relatively very low during summer and monsoon seasons. Weekly mean maximum temperatures more than 39°C in monsoon season was found to inhibit growth and multiplication of *H.armigera*.

In the field trial of Balakrishnan *et al.*, (2003) with pheromone traps at Regional Research Station, Aruppukottai, Tamil Nadu, during 2000-2001 and 2001-2002 on cotton, the moth catches of *H.armigera* showed an increasing trend. The activity of moths was found between 43 (October) to 3 MW (January) during which two peaks were obtained at 47 and 49 MW. The tomato fruit borer, *H.armigera* was recorded as a sporadic pest of amaranthus during 2002 year at seed farm, College of Agriculture, Vellanikkara. But during the month of November and December (2002) heavy incidence of all the instars of *H.armigera* was observed on the seed crop (irrigated). During this period mean maximum temperature was 32.2°C and minimum was 21.9°C. The peak population ranged from 2 to 5 larvae per plant (Lily Levin *et al.*, 2004).

Correlation between weather and the *H. armigera* :

Bilapate *et al.*, (1997) and Fitt (1989) have noted positive correlation between *H.armigera* and bright sunshine hours and negative with relative humidity. There was a negative relationship of *H.armigera* on cotton with mean maximum, minimum and average temperature and the morning humidity (Tadas *et al.*, 1994; Daware *et al.*, 1994; Dhawan and Simwat., 1996; Rajaram *et al.*, 1999 and Ramamurthy *et al.*, 2000).

Daware *et al.*, (1994) and Chaudhari *et al.*, (1999) studied the correlation matrix between the populations of *H.armigera* and weather parameters, indicating positive correlation with bright sunshine hours ($r = 0.50$) and negative association with minimum temperature ($r = -0.62$) and mean relative humidity ($r = -0.74$). Mohapatra *et al.*, (2004) studied the influence of various factors on the incidence of *H.armigera* on cotton crop during 1999-2000 and 2000-2001 and noticed positive corelationship between population build up of *H.armigera* with mean maximum, minimum and average temperatures.

2.1.6 *Spodoptera litura* (Fabricius)

The moth is nocturnal with mating and egg laying occur at night. Adults have 40 mm wingspan, forewings blackish-brown with lighter markings and

often with a purplish sheen, hind wings mainly white. Caterpillar is 40 to 45 mm long, pale to blackish-brown, finely speckled with white, dorsal and sub-dorsal lines orange-brown, the latter interrupted on the first and eighth abdominal segments by black patches and on the other segments by yellow spots, each bordered above with a black patch, yellow spots and black patches also present on the second and eighth thoracic segments, sub-spiracular line broad and pale reddish brown; dark forms are mainly blackish-brown. Pupa is 16 to 20 mm long, reddish brown.

Eggs are deposited in large groups on the underside of leaves and covered with a mat of scales from the females abdomen. They hatch within a few days at normal glasshouse temperatures. Development is completed in 2 to 4 weeks; the larvae then pupate in soil, adults emerging about two weeks later. Breeding is continuous under suitably warm condition.

The *S. litura* caterpillars damage the tuber crop initially by scrapping leaf tissues and subsequently by feeding on leaves. The extent of damage has been reported to ^{be} 16 to 80 per cent with population sometimes reaching to 63 caterpillars per leaf (Pillai and Prasad, 1983).

Chaudhari *et al.*, (1999) installed pheromone traps for capture of cotton bollworm, *S. litura* at Anand during 1994 to December 1996 to study the effect of weather on activity of *S. litura* in middle Gujarat agro-climatic condition. Peak activity of *S. litura* during all the three years occurred in second week of March. The number moths trapped at weekly interval indicated that *S. litura* populations reached their peaks between the standard meteorological weeks of 8 to 18. The peak occurred when weekly mean temperature and relative humidity ranged between 20 to 30°C and 50 to 65%, respectively, which seems to be optimum for their multiplication.

Bhosale *et al.*, (2003) reported the incidence of leaf eating caterpillar, *S. litura* on colocasia throughout during the period of crop grown in *Kharif* season. The peak activity of pest was noticed during the month of September. The average larval population per plant was ranged from 2.0 to 9.6. The

maximum 29 larvae were found feeding on a single leaf. Studies on bionomics of *S.litura* indicated that females laid 311 to 441 eggs (average of 376.9) on leaves of colocasia.

2.1.7 Mites

Adult female of two-spotted spider mite, *Tetranychus urticae* Koch, is 0.5 to 0.6 mm long, pale yellowish or greenish with two dark patches on the body. Body oval with moderately long dorsal setae on the hysterosoma form a diamond shaped pattern. Adult males are similar to female but body smaller, narrower and more pointed. Female mites over-winter amongst debris, in dry crevices in the soil and in other suitable shelter, often clustering in cracks in glasshouse structures, stakes and poles. They become active in March and April, invading host plants to feed and eventually deposit eggs.

The eggs were 0.13 mm across, translucent spherical and clear to pale yellow. they look like tiny drops on a leaf. Females can lay upto about one dozen eggs per day. eggs are usually laid in fine webbing. Mites begin as eggs that hatch into six-legged immature larvae; which is pale greenish with darker markings. Later-stage of immature spider mites are called nymphs which are pale greenish with darker markings and eight legged. Spider mite nymphs and adults have eight legs but otherwise look similar to mite larvae. Mites passing through egg, larval, protonymphal and deutonymphal stages before maturing; males often omit the deutonymphal stage.

Development was completed in less than two weeks at temperatures above 20°C, but is greatly protracted below 12°C, extending over almost two months at 10°C. During September, in response to short days, the orange winter-female forms are produced, after mating; these seek shelter for the winter. As plant vigour also declines, breeding ceases resulted into death of males and summer females (Alford, 1991).

Lee *et al.*, (1992) studied the development stages and damage symptoms of mite on gerbera. At 15°C development from egg to adult took 15 to 56 days but this was reduced to 6.8, 4.4, and 3.5 days at 20°C, 25°C and 30°C temperatures, respectively.

Incidence of *Tetranychus cinnabarinus* B. in relation to weather factor on okra plant was studied by Singh and Singh (1993) during the month of May and June, which indicated increase in population, was associated with period of high temperature and low humidity. They further concluded that a temperature was major regulatory factor for population build up of mites.

Hole and Salunkhe (1997) carried out field trials in winter and summer seasons, which showed that number of mites (*T.urticae*) increased in the second week of February and gradually reaching its peak (69.65 mites/plant) in second week of March and decline thereafter. The fluctuations in mite population was found to be positively correlated with maximum temperature and relative humidity. Nelson (1998) recorded the time span from egg to adult of 10 days at 27°C and 20 days at 21°C or several months at lower temperatures with indication of low relative humidity always favoured the development of *T.urticae*.

The *T.urticae* are of tropical origin and thrive best in high greenhouse temperature (Prasad and Kumar, 2000). The life cycle length varies markedly from sixty-two days at 10°C to six days at 35°C. The pests multiplication potential is extremely high in autumn, when the daylight period decreases to fourteen hours and temperatures fall, egg production ceases and the fertilized female, which are now red in colour, move into the greenhouses structure to hibernate (diapause), representing foci for next spring infestation.

Dreistadt (2001) noted the mite damage more in hot, dry environments and when plants were drought stressed. These conditions favoured reproduction of mites and suppressed the predatory mite population. The time required for spider mite to complete one-generation ranged from 1 week at 27°C to 3 weeks at 18°C. All stages occurred together on leaves, except outdoors during over

wintering when females were found in crevices, under bark, or in litter and eggs in bark crevices.

2.2 Screening of Rose Cultivars for Resistance to Pests in Polyhouse

Ananthakrishnan *et al.*, (1982) observed that the thrips, *S.dorsalis* was more abundant on the tender leaves of rose as compared to 3rd and 4th nodal leaves. Kevan (1983) studied host preference and put forth the role of olfaction and foliar shape as likely factors influencing host selection by the thrips. Different plant characters *viz.*, leaf morphology and chemistry could have impact on behaviours of western flower thrips on *Lycopersicon* (Miller and Strikler, 1984).

Pattern of spectral reflectance in both susceptible and resistant accessions of *Lycopersicon* followed a similar trend for all accessions tested with percentage reflectance (PR) remaining low (6%) at wavelength between 400-500 nm. Negative relationship between low incidence of western flower thrips and leaf colour in wavelength of 500-620 nm was observed by Krishna Kumar (1993). The existence of colour influences onion thrips landing rate on *Lycopersicon hirsutum* was reported by Vernon and Gillespie (1990).

Ananthakrishnan *et al.*, (1992) in the host plant studies indicated the secondary plant chemicals which determine the suitability of substances for colonization and exploitation by herbivores and thus govern host preference. Age-correlated biochemical profiles of host plant tissues also significantly influence the infestation patterns. Antixenosis of *L.hirsutum* to western flower thrips and mites was due to presence of glandular trichomes (Good and Synder, 1988) and trichome exudates (Krishna Kumar, 1993).

Frey (1993) inferred three damage threshold levels as a) low density level of 5-10 thrips/trap/week, b) medium density level of 18-30 thrips/trap/week and c) high density level of more than 40 thrips/trap/week and concluded that threshold levels were dependent on plant species and temperature.

Bergh *et al.*, (1997) reported that thrips infestation levels were high on younger leaves as compared to other leaf and floral parameters. He also reported that red and orange coloured rose varieties were least preferred when compared to white and yellow ones with regard to oviposition and larval development of *F.occidentalis*.

Dreistadt (2001) indicated significant gradient in susceptibility of rose cultivars to thrips. In case of rose cultivars with sepals that remain tightly wrapped around the bud until near harvest harbour fewer thrips than roses with sepals that open earlier.

Jhansi Rani and Eswara Reddy (2003) studied the preference of *S.dorsalis* for flower colours of polyhouse grown rose varieties revealed that none of the varieties tested found to be free from infestation. More number of thrips were found to be attracted to red and orange colored petals when compared to yellow. However, the per cent population settled on petals of other varieties differed within a narrow range i.e. 10.86 to 14.82 per cent indicating colour was not a major influencing factor. Probably, other genetical characters or traits might be influencing the thrips preference to flowers of different varieties. Percentage of thrips settled on petals of rose varieties in descending order was : First red > Versilia > Grand gala > Vivaldi > Lambada > Konfeti > Starlite.

2.3 Biological Control

2.3.1 Thrips

Prasad and Kumar (2000), Dreistadt (2001) reported the effectiveness of *Chrysoperla carnea* in greenhouse crops as a biological control agent for thrips and aphids. Several thrip species such as *Frankliniella occidentalis*, *Frankliniella schultzei* Pergande, *Thrips tabaci* and *Frankliniella tenuicornis* have been found to be infected by *Verticillium lecanii* (Zimm.).

2.3.2 Aphids

Singh *et al.*, (1994) recommended the higher releases of *C.carnea* @ 1 to 2 larvae per plant on tobacco crop against *Myzus persicae* Sulzer, *S.litura*

and *B.tabaci*; while Satpathy *et al.*, (1998) reported *C.carnea* as an effective predator for control of aphids and eggs of some lepidopterous borers, when first instar larvae released @ 50,000 per hectare.

The predator, *C.carnea* is being used in India for suppression of pests infesting cotton sunflower, groundnut and some fruit crops (Singh and Latif, 1998). Surender *et al.*, (2001) suggested at least three releases of *C.carnea* for managing the aphid population on mustard crop under caged conditions.

Several commercially available aphid predators and parasitoids can be introduced in greenhouses. Predators are most likely to be effective when released on dense colonies of aphids (localized hot spots in the crop). Aphid predators include lady beetle larvae and adults; larvae of lacewing (*C.carnea*), syrphid flies, aphid midge flies and minute pirate bugs found in green houses although at low densities were found to control rose aphids, *Macrosiphum rosae* (Prasad and Kumar, 2000; Dreistadt, 2001).

2.3.3 Whiteflies

Hall *et al.*, (1981) reported that the entomopathogenic fungus, *V.lecanii* infect various insects, including larvae of beetles, mites, aphids, scales insects and other homopterans particularly under greenhouse conditions. Ekbom (1981) noticed that the *V.lecanii* as a biological control agent was limited to particular environment, particularly high relative humidity required for its infection. Temperatures of 15 - 25°C and relative humidity of 95% were the strict environmental parameters for *V.lecanii* germination (Aggarwal, 1990; Helyer *et al.*, 1992). Two strains of *V.lecanii* have been developed for greenhouse pest control. In England both Vertalac^R and Mycotol^R are used in commercial greenhouse (Feng *et al.*, 1990).

Schreiter *et al.*, (2000), Meade and Byrne (1991) reported the successful use of *V.lecanii* worldwide to control greenhouse pest such as whitefly and various species of aphids. Among the entomopathogenic fungi, *Beauveria bassiana* (Bev Bas) and *V.lecanii* produced significant mortality in whitefly under greenhouse condition at 5 DAT (days after treatment). Significant effects

were not observed prior to this, reflecting the required period to produce mycosis. This could be because of the strict environmental requirements for germination of this fungus, which include temperatures of 25°C and relative humidity in excess of 95 per cent (Helyer *et al.*, 1992, Phadke and Phadke, 2000).

2.3.4 Mealy bugs

Singh (1995) carried out the survey of entomopathogenic fungus, *V.lecanii*, on *Coccus viridis* (Green) revealed that the fungus was the most effective natural mortality factor during the rainy season. Field trials for the control of this pest were conducted on arabica coffee before the rainy season with seven insecticides and their sub-lethal doses in combination with fungus at 10×10^6 spores/ml. A field trial was also conducted on Coorg mandarin. Tests on arabica coffee just before the onset of rainy season indicated that in the orchards where more light interception (4.8-23.9 klux) was recorded, the fungus alone or in combination with the micro-dosages of insecticides was ineffective, however, in orchard with more shade and less light interception (9-14.1 klux), sprays of fungus containing 10×10^6 spores/ml + 0.05% quinalphos + 0.05% Teepol even before the onset of rainy season in citrus were highly effective killing 95.58 and 97.50 per cent scales, respectively.

Larvae of the Australian lady beetle, *Cryptolaemus montrouzieri*, kill mealy bugs and also kill aphids and scale insects, if food is in short supply. The adult beetle lays eggs among the mealy bugs. When the beetle larva emerges, it sucks the body contents out of mealy bugs, eggs and nymphs. This predator requires large supply of food; thus the pest population does not have to be reduced to a low level before its introduction. Optimum conditions for egg laying and larval development are, a temperature of 22 to 25°C and relative humidity of 70 to 80%. The predator is released @ 2 predators/yd² (2.4 predators/m²) (Nelson, 1998).

Lindquist (1997) and Singh (2000) reported that the larvae of *C.montrouzieri* are very effective predators, especially when mealy bugs are in dense population. Adult beetles also feed on mealy bugs. Further, he recommended 3 - 4 releases at 2 - 3 weeks intervals @ 2 - 8 per 10 ft² or infested plant for effective management of mealy bugs in polyhouses. Predators do best in warm, humid conditions. A single predator is known to consume 300-500 mealy bugs in its lifetime.

Dreistadt (2001) and Prabhakar (2001) noted that the mealy bug destroyer lady beetle (*C.montrouzieri*) is an important predator of the citrus mealy bug. Both adults and larvae of lady beetles feed on all stages of mealy bugs, but adults and young larvae prefer mealy bug eggs and young nymphs only. One lady beetle generation from egg to adult requires about 1 month at 21°C and 2 months at 27°C. The predator prefers this temperature range and 60 to 80% relative humidity. Suggested release rates are about 2 beetles per small plant or 2 ft² (0.2m²) of infested growing area.

2.3.5 *Helicoverpa armigera* (Hubner)

Dabi *et al.*, (1979) and Deole *et al.*, (2003) conducted field experiment on chickpea variety *Chafa* at Central Institute for Cotton Research, Nagpur to evaluate bioagent formulation against *H.armigera*. The pathogens seem to be helpful to reduce the caterpillars after 36 hours in this regard *HaNPV* was seen to be inferior to *Bt*. formulation.

Navarajan Paul *et al.*, (1983) did not observe any difference between age and per cent parasitization in *Trichogramma chilonis* but found a definite relationship in case of *Trichogramma japonicum*; while Somchoudhary and Dutt (1980) reported that 24 - 72 hours old eggs of *Chilo partellus* and *H.armigera* were most preferred. Further they (Somchoudhary and Dutt, 1980) stated that the rate of parasitization by *T.chilonis* had an inverse relationship with the age of host. Jayaraj (1993) showed that parasitization by *T.chilonis* decreased with increased age of *Corcyra cephalonica* eggs.

Jayanthi (1992), Manjula and Padmavathamma (1999) stated that among the microbial pesticides used, the mean larval population of *H.armigera* and damage were in the decreasing order of *Btk.*, *HaNPV* and *B.bassiana*.

Trichogramma spp., is an important egg parasitoid of a number of lepidopterous pests and is one of the most extensively used natural enemies. These parasitoids attack eggs of many lepidopterous pests of many economically important crops, like sugarcane, cotton, sorghum, paddy, etc. (Singh and Jalali, 1994; Somchoudhary and Dutt, 1988; Dreistadt, 1994). Tandon and Baktavasalam (2001) reported that the inundative releases of *T.chilonis* synchronizing with egg laying of *H.armigera* from an appropriate strategy. Inter-specific, intera-specific and intra-population variability in host plants due to morphological, physiological and allelochemical characters play key role in the success or failure of *T.chilonis*.

B.thuringiensis is specific to the caterpillars of butterflies and moths. It is effective against young larvae that feed openly on foliage. Infected larvae stop feeding within a day and usually die within a few days. Extensive studies have been made with Nuclear Polyhedrosis Viruses (NPV) of *H.armigera*, which is a polyphagous pest of many crops. Three to four sprayings of polyhedral occlusion bodies (POBs) @ 250 LE/ha at 7–10 days interval at early stages effectively check the pest on chickpea, pigeon pea, cotton, sunflower and tomato (Satpathy *et al.*, 1998; Nelson, 1998; Prasad and Kumar, 2000 and Dreistadt, 2001).

Singh and Balla (1999); Balla and Singh (2003) have reported *T.chilonis* as the most effective egg parasitoid on sunflower under screen house as well as field conditions. Inundative releases of *T.chilonis* @ 2,50,000 parasitised *Corcyra* eggs has been found to control the fruit borer *H.armigera* in egg stage upto 80 per cent parasitization (Satpathy *et al.*, 1998). Tiwari (2000) reported that the freshly laid eggs of first day laying of *Corcyra cephalonica* yielded only 64.86 per cent mean parasitization.

Mandal *et al.*, (2003) found that the *B.thuringiensis* (*Btk.*) and *HaNPV* were effective in managing *H.armigera* on chickpea. *Btk.* was the most effective (applied twice @ 1 kg/ha) than *HaNPV*.

The fresh eggs of host are most preferred by the *T.chilonis* for effective and highest parasitisation. Hence, for biological control, careful monitoring of the insect pests in the field must precede the releases of parasitoids for better synchronization between the fresh eggs of the host and active adult stage of the parasitoids. The laboratory studies clearly showed that freshly laid eggs (0 hrs old) of *Spilosoma obliqua* were most preferred with mean per cent parasitization of 71.03 (70.73% in 12 hrs old); while 24 and 48 hours old eggs had insignificant difference regarding parasitism levels (Tiwari and Khan, 2003). These studies were further corroborated when 0 and 1-day-old eggs of *Plutella xylostella* were found suitable for *Trichogrammatoidea bactrae* parasitization with 89.6 and 92.8 per cent parasitism, respectively (Anonymous, 1993).

Balakrishnan *et al.*, (2004) studied the field efficacy of *C.carnea* in combination with biopesticides against *H.armigera*. The lowest mean larval population of *H.armigera* and higher yield were recorded in two releases of *C.carnea* and two sprays of *B.thuringiensis* var. *kurstaki* (*Btk.*) treated plots followed by *C.carnea*, *HaNPV* in conjunction with *HaNPV* and *B t k.* alone treated plots. The field recovery of *C.carnea*, *HaNPV* infected, *B t k.* infected and *B.bassiana* mycosed larvae was more in their respective sole treated plots. The incremental cost benefit ratio was obtained maximum in chlorpyrifos 20 EC alone (1:3.66), followed by *HaNPV* alone (1:3.5), two releases of *C.carnea* with two sprays of *HaNPV* (1:2.88) and two releases of *C.carnea* with one spray of *HaNPV* (1:2.48).

A study was undertaken to observe the combined effects of *T.chilonis* with some bio-pesticides viz., *HaNPV*, *B.thuringiensis* (*Btk.*) (Halt WP) and *B.bassiana*. Two releases of *T.chilonis* with two sprays of *Bt k.* recorded less mean larval population (0.33/plant), less damage on shed squares (42.78%),



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intact squares (9.12%), bolls (14.20%) and loculi (10.68%) and recorded higher yield (782 kg/ha). Two releases of *T.chilonis* with two sprays of *HaNPV* was the next best treatment regarding less mean larval population and damage on fruiting parts. Application of *B.bassiana* alone and in conjunction with *T.chilonis* proved less effective as compared to other treatments. Two releases of *T.chilonis* with one spray of *Btk.* or *HaNPV* and *T.chilonis* alone performed moderately in reducing the larval population and damage on fruiting parts (Balakrishnan *et al.*, 2004).

Tandon and Bakthavatsalam (2004) have conducted two experiments on the effect of sunflower genotypes (21nos) on the parasitization efficacy of *T.chilonis* Ishii on *H.armigera* under screen house conditions at PDBC (ICAR), Bangalore, Karnataka during 1999-2000. Pooled analysis of the data generated under these experiments revealed significant difference in per cent parasitization of *H.armigera* eggs by *T.chilonis* on these genotypes. Highest parasitism was observed on sunflower hybrid MSFII-17 (53.50%) among all the genotypes.

2.3.6 *Spodoptera litura* (Fabricius)

Jayaraj *et al.*, (1981) reported that the field application of *S/NPV* @ 250 to 500 I.E/ha on cotton (*Gossypium* spp.) resulted in 80.6 - 87.7% larval mortality; while *S/NPV* @ 750 I.E/ha increased 13.3 and 66.0 per cent yield of blackgram (*Phaseoleus mungo* L.) and groundnut (*Arachis hypogaea* L.), respectively (Krishnaiah *et al.*, 1984).

Larvae infected by *Nomuraea rileyi* (Farlow) Samson continue to feed and grow normally till death due to mycosis, which could be attributed to the absence of any toxin in the fungus. This feeding can result in considerable foliar damage before the larval death. Use of compatible antifeedants in combination with the fungus could help to reduce the foliar damage as well as hasten the death under stress (Vimala Devi and Prasad, 1996).

Vimala Devi *et al.*, (1996) observed the *N.rileyi*, an entomopathogenic fungus of cosmopolitan occurrence, causes epizootics of major noctuid pests like *H.armigera* and *S.litura* on a variety of crops. Jayachadran and Chaudhari (1996); Singh and Kaul (1998) recorded the efficacy of *S/NPV* against *S. litura* and toxicity of *B. thuringiensis* to its larvae on different crops.

Satpathy *et al.*, (1998); Prasad and Kumar, (2000) noted that the NPV was reported to give excellent control of *S.litura* @ 250 LE/ha at 10 days interval on cotton, tobacco, black gram, groundnut, cauliflower and vegetables. The *N.rileyi* had potential for the control of noctuid pests when applied inundatively as a foliar spray without affecting concurrent use of pesticides. It would be helpful in formulation of IPM modules for the management of *H.armigera* and *S.litura* using *N.rileyi* with compatible insecticides or fungicides (Vimala Devi, 1994, Vimala Devi *et al.*, 2002).

Pokharkar *et al.*, (2001) conducted field experiment on management of *S.litura* with biocontrol agents in comparison with insecticides on potato during 1997 to 2000. The spraying of *S/NPV* @ 750 LE/ha (4.5×10^{12} POBs/ha) was found effective, resulting in maximum larval mortality (91.68%) and 20.8 tones/ha yield of marketable potato. However, it was at par with *S/NPV* @ 500 LE/ha (3.0×10^{12} POBs/ha) and *B.thurinngiensis* @ 0.5 kg/ha. Based on the economics of treatments, application of *S/NPV* @ 500 LE and 750 LE/ha showed sufficiently higher indices of cost benefit ratio (ICBR) of 1: 22.40 and 1:20.29, respectively.

2.4 Chemical Control

2.4.1 Thrips

Chemical control of thrips is difficult because most of the life stages are protected from sprays. eggs are imbedded in tissue, larvae live in developing terminal leaves or buds and pupae are found in media. Re-infestation occurs when thrips are carried into crops by wind or fly from nearby host plants, so populations can develop rapidly. Some thrips have become resistant to pesticides. Management of thrips in vegetable and flower crops has relied

heavily on insecticides, which risks the development of insecticide resistance (Immaraju *et al.*, 1992; Robb *et al.*, 1995; Bauske, 1998).

Eger *et al.*, (1998) reported that the spinosad was highly toxic to *F.occidentalis*, *F.tritici* and *F.bispinosa* in laboratory bioassays but in field study it showed effectiveness only on *F.occidentalis*. Thompson and Hutchins (1999) suggested that the emamectin and spinosad were the most efficient insecticides for controlling the western flower thrips *F.occidentalis* in addition to their activity on other insect pests.

Clody and Sadaf (2000) conducted greenhouse studies to determine the efficacy of spinosad and acephate against western flower thrips on Transval daisy (*Gerbera jamesonii*). Three rates of spinosad 50, 100 and 200 mg and acephate 600 mg per liter were used which showed that both spinosad and acephate controlled the thrips effectively.

Retiz *et al.*, (2003) noted the effects of insecticides varied with species of thrips. Spinosad reduced abundance of *F.occidentalis*, but not of *F.tritici*. In contrast, fenvalerate and acephate reduced the number of *F.tritici* and *F.bispinosa*, but resulted in higher populations of *F.occidentalis*. Spinosad was the least disruptive insecticide to populations of predator, *Orius insidiosus* (Say). Hence, accurate identification of species existing in a field and an understanding of how and why species respond differently to various treatments were needed.

2.4.2 Aphids

Reduced-risk insecticides that control aphids include, *azadirachtin*; *B.bassiana*; buprofezin; cinnamaldehyde; fenoxycarb; imidacloprid; pyrethrum and pyridaben. Narrow-range oil and insecticidal soap provide temporary control if applied thoroughly to cover infested plant parts. Oil and soap provide no residual control, so application may need to be repeated. However, unlike some conventional materials, aphids have not been found to be resistant to soap or oil (Baker and Bailey, 1996; Prasad and Kumar, 2000; Dreistadt 2001).

Sreelatha and Divakar (1997) reported the effectiveness of imidacloprid as a seed treatment against aphids. John Palumbo *et al.*, (1998) evaluated new pesticides such as acetamiprid and thiamethoxam for the control of aphids in head lettuce. From the study, it was seen that thiamethoxam provides less than 90% reduction of aphids. Acetamiprid also provide a good control of aphids.

Thiamethoxam 25 WG was observed effective against sucking pests like aphids, jassids, thrips and whiteflies on cotton as a seed treatment and foliar spays. It was significantly better than oxydemeton methyl and at par with imidacloprid 4, 7 and 10 days after spray (Patil, 2000; Satpute *et al.*, 2001 and Dhawan and Simwat, 2002).

Misra (2002) tested some newer insecticides like thiamethoxam (Actara 25 WG), imidacloprid (Confider 200 SL) and profenophos + cypermethrin (Rocket 44 EC) alongwith conventional insecticides like dimethoate (Rogor 30 EC), cypermethrin (Superkiller 10 EC), profenophos (Curacron 50 EC) and a plant product azadirachtin (Neemarin 1500 ppm) against okra aphids and jassids. The result revealed that imidacloprid and thiamethoxam, both belonging to nitroguanidine group used @ 300 g.a.i/ha proved significantly superior in controlling aphids and jassids on okra.

2.4.3 Use of chemical and botanical pesticides against whiteflies

Benc-G-Del and Del-Bene-G (1979) tested effectiveness of insecticides against *T.vaporariorum* on gerbera in greenhouse. Malathion 50% at 300 g/ha, diflubenzuron 25% at 120 g/ha did not noticeably reduced the number of eggs laid by female of whitefly but acephate 50% at 200 g/ha, applied fortnightly and deltamethrin 2.5% at 60 g/ha when applied both fortnightly and monthly gave over 90 per cent reduction in oviposition.

Lupa (1989) conducted trials with Applaud WP (buprofezin), Lannate WP (methomyl) and Nomolt (teflubenzuron) on green house grown gerbera infected with *T.vaporariorum* in Poland and reported the effectiveness of buprofezin.

B.tabaci has been recorded from poinsettias and gerbera in greenhouses in Switzerland. Applaud (buprofezin) tested against *B.tabaci* was found to be most effective recording 56 per cent pupal mortality (Anonymous, 1989). Stenseth and Singh (1990) tested the insect growth regulator buprofezin in sprays at various temperatures against different stages of *T.vaporariorum* and *B.tabaci* on beans. The insecticide was active against both pests at a concentration of 0.00625% under temperature from 15 to 27°C.

Nanadihalli *et al.*, (1990) carried out field studies on cotton cv. *Laximi* in Karnataka, India, showed that neem products *viz.*, Neemguard and Neemark at 3 ml/lit used in conjunction with monocrotophos 36 WSC (1ml/lit) were more effective against *B.tabaci* than monocrotophos alone. Buprofezin is an insect growth regulator, which inhibits chitin synthesis in several homopteran pests including whiteflies (De Cock *et al.*, 1990). Due to vapour phase toxicity, buprofezin enables to control whitefly larvae present on the lower surface of leaves and it is harmless to aphelinid parasitoids such as *Encarsia formosa* Gahan and *Cades noaki* Howard (Mendel *et al.*, 1994; De Cock *et al.*, 1995).

Nimbalkar *et al.*, (1993) evaluated efficacy of phorate, monocrotophos, endosulfan, phosphamidon, dimethoate, phosalone, acephate, fenvalerate, neem seed extract and neem oil for the control of *B.tabaci* on cotton. Monocrotophos, fenvalerate and phorate applied at a depth of 10 cm at sowing were the most effective. Neem seed extract and neem oil gave considerable reduction in adult and nymphal population.

In greenhouse experiments, Cresswell *et al.*, (1994) observed that the mortality of *T.vaporariorum* was related to the concentration of acephate (Orthene) applied to gerbera. A single irrigation with 80 mg/litre acephate killed all immature stages of *T.vaporariorum* in 10 days with no apparent damage to the plants. Dankowska and Baranowski (1997) tested 15 insecticides against *B.tabaci* on *Euphorbia pulcherima* in the greenhouse during 1995. Results showed that endosulfan (Thiodan 35 EC) @ 0.1%, a mixture of Thiodan 35 EC @ 0.1% and buprofezin (Applaud 25WP) @ 0.1% and a

mixture of methomyl (Lannate 20 L) at 0.2% and Applaud 25 WP @ 0.1% were most effective.

Toscano *et al.*, (1998) tested buprofezin and pyriproxyfen against *B. argentifolii* on cotton. Both the compounds gave significant control at minute concentration. Pasini *et al.*, (1997) conducted trials with gerbera plants in green house and concluded that 6 sprays at 7 days intervals with either of 2 formulations of potassium salts of fatty acids gave control of *B. tabaci* equivalent to that of buprofezin (Applaud) and ethofenprox.

Borah (1995) evaluated the horticultural oil sun spray for effect on nymphs of the silver leaf whitefly, *Bemisia sp.* Bellows and Perring (1998) showed that among nymphs, pupae and crawlers emerging from treated eggs approximately 50 to 70 per cent were killed outright.

Insecticides are still important components in IPM systems designed to suppress whitefly populations on various crops (Liu *et al.*, 1993; Toscano *et al.*, 1998). Sonalkar (1999) reported the reduction of *B. tabaci* population to the tune of 52.7% on okra by the application of acephate @ 390 g.ai/ha; while *azadirachtin* reduced the adult population moderately. Spraying with buprofezin gave satisfactory control of citrus woolly whitefly, *Aleurothrixus floccosus* Mask. (Viaene, 1992; Singh and Singh, 1999).

Marium and Chandramohan (2000) evaluated dichlorvos, malathion, phosalone and fish oil rosin soap against various stages of spiraling whitefly (*Aleurodicus disperses* Russell) on mulberry. Dichlorvos gave 89.38% mortality followed by malathion (88.06%) and phosalone (82.96%). Fish oil rosin soap recorded less than 50 per cent mortality.

Whiteflies have developed resistance to many broad-spectrum insecticides including chlorinated hydrocarbons, organophosphates and pyrethroids but resistance to oil has not been observed. Unlike most other materials, oils kill whitefly eggs. Through oil coverage also adult whiteflies were found to repel from landing for about 1 week after applications to certain

crop including rose (Baker and Bailey, 1996; Prasad and Kumar, 2000; Dreistadt, 2001).

Baskaran *et al.*, (2003) observed moderate efficacy in neem oil 1500 ppm (78.97%) against spiraling whitefly (*A.disperses*) during January to May 2002 on guava at Hyderabad. Knauss and Walter (1995) were found that the neem formulations prevent greenhouse whitefly emergence, while emergence among untreated controls ranged from 75 to 85 per cent. Prasad and Kumar (2000) reported that soaps of vegetable origin based upon salts of fatty acids that have been selected for their insecticidal properties against aphids, mealy bugs, red spider mites and whiteflies. *Azadirachtin*, *B.bassiana* and oil were effective against whiteflies in greenhouse condition (Baker and Baily, 1996; Dreistadt, 2001).

2.4.4 Use of chemical and botanical pesticides against mealy bugs

Tandon and Beche Lal (1987) reported that the two foliar sprays of synthetic Garlic oil 0.75 per cent were found effective for the control of nymphs of *Drosicha mangiferae* Green, which is a serious pest of mango when first instar nymphs migrate to mango trees during December - January after hatching from eggs in soil. Mendal *et al.*, (1991) and Singh and Singh (1999) experienced 91 to 100 per cent nymphal mortality of *Icerya purchasi* and *P.citri* upon application of buprofezin.

Neem oil rich in *azadirachtin* has been tested on mealy bug population in brinjal field at Padappai, Tamil Nadu at different concentrations, viz., 0.25, 0.50, 0.75 and 1 per cent levels. One per cent neem oil spray reduced mealy bug population to 1.84 insects per leaf at 7th day after spray against the pre observation values of 8.31 insects per leaf. Reduction of 50% insect population was also recorded with 0.75% of neem oil spray at 3rd and 5th observations (Pugalenthil *et al.*, 1996).

Srivastava (1997) carried out the laboratory screening to assess the efficacy of buprofezin and alcoholic extract of *Alpinia galanga* against nymphs of mealy bug, *D.mangiferae*. From the data, it was evident that buprofezin

0.0625% and 3% alcoholic extract of *A.galanga* were found very effective in controlling the second instar nymphs.

Available reduced-risk insecticides include *B.bassiana*, imidacloprid, kinoprene, oil and soap, carbamates, organophosphates, pyrethroids and some botanicals also control mealy bugs (Lindquist, 1997; Nelson, 1998; Dreistadt, 2001).

Durairaj and Ganapath (2000) conducted field as well laboratory experiments at National Pulses Research Center, Vamban, Tamil Nadu to study the effect of certain synthetic insecticides against the mealy bug, *Coccidohystrix insolitus* Green on pigeon pea. The experimental results revealed that lambda cyhalothrin, dichlorvos and profenophos were highly effective with more than 95 per cent reduction in population.

2.4.5 *Helicoverpa armigera* (Hubner)

Srivastava and Sehgal (2002) carried a field experiment to evaluate the effect of various groups of insecticides on the pod damage caused by *H.armigera* in chickpea; the deltamethrin was also effective against *H.armigera* as compared to control.

Bhatt and Patel (2002) studied the efficacy of *HaNPV* and *B.thuringiensis* var. *kurstaki*, individually and in combination with insecticides on chickpea against *H.armigera* during *Rabi* season 1998-99. Among the different bio-pesticides and synthetic insecticides tested, endosulfan 0.035% + *HaNPV* 250 LE/ha, fenvalerate 0.005% + *HaNPV* 250 LE/ha and endosulfan 0.07% alone were significantly superior over rest of the treatment in controlling the larval population, reduction of pod damage and increasing the grain yield. The highest CBR was recorded in the treatment of fenvalerate 0.01% followed by monocrotophos 0.04%, endosulfan 0.035% + *HaNPV* 250 LE/ha and fenvalerate 0.005% + *HaNPV* 250 LE/ha and recommended for the management of this pest in chickpea crop.

Sureja *et al.*, (2005) conducted an experiment at Junagadh in Gujarat State with a view to know the effect of new molecules on *H.armigera* on

cotton crop. Spinosad 48 SC @ 50 g.a.i./ha showed significantly lower larval population and damage to fruiting bodies.

2.4.6 *Spodoptera litura* (Fabricius)

Pande and Srivastava (2003) evaluated a new oxidizine chemical indoxacarb (Avant 14.5 SC) for establishment of LC₅₀ and antifeedant activity in laboratory trials against 9 days old larvae of *S.litura*. Indoxacarb exhibited a high degree of toxicity to the larvae of *S.litura* at 0.004% concentration.

2.4.7 Mites

Rose is an important ornamental crop grown commercially in polyhouse. Amongst many reasons for low productivity of quality roses, its susceptibility to two-spotted spider mite, *Tetranychus urticae* (Koch) is a major constraint. Now days, this species is a threat to cultivation of roses particularly under polyhouse conditions. It is a serious pest on rose grown in polyhouse for export. The mite mainly damages matured leaves and in case of severe infestation population spreads to entire plant including buds and flowers, resulting in discolouration, drying of the affected parts and considerable yield loss (Jhansi Rani and Jagan Mohan, 1997; Dhooria, 1998; Jhansi Rani, 2001; Jayachandran, 2003; Sridhar and Jhansi Rani, 2004).

Edge and James (1982); Croft *et al.*, (1987); Hoyt *et al.*, (1987) and Welty *et al.*, (1987) reported the development of resistance by spider-mites to broad range of acaricides in polyhouse condition. Singh and Singh (1992) noted the effectiveness of abamectin (1.9 EC) and dicofol (18.5 EC) against *T.urticae* on okra and found equally effective. Aguiar *et al.*, (1993) studied the efficacy of difenthiuron in control of two spotted mites (*T.urticae*) on rose. Difenthiuron was highly efficient at 40 and 30 g. a.i./100 litres of water.

Aguiar *et al.*, (1995) studied efficacy of clofentezine and abamectin in the control of two-spotted spider mite (*T.urticae*) on rose plants. Clofentezine at 25 g and abamectin at 3.6 g a.i./100 liters of water were most effective treatments against mite. Recent acaricides like abamectin (0.0025%),

difenthiuron (0.025%), amitraz (0.05%) and flufenoxuron (0.015%) provide highly effective control of mite (Jhansi Rani and Jaganmohan, 1997).

Wang-wenjer *et al.*, (1997) carried out field experiments using two applications which showed that 2% abamectin and 68.1% propargite applied conventionally and 2.8% bifenthrin and 33% dienochlor applied twice with an interval of three days gave good control of *T.urticae* on rose. Kharmate and Chandele (1997) reported that the IGR difenthiuron 50 SC offered superior per cent efficacy exceeding 80 per cent for a long period of time against *T.urticae* under polyhouse condition.

Ozawa and Ishii (1997); Kim and Seo, (2001) observed that the milbemectin was highly effective against two-spotted spider mite, *T.urticae* and recorded very high susceptibility of *T.urticae* populations. Phytotoxicity was not observed in any of the milbemectin treated (doses of 3.5 to 5.0 g.a.i./ha) plants with reference to any of the parameters studied in both seasons. The chemical has low mammalian toxicity, relatively less toxic to beneficial organisms and quickly degrades in the environment.

Prasad and Kumar (2000) reported that the insecticidal soap of vegetable origin, based upon salts of fatty acids, have been effective against *T.urticae* under greenhouse condition. Somchoudhury *et al.*, (2000) evaluated the fenazaquin (Magister 10 EC) in three different dose levels *viz.*, 100, 125 and 150 g.a.i./ha against yellow mite, (*Polyphagotarsonemus latus* Banks) on chilli. The results revealed that fenazaquin provided effective control (>80%) of yellow mite when applied @ 125 to 150 g a.i./ha, fenazaquin @ 150 g a.i./ha was superior to dicofol; while all the three dosages of fenazaquin were superior to ethion.

Dhar *et al.*, (2000) evaluated some pesticides for the control of red spider mites (*Tetranychus* sp.) on okra. Reduction of mites was highest in fenazaquin 10 EC @ 2ml/lit (89.64%) followed by fenpropathrin (81.96%).

NCSU (1997) and Dreistadt (2001) indicated that the abamectin, cinnamaldehyde and pyridaben or IGRs are effective in controlling mites.

Narrow-range oil (or horticultural oil) and insecticidal soap are low-residual-toxicity pesticides that provide control if applied thoroughly cover plant parts where mites are feeding. For crops and growing situations where phytotoxicity is a concern 1% soap or 0.25 – 0.5% oil can provide control. More persistent acaricides are available, including some carbamates, organophosphates and pyrethroids. However, these materials can induce physiological changes in mite populations even though the labels may say they control mites. Insecticides applied for other pests during hot, dry conditions often cause dramatic outbreaks of mites within a few days.

Tatagar and Prabhu (2001) reported the superiority of Vertimec in checking mites and thrips infesting chilli crop. *T.urticae* was effectively controlled by the release of predatory mites @ 3/m². At least two monthly releases were required, both for strawberry crops maturing at the normal time (February or early March) and for early maturing crops (maturing in December and January). A schedule of abamectin plus the release of the predatory mites was compared with the application of fenazaquin. Abamectin enhanced the control of *T.urticae* significantly, whereas fenazaquin did not. Fenazaquin was not effective in controlling *T.urticae* (Yong-Hoon Kim, 2001).

Traditionally used acaricide like dicofol and sulphur were not ideal for mite control in polyhouse rose cultivation, due to phytotoxicity, deposition of white stains on plants, reduced effectiveness, resurgence and development of resistance in mites, necessitated exploration of other acaricides such as abamectin, difenthiuron, fenazaquin, clofentazine, etc. (Pirone, 1978; Shaila, 1999; Ghosh, 2001; Jhansi Rani and Sridhar, 2002).

Jyachandran (2003) carried out two field experiments to see the efficacy of abamectin (Vertimec 1.8 EC) on rose mite, *T.urticae* Koch. In both experiments, Vertimec @ 0.25 ml/lit was very effective in controlling the population upto three weeks. Dicofol 2.5 ml/lit and ethion 2 ml/lit gave moderate control and monocrotophos 2.5 ml/lit was less effective. No phytotoxicity was observed with Vertimec at all dosage levels tested in both the

seasons. Mani *et al.*, (2003) studied efficacy of acaricides under field conditions at Vegetable Research Farm, B.H.U., Varanasi, in the month of March to June 2000 on the okra crop against two-spotted mite, *T.urticae* Koch, where in abamectin (1.9% w/w EC) and Neem oil (2.0%) were found effective.

Akashe *et al.*, (2003) evaluated selective miticides at different concentrations for their toxicity on rose against *T.urticae* under polyhouse condition. The lowest LC₅₀ value (0.00006) was recorded in abamectin with corrected mortality ranging from 95.85 to 100%. The least per cent mortality (35.85 to 63.57) was recorded in treatment with sulphur.

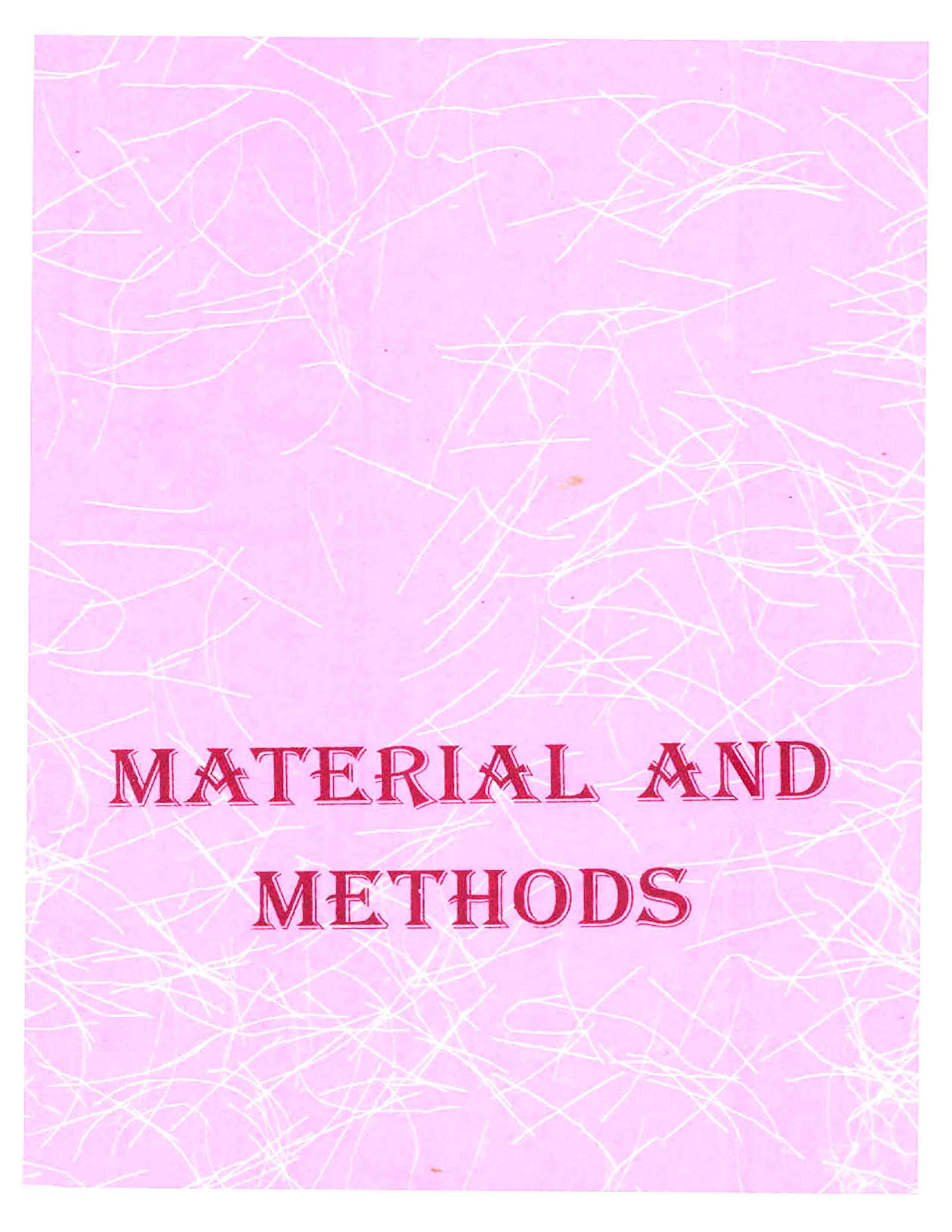
2.5 IPM Modules Against Pests

Suganthi and Tej Kumar (2000) conducted studies to evaluate the relative efficacy of various plant protection options against *H.armigera* in chickpea at the International Crops Research Institute for the Semi-Arid Tropics during post-rainy season, 1998-99. IPM was adjudged as the best treatment in the management of *H.armigera* larvae (37% reduction over control) followed by endosulfan (33), *HaNPV* (29), neem (25) and erecting bird perches (23). IPM registered the least percentage of pod damage (9.4), followed by endosulfan (10.2) as against the higher percentage of pod damage in control (18.8). The maximum yield of 11.7 q ha⁻¹ was obtained with IPM, followed by endosulfan spray (10.5 q ha⁻¹) as against 7.4 q ha⁻¹ in the control plots. IPM was concluded as the best treatment in terms of cost benefit ratio (1:6.3) followed by endosulfan.

Patel *et al.*, (2002) conducted field experiment at Bansilal Amrutlal College Farm of Gujarat Agricultural University (GAU) Campus, Anand, during 1996-97 to 1998-1999 to evaluate the effectiveness of the various IPM modules for the pests of pigeonpea cv. GT-100. Among the various modules studied GAU IPM module (Installation of pheromone trap, spray of *HaNPV* @ 250 LE/ha, spray of NSKE 5% and spray of monocrotophos 0.04% followed by endosulfan 0.07% spray) effectively managed the population of *H.armigera*. The effectiveness of GAU IPM module was also reflected on grain yield.

which was significantly higher in comparison to bio-intensive IPM module and module consisting of recommended package of practices.

Srinivasa Rao and Dharma Reddy (2003) have conducted field trials to evaluate and compare the individual IPM components against lepidopteran borers and pod fly of long duration pigeon pea. The IPM module I (sequential application of *HaNPV* 500 LE ha⁻¹ + endosulfan 0.075% and NSKE 5% with bird perches) and IPM module II (sequential application of *HaNPV* 250 LE ha⁻¹ + NSKE 2.5%, endosulfan 0.07% and *HaNPV* 250 LE + NSKE 2.5% with bird perches) were effective against lepidopteran pod borers recorded highest per cent reduction of larval population. The pod and grain damage was also less in both IPM modules (8.6-9.6%) followed by endosulfan and NPV treatments. The activity of coccinellids and spiders was more in IPM modules. The highest grain yields (11.99 – 13.11 q ha⁻¹) and CBR (9.03 – 10.14) were obtained from both the IPM modules.

The background of the entire page is a solid pink color. Overlaid on this background is a dense, intricate pattern of thin, white, irregular lines that resemble marbled paper or a network of fine scratches. These lines are scattered across the entire surface, creating a textured, organic feel.

MATERIAL AND METHODS

3. MATERIAL AND METHODS

The present investigations on seasonal incidence of thrips, *Frankliniella schultzei*; aphids, *Macrosiphum rosae*; whiteflies, *Trialeurodes vaporariorum*; mealy bugs, *Planococcus citri*; foliage feeders/bud borers, *Helicoverpa armigera*; *Spodoptera litura* and mites, *Tetranychus urticae*, reaction of rose cultivars and evaluation of various components of IPM against these pests infesting rose were carried out at Hi-Tech Floriculture and Vegetable Project, College of Agriculture, Pune and Horticulture Training Center (Talegaon Dhabhade), Century International Polyhouse Ltd. (Shirgaon), Deccan Florabase Ltd. (Jambhul gaon) at Maval, under the polyhouse conditions during the year 2004 to 2006. The mean sea level (MSL) at experimental sites of Pune and Maval are 559 and 714 m, respectively. The material and methods employed for these studies are described in this chapter.

3.1 Material

Observations on varietal resistance and seasonal incidence of thrips, aphids, whiteflies, mealy bugs, *H.armigera*, *S.litura* and mites were recorded on 35 rose cultivars commercially grown for export (Table 1) planted in June, 2002, each in a bed of 5x1 m. The distance between two rows and plants within a row was 0.50 and 0.30 m, respectively. Studies on evaluation of IPM components against these pests were carried out on cultivars given in 3.2.4.1. The details of bioagents, biopesticides and pesticides used are given in Table 2.

For assessing the effect of planting media on pest incidence, earthen pots of 3-liter capacity having 20 cm diameter were used for raising rose plants. Cocopeat was used as planting medium. Iron stands measuring 45 cm height with top width of 45 cm and bottom width of 60 cm were used for keeping the pots. Plant to plant and alley distance was 30 and 60 cm, respectively. One iron stand accommodated two rows of 15 plants each. Six such stands were kept in one row (Plate 1). The other planting medium following distance of 0.50 and 0.30 m between rows and plants, respectively. The standard cultivation

Plate 1. Experimental Crop in Polyhouse



Plate 2. Microclimate in Crop Canopy



Thermohygrometer placed in crop canopy

Table 1. Internationally popular rose cultivars used in experiment.

Sr. No.	Name of cultivars	Breeder	Flower type	Flower Colour	Stem length (cm)	Production of flowers/ year /m ²	Vas life (days)	Scent
1.	Akito	Tantau	Sweet heart	White	60-70	225-250	8-10	Yes
2.	Bianca	Preesman	Hybrid teas	White	60-90	200-220	10-12	Yes
3.	Eldorado	Tantau	Hybrid teas	Deep orange	50-60	200-230	10-12	No
4.	First Lady	Tantau	Hybrid teas	Rhodamine pink	50-80	200-220	9-11	No
5.	First Red	Deruiter/NIRP	Hybrid teas	Red	70-80	180-220	8-10	Yes
6.	Flint Stone	De Ruiter	Hybrid teas	Orange	60-90	170-190	12-14	No
7.	Golden gate	Kordes	Sweet heart	Yellow	60-70	250-275	8-10	No
8.	Grand Gala	Preesman	Hybrid teas	Dark Red	50-70	160-180	8-10	No
9.	Inka	Tantau	Sweet heart	Rose pink	50-60	250-275	8-9	Yes
10.	Konfetti	Tantau	Hybrid teas	Golden yellow	60-80	180-200	12-14	No
11.	Kronos	Tantau	Hybrid teas	Yellow	50-60	180-210	8-9	Yes
12.	Merilan	Tantau	Hybrid teas	Bright pink	50-80	180-200	10-11	No
13.	Mikado	Tantau	Floribundas	Purple	50-60	120-140	9-10	Yes
14.	Milva	Tantau	Hybrid teas	Orange	40-60	160-180	8-10	No
15.	Miracle	De Ruiter	Sweet heart	Dark pink	60-70	250-275	8-10	No
16.	Monte Carlo	Preesman	Hybrid teas	Reddish pink	60-90	200-240	12-14	No
17.	Moviestar	Tantau	Hybrid teas	Pink orange	50-80	180-200	10-12	No
18.	Naranga	Tantau	Hybrid teas	Golden orange	40-60	160-180	8-10	Yes
19.	Papillion	Tantau	Hybrid teas	Light yellow	70-90	150-170	9-10	Yes
20.	Passion	Preesman	Hybrid teas	Red	60-90	190-210	10-12	No
21.	Pink Noblesse	Tantau	Sweet heart	Light pink	50-60	190-220	9-11	No
22.	Polo	Tantau	Hybrid teas	White	50-80	200-225	10-11	No
23.	Queensday	Tantau	Sweet heart	Orange	40-60	180-200	11-12	No
24.	Saphir	Tantau	Hybrid teas	Pink	50-60	190-220	10-11	No
25.	Shanty	Tantau	Sweet heart	Pink red	60-70	200-225	11-12	No
26.	Skyline	Tantau	Hybrid teas	Lemon yellow	60-90	180-200	9-11	No
27.	Sphinx	Preesman	Sweet heart	Yellow	50-80	220-260	14-16	Yes
28.	Sublime	Preesman	Sweet heart	Light pink	60-70	240-275	12-14	Yes
29.	Suela	Tantau	Hybrid teas	Yellow	50-60	180-200	9-10	Yes
30.	Sweet Renate	Preesman	Hybrid teas	Salama pink	70-80	200-220	12-14	No
31.	Sweetnesse	Tantau	Hybrid teas	Rosy	50-70	190-220	8-10	Yes
32.	Temptation	Preesman	Hybrid teas	Scarlet red	60-90	200-220	10-12	No
33.	Teneki	Terra Nigra	Hybrid teas	White	50-60	180-210	9-10	Yes
34.	Texas	Kordes	Hybrid teas	Yellow	60-70	140-160	8-9	Yes
35.	White Noblesse	Tantau	Hybrid teas	Milky white	50-60	200-225	10-14	No

practices like regular de-shooting, fertilizer application, watering, *etc.*, were followed to grow the plants. Drip irrigation system was installed for watering plants and fertilizers were applied through fertigation.

3.2 Methods

In order to study the seasonal incidence, varietal reaction to pests and evaluation of bioagents, biopesticides and chemical pesticides against different pests, the established plots of two-year-old cultivars were selected. Light pruning of rose plants was done on 5th December 2003. To control early season sucking pests, a uniform spray of 0.04% dimethoate was applied on 17th December 2003 to all plots including untreated check. This helped to have a uniform build up of population of pests on new sprouts. Observations on the pest incidence were recorded at weekly intervals from 1st January 2004 to 31st December 2005 on rose cultivars in the morning hours between 6.30 to 8.30 hours.

3.2.1 Seasonal incidence of pests infesting rose

The pest population fluctuates with climatic conditions, hence the studies on seasonal incidence of these pests were undertaken to ascertain the peak and lean periods of pest activity under polyhouse condition on rose to determine the appropriate time to undertake the control measures. These studies were undertaken during 1st January 2004 to 31st December 2005 on rose cultivars grown under polyhouse conditions. Seasonal incidence of pests was assessed at weekly interval on randomly selected 10 plants. Some of the varieties of a crop are relatively more attractive to pest than others. These varieties were watched carefully.

Yellow sticky cards (for whitefly and aphids) and blue sticky cards were installed on sticks adjustable to be raised as the crop grows to keep them just above the height of the plants. The blue card was particularly effective for western flower thrips (*F.schultzei*). For greenhouse blocks of 1000 ft² (93m²) one card was used. Plants and cards were inspected at a time with the help of

Table 2. Details of experimental material used against pests infesting rose.

A. Chemical pesticides

Sr. No	Common Name	Trade Name	Formulation	Cost (Rs.)	Conc/dose	Source
1.	Abamectin	Vertimec	1.9 EC	100 ml, Rs.1300/-	0.005%	Syngenta India Ltd., 14, J. Tata Road, Mumbai-20.
2.	Acephate	Asataf	75 SP	250 gm, Rs. 118/-	0.075%	Rallis India Ltd., Apeejay house, Churchgate, Mumbai-400 020.
3.	Acetamiprid	Polar	20 SP	20 gm, Rs. 122/-	0.005%	Gharda Chemicals Ltd., Bandra (W), Mansion, Mumbai-400 050.
4.	Bifenthrin	Talstar	10 EC	250 ml, Rs. 289/-	0.06%	Rallis India Ltd., Apeejay House, Churchgate, Mumbai-400 020.
5.	Buprofezin	Applaud	25 EC	100ml, Rs.508/-	0.0625%	Rallis Reseach Center, Peenya Industrial Area, Bangalore-560 058.
6.	Deltamethrin	Decis	2.8 EC	250 ml, 122/-	0.002%	M/s. Bayer Cropscience India Ltd., Aventis House, Chakala, Andheri (E), Mumbai-93.
7.	Difenthiuron	Pegasus	50 WP	25 gm, Rs.69/-	0.15%	Syngenta India Ltd., 14, J. Tata Road, Mumbai-020.
8.	Fenazaquin	Magister	10 EC	100 ml, Rs.250/-	0.02%	E.I.DuPont India Pvt. Ltd., DLF Quatab Enclave, Gurgaon-122 002 (Haryana).
9.	Fenpropathrin	Meothrin	30 EC	250 ml, Rs.300/-	0.02%	Sumitomo Chemical India Pvt. Ltd., Jeedimetla, Hyderabad-500 055.
10.	Fipronil	Regent	5 SC	100 gm, Rs.104.40	0.01%	M/s. Bayer Crop Science India Ltd., Aventis House, Chakala, Andheri (E), Mumbai-93.
11.	Imidacloprid	Imiden	17.80 SL	100ml, Rs.261/-	0.005%	M/s. DE-Nocil Crop Protection Ltd., Corporate Park, Chembur, Mumbai – 400 022.
12.	Indoxacarb	Daksh	14.5 SC	100 ml, Rs.379/-	0.0145%	E.I.DuPont India Pvt. Ltd., Manjusar-391775, dist. Vadodara, Gujarat.
13.	Lambda-cyhalothrin	Karate	5 EC	100 ml, Rs.70/-	0.0017%	Syngenta India Ltd., 14, J. Tata Road, Mumbai-400 020.
14.	Milbemectin	Milbeknock	1 EC	100 ml, Rs.486/-	0.009%	M/s. Nagarjuna Agrichem Ltd., Nagarjuna hills, Punjagutta, Hyderabad-82.

Table 2. Details of experimental material used against pests infesting rose.

A. Chemical pesticides

Sr. No	Common Name	Trade Name	Formulation	Cost (Rs.)	Conc/dose	Source
1.	Abamectin	Vertimec	1.9 EC	100 ml, Rs.1300/-	0.005%	Syngenta India Ltd., 14, J. Tata Road, Mumbai-20.
2.	Acephate	Asataf	75 SP	250 gm, Rs. 118/-	0.075%	Rallis India Ltd., Apeejay house, Churchgate, Mumbai-400 020.
3.	Acetamiprid	Polar	20 SP	20 gm, Rs. 122/-	0.005%	Gharda Chemicals Ltd., Bandra (W), Mansion, Mumbai-400 050.
4.	Bifenthrin	Talstar	10 EC	250 ml, Rs. 289/-	0.06%	Rallis India Ltd., Apeejay House, Churchgate, Mumbai-400 020.
5.	Buprofezin	Applaud	25 EC	100ml, Rs.508/-	0.0625%	Rallis Reseach Center, Peenya Industrial Area, Bangalore-560 058.
6.	Deltamethrin	Decis	2.8 EC	250 ml, 122/-	0.002%	M/s. Bayer Cropscience India Ltd., Aventis House, Chakala, Andheri (E), Mumbai-93.
7.	Difenthiuron	Pegasus	50 WP	25 gm, Rs.69/-	0.15%	Syngenta India Ltd., 14, J. Tata Road, Mumbai-020.
8.	Fenazaquin	Magister	10 EC	100 ml, Rs.250/-	0.02%	E.I.DuPont India Pvt. Ltd., DLF Quatab Enclave, Gurgaon-122 002 (Haryana).
9.	Fenpropathrin	Meothrin	30 EC	250 ml, Rs.300/-	0.02%	Sumitomo Chemical India Pvt. Ltd., Jeedimetla, Hyderabad-500 055.
10.	Fipronil	Regent	5 SC	100 gm, Rs.104.40	0.01%	M/s. Bayer Crop Science India Ltd., Aventis House, Chakala, Andheri (E), Mumbai-93.
11.	Imidacloprid	Imiden	17.80 SL	100ml, Rs.261/-	0.005%	M/s. DE-Nocil Crop Protection Ltd., Corporate Park, Chembur, Mumbai – 400 022.
12.	Indoxacarb	Daksh	14.5 SC	100 ml, Rs.379/-	0.0145%	E.I.DuPont India Pvt. Ltd., Manjusar-391775, dist. Vadodara, Gujarat.
13.	Lambda-cyhalothrin	Karate	5 EC	100 ml, Rs.70/-	0.0017%	Syngenta India Ltd., 14, J. Tata Road, Mumbai-400 020.
14.	Milbemectin	Milbeknock	1 EC	100 ml, Rs.486/-	0.009%	M/s. Nagarijuna Agrichem Ltd., Nagarjuna hills, Punjagutta, Hyderabad-82.

15.	Profenophos	Aurifos	50 EC	250 ml, Rs.125/-	0.20%	Cheminova India Ltd., Panoli, Dist.-Bharuch- 394 116, Gujarat.
16.	Spinosad	Tracer	45 SC	75 ml, Rs. 855/-	0.015%	M/s. DE-Nocil Crop Protection Ltd., Corporate Park, Chembur, Mumbai – 400 022.
17.	Thiamethoxam	Actara	25% WG	5 gm, Rs.28/-	0.005%	Syngenta India Ltd., 14 J. Tata Road, Mumbai- 400 020.

B. Oil and soap

Sr. No	Common Name	Trade Name	Formulation	Cost (Rs.)	Conc/dose	Source
1.	Mineral oil	Tree spray Grapple oil	-----	500 ml, Rs.150/-	15 ml/l	Greencrop International Pvt. Ltd., 161-A. Shyam-Shakuntal Heights, Pune-16.
2.	Fish oil rosin soap	Bio-FORS	-----	500gm, Rs.194.67	5 g/l	M/s Rongai Herbals Pvt. Ltd. Prkalp, Pune.

C. Botanical and biopesticides

Sr. No	Botanical / Scientific Name	Trade Name	Formulation	Cost (Rs.)	Conc/dose	Source
1.	<i>Azadirachta indica</i>	Nemazal (Neem)	1 EC	1 lit, Rs.524.48	0.5%	M/s EID parry (India) Ltd. Dave House, Chennai, India.
2.	<i>Bacillus thuringiensis</i>	Dipel (Bt.k) 8 L	176x10 ¹² spores/ ml	50 ml, Rs. 164/-	1 kg/ha	M/s. Cheminova India Ltd., Mumbai.
3.	<i>HaNPV</i>	Helio-Cide 500 LE	1.5x10 ¹² POB's/ml	100 ml, Rs.240/-	1.5x10 ¹² POB's/ml	Pest Control (India) Pvt. Ltd., Division: Bio Control Research Laboratories (BCRL) P.O.Box 6426, Yelahanka, Bangalore-56 0064.
4.	S/NPV	Spodo-cide 500 LE	1.5x10 ¹² POBs/ml	100ml, Rs. 240/-	1.5x10 ¹² POB's/ml	PCI Pvt. Ltd., BCRL, Bangalore.

5.	<i>Nomuraea rileyi</i>	-----	2x10 ⁸ CFU/g	500 gm. Rs. 150/-	2 kg/ha	Pathology Division, PDBC, Bangalore.
6.	<i>Verticillium lecanii</i>	Vertiguard	2x10 ⁸ CFU/g	1kg. Rs. 250/-	2 kg/ha	Ajay Farm Chem Pvt. Ltd., Village-Khalad, Tal.-Purandhar, Dist.-Pune- 412 301.

D. Bioagents

Sr. No	Scientific Name	Common Name	Formulation	Cost (Rs.)	Dose	Source
1.	<i>Trichogramma chilonis</i>	Phule trichocard	18,000-20,000 parasitoid/card	1 card. Rs.40/-	1,50,000 parasitised eggs/ha	Bio-control Laboratory, College of Agriculture, Pune-411 005.
2.	<i>Chrysoperla carnea</i>	Green lace wing	_____	1000eggs. Rs. 330/-	50,000 larvae/ha	Nomin Agri Bio Pvt. Ltd., Village-Savargaon, Tal-Mulshi, Dist-Pune.
3.	<i>Cryptolaemus montouzieri</i>	Australian lady bird beetle	_____	1 larvae. Rs.1.25	4 grubs/plant	Nomin Agri Bio Pvt. Ltd., Village-Savargaon, Tal-Mulshi, Dist-Pune.

E. Traps

Sr. No	Name of trap/lure	Common Name	Cost (Rs.)	Rate/r	Source
1.	Yellow sticky trap	-----	1 trap, Rs. 25/-	1 trap for 93m ² /1000ft ²	PCI Pvt. Ltd., BCRL, Bangalore.
2.	Blue sticky trap	-----	1 trap, Rs. 25/-	1 trap for 93m ² /1000ft ²	PCI Pvt. Ltd., BCRL, Bangalore.
3.	Pheromone trap	-----	1 trap, Rs. 19.50	1 trap/5r	PCI Pvt. Ltd., BCRL, Bangalore.
4.	Sticky tape trap	-----	1 trap, Rs. 27/-	-----	Venus traders Ltd. Pune.
5.	Pheromone	Helilure	1 lure, Rs. 15/-	1 lure/5r	PCI Pvt. Ltd., BCRL, Bangalore.
6.	Pheromone	Spodolure	1 lure, Rs. 17/-	1 lure/5r	PCI Pvt. Ltd., BCRL, Bangalore.

10x lens. The type and number of insects were determined and recorded. Cards were replaced weekly. An accurate estimate of pest population was obtained at weekly interval by counting only a central vertical column of one-inch (25 mm) width over a 30 cm trap length with a hand lens.

The traps made of sticky tape were used for monitoring mealy bug crawlers. The stem of five plants infested with mealy bugs was snugly wrapped with transparent tape, which was sticky on both sides. The loose end of the tape was doubled over so as to pull the end easily to unwind it. Tapes were changed at weekly interval. Crawlers get stuck on the tapes and appear orange specks. Prior to observations, the tapes were examined with hand lens to distinguish the crawlers from pollen and dust.

Caterpillars were monitored for their damage and timely counted by shaking the plants. Visual inspection and pheromone traps were also used for monitoring caterpillars and moths. Visual inspection *viz.*, chewing damage, dark faecal pellets (frass) on chewed plants and on media beneath the plant was done for caterpillars, by randomly selected leaves, growth terminals and also on entire plants. To record population of *H.armigera* and *S.litura* pheromone traps were installed in the polyhouse at Pune and Maval for year round. Pheromone-lures were replaced every month in respective traps. Moths were collected weekly from each trap early in the morning during the study period.

Monitoring of mites was done randomly by selecting plants infested areas and inspecting middle to lower leaves for damage with a hand lens as well as holding a sheet of white paper on a clipboard beneath the plant and tapping the foliage sharply and inspecting the paper for any dislodged mites to the naked eye as they look like moving specks.

3.2.2 Method of recording observations

Thrips, *Frankliniella schultzei* :

Observations on thrips were recorded by counting the mean number of thrips on five randomly selected plants. Number of thrips per flower was

counted by three tapping of flower on black paper. The pest population per flower was computed. The methodology for assessing thrips incidence was adopted as suggested by Bagale (1993), Duraimurugan and Jagadish (2004). Blue sticky cards were used for monitoring thrip population.

Aphids, *Macrosiphum rosae*:

The population count of nymphs and adults was recorded from five tagged plants by selecting three tender shoots of 10 cm length from each plant on the basis of method adopted by Shukla (1983) and Hole *et al.*, (1997). The pest population for one shoot per plant was computed. Yellow sticky cards were used for monitoring aphid population.

Whiteflies, *Trialeurodes vaporariorum* :

The adult count on five randomly selected plants was taken on three leaves from upper, middle and lower plant canopy on each plant as method adopted by Sangha *et al.*, (1995). Whiteflies population was also monitored by counts taken on yellow sticky cards.

Mealy bugs, *Planococcus citri* :

Observations on nymphal counts were recorded on mealy bugs infested twig of 30 cm length on five randomly selected and tagged plants by following the method adopted by Bhat *et al.*, (1988). The pest population per twig of 30 cm was computed. The sticky tape traps wrapped around infested stems were used for monitoring mealy bug crawlers.

***Helicoverpa armigera* and *Spodoptera litura* :**

Observations on number of larvae were recorded on five randomly selected plants from each plot. The plants were examined thoroughly and absolute population of larvae was recorded at weekly interval on the basis of method adopted by Patel and Koshiya (1997). The pest population per plant was computed. The pheromone traps were used for monitoring adult population.

Mites, *Tetranychus urticae* :

The population counts of nymphs and adults were taken on two randomly selected leaves, one each from middle and lower part of plant. On five plants by using magnifying lens (10x) by following method adopted by Hole and Salunke (2005). The pest population per leaf was worked out.

Meteorological parameters:

For developing insect pest management programme for specific agro-ecosystems, information on abundance and distribution of pest in relation to weather parameters is basic. For this study, the instruments like maximum and minimum thermometer, dry and wet bulb thermometer, thermohygrometer (Plate 2) were installed in the experimental polyhouse and the observations were recorded daily at 7.30 a.m. and 2.30 p.m. during the experimental period and same are presented in appendixes I, II and graphically depicted in Fig. 1, 2.

3.2.3. Reaction of Rose Cultivars to Pests

To judge the susceptibility and/or tolerance of each of thirty-five rose cultivars, pest incidence was recorded at weekly intervals. The grouping of cultivars was made into four classes viz., i) less susceptible, ii) moderately susceptible, iii) susceptible and iv) highly susceptible as follows:

Pest Species	Category / Pest population			
	Less susceptible	Moderately susceptible	Susceptible	Highly susceptible
Thrips/flower	0.00-5.00	5.01 to 10.00	10.01 to 15.00	15.01 & above
Aphids/shoot	0.00-10.00	10.01 to 20.00	20.01 to 30.00	30.01& above
Whiteflies/leaf	0.00-5.00	5.01 to 10.00	10.01 to 15.00	15.01 & above
Mealy bugs/twig	0.00-25.00	25.01 to 50.00	50.01 to 75.00	75.01 & above
<i>H.armigera</i> /plant	0.00-1.00	1.01 to 1.50	1.51 to 2.00	2.01& above
<i>S. litura</i> /plant	0.00-1.00	1.01 to 2.00	2.01 to 3.00	3.01& above
Mites/leaf	0.00-25.00	25.01 to 50.00	50.01 to 75.00	75.01 & above

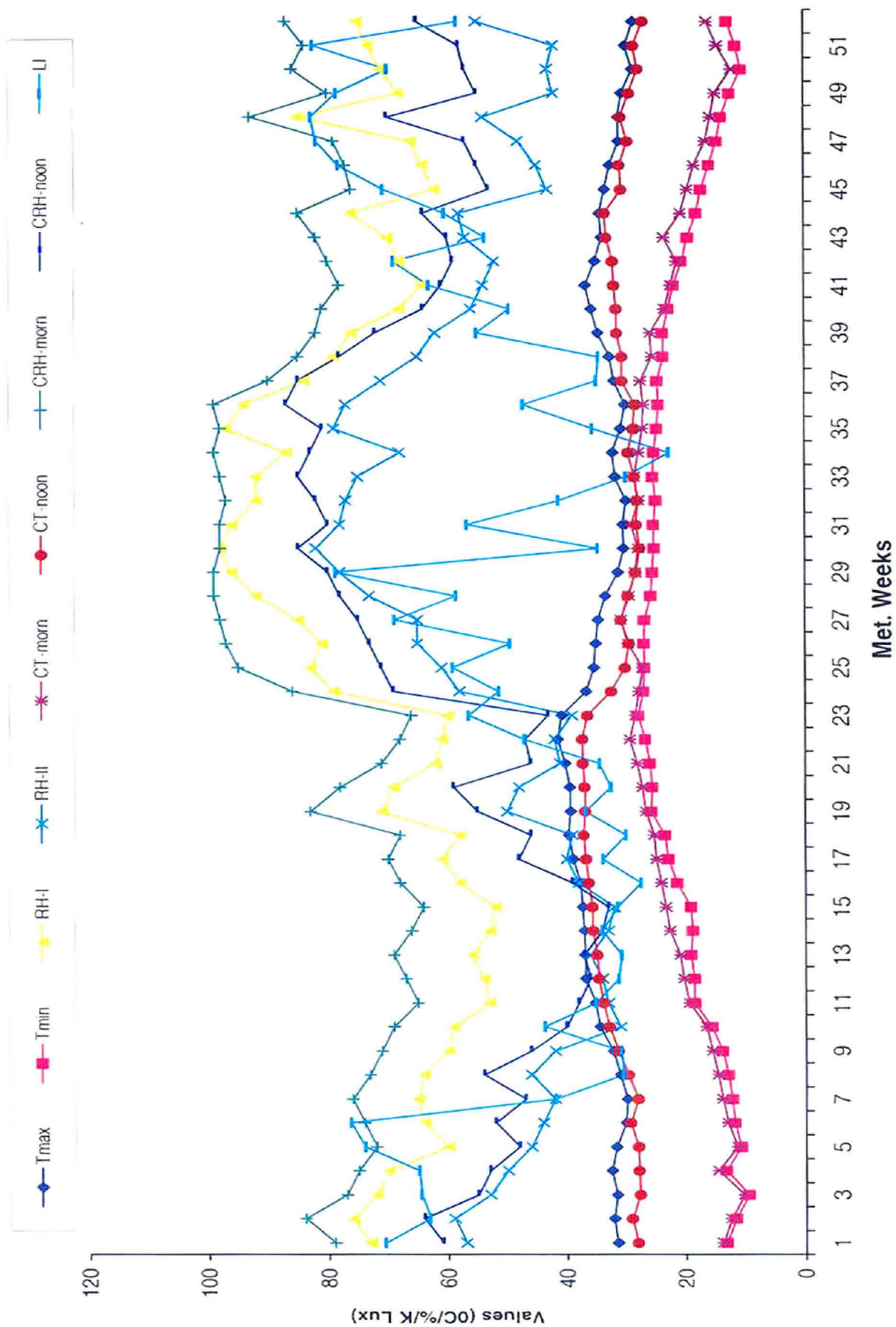


Fig. 1. Meteorological data during experimental period at Pune

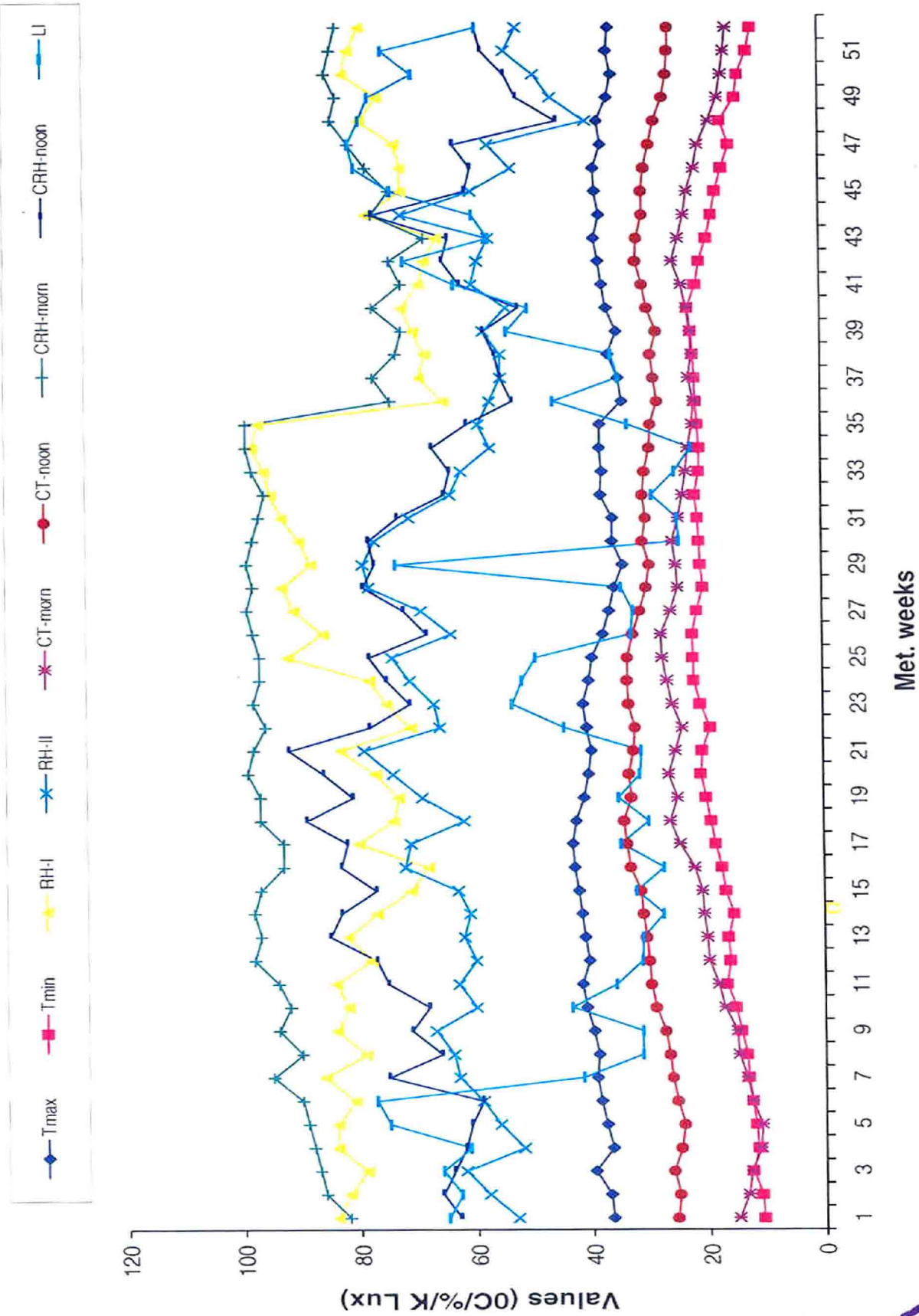


Fig. 2. Meteorological data during experimental period at Maval

T-6524

M.P.K.

Analysis of experimental data:

To find out the significance of differences in various cultivars for infestation by each pest, all observations were subjected to the square root transformation for counts and the significance was assessed at 5% level (Snedecor and Cochran, 1967). Per cent flower bud damage and yield from each plot were subjected to analysis of variance.

3.2.4 Bioefficacy of Various Bioagents, Biopesticides and Chemical Pesticides

3.2.4.1 Experimental details :

A statistically designed experiment was laid out under polyhouse conditions to study the efficacy of various treatments against pests of rose. The experimental details were as follows:

Duration : September, 2004 to July, 2006.

Location : Ili-Tech Floriculture and Vegetable Project, Agriculture College Campus, Pune-5 and Deccan Flora Base Ltd., Maval.

Design : Randomised Block Design

Replications : Five

No. of treatments : 7 (Including untreated control)

Spacing : Row to row–50 cm; Plant to plant–30 cm

No. of plants/plot : 30

Treatment details:

- A. Pests, cultivars and dates of treatment application.
- B. Pests wise groups of treatments

A. Pests, cultivars and dates of treatment application.

Pests	Cultivars	Dates of spraying/bioagent release
Thrips, <i>F.schultzei</i>	Sublime	2004 = 16.8, 7.9, 25.9 2005 = 20.8, 5.9, 22.9
Aphids, <i>M. rosae</i>	Bianca	2005 = 8.1, 20.1, 7.2, 2005/2006 = 9.12, 26.12, 15.1
Whiteflies, <i>T.vaporariorum</i>	Sphinx	2005 = 2.8, 19.8, 3.9 2006 = 23.7, 7.7, 29.7
Mealy bugs, <i>P.citri</i>	Milva	2004/2005 = 7.7, 20.7, 7.8 2006 = 3.7, 21.7, 9.8
<i>H.armigera</i>	First red	2004 = 17.12, 2.1, 20.1 2005 = 23.12, 7.1, 28.1
<i>S.litura</i>	Grand gala	2005=5.7,19.7,7.8 2006=21.6.6.7,28.7
Mites, <i>T.urticae</i>	Bianca	2005 = 14.3, 3.4, 20.4 2006 = 18.3, 5.4, 24.4

3.2.4.2 Release of bioagents and biopesticide spraying

In each replication, one plot was covered with mosquito net till the observation period. For the erection of mosquito net, the rectangular iron frame was welded together. The height and width of the cage was more than the plant height and width (5 x 1.50 x 2.0 m). This iron frame was covered with the mosquito net. In this cage, a window was also cut and zip was put on this cut for facilitating to open and close the cage at the time of observation. Five cages were installed. The release of bioagents and spraying of biopesticides were undertaken in evening hours at 16.30 to 17.30 hours.

[illegible]

The predator, *C.carnea* was released @ 4 larvae/plant/release against aphids and thrips; while *C.montrouzieri* was released @ 4 grubs/plant/release against mealy bugs. *T.chilonis* parasitized eggs card bits were stapled @ 75/cage/release on under-surface of leaves at various places in the treatment plots for assessing against *H.armigera*. NPV was sprayed after adding jaggery @ 0.5%, Triton @ 0.1% and UV protectant (fabric whitener @ 1ml/lit). *B.thuringiensis* var. *kurstaki*, *N.rileyi* and *V.lecanii* were sprayed with mixing Triton @ 0.1% at 15 days interval. The subsequent releases and spraying were made for three times at an interval of 15 days.

Method of recording observations and ICBR :

The observations on aphids, thrips and mealy bugs population were recorded at an interval of 2/3, 7 and 10 days. Four days after every release of *T.chilonis*, per cent parasitisation was recorded initially based on blackening of *H.armigera* eggs and later on confirmed by adult emergence in the laboratory. Ten days after every release of *T.chilonis*, percent parasitisation was recorded on the basis of emerged larval count. Virosed, *Btk*. infected and mycosed larvae were recorded at weekly interval in respective treatments. The yield data were recorded and incremental cost benefit ratio (ICBR) was worked out by considering additional income derived over untreated check and total cost incurred on plant protection towards the particular pest.

Preparation of pesticide spray fluid and application:

The quantity of spray volume required per treatment was calibrated by spraying water with hydraulic knapsack sprayer on the control plot. The quantity of insecticide required for preparing spray solution of required concentration was calculated for each of the treatment. At the time of preparing spray solution, the measured quantity of insecticide was first dissolved in water in bucket and then remaining quantity of water was added. It was thoroughly stirred with the help of a long wood stick. The group of insecticides for each pest is given in treatment detail 3.2.4.1.

The spraying was undertaken in evening hours at 16.30 to 18.30 using manually operated hydraulic knapsack sprayer. Five replications of each treatment were sprayed at a time, by avoiding drift of spray solution on neighbouring plots. Three sprays of each insecticide were given at fortnightly interval in each year.

3.2.4.3 Method of recording observations and data analysis

For recording observations, five plants were randomly selected and tagged. The observations on thrips were taken by tapping flowers on black paper; while for aphid population counts of nymphs and adults were recorded from tagged plants by selecting five tender shoots of 10 cm length from each plant. Observations for whiteflies were taken by counting number of adults per leaf; while for mealy bugs number of crawler per 30 cm twig of plant were counted. The count of nymphs and adults mites was taken from three randomly selected leaves, one each from lower, middle and upper part of five tagged plants with the help of magnifying lens (10x).

Observations were recorded by counting larvae and per cent damage of floral buds per plant in case of *H.armigera* and *S.litura*. Observations were recorded before treatment and 2/3, 7 and 10 days after treatment in morning hours at 7.30 to 9.30 am. Efficacy of insecticides was calculated on the basis of survival nymphal, larval, adult population per plant or leaf or shoot or twig or flower. The data on pre and post treatment pest population were averaged and analysed statistically after transforming the values using Poisson formula $\sqrt{X+1}$ (square root transformation for counts).

The null hypothesis was tested by 'F' test of significance to know whether observed treatment effects were real or not, from the data in which treatment effects were significant. The standard error (S.E) and critical difference (C.D.) at 5% level of significance were calculated, in order to ascertain the bio-efficacy of each pesticide against thrips, aphids, whiteflies, mealy bugs, *H.armigera*, *S.litura* and mites.

3.2.5 Comparative Economics of Different Treatments Against Pests of Rose

The yield of rose flowers (number of flowers/treatment) from each treatment was recorded at every picking. The yield was recorded for a period of one month commencing from one month after first spray. The total yield obtained from each treatment over a period of one month was converted to yield in terms of number of flowers per 5r.

The flowers having diameter 10 cm and above, depth 4 cm and above with shoot length 75 cm and above were considered as grade 'A' flowers; while the flowers having qualities below than above standards were considered as grade 'B' flowers. The cost benefit ratio for different insecticidal treatments was computed for an area of 5r. The parameters used for working out the cost benefit ratio of different treatments were:

A) Gross monetary benefit

Gross monetary benefit was calculated by multiplying additional yield over control with prevailing average local market rate of rose flowers (Rs. 2.5 per flower for 'A' grade and Rs. 2.00 for 'B' grade flowers).

B) Cost of treatments

The cost of treatments for three sprays was calculated as per market price of insecticides. Labour cost was calculated at prevailing rates of Rs. 60 per day. Although spraying of 5r area required about one to two hours, labours had required paying charges of half day. Thus, 0.5 Labour Day was considered sufficient for covering , one spray. The total cost of treatments required for three sprays or releases was summed up to determine total cost of application for each treatment. This cost was taken as additional cost required for treatment against the pest.

C) Net monetary returns

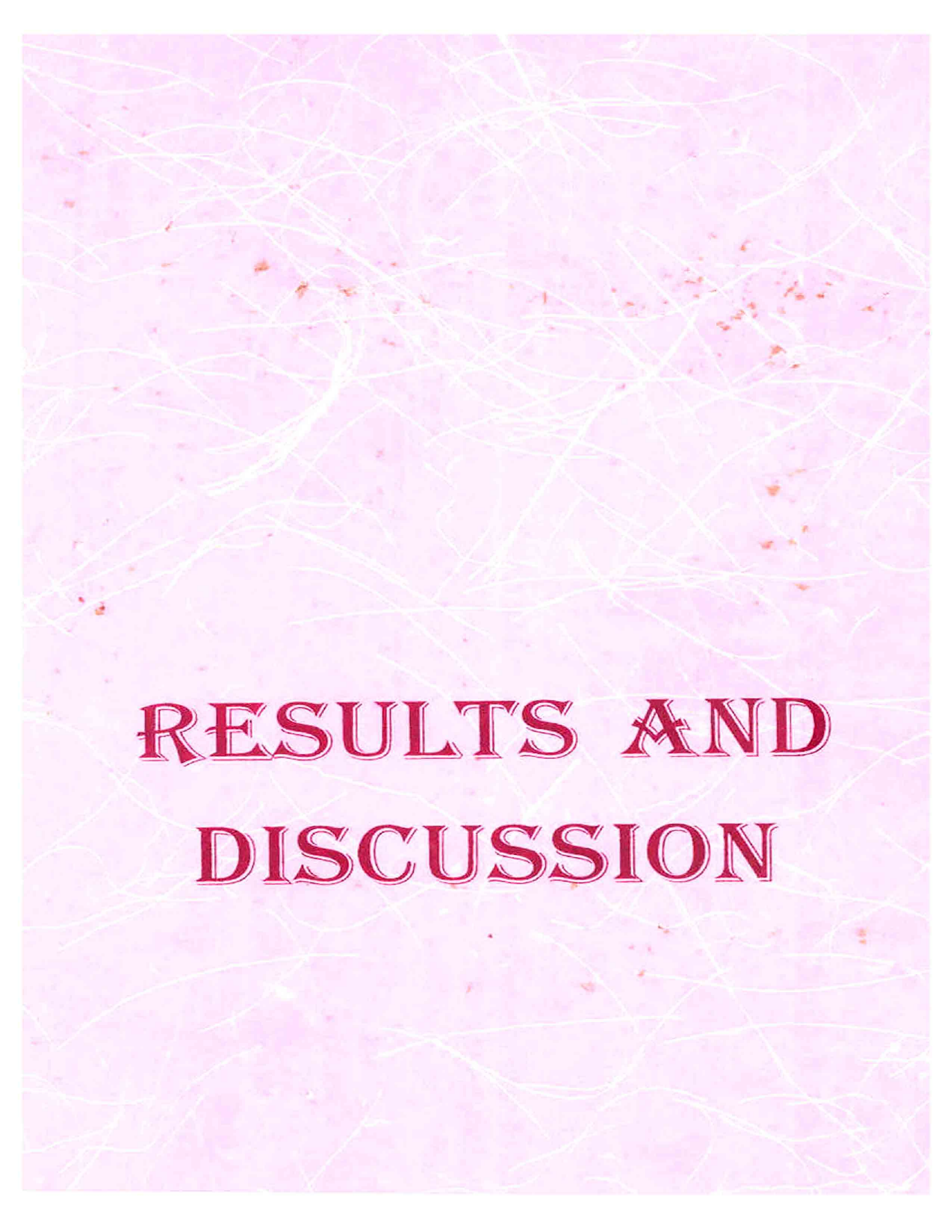
This was calculated by subtracting the total additional cost required for treatment (as worked under B) from the monetary benefit (as worked out under A) for each treatment separately.

D) Cost benefit ratio

The cost benefit ratio (CBR) was calculated by dividing the net monetary returns (C) by total additional cost due to treatments (B).

3.2.6 Efficacy of IPM-Technology Over Control

The experiment was taken up in two polyhouses of 5r each, with First red rose variety. In one polyhouse IPM technology was practiced and other without IPM technology. Other recommended package of practices for cultivation of rose was followed. An area of 5x2 m in three places in each polyhose was marked for recording weekly observations, which were also considered as replications. Ten randomly selected plants in each treatment from each marked areas were used for recording observations on incidence of various pests as described in 3.2.2. The marketable yield and quality parameters were recorded at harvest of flowers on whole plot basis.



RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The present investigations were undertaken under ployhouse conditions to record seasonal incidence, reaction of rose cultivars and to evaluate various components of IPM against *F.schultzei*, *M.rosae*, *T.vaporariorum*, *P.citri*, *H.armigera*, *S.litura* and *T.urticae* during the year 2004 to 2006 at Pune and Maval. The results of these experiments are presented and discussed in the light of relevant references in this chapter.

4.1 Seasonal Incidence

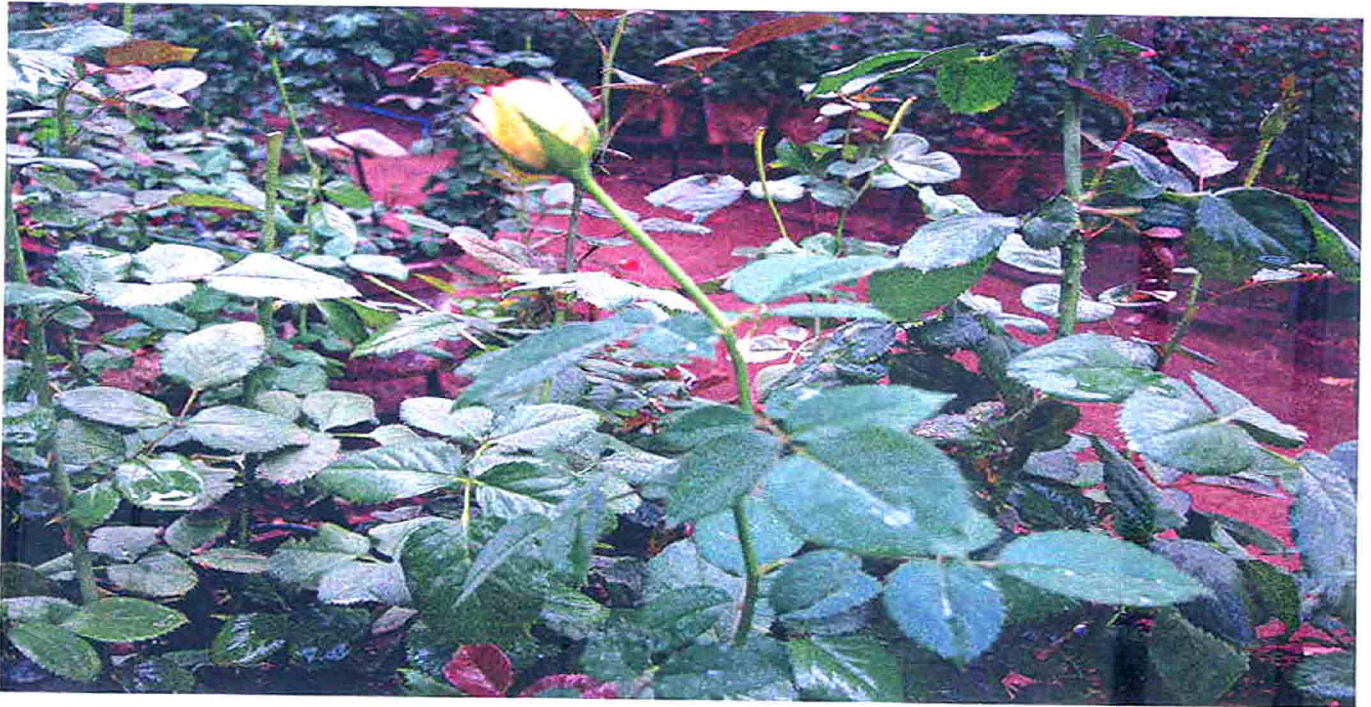
4.1.1 Thrips, *Frankliniella schultzei* (Pergande)

Seasonal incidence of *F.schultzei* on rose was studied by taking count of thrips per flower as well as number of adults trapped on blue sticky cards. The pest activities were observed twice in a year first being from third week of June to second week of January and second in last week of February to last week of April (Plate 3). Thrips population recorded at Pune was found higher as compared to Maval. The data are presented in Table 3, 4, 5, 6 and graphically depicted in Fig. 3, 4, 6, 7 and 8.

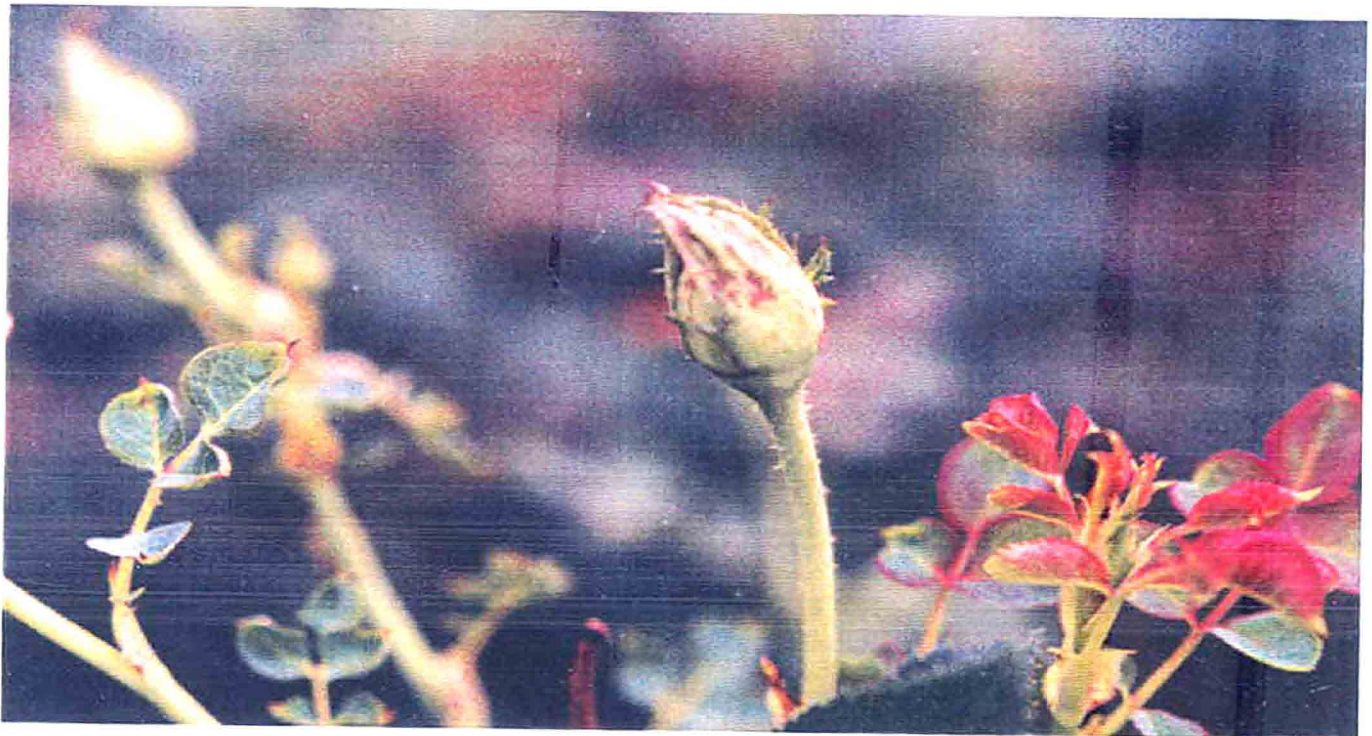
Pune:

The incidence of thrips during experimental period was found to range from 0.44 to 26.14 thrips per flower. The maximum population was noticed in 45 MW (Table 3). The number of adults trapped on blue sticky traps gradually increased and reached to its peak in second week of November (52.5 thrips/trap). Thereafter, the pest activity slowly decreased upto January (Table 4). The temperature and humidity during the peak activity period were found to range between 17.2 to 33.4 °C and 43 to 62 per cent, respectively with light intensity of 70.5 klux. The data on correlation coefficient between pest and weather parameters are presented in Table 7. It could be seen that thrips population was found positively correlated with LI ($r = 0.44$) and negatively with $T_{\max}$ ($r = -0.28$) and was significant.

Plate 3. Infestation of Thrips



Less susceptible cultivar (Temptation)



Highly susceptible cultivar (Mikado)

Table 3. Seasonal incidence of pests on rose at Pune during 2004 and 2005.

MSW	Month	Thrips /flower	Aphids /shoot	Whiteflies /leaf	<i>H.armigera</i> larvae/plant	<i>S.litura</i> larvae/plant	Mites /leaf
1.	Jan.	6.28	32.90	-	0.59	-	1.04
2.		2.66	59.57	-	1.23	-	-
3.		0.72	15.43	-	0.84	-	-
4.		-	63.70	1.17	0.54	-	-
5.	Feb.	-	42.87	1.53	1.48	-	-
6.		-	31.40	0.33	1.76	-	0.58
7.		-	28.71	0.11	1.84	-	0.94
8.		-	19.37	-	1.36	-	1.78
9.	Mar.	0.54	1.64	-	1.33	-	5.84
10.		1.12	-	-	1.68	-	18.24
11.		1.78	-	-	0.99	-	11.68
12.		7.96	-	-	0.32	-	45.76
13.		3.56	-	-	-	-	28.54
14.	April	6.06	-	-	-	-	72.04
15.		7.22	-	-	-	-	105.3
16.		2.38	-	-	-	-	89.18
17.		1.32	-	-	-	-	121.08
18.	May	0.44	-	-	-	-	162.68
19.		-	-	-	-	-	101.86
20.		-	-	-	-	-	88.48
21.		-	-	-	-	0.64	140.72
22.		-	-	-	-	1.36	92.34
23.	June	-	-	-	-	1.18	109.80
24.		-	-	0.37	-	1.62	62.96
25.		-	-	0.70	-	2.28	49.54
26.		-	-	2.20	-	1.96	85.24
27.	July	-	1.41	6.33	-	2.80	39.18
28.		2.54	4.60	4.48	-	3.44	27.06
29.		1.78	10.82	5.61	-	3.99	12.88
30.		8.90	6.33	7.40	-	4.26	4.30
31.	Aug.	9.48	9.72	6.77	-	4.45	-
32.		15.32	16.53	11.07	-	2.77	-
33.		11.08	20.45	10.53	-	1.67	-
34.		13.28	6.95	9.17	-	1.92	1.12
35.		9.48	2.92	11.60	-	1.77	5.64
36.	Sept.	13.94	2.53	12.13	-	2.61	12.34
37.		16.44	0.50	10.87	-	1.32	17.28
38.		20.64	-	9.17	-	1.37	21.82
39.		21.94	-	11.60	-	0.42	58.70

40.	Oct.	22.08	-	5.80	-	0.20	118.26
41.		17.98	-	2.83	-	0.28	98.90
42.		19.34	-	0.63	-	0.10	87.80
43.		23.80	-	0.17	-	-	56.42
44.	Nov.	24.38	-	-	0.92	-	47.96
45.		26.14	1.83	0.83	0.16	-	54.68
46.		23.28	1.53	5.43	0.84	-	58.24
47.		21.90	5.21	7.63	0.38	-	94.76
48.		20.54	24.23	7.4	0.22	-	60.12
49.	Dec.	19.16	12.73	2.1	0.72	-	23.86
50.		17.08	32.30	-	0.40	-	17.46
51.		16.12	51.13	-	1.76	-	44.56
52.		13.22	25.1	-	2.68	-	6.14

Maval:

The incidence of thrips per flower and number of adults trapped on blue sticky traps ranged from 0.60 to 23.43 (Table 5) and 2 to 57 (Table 6), respectively. The number of thrips gradually increased and reached to its peak in fourth week of October (43 MW) and thereafter started declining. The mean existing meteorological parameters during 43 MW were 38.7 °C ($T_{\max}$), 19.4°C ($T_{\min}$), 66% (RH-I), 57% (RH-II) and 57 klux (LI); while the $Ct_{\min}$, $Ct_{\max}$, $Crh-I$ and $Crh-II$ were 24.3°C, 31.5°C, 68% and 64%, respectively. The correlation analysis of thrip incidence with meteorological parameters (Table 8) revealed highly significant negative correlation with humidity (RII-I $r = -0.46$, RII-II $r = -0.37$, $Crh-I$ $r = -0.73$ & $Crh-II$ $r = -0.53$), maximum temperature ($T_{\max}$ $r = -0.37$) and positive correlation with minimum temperature ($T_{\min}$ $r = 0.37$, $Ct_{\min}$ $r = 0.30$).

In present studies, the highest thrips population was recorded in the month of October, which is in conformity with findings of Jadhav and Bhujbal (1990), who reported peak population of thrips in the first week of October when meteorological parameters were $T_{\max}$ 31.6 °C and $T_{\min}$ 15.2°C. Bagale (1993) found the abundance of population during June to August and prolonged dry spell after rains was reported to be favoured for increase in population of thrips.

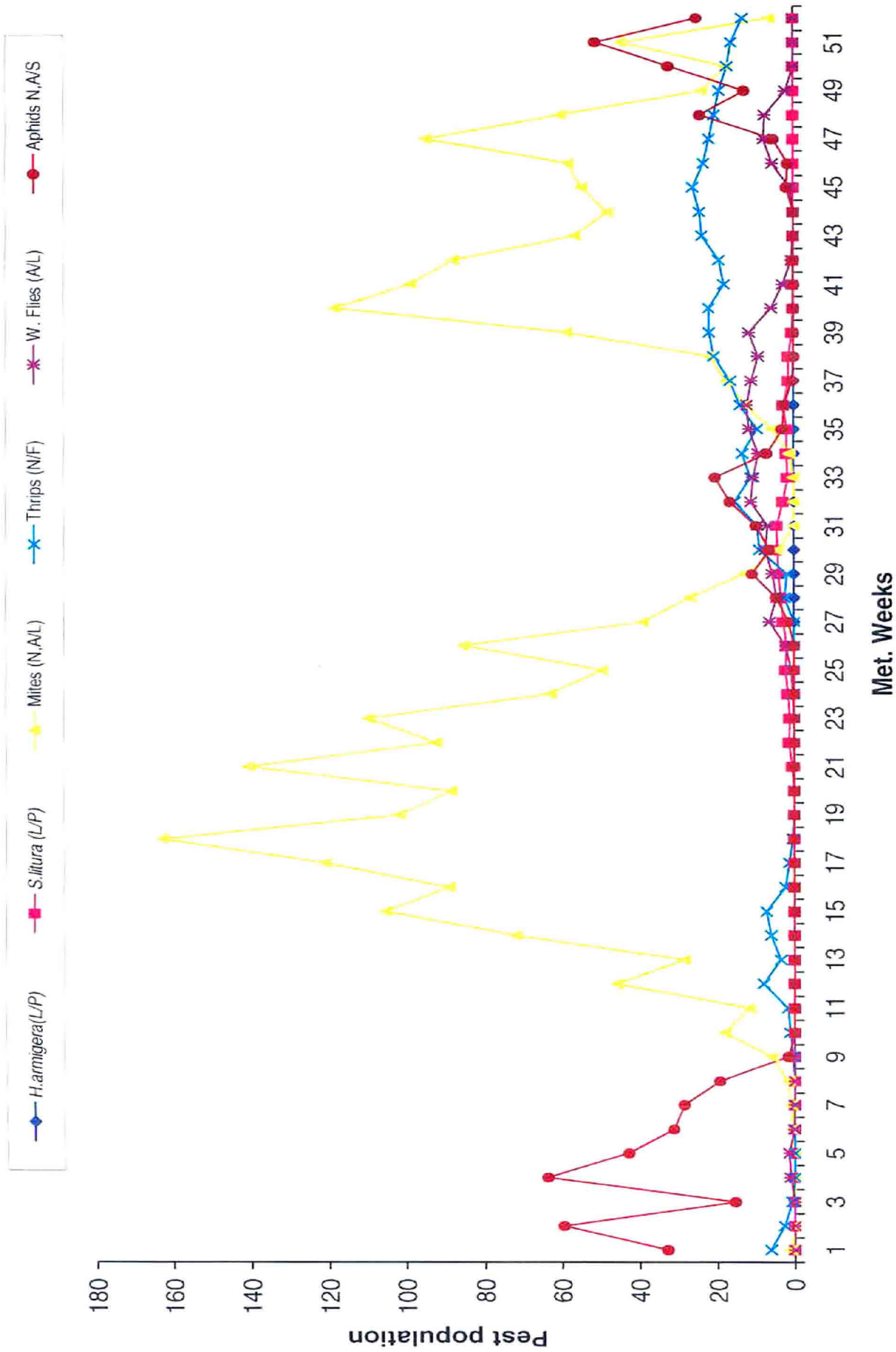


Fig. 3. Seasonal incidence of pest infesting rose in polyhouse at Pune (2004-2005)

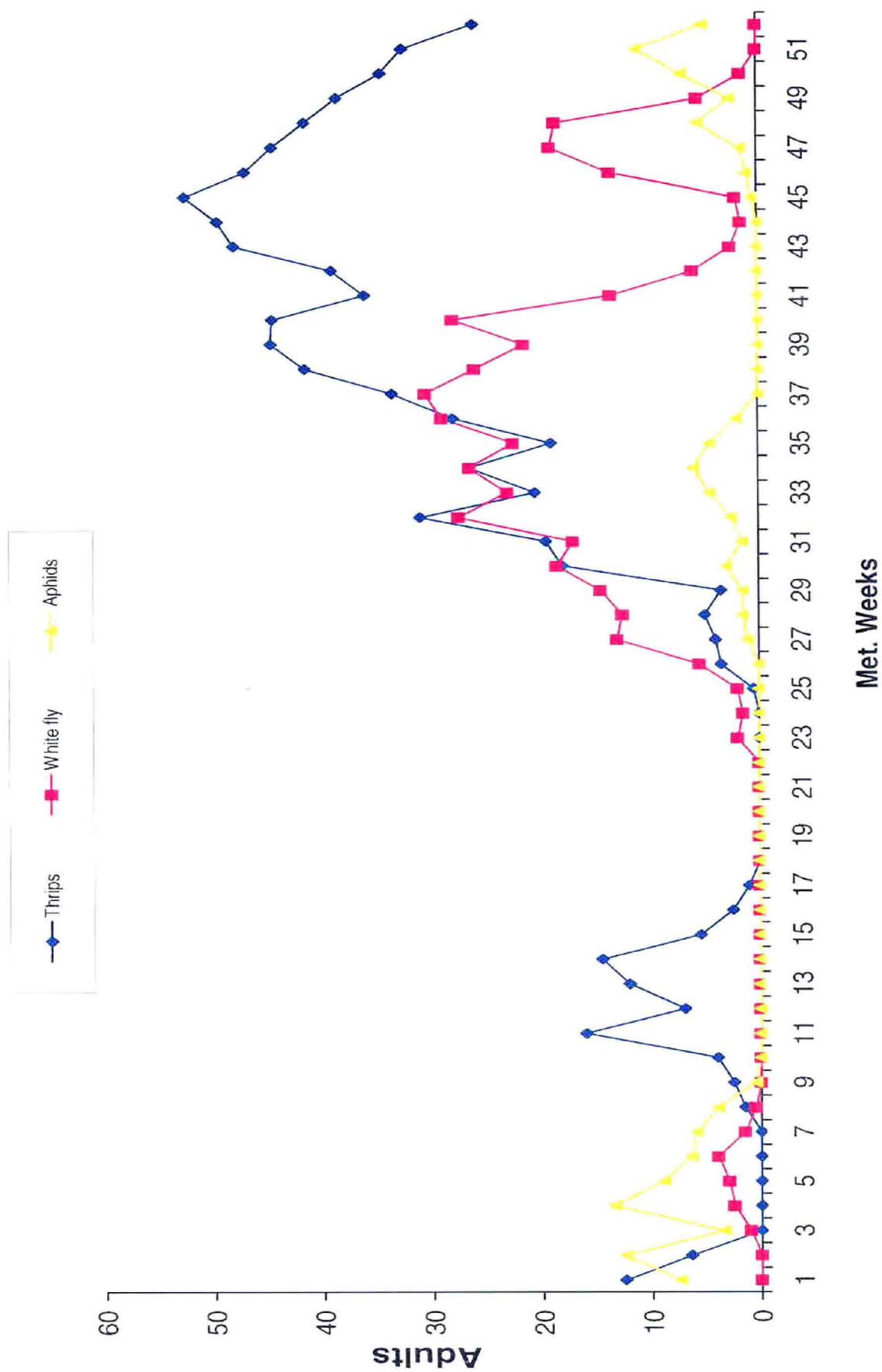


Fig. 4. Number of adults (sucking pest) trapped in polyhouse at Pune (2004-05)

4.1.2 Aphids, *Macrosiphum rosae* (Linnaeus)

Observations on seasonal incidence of *M.rosae* infesting rose were recorded at weekly interval by taking counts of aphids on 10 cm shoot. The data are presented in Table 3, 4, 5 and 6 and graphically depicted in Fig. 3, 4, 6, 7 and 8. There were two broods in a year first from July to September and second in November to February (Plate 4). The aphid population on rose at Maval was higher as compared to Pune.

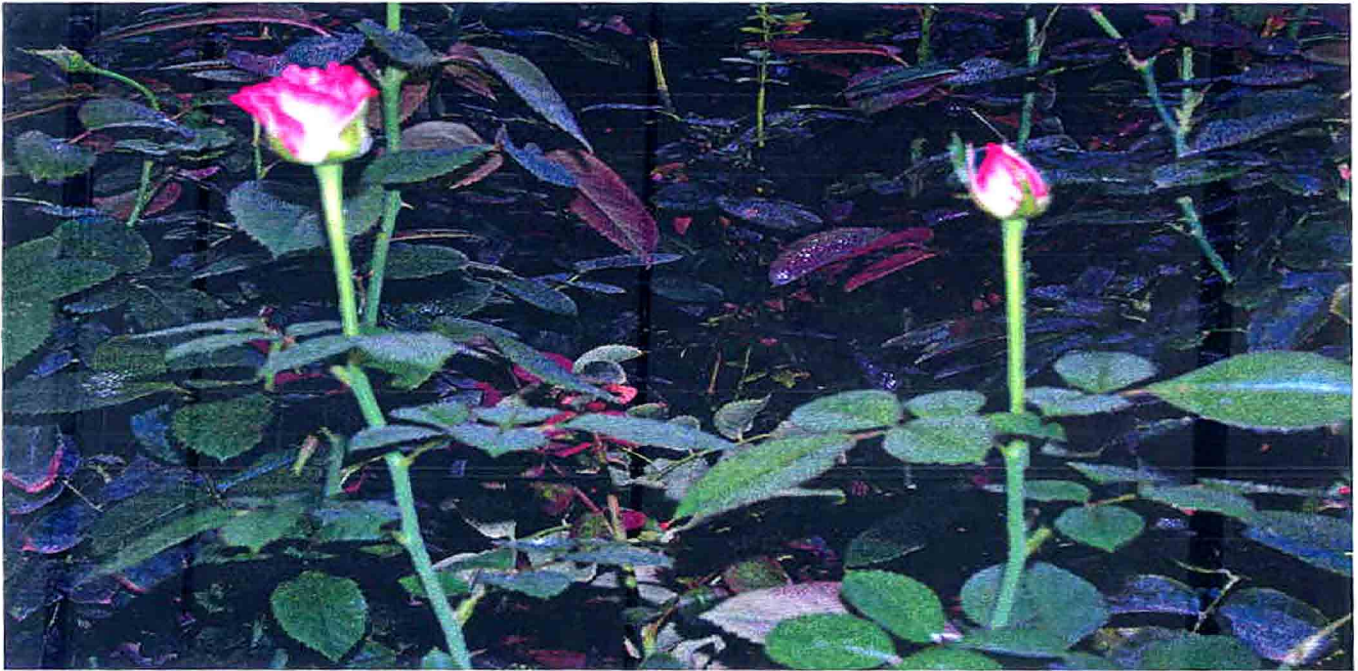
Pune:

The incidence of aphids ranged from 0.50 to 63.70 aphids per shoot (Table 3). The number of adults trapped on yellow sticky traps ranged from 0.5 to 13.5 (Table 4). The maximum population was noticed in 4 MW. Thereafter, the aphid population was found slowly decreased upto March. The climatic conditions during 4 MW were 32.5°C (T_{max}), 13.3°C (T_{min}), 70% (RH-I), 50% (RH-II) and 64.9 klux (LI); while the Ct_{min} , Ct_{max} , Crh-I and Crh-II were 14.7°C, 28°C, 75% and 53%, respectively. The highly significant negative correlation was found to exist between aphid incidence and meteorological parameters (T_{min} $r = -0.61$, Ct_{min} $r = -0.61$, Ct_{max} $r = -0.43$) and humidity (RH-I $r = -0.33$, RH-II $r = -0.34$, Crh-I $r = -0.38$, Crh-II $r = 0.42$) (Table 7).

Maval:

Comparatively higher incidence of aphid was noticed in 5 MW (86.96 aphids/shoot) and 6 MW (21 aphids/trap) (Table 5, 6). During this period temperature, humidity and LI in polyhouse ranged from 11.9 to 38.5°C, 56 to 84% and 74.9 to 77.1 klux and in crop canopy 10.9 to 25.5 °C and 59 to 90%, respectively. The rose crop was found to be free from aphid infestation from March to June due to high temperatures (34.3 to 41.6 °C). Aphid population had negative correlation with temperature (T_{min} $r = -0.69$, Ct_{min} $r = -0.75$, Ct_{max} $r = -0.75$) and humidity (RH-II $r = -0.36$) and positive correlation with LI ($r = 0.38$).

Plate 4. Infestation of Aphids (*M.rosae*)



Less susceptible cultivar (Saphir)



Highly susceptible cultivar (Suela)

The earlier findings of Chattopadhyay *et al.*, (1996) were on similar line with significant variation where in they reported sharp rise in aphid population when temperatures drop below 25°C. Further, they reported appearance of pest in 23rd July and continued the infestation upto 3rd February. However, in present findings the period of 3rd week of September upto 1st week of November was found to be lean period of pest activities.

4.1.3 Whitefly, *Trialeurodes vaporariorum* (Westwood)

Seasonal incidence of whitefly on rose was studied by recording adult count per leaf and per trap. The data are presented in Table 3, 4, 5, 6 and graphically depicted in Fig. 3, 4, 6, 7 and 8. In general, the pests activities were observed twice in a year, first in January to February and second in June to December (Plate 5). In case of whitefly, population recorded at Maval was higher than recorded at Pune.

Pune:

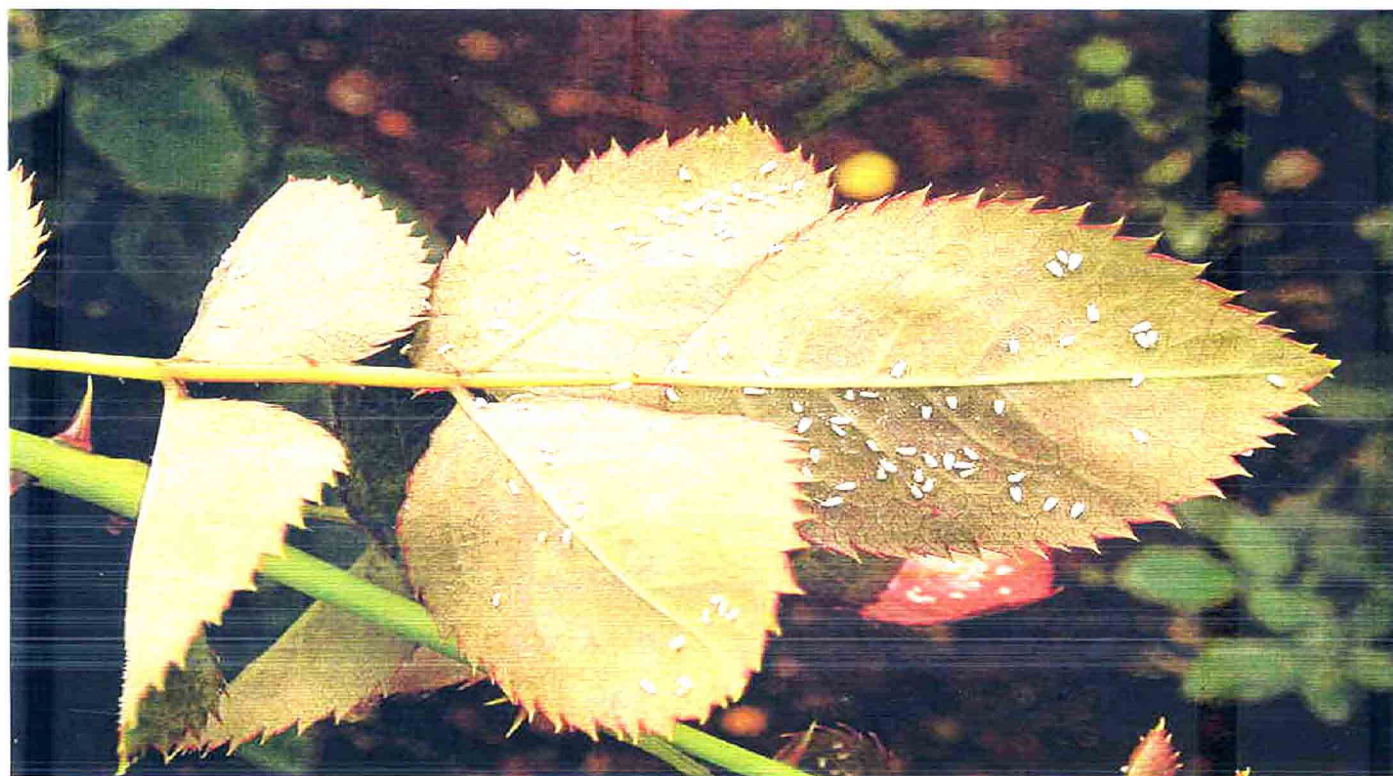
The incidence of whitefly during experimental period was ranged from 0.11 to 12.13 per leaf (Table 3). The maximum population was noticed in 36 MW. The number of adults trapped on yellow sticky traps showed gradual increase from June and reached to its peak (30.5 adults/trap) in 2nd week of September (Table 4). Thereafter, the pest activities were found slowly decreased. The crop was found free from whiteflies from 3rd week of December to 2nd week of January and reappeared in 3rd week of January and continued up to last week of February.

The climatic conditions during 36 and 37 MW in respect of $T_{\max}$, $T_{\min}$, RH-I, RH-II and LI were found in the range of 30.0 - 31.8°C, 24.4 - 24.6°C, 84 - 94%, 71 - 77% and 34.8 - 47.2 klux, respectively; while the canopy $Ct_{\min}$, $Ct_{\max}$, Crh-I and Crh-II were ranged between 26.9 - 27.4°C, 28.4 - 30.5°C, 90 - 99% and 85 - 87%, respectively. The data on correlation coefficient are presented in Table 7 and 8. During the studies positive correlations between whitefly population and $T_{\min}$ ($r = 0.44$), $Ct_{\min}$ ($r = 0.47$), RH-I ($r = 0.63$), RH-II ($r = 0.67$), Crh-I ($r = 0.56$), Crh-II ($r = 0.75$) was found to exist. However, the negative correlation was found with $T_{\max}$ (-0.36) and LI (-0.44).

Plate 5. Infestation of Whiteflies (*T.vaporariorum*)



Less susceptible cultivar (Merilan)



Highly susceptible cultivar (Golden gate)

Table 4. Average number of insect population catches per trap at Pune during 2004 and 2005.

MSW	Month	Thrips (Adults)	Aphids (Adults)	Whiteflies (Adults)	<i>H. armigera</i> (Moths)	<i>S. litura</i> (Moths)
1.	Jan.	12.5	7.5	-	8.5	-
2.		6.5	12.5	-	7	-
3.		-	3.5	1	6	-
4.		-	13.5	2.5	5.5	-
5.	Feb.	-	9	3	14	-
6.		-	6.5	4	11	-
7.		-	6	1.5	17	-
8.		1.5	4	0.5	7.5	-
9.	Mar.	2.5	0.5	-	9.5	-
10.		4	-	-	9	-
11.		16	-	-	3	-
12.		7	-	-	-	-
13.		12	-	-	-	-
14.	April	14.5	-	-	-	-
15.		5.5	-	-	-	-
16.		2.5	-	-	-	-
17.		1	-	-	-	-
18.	May	-	-	-	-	-
19.		-	-	-	-	-
20.		-	-	-	-	2
21.		-	-	-	-	3.5
22.		-	-	-	-	6.5
23.	June	-	-	2	-	4
24.		-	-	1.5	-	8
25.		0.5	-	2	-	12.5
26.		3.5	-	5.5	-	8
27.	July	4	1	13	-	11.5
28.		5	1.5	12.5	-	13.5
29.		3.5	1.5	14.5	-	15
30.		18	3	18.5	-	17
31.	Aug.	19.5	1.5	17	-	19
32.		31	2.5	27.5	-	14.5
33.		20.5	4.5	23	-	9
34.		26.5	6	26.5	-	10
35.		19	4.5	22.5	-	9.5
36.	Sept.	28	2	29	-	13
37.		33.5	-	30.5	-	8.5
38.		41.5	-	26	-	7

39.		44.6	-	21.5	2.5	3
40.	Oct.	44.5	-	28	8	6
41.		36	-	13.5	11	2.5
42.		39	-	6	10	-
43.		48	-	2.5	9.5	-
44.	Nov.	49.5	-	1.5	10	-
45.		52.5	0.5	2	4	-
46.		47	1	13.5	7	-
47.		44.5	1.5	19	3.5	-
48.		41.5	5.5	18.5	5	-
49.	Dec.	38.5	2.5	5.5	6	-
50.		34.5	7	1.5	6.5	-
51.		32.5	11	-	12	-
52.		26	5	-	10	-

Maval:

The incidence of whitefly per leaf and number of adults trapped on yellow sticky traps ranged from 0.22 to 19.66 and 1.5 to 49.5, respectively (Table 5, 6). The number of whiteflies gradually increased and reached to its peak in the first week of September. The maximum population was noticed in 36 MW, during this period $T_{\max}$, $T_{\min}$, RH-I, RH-II and LI were 34.2°C, 21.5°C, 65%, 57% and 46 klux, respectively; while the $Ct_{\min}$, $Ct_{\max}$, Crh-I and Crh-II were 21.8°C, 28.1°C, 74% and 53%, respectively. Correlation analysis of whitefly incidence with meteorological parameters revealed highly significant negative correlation with $T_{\max}$ ($r = -0.48$) and LI ($r = -0.63$); while positive correlation with temperature $T_{\min}$ ($r = 0.33$) and $Ct_{\min}$ ($r = 0.46$) (Table 8). Thus, maximum temperature and high light intensity had adverse effect on build up of whitefly population.

Nene (1972) recorded rapid development and multiplication of whitefly, when average maximum temperature ranged from 15 to 35°C. Patel and Jhala (1992) recorded increase in whitefly population from August to December. Similarly, during present study the higher population was observed during August to November. Wang and Tsai (1996) noted the effect of temperature on life cycle and reported the development time from egg to adult of 105 days at 15°C and 14 days at 30°C.

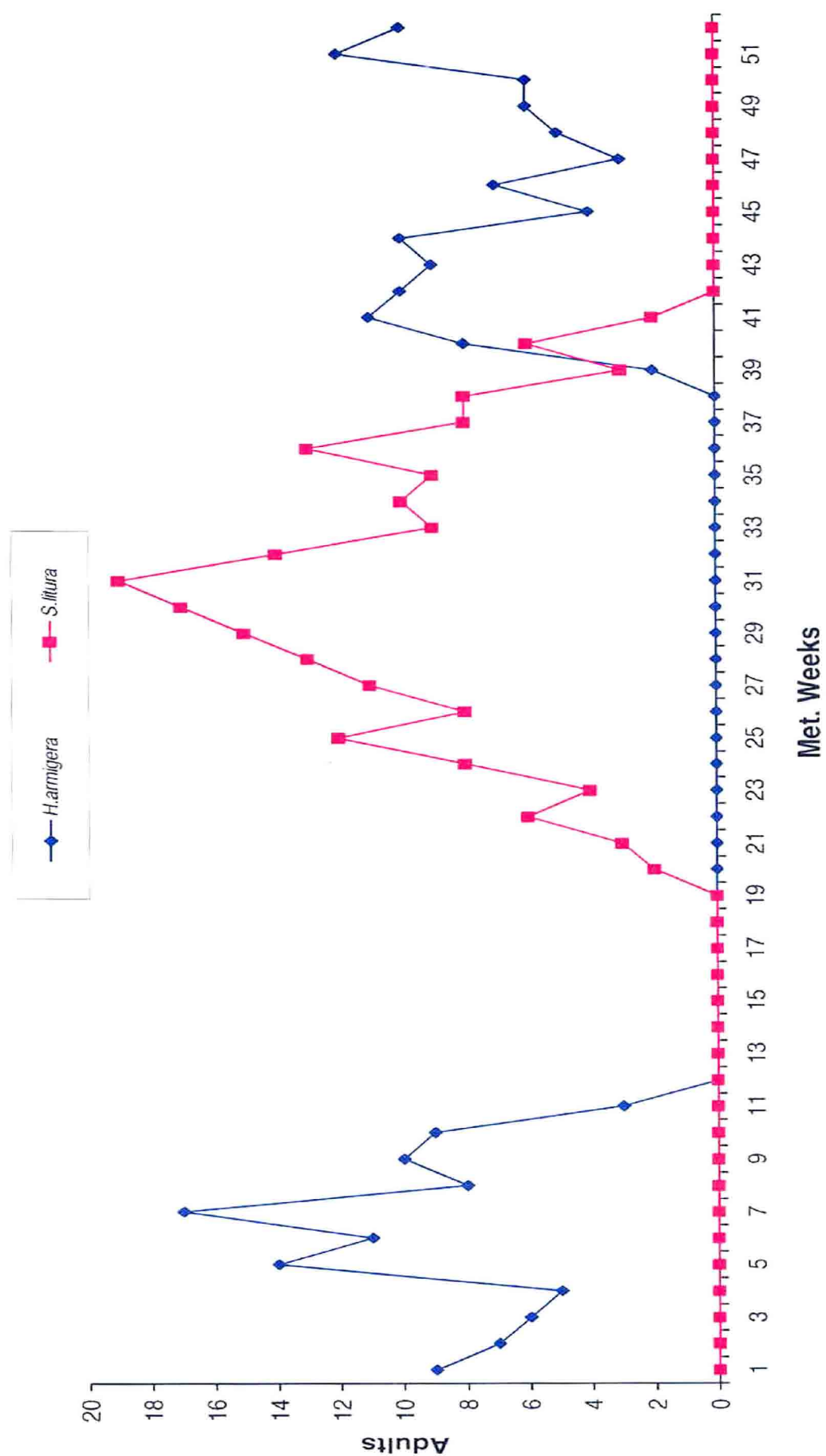


Fig. 5. Number of adults (moths) trapped in polyhouse at Pune (2004-2005)

4.1.4 Mealy bugs, *Planococcus citri* (Risso)

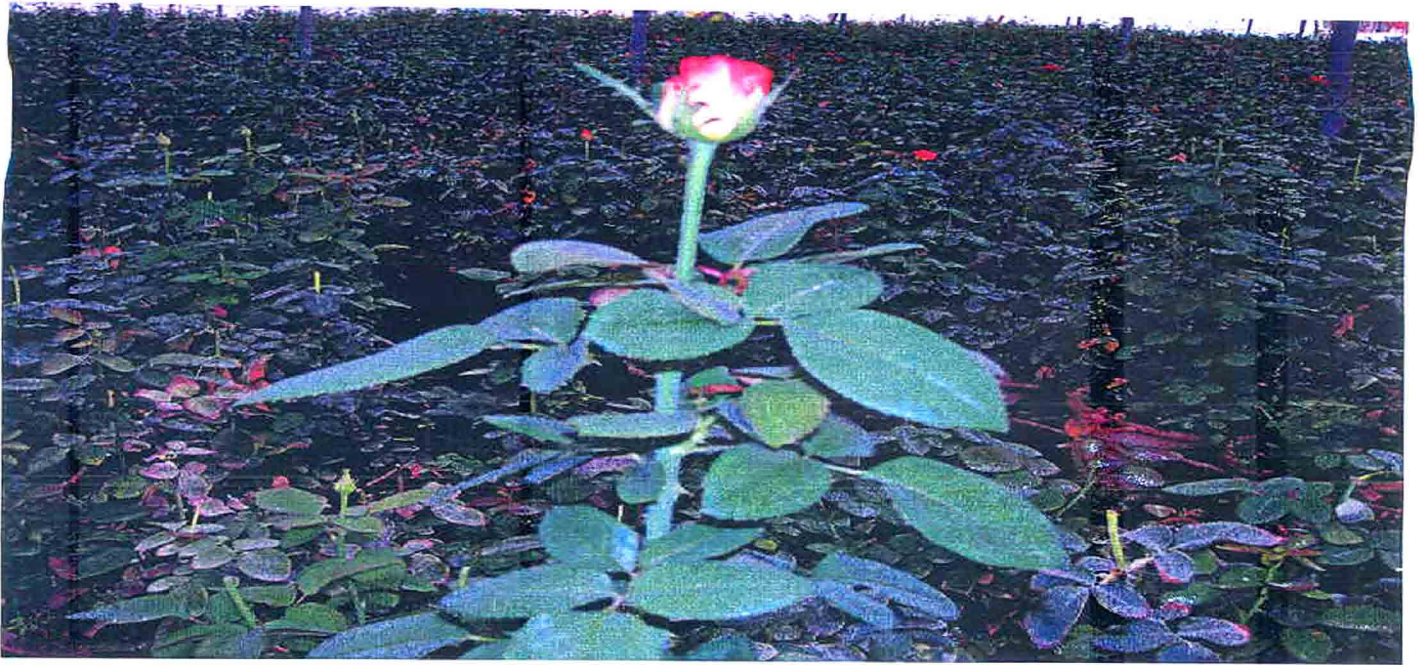
Observations on seasonal incidence of *P.citri* on rose were recorded at weekly interval by taking the nymphal counts of mealy bugs on 30 cm twig and sticky tape traps. The data are presented in Table 6, 8 and graphically depicted in Fig. 7, 8. The pest activities were observed through out the year at Maval (Plate 6); while it was very trace at Pune.

The incidence of mealy bugs was found to range from 1.52 to 144.28 per twig. The maximum population (144.28/twig) was noted in 12 MW. Thereafter, due to risen temperatures and decreased humidity, the pest activities slowly decreased upto April-May. The meteorological conditions during 12 MW were 40.4°C ($T_{\max}$), 16.2°C ($T_{\min}$), 78% (RH-I), 60% (RH-II) and 31.4 klux (LI), respectively; while the $Ct_{\min}$, $Ct_{\max}$, Crh-I and Crh-II were 19.9°C, 30.2°C, 98% and 77%, respectively. The correlation analysis between mealy bug incidence and meteorological parameters showed highly significant negative correlation between temperature ($Ct_{\min}$ $r = -0.43$, $Ct_{\max}$ $r = -0.44$) and positive with RH-I ($r = 0.31$) (Table 8).

The number of crawlers trapped on sticky tape ranged between 0.75 to 62.5. The maximum numbers of crawlers (62.5) were trapped in the first week of March, when $T_{\max}$, $T_{\min}$, RH-I, RH-II and LI were 39.7°C, 14.4°C, 84%, 67% and 31.4 klux, respectively; while the $Ct_{\min}$, $Ct_{\max}$, Crh-I and Crh-II were 15.1°C, 27.5°C, 94% and 71%, respectively.

The present findings are corroborative with the findings of Prasad and Kumar (2000). They reported most quick development of *P.citri* in high temperatures and humidity. The developmental period of one generation recorded at 30°C was found 22 days. Lakra *et al.*, (1980) and Dwivedi *et al.*, (2003) observed that the population of mealy bug, *Drosicha mangiferae* Green found higher (84.6) at the base of tree trunk in the month of February and lower (0.58) in the month of December. They also recorded population of *D.mangiferae* on terminal twig in addition to tree trunk. In the studies, they found population range of 0.58 to 31.8, 4.90 to 44.10 and 15.1 to 84.6 on trunk and twig in the month of December, January and February, respectively.

Plate 6. Infestation of Mealy bugs (*P.citri*)



Less susceptible cultivar (Naranga)



Highly susceptible cultivar (Pink Noblesse)

Table 5. Seasonal incidence of pests on rose at Maval during 2004 and 2005.

MW	Month	Thrips /flower	Aphids /shoot	W.flies /leaf	Mealy bugs/twig	<i>H.armigera</i> larvae/plant	<i>S.litura</i> larvae/plant	Mites /leaf
1.	Jan.	5.49	42.67	-	32.89	1.08	-	4.36
2.		2.12	84.16	-	48.11	1.64	-	1.76
3.		0.71	19.8	1.74	62.24	1.16	-	-
4.		-	80.80	1.26	36.40	1.12	-	-
5.	Feb.	-	86.96	6.11	33.19	2.04	-	-
6.		-	67.93	1.83	89.81	2.32	-	-
7.		-	27.39	4.37	115.6	2.52	-	0.66
8.		-	15.05	0.22	100.21	2.14	-	1.32
9.	Mar.	-	3.87	-	123.88	1.92	-	5.17
10.		0.80	-	-	134.01	1.48	-	35.07
11.		1.53	-	-	122.28	0.86	-	25.13
12.		7.60	-	-	144.28	0.55	-	21.14
13.		5.03	-	-	84.37	0.24	-	49.13
14.	April	7.05	-	-	46.88	-	-	38.64
15.		5.44	-	-	25.63	-	-	33.1
16.		2.10	-	-	15.10	-	-	52.47
17.		0.78	-	-	6.70	-	-	73.14
18.	May	-	-	-	8.06	-	-	117.62
19.		-	-	-	3.28	-	-	89.76
20.		-	-	-	1.52	-	0.92	103.13
21.		-	-	-	2.82	-	1.44	54.03
22.		-	-	-	7.01	-	1.67	77.59
23.	June	-	-	0.70	8.92	-	1.26	100.30
24.		-	-	1.24	12.01	-	1.78	82.18
25.		-	-	6.45	11.80	-	3.14	56.7
26.		-	0.33	11.80	22.57	-	2.20	69.09
27.	July	0.60	1.37	6.21	33.95	-	4.44	38.16
28.		1.68	1.83	10.84	46.95	-	4.60	24.75
29.		0.79	6.77	13.31	65.94	-	4.48	10.44
30.		8.71	13.63	15.60	49.99	-	4.12	-
31.	Aug.	12.89	5.53	18.50	68.28	-	3.56	-
32.		11.42	12.43	17.46	105.83	-	2.84	-
33.		9.82	19.97	12.39	89.35	-	1.24	-
34.		7.69	27.63	16.11	78.79	-	2.22	-
35.		11.96	19.73	18.24	98.88	-	1.56	4.35
36.	Sept.	14.88	8.57	19.66	71.41	-	1.64	15.02
37.		13.66	0.83	17.96	53.98	-	1.52	19.88
38.		15.8	-	19.14	79.8	-	1.46	31.17
39.		20.02	-	6.70	50.22	0.55	0.73	59.15

40.	Oct.	22.10	-	9.99	42.44	1.62	0.98	95.40
41.		14.81	-	7.07	53.27	2.33	0.88	86.03
42.		20.35	3.09	10.63	29.28	1.52	0.52	72.53
43.		23.43	9.17	11.68	45.17	1.10	0.28	44.14
44.	Nov.	18.89	11.56	13.59	24.84	1.40	-	51.53
45.		17.37	20.08	3.08	35.45	0.85	-	55.63
46.		14.74	10.32	2.69	38.79	1.06	-	58.84
47.		12.99	11.74	1.41	36.31	0.82	-	95.75
48.		11.11	24.27	0.64	56.57	1.17	-	63.20
49.	Dec.	8.60	13.80	0.59	82.62	1.47	-	26.83
50.		12.28	30.95	1.06	60.59	1.22	-	18.53
51.		8.02	47.80	-	39.83	1.27	-	40.15
52.		12.02	24.28	-	34.85	1.61	-	9.46

4.1.5 *Helicoverpa armigera* (Hubner)

Observations on seasonal incidence of *H.armigera* on rose were recorded at weekly interval by counting the number of caterpillars per plant on five randomly selected plants. The data are presented in Table 3, 4, 5, 6 and graphically depicted in Fig. 3, 5, 6, 7 and 8. The pest was found active once in a year from October to March (Plate 7). The incidence of *H.armigera* was found to be higher at Maval than recorded at Pune.

Pune:

The incidence *H.armigera* was started in November and reached its peak in second fortnight of February (1.84 larvae/plant). The adult trapping in pheromone trap started in last week of September (39 MW) and peak trapping (17 moths/trap) noted in 3rd week of February (7 MW). The trapping of adult was not noticed from 4th week of March to 3rd week of September. The climatic conditions during 7 MW was 29.9°C (T_{max}), 12.3°C (T_{min}), 65% (RH-I), 42% (RH-II) and 41.9 klux (LI), respectively; while Ct_{min} , Ct_{max} , $Crh-I$ and $Crh-II$ were 13.9°C, 28.1°C, 76% and 47%, respectively. Association of negative correlation between *H. armigera* and temperatures was found (T_{max} $r = -0.37$, T_{min} $r = -0.32$, Ct_{min} $r = -0.27$).

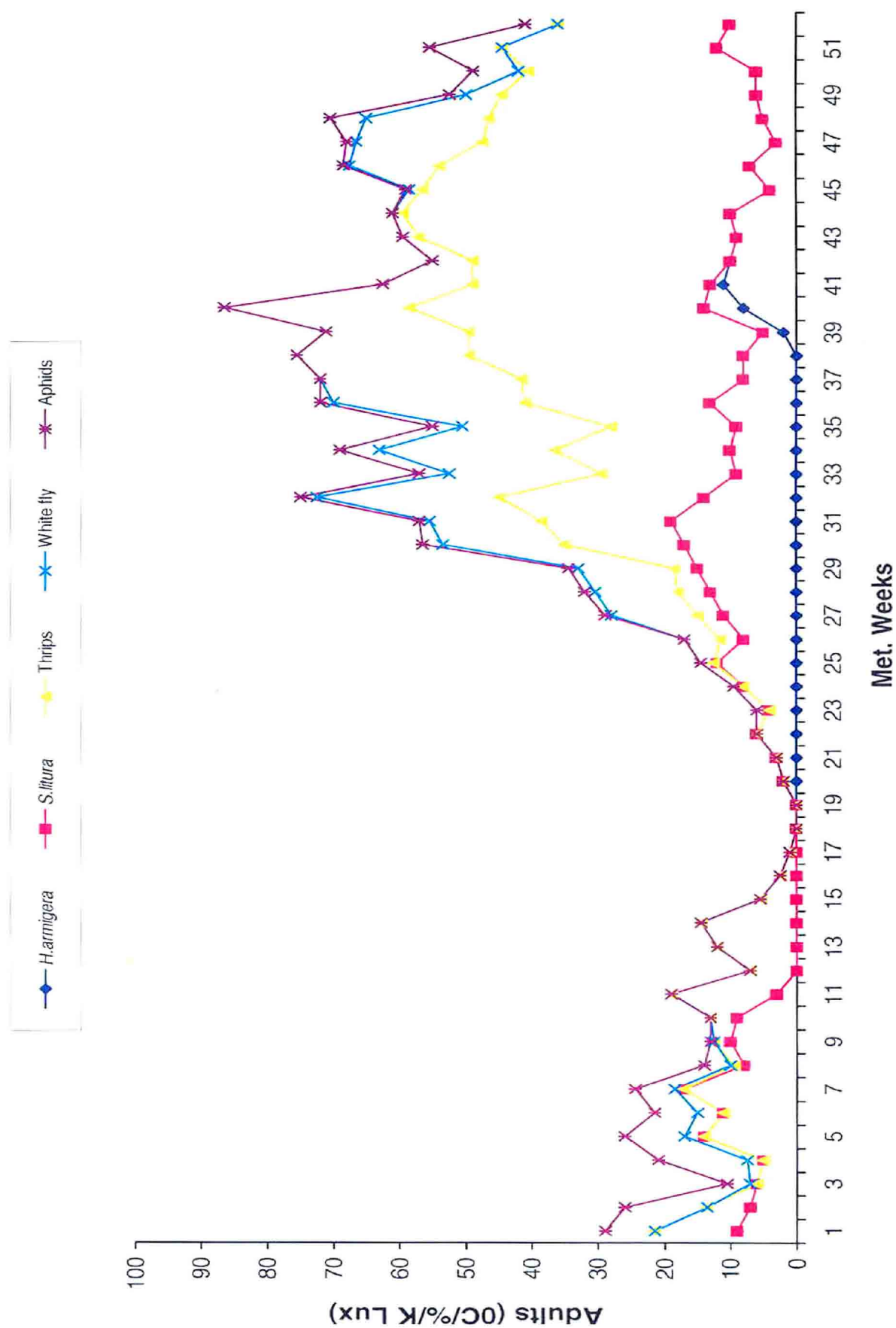


Fig. 6. Average number of insect population catches per traps in polyhouse at Pune (2004-2005)

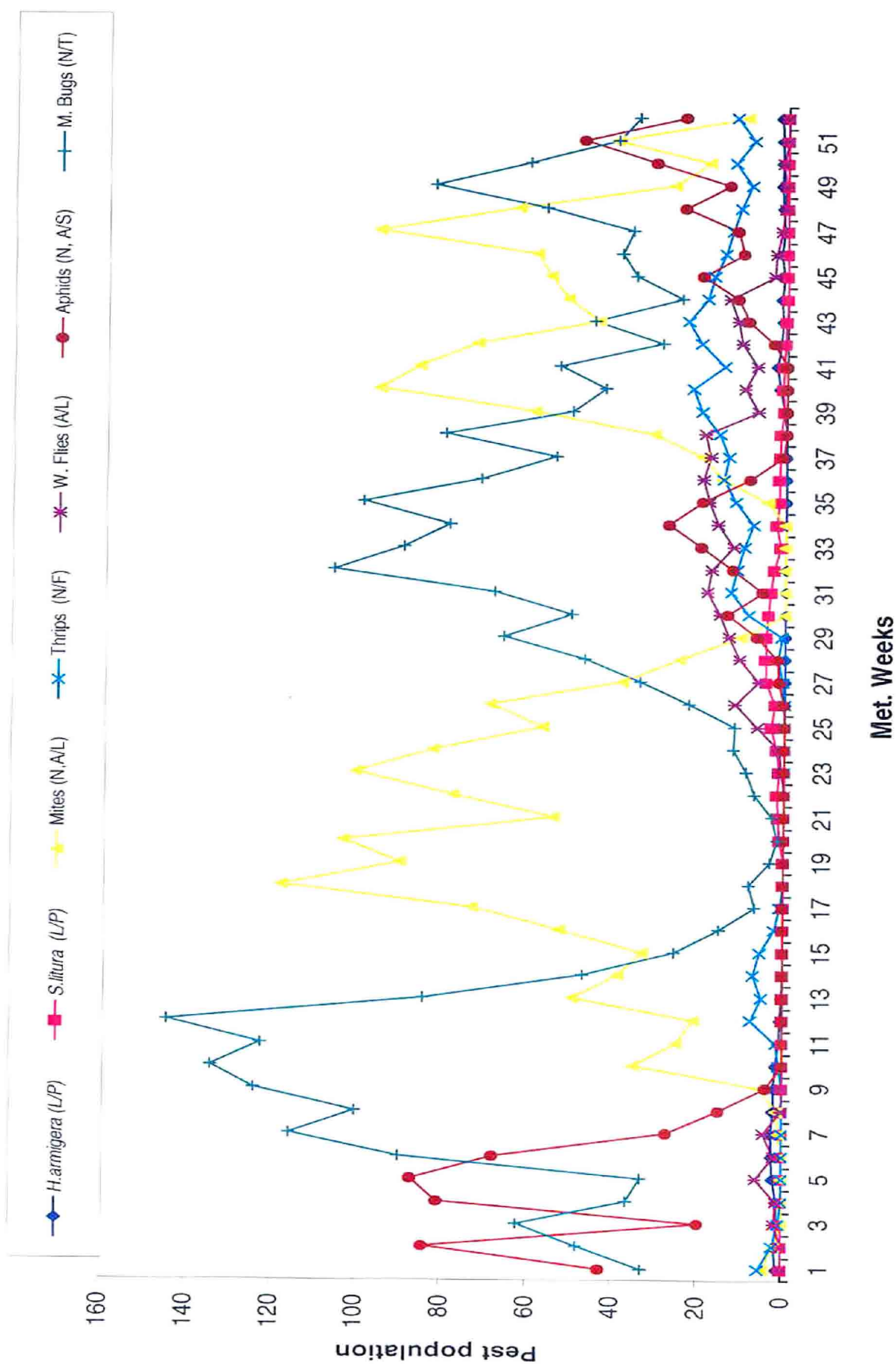
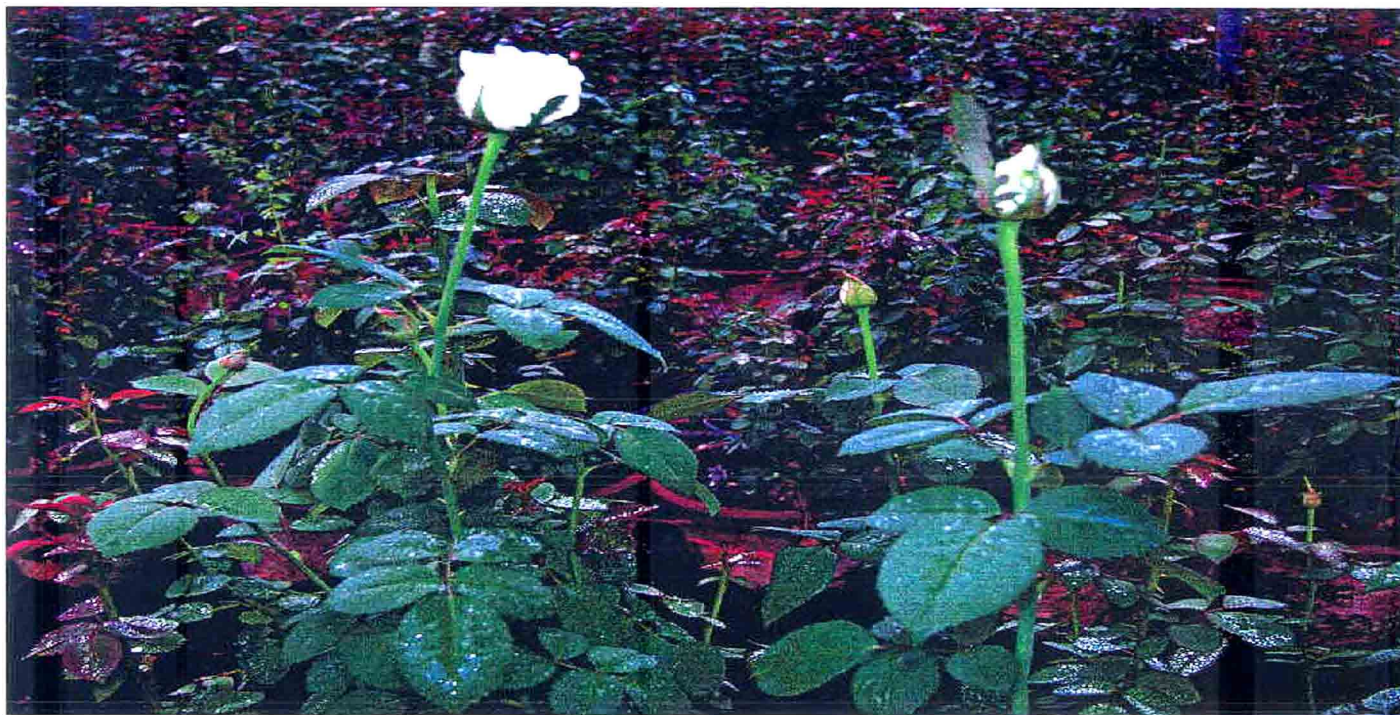
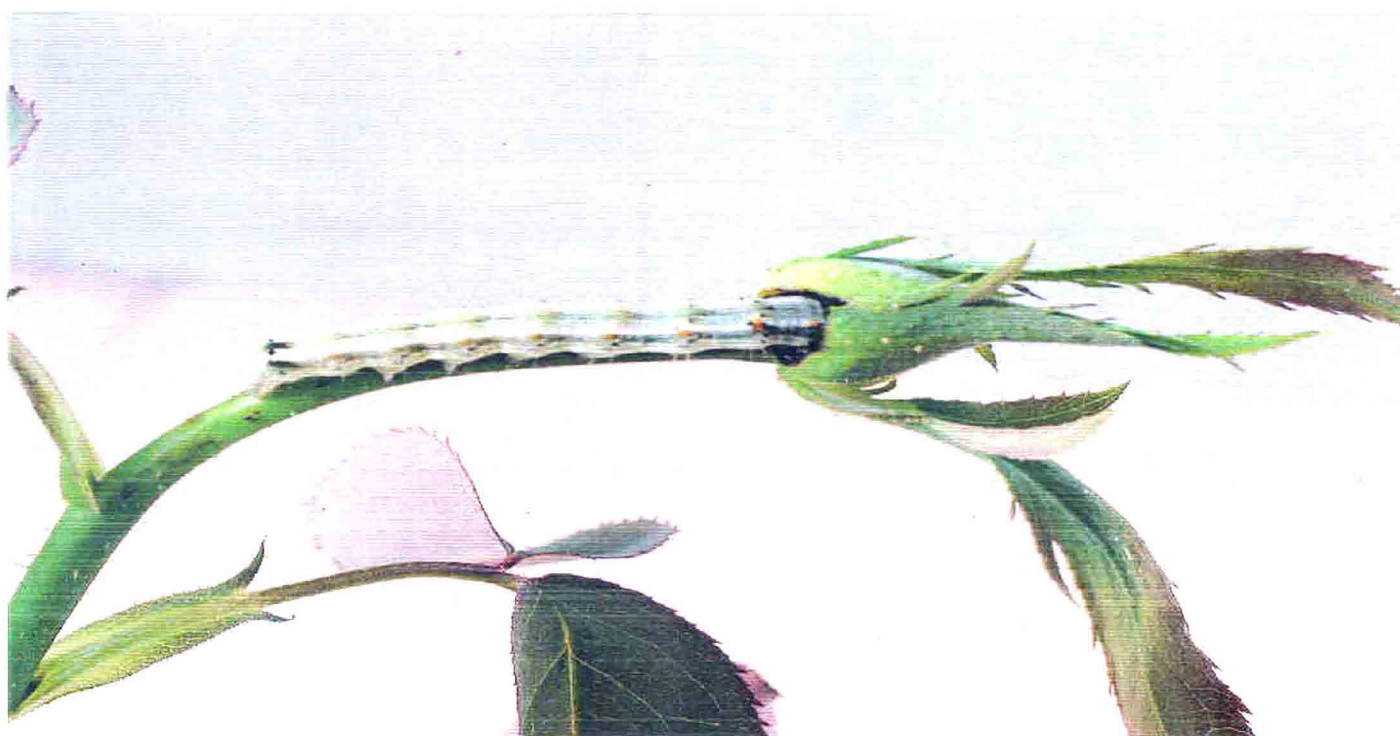


Fig. 7. Seasonal incidence of pests infesting rose in polyhouse at Maval (2004-2005)

Plate 7. Infestation of *H.armigera*



Less susceptible cultivar (Teneki)



Highly susceptible cultivar (Grand gala)

Table 6. Average number of insect population catches per trap at Maval during 2004-2005

MW	Month	Thrips (Adult)	Aphids (Adult)	W. flies (Adult)	M. bugs (Crawlers)	<i>H. armigera</i> (Moths)	<i>S. litura</i> (Moths)
1.	Jan.	10.5	3	2	-	11	-
2.		5	10.5	4.5	-	23	-
3.		-	18.5	5	-	12.5	-
4.		-	7.5	3.5	9.8	8	-
5.	Feb.	-	19	16	15.6	26.5	-
6.		-	21	5.5	33.1	37	-
7.		-	18.5	11	57.5	42	-
8.		-	9.5	1.5	50.4	24.5	-
9.	Mar.	2	7	-	62.5	29.5	-
10.		3.5	4.5	-	35.5	33	-
11.		4.5	-	-	62.5	14	-
12.		11	-	-	52.5	2	-
13.		7	-	-	42.5	-	-
14.	April	9	-	-	23.5	-	-
15.		8.5	-	-	12.5	-	-
16.		3	-	-	7.5	-	-
17.		-	-	-	3.5	-	-
18.	May	-	-	-	4.5	-	-
19.		-	-	-	3.2	-	4
20.		-	-	-	0.75	-	7.5
21.		-	-	3.5	1.9	-	10
22.		-	-	3	3.4	-	18
23.	June	-	-	2	4.5	-	15
24.		-	-	3	6.1	-	21.5
25.		-	-	18	5.6	-	44
26.		3.5	2	29.5	11.8	-	31.5
27.	July	2	7.5	17.5	17.5	-	42
28.		5.5	9.5	27.5	23.5	-	57.5
29.		3.5	6.5	34	32.5	-	68
30.		16	14.5	39	25.5	-	75
31.	Aug.	28.5	6	45.5	34.5	-	91.5
32.		24.5	8.5	42.5	53.5	-	57
33.		19.5	10.5	32.5	45.5	-	33.5
34.		11	12.5	41	39.5	-	37.5
35.		24	5.5	43.5	49.8	-	34

36.	Sept.	32.5	4	49.5	35.6	-	49.5
37.		19.5	2	44.5	26.5	3	24
38.		27	-	47	40.5	5.5	26
39.		46	-	22	25.6	8	14.5
40.	Oct.	54.5	-	29.5	21.5	17.5	17
41.		33.5	2.5	18.5	26.5	28	8
42.		51.5	6.5	27.5	30.1	23	5
43.		57	10	33	23.4	14.5	-
44.	Nov.	45.5	12.5	36.5	12.4	18	-
45.		42	14	9.5	17.5	11	-
46.		33.5	7	7.5	19.6	16	-
47.		29.5	8	4.5	18.2	9	-
48.		24.5	14.5	2.5	28.5	12.5	-
49.	Dec.	14	5.5	2	42.5	17	-
50.		25	9.5	2.5	30.2	13	-
51.		11.5	7.5	2	20.8	22.5	-
52.		23	4.5	-	17.6	38	-

Maval:

Observations taken on the seasonal incidence of *H.armigera* indicated the higher infestation (2.52 larvae/plant and 42.00 adults/trap) in 7 MW. During this period temperature, humidity and LI in polyhouse ranged from 13.1 to 39.2 °C, 63 to 86% and 41.5 klux and in crop canopy 13.4 to 26.3 °C and 75 to 95%, respectively. *H.armigera* population was not observed on rose from April onwards due to high temperature (40.9 to 43.1°C) and low humidity (60 to 71%). Correlation studies revealed significant negative correlation of *H.armigera* population with crop canopy temperature ($C_{t_{min}}$ $r = -0.34$, $C_{t_{max}}$ $r = -0.35$).

The present findings with regard to population build up of *H.armigera* are in the line of Ravi and Verma (1997), Patel and Koshiya (1997) who conducted the field experiment on the seasonal incidence of *H.armigera*. These workers indicated initiation of infestation in first week of January and its peak by March on chickpea.

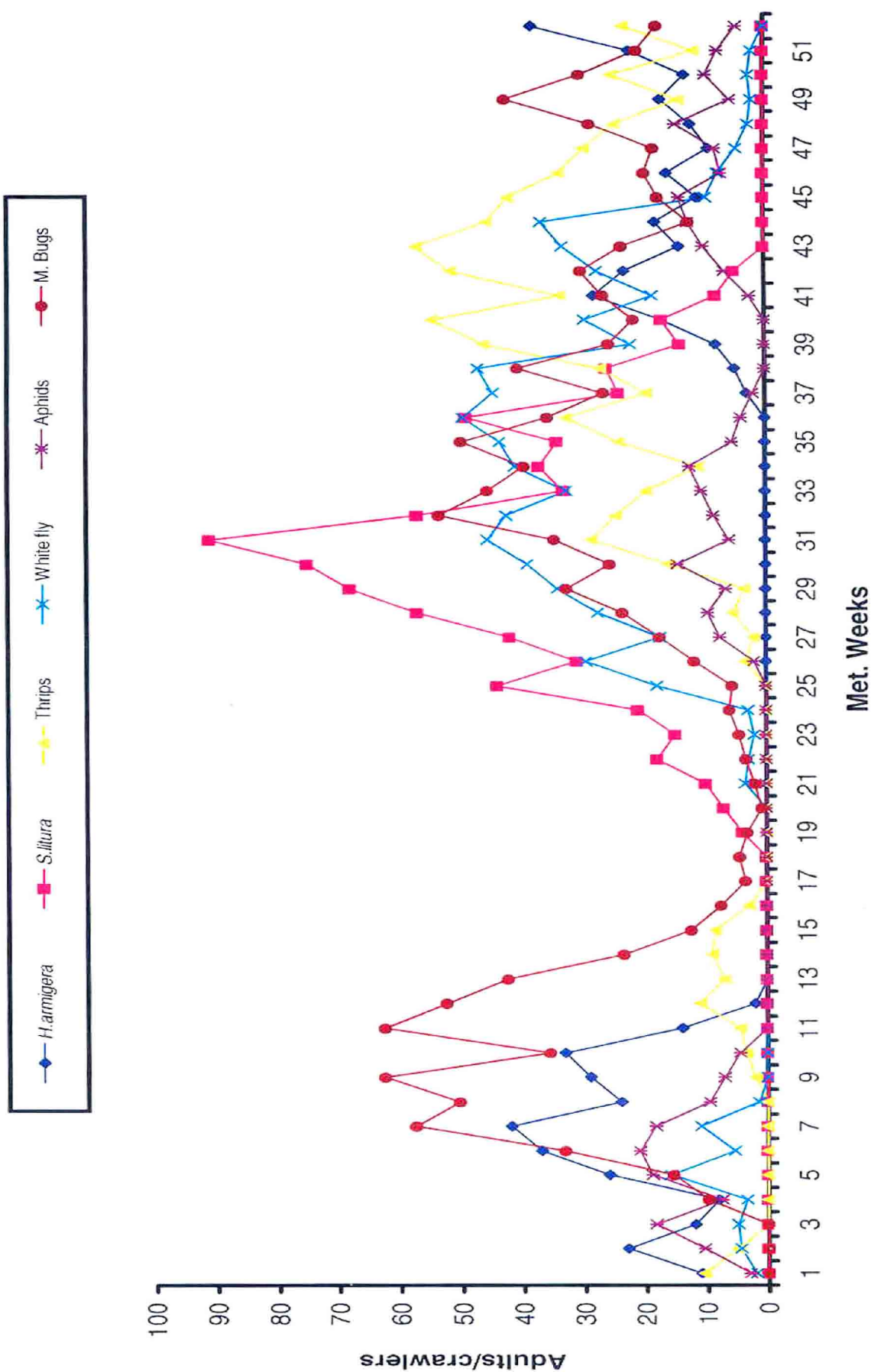


Fig. 8. Number of adults/crawlers trapped in polyhouse at Maval (2004-2005)

Chaudhari *et al.*, (1999), Balakrishnan *et al.*, (2003) and Lily Levin *et al.*, (2004) installed the pheromone traps to capture of adults of *H.armigera*. The number of moths trapped indicated higher values during the months of January and October to December. The mean maximum temperature during the period was 32.2°C and minimum was 21.9°C. The peak larval population ranged from 2 to 5 larvae per plant. The findings emerged in present studies are also on similar line.

Earlier workers in cotton reported a negative relationship of *H.armigera* with T_{max} , T_{min} and T_{mean} (Tadas *et al.*, 1994, Daware *et al.*, 1994, Dhawan and Simwat, 1996, Ramamurthy *et al.*, 2000 and Mohapatra *et al.*, 2004) and these findings are in conformity with present studies.

4.1.6 *Spodoptera litura* (Fabricius)

Seasonal incidence of *S.litura* on rose was studied by recording larval count per plant taken on five randomly selected plants and number of adults caught in pheromone traps. The data are shown in Table 3, 4, 5, 6 and graphically presented in Fig. 3, 5, 6, 7 and 8. In general, level of infestation of *S.litura* at Maval was higher than Pune. The activity of *S.litura* was observed from May and continued up to October (Plate 8).

Pune:

The incidence of *S.litura* during experimental period was ranged from 0.10 to 4.45 larvae per plant. The adult trapping (19 adults/trap) and larval count per plant (4.45 larvae/plant) was found to be at it's peak in 1st week of August (31 MW), (Table 3, 4). Thereafter, the pest activity slowly declined towards winter due to lower the temperature. The climatic conditions during 31 MW were 30.4°C (T_{max}), 25.3°C (T_{min}), 96% (RH-I), 78% (RH-II) and 56.7 klux (LI), respectively; while the Ct_{min} , Ct_{max} , Crh-I and Crh-II were 28.9°C, 28.2°C, 98% and 80% respectively. The correlation coefficient values are presented in Table 7 and 8. There were significant positive correlations between *S.litura* population and T_{min} ($r = 0.42$), Ct_{min} ($r = 0.63$), RH-I ($r = 0.80$), RH-II ($r = 0.70$), Crh-I ($r = 0.71$), Crh-II ($r = 0.57$) and negatively with T_{max} ($r = -0.57$) and Ct_{max} ($r = -0.59$).

Table 7. Correlation between pest population and meteorological parameters at Pune (r values).

Pests	Meteorological parameters								
	T _{max}	T _{min}	RH-I	RH-II	Ct _{min}	Ct _{max}	Crh-I	Crh-II	LI
Thrips	-0.28*	-0.04	+0.14	+0.16	-0.02	-0.24	+0.25	+0.31	+0.44**
Aphids	-0.22	-0.61**	-0.33*	-0.34*	-0.61**	-0.43**	-0.38**	-0.42**	+0.29*
Whitefly	-0.36**	+0.44**	+0.63**	+0.67**	+0.47**	-0.25	+0.56**	+0.75**	-0.44**
<i>H.armigera</i>	-0.37**	-0.32*	-0.04	-0.03	-0.24	-0.27*	-0.04	-0.04	-0.23
<i>S. litura</i>	-0.57**	-0.42**	+0.80**	+0.70**	+0.63**	-0.59**	+0.71**	+0.57**	+0.11
Mites	+0.77**	+0.38**	-0.42**	-0.35**	+0.36**	+0.72**	-0.39**	-0.36**	-0.12

*, ** Significant at $p = 0.05$ and $p = 0.01$, respectively.

Maval:

The incidence of *S.litura* larvae per plant ranged from 0.28 to 4.60. The maximum population was noticed in 2nd week of July (28 MW). A wide variation in adult trapping in pheromone trap was noticed and found in the range of 4.00 to 91.50 adults per trap. The peak trapping of adult was noticed in 1st week of August (31 MW). During this period T_{max}, T_{min}, RH-I, RH-II and LI were ranged from 35.8 to 36.1°C, 20.5 to 21.3°C, 88 to 93%, 71 to 78% and 24.5 to 73.3 klux, respectively; while the Ct_{min}, Ct_{max}, Crh-I and Crh-II were 24.6 to 25.7°C, 29.7 to 30.9°C, 97 to 99% and 73 to 79%, respectively. Correlation studies of *S.litura* incidence with meteorological parameters showed highly significant negative correlations with T_{max} ($r = -0.36$) and LI ($r = -0.27$); while positive correlations with temperature RH-I ($r = 0.66$), RH-II ($r = 0.65$), Ct_{min} ($r = 0.32$), Crh-I ($r = 0.59$) and Crh-II ($r = 0.41$).

Plate 8. Infestation of *S.litura*



Less susceptible cultivar (Texas)



Highly susceptible cultivar (Passion)

The present results corroborate with findings of Chaudhari *et al.*, (1999), Bhosale *et al.*, (2003) and Daware *et al.*, (1994). Chaudhari *et al.*, (1999), who installed pheromone traps to capture adults of cotton bollworm, *S.litura*. Peak activity of *S.litura* occurred in second week of March when weekly mean temperature and relative humidity ranged between 20 to 30°C and 50 to 65%, respectively, which seems to be optimum for their multiplication. Bhosale *et al.*, (2003) found the incidence of leaf eating caterpillar, *S.litura* on colocasia throughout during the period of crop grown in *Kharif* season. The peak activity of pest was noticed during the month of September. The average larval population per plant was ranged from 2.0 to 9.6. As many as 29 larvae were found feeding on a single leaf. Hence, slight deviation was noted in comparison of present findings with results of Chaudhari *et al.*, (1999) and Bhosale *et al.*, (2003) in seasonal incidence.

Incidentally, it was observed that during absence of infestation of *H.armigera*, infestation of *S.litura* was noticed on leaves and floral buds particularly in rainy season (Table 3, 4, 5, 6).

Table 8. Correlation between pest population and meteorological parameters at Maval (r values).

Pests	Meteorological parameters								
	T _{max}	T _{min}	RH-I	RH-II	Ct _{min}	Ct _{max}	Crh-I	Crh-II	LI
Thrips	-0.37**	-0.37**	-0.46**	-0.37**	+0.30*	+0.02	-0.73**	-0.53**	+0.27*
Aphids	+0.07	-0.69**	+0.08	-0.36**	-0.75**	-0.75**	-0.02	-0.24	+0.38**
Whitefly	-0.48**	+0.64**	+0.20	+0.27	+0.46**	+0.26	+0.03	+0.13	-0.63**
Mealy bugs	-0.14	-0.23	+0.31*	-0.25	-0.43**	-0.44**	+0.05	-0.27*	-0.15
<i>H.armigera</i>	-0.09	-0.20	+0.14	+0.12	-0.34*	-0.35**	-0.04	-0.16	+0.08
<i>S.litura</i>	-0.36**	-0.05	+0.66**	+0.65**	-0.32*	-0.03	+0.59**	+0.41**	-0.27*
Mites	+0.38**	+0.50**	-0.38**	+0.16	+0.37**	+0.72**	-0.02	+0.24	+0.05

*, ** Significant at $p = 0.05$ and $p = 0.01$, respectively.

4.1.7 Mites, *Tetranychus urticae* Koch

Observations on seasonal incidence of *T.urticae* on rose were undertaken at weekly interval by taking counts of mites per leaf. The data are presented in Table 3, 5 and graphically depicted in Fig. 3 and 7. The pest activity was observed throughout the year except in mid monsoon and severe cold both at Pune and Maval (Plate 9).

Pune:

The incidence of mites ranged from 0.58 to 162.68 per leaf. The maximum population was (162.68 mites/leaf) noticed in 1st week of May (18 MW). The weather conditions during 18th MW were 39.6°C ($T_{\max}$), 23.5°C ($T_{\min}$), 58% (RH-I), 39% (RH-II) and 30.0 klux (LI), respectively; while the $Ct_{\min}$, $Ct_{\max}$, Crh-I and Crh-II were 25.3°C, 37.1°C, 68% and 46%, respectively. The data when subjected to statistical analysis exhibited highly significant positive correlation between mite infestation and temperatures ($T_{\max}$ $r = 0.77$, $T_{\min}$ $r = 0.38$, $Ct_{\min}$ $r = 0.36$, $Ct_{\max}$ $r = 0.72$) and negative with humidity (RH-I $r = -0.42$, RH-II $r = -0.35$, Crh-I $r = -0.39$, Crh-II $r = -0.36$) (Table 7).

Maval:

Seasonal incidence of mites showed significantly higher population (117.62 mites/leaves) in 1st week of May (18 MW). During this period temperatures and humidity in polyhouse ranged from 19.4 to 42.5°C, 62 to 74% and in crop canopy 26.4 to 34.4 °C and 89 to 97%, respectively. The light intensity was found 30.1 klux. The mite infestation in polyhouse was noticed throughout the year except during the period from 3 to 6 and 30 to 34 MW due to high humidity coupled with low temperature and prevalent high humidity, respectively. The mite incidence was found to be positively correlated with $T_{\max}$ ($r = 0.38$) and negatively with RH-I ($r = -0.38$) (Table 8).

Similar type of results has been reported earlier by Holey and Salunkhe (1997). The population was positively correlated with temperature. Singh and Singh (1993) also reported peak population of mites during the month of May and June under the condition of high temperature and low humidity. In present studies, in general mite infestation was found to be at higher at Pune than

Plate 9. Webbing on leaves by mites (*T.urticae*)



Less susceptible cultivar (Passion)



Highly susceptible cultivar (Teneki)

Table 9. Effect of cocopeat as a growth medium on the incidence of pests infesting rose (2004-2005).

MW	Month	Thrips /flower	Aphids /shoot	W.flies /leaf	Mealy bugs /twig	<i>H.armigera</i> Larvae /plant	<i>S.litura</i> Larvae /plant	Mites /leaf
1.	Jan.	4.12	30.21	-	3.28	1.92	-	-
2.		1.74	54.73	-	5.68	0.16	-	-
3.		0.62	14.13	0.80	7.64	0.20	-	-
4.		-	49.63	-	3.56	-	-	-
5.	Feb.	-	60.13	-	5.44	0.96	-	-
6.		-	30.40	1.11	12.58	1.08	-	-
7.		-	26.33	0.57	26.46	2.00	-	-
8.		-	4.31	-	15.32	1.84	-	0.36
9.	Mar.	-	2.27	-	17.86	1.66	-	3.34
10.		0.96	-	-	16.5	0.66	-	7.96
11.		1.60	-	-	14.24	0.42	-	6.68
12.		4.66	-	-	12.64	0.08	-	20.34
13.		2.66	-	-	8.74	-	-	11.84
14.	April	3.56	-	-	4.78	-	-	34.04
15.		4.24	-	-	2.16	-	-	54.24
16.		2.58	-	-	1.24	-	-	45.58
17.		0.48	-	-	-	-	-	68.68
18.	May	-	-	-	-	-	-	67.80
19.		-	-	-	-	-	-	58.88
20.		-	-	-	-	-	0.52	45.94
21.		-	-	-	-	-	1.28	48.72
22.		-	-	-	-	-	0.92	50.64
23.	June	-	-	0.47	-	-	0.24	19.14
24.		-	-	0.87	-	-	0.96	34.28
25.		-	-	2.51	-	-	1.84	27.44
26.		-	-	7.23	-	-	1.88	45.28
27.	July	0.46	0.47	5.51	-	-	4.16	25.16
28.		1.68	2.33	6.37	-	-	4.52	37.08
29.		0.62	4.63	8.47	-	-	4.36	40.84
30.		5.24	0.87	7.73	2.12	-	3.60	34.28
31.	Aug.	5.58	1.43	12.67	5.14	-	2.64	37.08
32.		9.12	0.43	12.07	11.84	-	0.72	37.74
33.		6.52	9.53	10.47	9.52	-	0.56	37.16
34.		7.80	4.83	13.21	7.18	-	0.78	18.7
35.		5.58	1.57	13.87	12.24	-	-	7.96
36.	Sept.	8.20	-	12.37	16.28	-	0.16	0.36
37.		9.66	-	10.47	10.86	-	1.16	4.46
38.		12.14	-	13.21	20.82	-	1.12	18.58
39.		12.88	-	5.71	17.80	-	0.64	44.06

40.	Oct.	12.96	-	3.23	11.70	-	-	59.24
41.		10.56	-	1.53	12.28	-	-	54.66
42.		11.36	1.73	0.23	9.08	-	-	40.66
43.		13.98	4.91	-	10.76	-	-	19.40
44.	Nov.	14.32	7.83	-	5.30	-	-	19.08
45.		15.36	17.67	1.71	7.58	0.36	-	34.26
46.		13.68	11.13	3.31	8.54	0.60	-	37.04
47.		12.86	7.33	4.63	6.04	0.04	-	75.34
48.		12.08	21.7	3.87	9.20	0.12	-	54.26
49.	Dec.	10.58	9.03	1.17	11.70	0.32	-	17.32
50.		9.98	25.70	0.71	8.46	0.36	-	6.48
51.		9.44	27.87	-	4.34	1.12	-	18.16
52.		7.76	23.53	-	2.74	2.60	-	4.76
Pooled Mean		7.23	15.75	5.73	9.73	0.87	1.69	31.90
S.E. _±		0.78	3.12	0.88	0.89	0.17	0.33	2.99
C.D. at 5%		2.34	9.34	2.64	2.70	0.53	0.96	8.87

Maval. The higher temperatures and low humidity favoured the multiplication of mites; while low temperature coupled with high humidity adversely affected the mite population.

4.2 Effect of Growth Media on the Incidence of Pests of Rose

The experiment was conducted at Maval for assessing the effect of planting media viz; sole cocopeat and soil, on the pest incidence. The data are presented in Table 9 and 10 and graphically depicted in Fig. 9. The rose plants grown in sole cocopeat medium recorded the pest incidence of *F.schultzei*, *M.rosae*, *T.vaporariorum*, *P.citri*, *H.armigera*, *S.litura* and *T.urticae* in the range of 0.46 to 15.36 thrips per flower, 0.47 to 60.13 aphids per shoot, 0.23 to 13.87 whiteflies per leaf, 1.24 to 26.46 mealy bugs per twig, 0.08 to 2.00 larvae per plant, 0.16 to 4.52 larvae per plant and 0.36 to 68.68 mites per leaf, respectively. However, the plants grown in soil medium showed the incidence as 0.56 to 28.34 thrips per flower, 0.13 to 146.51 aphids per shoot, 0.33 to 29.60 whiteflies per leaf, 1.22 to 151.94 mealy bugs per twig, 0.16 to 2.52 larvae per plant, 0.16 to 4.68 larvae per plant and 0.58 to 162.68 mites per leaf, respectively.

Table 10. Effect of soil as a growth medium on the incidence of pests infesting rose (2004-2005).

MW	Month	Thrips /leaf	Aphids /shoot	W.flies /leaf	Mealy bugs/twig	<i>H.armigera</i> larvae/plant	<i>S.litura</i> larvae/plant	Mites /leaf
1.	Jan.	8.12	71.47	-	18.64	1.68	-	-
2.		3.04	133.37	-	30.04	1.96	-	-
3.		1.06	34.50	2.41	44.28	1.64	-	-
4.		-	120.93	9.93	14.86	2.12	-	-
5.	Feb.	-	146.51	0.29	17.40	1.14	-	-
6.		-	74.03	7.37	46.96	2.34	-	-
7.		-	62.33	4.07	129.94	2.52	-	0.58
8.		-	28.13	3.80	102.42	2.16	-	1.74
9.	Mar.	-	8.40	-	151.94	1.94	-	5.86
10.		0.80	2.83	-	146.26	0.6	-	18.24
11.		1.96	-	-	140.08	0.24	-	11.68
12.		8.62	-	-	132.4	0.16	-	45.76
13.		3.94	-	-	90.88	-	-	28.54
14.	April	6.56	-	-	51.06	-	-	72.04
15.		7.82	-	-	24.94	-	-	105.30
16.		2.74	-	-	16.74	-	-	89.18
17.		0.56	-	-	5.88	-	-	121.08
18.	May	-	-	-	7.92	-	-	162.68
19.		-	-	-	3.14	-	0.64	101.86
20.		-	-	-	1.22	-	0.96	88.48
21.		-	-	0.33	-	-	1.28	140.72
22.		-	-	0.41	-	-	1.52	92.34
23.	June	-	-	1.03	-	-	1.32	109.80
24.		-	-	1.91	-	-	1.88	62.96
25.		-	-	5.37	2.78	-	2.74	38.66
26.		-	0.13	15.43	7.42	-	2.32	85.24
27.	July	-	1.97	11.73	12.16	-	4.46	39.18
28.		2.64	5.70	13.61	20.84	-	4.68	74.54
29.		1.06	14.57	19.91	55.16	-	4.60	45.60
30.		9.66	4.33	16.37	38.84	-	4.16	62.96
31.	Aug.	10.28	7.37	26.97	61.74	-	3.56	43.64
32.		16.60	12.67	25.70	104.94	-	2.56	56.04
33.		12.02	23.23	22.23	89.46	-	2.34	48.90
34.		14.40	16.1	28.07	78.02	-	2.54	14.44
35.		10.28	7.10	29.6	100.36	-	0.24	18.24
36.	Sept.	15.12	0.63	26.33	59.16	-	1.08	16.34
37.		17.82	1.07	22.23	39.62	-	1.64	28.32
38.		22.38	-	28.07	79.64	-	1.32	33.46
39.		23.78	-	12.17	45.54	-	0.96	76.18

40.	Oct.	23.94	-	6.97	35.48	-	0.58	122.36
41.		19.48	-	7.77	41.70	0.52	0.44	106.12
42.		20.96	4.37	0.73	16.04	0.88	0.16	92.44
43.		25.8	11.97	0.93	40.40	1.26	-	62.18
44.	Nov.	26.44	19.1	-	13.50	2.4	-	44.88
45.		28.34	43.07	2.67	31.66	0.88	-	50.64
46.		25.24	27.23	13.23	27.56	1.32	-	53.44
47.		23.76	36.03	18.57	25.08	0.76	-	90.46
48.		22.26	53.00	15.83	45.72	1.12	-	53.24
49.	Dec.	19.52	27.13	5.43	73.84	1.60	-	16.84
50.		18.42	62.63	4.47	50.16	1.60	-	10.44
51.		17.40	76.7	-	24.12	2.20	-	37.54
52.		14.32	48.93	-	19.66	3.20	-	5.34
Pooled Mean		13.53	35.99	11.77	50.37	1.51	2.00	58.30
S.E. _±		1.47	6.82	1.64	5.99	0.15	0.28	5.87
C.D. at 5%		4.41	19.47	4.92	17.68	0.47	0.85	17.53

The development of pest population was found to be more on rose grown in soil medium as compared to sole cocopeat medium. The pH of cocopeat medium was slightly acidic (pH 5.9) and most of the ornamental plants favour the growth in medium of pH ranging 4.9 to 6.14. The cocopeat medium makes the most suited conditions for availability of macro and micronutrients, resulted in healthy crop growth, which also developed resistance in rose crop to different pests. Further, the cocopeat medium as compared to soil medium was not found suitable for pests for taking shelter, oviposition, hibernation, etc.

The earlier work done on the effect of planting media on pest population build up on rose plants is lacking. However, the observation made by Abad *et al.*, (2002), could be cited in support of present findings as they had reported results on similar line.

4.3 Reaction of Rose Cultivars to Pests

During the course of the present investigations, thirty-five rose cultivars (Table 1) were screened for their reaction to *F.schultzei*, *M.rosae*, *T.vaporariorum*, *P.citri*, *H.armigera*, *S.litura* and *T.urticae*. The observations on the population of these pests were recorded at weekly interval from 01.01.2004 to 31.12.2005 and the same are reported in Table 11.

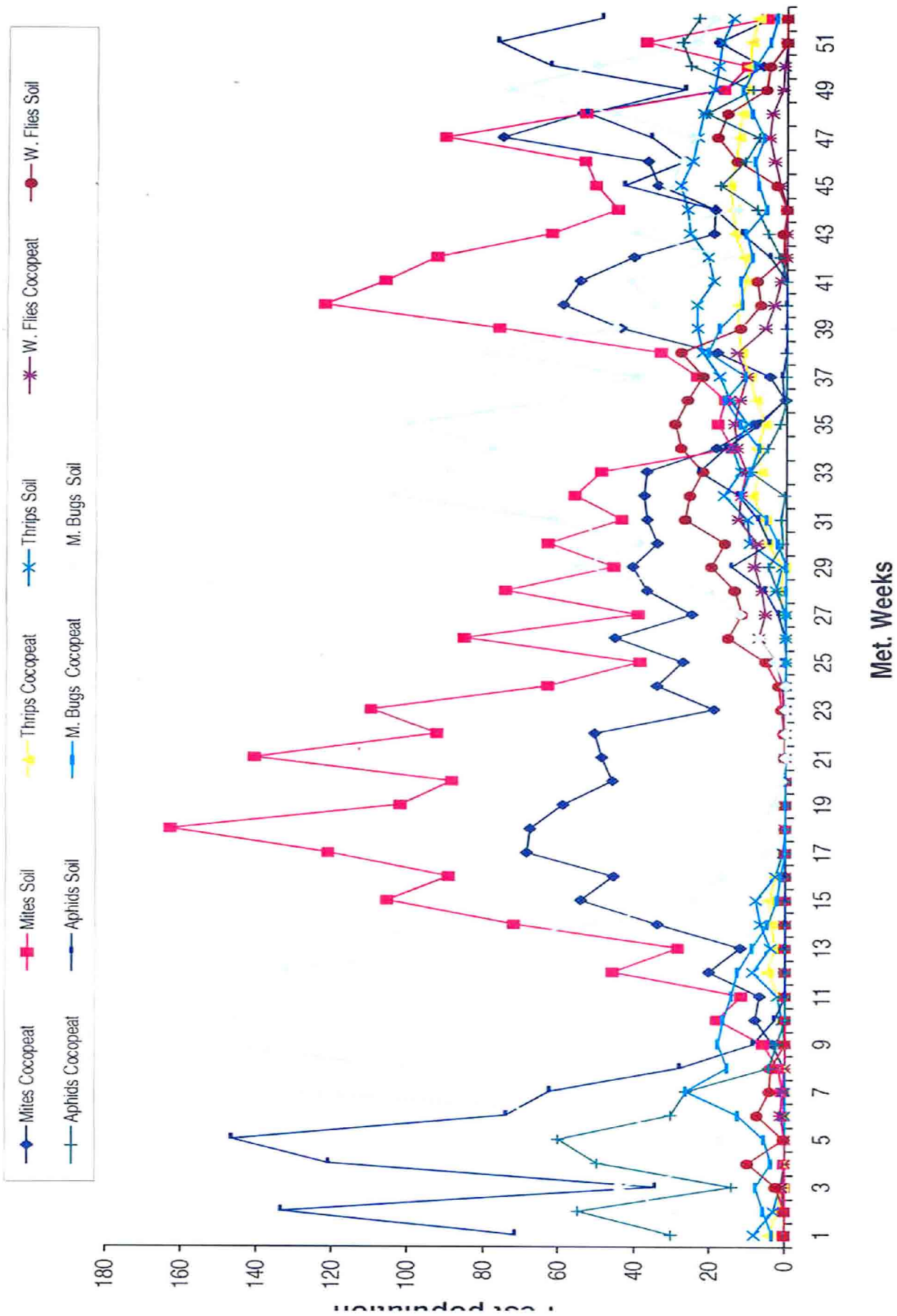


Fig. 9. Effect of growth media on pest population (2004-2005)

4.3.1 Reaction to thrips, *Frankliniella schultzei*

The reaction of different polyhouse grown rose cultivars to thrips infestation revealed that none of the cultivars evaluated was completely free from the thrips damage.

It could be seen from Table 11 that amongst thirty-five cultivars screened the cultivar viz., 'Temptation' showed significantly lowest thrip population (1.39 thrips/flower). However, it was on par with Texas (2.71 thrips/flower). These cultivars are considered to be the less susceptible to thrips. The cultivar viz., Mikado (Plate 3) was found to harbour higher population of thrips (17.21 thrips/flower) and found to be at par with Golden gate, Inka, Sublime and Akito (15.82, 16.70, 15.47 and 15.36 thrips/flower, respectively).

The cultivars, Mikado, Golden gate, Inka, Sublime and Akito are found to be highly susceptible to thrips. The cultivars having low flower yield with purple and pink flower colour showed susceptibility to thrip infestation.

The perusal of literature on the reaction of various cultivars to thrip infestation revealed that there is no evidence of published information on this aspect, except that of Ananthakrishnan *et al.*, (1982), Bergh *et al.*, (1997), who had reported the red and orange coloured rose cultivars more preferred by thrips for oviposition in comparison with white and yellow ones. Jhansi Rani and Eswara Reddy (2003) noted *S.dorsalis* attracted to red and orange colored petals when compared to yellow. Percentage of thrips settled on petals of rose cultivars in descending order was: First red > Versilia > Grand gala > Vivaldi > Lambada > Konfeti > Starlite. Thus, the present findings are in agreement with those of earlier workers.

4.3.2 Reaction to aphids, *Macrosiphum rosae*

The overall reaction of rose cultivars to aphid infestation on the basis of pooled analysis of data on aphid population of varied degrees of infestation recorded at weekly intervals are given in Table 11. The perusal of data on population build up of aphid revealed that the cultivar 'Saphir' showed lowest

incidence of aphids (3.05/shoot) throughout the year. However, it was at par with Pink Noblesse and Miracle (4.04 and 6.11 aphid/shoot). Thus, the cultivar Saphir, Pink Noblesse and Miracle were found to be less susceptible to aphids. The maximum overall significantly higher mean aphid population of 40.29 aphids per shoot was observed on the cultivar Suella (Plate 4). However, it was on par with Kronos and Akito (37.25 and 36.80 aphids/twig).

On the basis of the rating at 3.2.3 in previous chapter, the cultivars were grouped into four categories. Out of 35 cultivars tested, four cultivars were found less susceptible, nine moderately susceptible, twelve susceptible and ten highly susceptible to aphids. The data on flower colour of all thirty cultivars revealed that the cultivars having white flowers have always recorded higher infestation.

The perusal of the literature revealed no published information regarding the reaction of various rose cultivars to aphids. However in present experimentation, the cultivars *viz.*, Saphir, Pink Noblesse and Miracle have emerged as the less susceptible to aphids.

4.3.3 Reaction to whitefly, *Trialeurodes vaporariorum*

The data presented in Table 11 showed that amongst thirty-five cultivars screened, the five cultivars *viz.*, Merilan, Miracle, Grand gala, Eldorado and Pink Noblesse recorded less population of 0.59 to 2.78 whiteflies per leaf and have emerged as less susceptible cultivars. The highest whitefly infestation (17.94 whitefly/leaf) was observed on cultivar Golden gate (Plate 5). However, it was found to be at par with Kronos, Sphinx, Suella (15.44 to 17.60 whiteflies/leaf). The data on the morphological characters of all 35 cultivars revealed that in general cultivars with yellow flowers recorded higher infestation.

Perusal of literature on the reaction of various cultivars to whitefly damage revealed that there is no published information on this aspect and hence the present findings could not be compared with findings of others.

Table 11. Reaction of various rose cultivars to pests (2004-2005).

Sr. No.	Cultivar	Thrips /flower	Aphids / shoot	White flies / leaf	Mealy bugs / twig	<i>H. armigera</i> larvae/plant	<i>S. litura</i> larvae/plant	Mites/ leaves
1.	Akito	15.36	36.80	14.82	40.59	0.75	0.90	69.05
2.	Bianca	11.36	29.07	13.30	22.29	0.35	1.58	79.37
3.	Eldorado	14.40	15.78	2.21	0.00	1.35	2.56	53.96
4.	First Lady	12.64	24.56	10.40	54.72	0.94	2.50	19.45
5.	First Red	9.20	29.28	9.42	15.31	1.65	2.80	23.84
6.	Flint Stone	6.95	21.92	5.99	29.77	1.08	2.85	43.26
7.	Golden gate	15.82	32.81	<u>17.94</u>	38.16	0.57	1.20	47.55
8.	Grand Gala	4.02	28.56	1.24	65.30	<u>2.12</u>	3.08	23.41
9.	Inka	16.70	10.27	11.36	78.80	1.85	2.79	40.75
10.	Konfetti	7.10	31.13	10.36	36.10	0.27	0.90	48.18
11.	Kronos	8.64	37.25	16.43	72.48	0.75	1.35	68.44
12.	Merilan	7.39	15.09	0.59	60.23	1.20	2.68	32.98
13.	Mikado	<u>17.21</u>	26.74	9.04	79.27	0.67	1.51	44.23
14.	Milva	4.69	19.62	5.36	69.29	1.67	2.54	42.28
15.	Miracle	13.21	6.11	0.92	47.71	0.82	2.91	36.43
16.	Monte Carlo	14.76	11.77	9.96	25.85	2.01	2.57	36.37
17.	Moviestar	8.08	15.06	7.51	56.77	0.59	1.78	67.03
18.	Naranga	6.63	19.28	3.65	0.00	0.94	1.89	66.71
19.	Papillion	3.86	29.55	4.78	11.67	0.84	1.21	72.94
20.	Passion	9.82	34.82	9.75	28.04	1.41	<u>3.12</u>	13.10
21.	Pink Noblesse	10.61	4.04	2.78	<u>81.72</u>	1.09	2.18	31.22
22.	Polo	13.52	35.17	13.86	52.70	0.19	1.47	74.64
23.	Queensday	8.15	17.81	6.82	0.00	1.26	2.60	35.01
24.	Saphir	10.86	3.05	7.16	79.54	1.04	2.13	26.52
25.	Shanty	13.61	26.11	8.14	42.38	2.03	2.99	30.82
26.	Skyline	8.32	21.16	3.87	31.44	0.82	1.56	74.66
27.	Sphinx	15.00	34.88	17.60	50.79	0.73	1.79	42.41
28.	Sublime	15.47	9.21	4.05	43.28	0.76	2.56	37.17
29.	Suela	8.42	<u>40.29</u>	15.44	74.60	0.78	1.74	54.96
30.	Sweet Renate	12.72	11.89	12.11	14.94	1.21	2.09	38.86
31.	Sweetnesse	10.91	22.86	11.55	62.27	1.63	2.38	34.82
32.	Temptation	1.39	26.58	12.40	24.35	1.79	2.85	35.16
33.	Teneki	9.06	26.76	12.89	76.03	0.11	2.06	<u>82.85</u>
34.	Texas	2.71	30.97	15.28	38.72	0.82	0.82	76.33
35.	White Noblesse	14.04	30.39	4.94	80.99	0.78	1.84	77.20
	Pooled Mean	9.87	23.33	8.54	52.75	1.05	2.11	48.05
	SE $\pm$	0.70	1.71	0.84	3.89	0.09	0.10	3.32
	CD at 5%	2.08	5.02	2.53	13.54	0.28	0.32	8.96

4.3.4 Reaction to mealy bugs, *Planococcus citri*

The evaluation of 35 rose cultivars to mealy bugs was undertaken during the year 2004 and 2005. The mealy bug population on these cultivars ranged from 0.00 to 81.72 per twig. The cultivars, Eldorado, Naranga and Queensday reported to be free from infestation of mealy bugs and are considered to be immune for mealy bug. The cultivar viz., 'Papillion' recorded the lowest mealy bug infestation (11.67 mealy bugs/twig) and found less susceptible to mealy bug. The cultivar, Pink Noblesse (Plate 6) recorded the highest mealy bug population of 81.72 per twig and was found to be at par with Inka, Kronos, Mikado, Milva, Saphir, Sucla, Teneki and White Noblesse (69.29 to 80.99 mealy bugs/twig). These cultivars are considered to be highly susceptible to mealy bugs. The cultivars having shorter stem length were found to have less infestation of mealy bugs.

Close scrutiny of literature on the reaction of the various cultivars of roses to mealy bugs revealed no evidence of published work on this aspect and hence the present findings could not be compared with others work.

4.3.5 Reaction to *Helicoverpa armigera*

It could be seen from Table 11 that of the thirty-five cultivars screened against *H.armigera*, none was found immune. On the basis of peak pest population, amongst the 35 cultivars, 19 were categorised as less susceptible, 8 moderately susceptible, 5 susceptible and 3 highly susceptible. However, the cultivar 'Teneki' (Plate 7) was found to be less susceptible recording the lowest mean population of 0.11 larva per plant; while the cultivar, Monte Carlo, Shanty and Grand gala were noted as highly susceptible, recording highest larval population of 2.01, 2.03 and 2.12, respectively. The data on flower colour of all 35 rose cultivars indicated that the cultivars with red flower colour tend to be highly susceptible to *H.armigera*.

Perusal of literature on the reaction of cultivars of rose to *H.armigera* revealed that there is no published information on this aspect. Thus, in absence

of any published information the present findings could not be corroborated with other work.

4.3.6 Reaction to *Spodoptera litura*

Different cultivars tested exhibited differential responses to infestation by *S. litura* and none of the accessions was found to be free from its attack. The variations in susceptibility to pest may be due to the physicochemical characters of the host. The data presented in Table 11 showed that amongst thirty-five cultivars screened the Texas, Konfetti and Akito recorded less population of 0.82 to 0.90 larva per plant and have emerged as less susceptible cultivars. However, the cultivar 'Texas' was found to be the most tolerant recording the lowest average population of 0.82 larvae per plant; while the cultivar, Passion (Plate 8) and Grand gala were noted as highly susceptible to *S. litura*, recording the highest population of 3.12 and 3.08 larva per plant. Out of 30 remaining cultivars 12 were found to be moderately susceptible and 18 susceptible to *S. litura*. As regard to morphological characters of all thirty-five rose cultivars, the cultivars having red and pink flower colour were found comparatively more preferred by *S. litura*.

Perusal of literature on the reaction of various cultivars of rose to *S. litura* revealed that there is no published information available on this line and hence the present findings could not be compared with others.

4.3.7 Reaction to *Tetranychus urticae*

On the basis of pooled analysis of entire data of mite population on varied degrees of infestation recorded at weekly intervals, the overall reactions of rose cultivars to mite infestation are given in Table 11. The perusal of data on population build up revealed that the cultivar 'Passion' showed significantly lowest (13.10 mites/leaf) incidence of mites throughout the year. However, it was at par with First Lady (19.45 mites/leaf). Thus, the cultivar Passion and First Red were found to be less susceptible to mites. The significantly higher mite population of 82.85 mites per leaf was observed on the cultivar Teneki

(Plate 9) and was found to be at par with Polo, Skyline, Texas, White Noblesse and Bianca.

On the basis of the rating at 3.2.3 in previous chapter, the 35 cultivars tested were grouped into four categories. The four cultivars were found to be less susceptible, eighteen moderately susceptible, nine susceptible and four highly susceptible categories to mites. The data on flower colour of all thirty cultivars revealed that the cultivars having white flowers were found to be most susceptible to mites.

Perusal of the literature revealed no published information regarding the reaction of various rose cultivars to mites. Hence, the present findings wherein cultivars, viz., Passion, First Lady, Grand gala and First Red have emerged as the less susceptible and could not be compared with others.

4.4 Influence of Rose Genotypes on Parasitisation Efficiency of

***T.chilonis* on Eggs of *H. armigera*.**

In present experimentation, a significant variability in terms of percent parasitism of *H.armigera* eggs by *T.chilonis* was noticed, when data were analysed (Table 12). The per cent parasitism were categorised as low (less than 30%), moderate (30 to 50%) and high parasitisation (more than 50%). Highest parasitism was recorded on rose cultivar First red (52.59%), which was significantly differed from all other cultivars evaluated and formed to categorise into high parasitisation. Second highest parasitism (42.75%) was recorded in the cultivar Passion, catergorised as moderate parasitisation. However, this was on par with Grand gala (40.21%) and Saphir (37.28%). Significantly low per cent parasitism was recorded in cultivar Pink Noblesse (29.74%) and considered as low parasitization.

Singh and Balla (1999) have reported 80% parasitisation of *H.armigera* in egg stage by *T.chilonis* on sunflower genotypes under screen house as well as field conditions. Balla and Singh (2003) also reported 50.1 per cent

Table 12. Influence of rose cultivars on parasitisation efficiency of *T.chilonis* on eggs of *H.armigera*.

Sr. No.	Cultivars	First release*			Second release*			Third release*			Mean parasitisation (%)
		No. of eggs / plant	No of parasitised eggs/plant	Parasitisation of eggs/plant (%)	No. of eggs / plant	No of parasitised eggs/plant	Parasitisation of eggs/plant (%)	No. of eggs / plant	No of parasitised eggs/plant	Parasitisation of eggs/plant (%)	
1.	Pink	9.87 (18.28)	2.87 (9.75)	29.08 (32.75)	9.07 (17.51)	2.53 (9.12)	27.89 (32.14)	8.87 (17.29)	2.86 (9.73)	32.24 (34.75)	29.74 (32.21)
2.	Grand gala	10.47 (18.85)	3.87 (11.33)	36.96 (37.48)	8.87 (17.29)	3.47 (10.72)	39.12 (39.16)	9.27 (17.71)	4.13 (11.71)	44.55 (43.02)	40.21 (39.88)
3.	Saphir	10.07 (18.48)	3.60 (10.91)	35.75 (36.82)	9.34 (17.76)	3.33 (10.44)	35.65 (36.43)	9.07 (17.51)	3.67 (10.99)	40.46 (39.43)	37.28 (37.56)
4.	Passion	10.07 (18.48)	4.13 (11.71)	41.02 (39.86)	9.40 (17.84)	3.80 (11.23)	40.43 (39.72)	9.40 (17.83)	4.40 (12.02)	46.81 (41.91)	42.75 (40.49)
5.	First Red	10.33 (10.74)	5.53 (13.59)	53.54 (47.02)	9.47 (17.91)	5.00 (12.92)	52.80 (46.79)	9.47 (17.91)	4.87 (12.72)	51.43 (46.05)	52.59 (46.62)
	Mean	10.16 (18.57)	4.00 (11.46)	39.27 (37.78)	9.23 (17.66)	3.63 (10.88)	39.18 (38.85)	9.22 (17.65)	3.98 (11.43)	43.09 (41.03)	40.52 (39.35)
	SE±	0.48	0.30	0.94	0.45	0.41	2.09	0.47	0.48	1.93	1.64
	CD (P=0.05)	NS	0.89	2.79	NS	1.22	6.19	NS	1.43	5.61	4.86

* Mean of five replications. Figures in parenthesis are arcsin-transformed values

parasitism of *H.armigera* eggs on genotypes of pigeon pea under screen house condition. However, no study has been conducted on the influence of rose genotypes on parasitism efficiency of *T.chilonis* against *H.armigera* under polyhouse condition.

4.5 Bioefficacy of Different Pesticides and Bioagents Against Pests Infesting Rose

The observations on the mean pest survival population in the different treatments after each of three sprays in the trial conducted under polyhouse condition are presented in Table 13, 15, 17, 19, 21, 23 and 25. Pre-treatment count was taken one day before spraying and post-treatment counts were taken 2/3, 7 and 10 days after each spray. The data of pest counts were transformed into square root and subjected to analysis of variance.

4.5.1 Bioefficacy of different pesticides and bioagents against thrips (*F.schultzei*).

The data on pre-count recorded one day prior to spraying are presented in Table 13. It could be seen from the data that pre-count in various treatments ranged between 4.64 to 5.76 thrips per flower. These observations on incidence were statistically significant at 5% level of significance, suggesting slight deviation in uniformity in thrip population.

The data recorded on 2nd day after treatment revealed that all the insecticidal treatments were significantly superior over control. The treatment with spinosad (0.015%) emerged as the significantly superior to all other treatments and recorded significantly less number of thrips i.e. 0.33. The treatments with thiamethoxam (0.005%), fipronil (0.02%), mineral oil, *C.carnea*, and *V.lecanii* were next in efficacy to spinosad. The highest thrip population amongst treated plots was observed in *V.lecanii* treated plot, which was significantly more than other treatment plots except *C.carnea*.

On the 7th day after application, all the treatments were significantly superior over control in reducing pest population. The lowest incidence of thrips was observed in plots treated with spinosad (0.015%) and consistently emerged as a significantly superior treatment, followed by thiamethoxam (0.005%), fipronil (0.02%), mineral oil, *V.lecanii* and *C.carnea*. The higher thrips population was observed in *C.carnea* (4.39) and *V.lecanii* (4.15) treated plots, which were found to be at par with each other.

Similar trend was observed in observation taken on 10th day after application. The data recorded revealed that spinosad (0.015%) was most effective and recorded significantly less thrips i.e. 1.35 thrips per flower and emerged as the significantly superior treatment, followed by thiamethoxam (0.005%), fipronil (0.02%), mineral oil, *V.lecanii* and *C.carnea*. *C.carnea* released treatment recorded significantly maximum population i.e. 4.40 amongst treated plots.

The data of overall mean of thrips population recorded on 2, 7 and 10 days after spraying presented in Table 13 revealed that all the treatment were significantly superior over control in reducing thrips population. Amongst the pesticides tested, spinosad (0.015%) proved to be the most effective followed by thiamethoxam (0.005%), fipronil (0.02%), mineral oil, *V.lecanii* and *C.carnea*.

In the present investigations, spinosad (0.015%) showed promise against thrips which is in conformity with earlier findings of Eger *et al.*, (1998), Thompson and Hutchins (1999), Clody and Sadaf (2000) and Prasad and Kumar (2000), Dreistadt (2001). Eger *et al.*, (1998), also reported higher toxicity of spinosad to *F.occidentalis*, *F.tritici* and *F.bispinosa* in laboratory bioassays. However, the field study showed significant effects only on *F.occidentalis*. Thompson and Hutchins (1999) suggested that the emamectin and spinosad were the most efficient insecticides for controlling the western flower thrips *F. occidentalis* in addition to their activity on other insect pests.



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Clody and Sadaf (2000) conducted greenhouse studies to determine the efficacy of spinosad and acephate against western flower thrips on Transval daisy (*Gerbera jamesonii*). Three rates of spinosad 50, 100 and 200 mg and acephate 600 mg per litre were used and found that both spinosad and acephate found effective in controlling the thrips.

Prasad and Kumar (2000), Dreistadt (2001) reported the effectiveness of *C.carnea* in greenhouse crops as a biological control agent for thrips and aphids. Further, they stated that the several thrips species including *F.occidentalis*, *T.tabaci* and *F.tenuicornsi* infected by *V.lecanii*.

4.5.2 Comparative economics of different treatments against *F.schultzei* in terms of flower yield.

The yield of rose flowers was recorded for a period of one month in terms of number of flowers per treatment plot and was converted into number of flower per 5r. The data thus obtained are presented in Table 14. It could be seen from data that yield varied from 3008 to 5033 flowers in treated plots as against 3033 flowers in untreated control plots. Further, the yield obtained from all the treatments was superior over control except *C.carnea* released plots (3008 flowers). The maximum yield of 5033 flowers was obtained in the treatment with spinosad (0.015%) followed by fipronil (0.02%), mineral oil, thiamethoxam (0.005%) and *V.lecanii*.

The data on yield of 'A' grade flowers indicated the yield ranged of 2564 to 4614 flowers as against 1268 flowers from the untreated plots. Maximum numbers of 'A' grade flowers were obtained from plots receiving spinosad treatment (4614 flowers), while minimum flowers were obtained from the plots where *C.carnea* (2564 flowers) was released.

The data on yield of 'B' grade flowers revealed that the yield ranged from 398 to 883 flowers as against 1765 flowers from untreated plot. Maximum number of 'B' grade flowers were produced in the plots treated with fipronil (883 flowers) and least number of grade 'B' flower were obtained from the plot received thiamethoxam treatment (398 flowers).

Table 13. Comparative efficacy of different treatments against thrips (*F.schultzei*) infesting rose.

Sr. No.	Treatment	Pre-count	Survival population 2 DAS/flower				Survival population 7 DAS/flower				Survival population 10 DAS/flower				Overall Mean
			I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	
1.	Fipronil 5SC	5.52 (2.45)	1.48 (1.41)	1.16 (1.29)	0.72 (1.11)	1.12 (1.27)	1.72 (1.49)	2.04 (1.59)	1.08 (1.25)	1.61 (1.44)	3.80 (2.07)	2.76 (1.80)	1.16 (1.29)	2.57 (1.72)	1.77 (1.48)
2.	Spinosad 45 SC	5.76 (2.51)	0.56 (1.02)	0.44 (0.96)	0.00 (0.71)	0.33 (0.90)	1.60 (1.45)	0.96 (1.21)	0.00 (0.71)	0.85 (1.12)	2.08 (1.61)	1.84 (1.53)	0.12 (0.79)	1.35 (1.31)	0.84 (1.11)
3.	Thiamethoxam 25 WG	5.44 (2.44)	1.36 (1.36)	0.84 (1.15)	0.00 (0.71)	0.73 (1.07)	1.84 (1.53)	1.64 (1.46)	0.32 (0.90)	1.27 (1.30)	3.24 (1.93)	2.40 (1.70)	0.72 (1.10)	2.12 (1.58)	1.37 (1.32)
4.	Mineral oil	4.64 (2.27)	2.92 (1.85)	3.04 (1.88)	2.84 (1.83)	2.93 (1.85)	3.16 (1.92)	3.24 (1.94)	3.04 (1.88)	3.15 (1.91)	3.36 (1.96)	3.92 (2.10)	3.80 (2.07)	3.69 (2.04)	3.26 (1.94)
5.	<i>V. lecanii</i>	4.92 (2.33)	4.48 (2.23)	5.16 (2.38)	5.48 (2.45)	5.04 (2.35)	3.24 (1.93)	3.60 (2.03)	5.60 (2.47)	4.15 (2.14)	2.68 (1.78)	3.48 (1.99)	5.92 (2.53)	4.03 (2.10)	4.40 (2.20)
6.	<i>C. carnea</i>	5.44 (2.44)	3.72 (2.05)	3.84 (2.08)	6.08 (2.57)	4.55 (2.23)	3.32 (1.95)	3.76 (2.06)	6.08 (2.57)	4.39 (2.19)	2.84 (1.83)	4.16 (2.16)	6.20 (2.59)	4.40 (2.19)	4.44 (2.21)
7	Untreated control	5.72 (2.49)	6.44 (2.64)	10.56 (3.33)	13.04 (3.68)	10.01 (3.22)	8.52 (3.01)	12.20 (3.56)	13.52 (3.75)	11.41 (3.44)	9.60 (3.18)	12.40 (3.59)	14.28 (3.85)	12.09 (3.54)	11.17 (3.40)
	S.E.±	0.03	0.05	0.05	0.02	0.04	0.03	0.04	0.03	0.03	0.04	0.05	0.04	0.04	0.04
	C.D. at 5%	0.08	0.15	0.15	0.07	0.12	0.09	0.12	0.10	0.10	0.11	0.14	0.12	0.12	0.12

DAS: Days after spraying

Figures in parentheses indicate square root transformed values $\sqrt{n + 0.5}$

Table 14. Comparative economics of different treatments against thrips (*F.schultzei*) (5r area).

Sr. No.	Treatment	Dose / liter	Cost of insecticide (3 sprays) Rs.	Yield (No of flowers / 5r)			Increases in yield over control			Cost of 3 treatment (B) Rs.	Gross monetary benefit (A) (Rs.)			Net monetary returns (C)	C : B ratio
				5			6				8				
				A	B	Total	A	B	Total		A	B	Total		
1	2	3	4						7				9	10	
1.	Fipronil 5SC	3 ml	445.5	3856	883	4739	2588	-882	535.5	7764	-1764	6000	5464.5	1:10.20	
2.	Spinosad 45SC	0.33 ml	507.9	4614	419	5033	3346	-1346	597.9	10038	-2692	7346	6748.1	1:11.29	
3.	Thiamethoxam 25 WG	0.2 g	224	3471	398	3869	2203	-1367	314	6609	-2734	3875	3561	1:11.34	
4.	Mineral oil	15 ml	270	3456	504	3960	2188	-1261	360	6564	-2522	4042	3682	1:10.23	
5.	V. lecanii	2 g	250	3230	448	3678	1962	-1317	340	5886	-2634	3252	2912	1:8.56	
6.	C. carnea (Larvae)	4 /plant	33	2564	444	3008	1296	-1321	123	3888	-2642	1246	1123	1:9.13	
7.	Control	-	-	1268	1765	3033	-	-	-	-	-	-	-	-	

1. Concentration and prices of treatments are given in Table 2.
2. Labour required /spraying : 0.5
3. Labour charges @ Rs. 60/labour/day
4. Spray volume: 45 lit/spray (135 litre for 3 sprays/5r)
5. Average market rate of rose flowers: Grade 'A' = Rs. 3.00/flower and Grade 'B' = 2.00/flower
6. Yield recorded for a period of one month commencing from one month after 1st spray upto 30th day after 3rd spray.

Cost : Benefit ratio (C:B)

The cost benefit ratio of different insecticidal treatments used against *F.schultzei* were calculated based on 5r area and yield of flower from each treatments recorded for a period of one month and presented in Table 14.

It is seen from the Table 14 that maximum net monetary returns of Rs. 6748.1 from 5r area were obtained from the plot received spinosad sprays. The next best treatments in this context were fipronil and mineral oil. The net monetary returns obtained from these treatments were Rs. 5464.5 and Rs. 3686. The least net monetary returns were obtained from the treatment with *C.carnea* (Rs. 1123/-).

The highest cost benefit ratio of 1:11.34 was recorded from the treatment with thiamethoxam sprays and was closely followed by plots received sprays with spinosad and fipronil with cost benefit ratios of 1:11.29 and 1:10.20, respectively. The least cost benefit ratio (1:8.56) was obtained from treatment with *V.lecanii*.

It could be interpreted from these results that although the treatment with thiamethoxam provided highest cost benefit ratio, the additional returns over cost of treatment in thiamethoxam treated plots (Rs. 3561/-) were less than that obtained from plot received treatment with spinosad (Rs. 6748.1/-). Further, the overall efficacy of thiamethoxam in controlling the pest was less as compared to spinosad.

Perusal of literature on the insecticide cost benefit ratio of rose to *F.schultzei*, revealed that there is no published information of this aspect available. Thus, in absence of any published information the present findings could not be compared with others.

4.5.3 Bioefficacy of different pesticides and bioagents against aphids (*M.rosae*)

The data on pre-count and post count observations of average number of aphid population are presented in Table 15. It could be seen from the data that

pre-count in different treatment plots ranged from 47.84 to 63.61 aphids per shoot. These observations were statistically significant ($p = 0.05$), indicating the uniformity of aphid population in different plots.

The data recorded on 3rd day after treatment revealed that aphid population varied from 0.62 to 63.47 in different treatments. All the treatments were significantly superior over control in reducing aphid population. The treatment with imidacloprid (0.005%) emerged as the significantly superior over other treatments recording significantly less number of aphids i.e. 0.62. However, it was statistically at par with thiamethoxam (0.005%), in which 0.65 aphids per shoot were recorded followed by acetamiprid (0.005%), mineral oil, *V.lecanii* and *C.carnea*. The significantly higher aphid population (37.20) was noticed in *C.carnea* released plots.

On the 7th day after application, the treatment, imidacloprid (0.005%) was found most effective and recorded significantly less aphids i.e. 1.63 and emerged as the significantly superior, followed by thiamethoxam (0.005%), acetamiprid (0.005%), mineral oil, *V.lecanii* and *C.carnea*. In *C.carnea* released plots significantly maximum population of 33.23 aphids per shoot was noted.

The data recorded on 10th days after application indicated the imidacloprid (0.005%) as most effective and promising insecticide showing aphid population of 13.96 per shoot. Further, the survival population of aphid recorded in *V.lecanii* treated plots was 14.81, which was on par with treatment of imidacloprid.

The data of overall means of aphid population recorded on 3, 7 and 10 days after spraying showed the superiority of all the treatments over control in reducing aphid population. Amongst the treatments, imidacloprid (0.005%) was found to be most effective and significantly superior to all other treatments. Each of the treatments to be differed significantly. The efficacy of treatments was in the order of : imidacloprid 0.005% > thiamethoxam 0.005% > acetamiprid 0.005% > mineral oil > *V.lecanii* > *C.carnea*.

In present study, the insecticides *viz.*, imidacloprid, thiamethoxam and acetamiprid showed promise in reducing the aphid population on 3, 7 and 10th days after application. Earlier workers also found effectiveness of these insecticides on sucking pests like aphids, jassids, thrips and whiteflies infesting cotton and lettuce where in these insecticides were found to be promising (Sreelatha and Divakar, 1997, Patil, 2000; Satpute *et al.*, 2001, Dhawan and Simwat, 2002 and Misra, 2002) at 3, 7 and 10 days after application. There is no evidence of research work done on efficacy of *V.lecanii* on rose aphid. As regards *C.carnea*, the aphid population in present experimentation was found reduced by *C.carnea* as compared to untreated control. In support of these findings the earlier workers recommendation could be cited. Singh *et al.*, (1994) recommended the higher release of *C.carnea* @ 1-2 larvae per plant on tobacco against *M.persicae*, *S.litura* and *B.tabaci*. Satpathy *et al.*, (1998) also reported effectivity of *C.carnea* on cotton aphid and eggs of some lepidopterous borers. when first instar larvae released @ 50,000 per hectare.

4.5.4 Comparative economics of different treatments against *M.rosae* in terms of flower yield.

It could be seen from the data (Table 16) that the flower yield varied from 1738 to 3209 flowers per 5r in treated plots as against 1617 flowers/5r in untreated control plots. The data revealed that yield obtained from all the treatments were higher over control. The maximum yield of 3209 flowers was obtained in the treatment with imidacloprid (0.005%) followed by thiamethoxam (0.005%), acetamiprid (0.005%), *V.lecanii*, mineral oil and *C.carnea*.

The data on yield of 'A' grade flowers indicated that the yield ranged from 713 to 2247 flowers as against 665 flowers from the untreated plots. A maximum number of 'A' grade flowers were obtained from plots received

Table 15. Comparative efficacy of different treatments against aphids (*M.rosae*) infesting rose.

Sr. No.	Treatment	Pre-count	Survival population 3 DAS/shoot			Survival population 7 DAS/shoot			Survival population 10 DAS/shoot			Overall Mean			
			I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	I st spray		II nd spray	III rd spray	Av.
1.	Imidacloprid 17.8 SL	54.76 (7.44)	1.07 (1.25)	0.80 (1.13)	0.00 (0.71)	0.62 (0.99)	2.41 (1.69)	1.34 (1.35)	1.15 (1.26)	1.63 (1.43)	18.74 (4.38)	13.80 (3.78)	9.33 (3.14)	13.96 (3.77)	5.40 (2.08)
2.	Thiamethoxam 25 WG	48.11 (6.97)	1.94 (1.55)	0.00 (0.71)	0.00 (0.71)	0.65 (1.03)	2.60 (1.76)	6.80 (2.69)	3.28 (1.94)	4.23 (2.13)	21.07 (4.64)	16.87 (4.17)	12.08 (3.54)	16.67 (4.12)	7.18 (2.41)
3.	Acetamiprid 20 SP	63.61 (8.00)	5.40 (2.43)	7.27 (2.79)	2.82 (1.82)	5.16 (2.35)	7.40 (2.81)	9.14 (3.11)	4.15 (2.15)	6.90 (2.69)	24.27 (4.98)	19.73 (4.50)	15.33 (3.98)	19.78 (4.49)	10.61 (3.18)
4.	Mineral oil	50.44 (7.14)	13.60 (3.75)	15.26 (3.97)	11.48 (3.46)	13.45 (3.73)	18.53 (4.36)	21.60 (4.70)	16.62 (4.14)	18.92 (4.40)	27.60 (5.30)	25.46 (5.09)	18.62 (4.37)	23.89 (4.92)	18.75 (4.35)
5.	<i>Verticillium</i> <i>lecanii</i>	58.88 (7.71)	49.37 (7.09)	26.00 (5.15)	24.29 (4.98)	33.22 (5.74)	30.20 (5.54)	15.94 (4.05)	14.74 (3.91)	20.29 (4.50)	23.27 (4.87)	11.53 (3.47)	9.62 (3.18)	14.81 (3.84)	22.77 (4.69)
6.	<i>Chrysoperla</i> <i>carnea</i>	61.09 (7.85)	50.67 (7.15)	36.40 (6.07)	24.53 (5.01)	37.20 (6.08)	47.54 (6.93)	31.40 (5.65)	20.75 (4.61)	33.23 (5.73)	39.73 (6.34)	24.60 (5.01)	22.49 (4.80)	28.94 (5.38)	33.12 (5.23)
7.	Control	47.84 (6.95)	50.41 (7.13)	64.13 (8.04)	75.88 (8.74)	63.47 (7.97)	54.14 (7.39)	67.20 (8.23)	78.82 (8.91)	66.72 (8.18)	61.80 (7.89)	43.40 (8.60)	82.48 (9.11)	62.56 (8.53)	64.25 (8.23)
	S.E.+	0.11	0.06	0.06	0.05	0.06	0.07	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.06
	C.D. at 5%	0.31	0.19	0.18	0.15	0.17	0.20	0.24	0.22	0.22	0.20	0.18	0.19	0.19	0.19

DAS: Days after spraying

Figures in parentheses indicate square root transformed values $\sqrt{n} + 0.5$

Table 16. Comparative economics of different treatments against aphids (*M.rosae*) (5r area).

Sr. No.	Treatment	Dose / liter	Cost of insecticide (3 sprays) Rs.	Yield (No of flowers / 5r)			Increases in yield over control			Cost of 3 treatment (B) Rs.	Gross monetary benefit (A) (Rs.)			Net monetary returns (C)	C : B ratio
				5			6				8				
				A	B	Total	A	B	Total		A	B	Total		
1	2	3	4						7				9	10	
1.	Imidacloprid 17.8 SL	0.5 ml	261	2247	962	3209	1582	-190	351	4746	-380	4366	4015	1:11.14	
2.	Thiamethoxam 25WG	0.2 g	224	2115	895	3010	1450	-57	314	4350	-114	4236	3922	1:12.49	
3.	Acetamiprid 20SP	0.25 g	244	1945	883	2828	1280	-69	334	3840	-138	3702	3368	1:10.08	
4.	Mineral oil	15 ml	270	1538	753	2291	873	-199	360	2619	-398	2221	1861	1:5.17	
5.	<i>V.lecarii</i>	2 g	250	1442	948	2390	777	-4	340	2331	-8	2323	1983	1:5.83	
6.	<i>C. caricae</i> (Larvae)	4 /plant	33	713	925	1738	148	-27	123	444	-54	390	267	1:2.17	
7.	Control	-	-	665	952	1617	-	-	-	-	-	-	-	-	

Concentration and prices of treatments are given in Table 2.

imidacloprid treatment (2247 flowers); while minimum in case of treatment with *C.carnea* (713 flowers).

The data on yield of 'B' grade flowers in different treatments ranged from 925 to 962 flowers as against 952 flowers from untreated control plots. Maximum numbers of 'B' grade flowers were produced in the plot treated with imidacloprid (962 flowers) and least number of grade 'B' flower in mineral oil treatment (753 flowers).

Cost : Benefit ratio (C:B)

The cost benefit ratio of different insecticidal treatments were worked out on the basis of flower yield (5r area) obtained from each of treatments recorded for a period of one month and are presented in Table 16.

Considering the cost benefit ratios of different treatments, the highest financial gain of Rs. 4015 was recorded in treatment with imidacloprid. The next best treatments in this context were thiamethoxam and acetamiprid. The net monetary returns obtained from these treatments were Rs. 3922 and Rs. 3368. The least net monetary returns were obtained from the treatment with *C.carnea* (Rs. 267).

The highest cost benefit ratio of 1:12.49 was observed in the treatment with thiamethoxam sprays and was followed by plots received sprays with imidacloprid and acetamiprid with cost benefit ratios of 1:11.14 and 1:10.08, respectively. The least cost benefit ratio (1:2.17) was obtained from treatment with *C.carnea*. It could be interpreted from these results that the insecticide imidacloprid showed consistent highest efficacy in controlling *M.rosae*. However, the cost benefit ratio of imidacloprid generated is comparatively lower (1:11.14) than thiamethoxam (1:12.49). This deviation is due to higher cost of imidacloprid than thiamethoxam.

The rigorous scrutiny of literature pertaining to control of *M.rosae* showed absence of work done and hence present findings could not be compared with other researchers work.

4.5.5 Bioefficacy of different treatments against whitefly (*T.vaporariorum*)

The data on average number of whiteflies per leaf recorded in respect of pre and post counts are presented in Table 17. The data recorded on 3rd day after treatment showed that all the treatments were significantly superior over untreated control. The treatment with buprofezin (0.06%) emerged as the significantly superior over all others recording significantly less number of whiteflies (0.70/leaf). Treatments with neem (0.5%), acephate (0.07%), mineral oil, fish oil rosin soap (0.05%) and *V.lecanii* were next in efficacy to buprofezin. The maximum whitefly population (4.23/leaf) amongst treated plots was observed in *V.lecanii* treated plot, which was significantly higher.

The observation recorded on 7th DAS indicated consistent higher efficacy of buprofezin (0.06%) with survival population of 1.17 whiteflies per leaf. Further, the treatment with neem (0.05%) stood second in efficacy and significantly superior over control.

Similar trend in controlling whiteflies was observed on 10th DAS. The data recorded revealed that buprofezin (0.06%) was most effective and recorded significantly less whitefly i.e. 1.25 per leaf and emerged as the significantly superior treatment. *V.lecanii* was significantly superior over rest of treatments and statistically at par with neem (0.5%) with average survival whiteflies of 2.02 and 2.05, respectively. Mineral oil found to be least effective and recorded highest survival whiteflies (5.27/leaf), which was significantly more as compared to other treatments. Further, it was observed that all the treatments were significantly superior over control in reducing whitefly population.

Considering the overall effectiveness of different treatments, the treatment of buprofezin 0.06% found to be the most promising and significantly superior recording 1.13 whiteflies per leaf. The treatment with neem 0.5% stood second in efficacy and recorded 1.52 whiteflies per leaf. The rest of the treatments in order of their overall efficacy in controlling the pest were: acephate 0.07 per cent (2.41 whitefly/leaf) > fish oil rosin soap 0.05

per cent (3.10 whitefly/leaf) > *V. lecanii* (3.29 whitefly/leaf) > mineral oil (3.54 whitefly/leaf).

The literature on efficacy of various pesticides for the control of *T.vaporariorum* infesting rose is scanty. However, Feng *et.al.*, (1990), Meade and Byrne (1991), Helyer *et al.*, (1992), Phadke and Phadke (2000) reported the successful use of *V.lecanii* worldwide to control greenhouse pest such as whitefly and various species of aphids. Prasad and Kumar (2000) reported that soaps of vegetable origin based upon salts of fatty acids that have been selected for their insecticidal properties against aphids, mealy bugs, red spider mites and whiteflies. According to Baker and Baily (1996), Dreistadt, 2001), azadirachtin, *B.bassiana* and oil were effective against whiteflies in greenhouse condition. In present study, *V.lecanii*, neem, mineral oil and fish oil rosin soap were found to reduce the whitefly population. Thus, present finding could be compared with those of earlier workers.

4.5.6 Comparative economics of different treatments against *T.vaporariorum* in terms of flower yield.

It could be seen from the data (Table 18) that the flower yield varied from 3304 to 5149 flowers per 5r in treated plots as against 3119 flowers per 5r in untreated control plots. The maximum yield of 5149 flowers was obtained in the treatment with buprofezin (0.06%) followed by neem (4981), *V.lecanii* (3431), acephate (3351), mineral oil (3341) and fish oil rosin soap (3304).

The data on yield of 'A' grade flowers indicated that the yield in treated plots ranged from 2258 to 4464 flowers as against 854 flowers from the untreated plot. Maximum numbers of 'A' grade flowers were obtained from plots of buprofezin treatment (4464 flowers); while minimum number from treatment with mineral oil (2258 flowers).

As regards of 'B' grade flowers, the yield was ranged between 685 to 1083 flowers in treated plots; while it was 2265 flowers in untreated plots. It was notable to obtain minimum number of 'B' grade flowers (685) from buprofezin treatment plots.

Table 17. Comparative efficacy of different treatments against white fly (*T.vaporariorum*) infesting rose.

Sr. No.	Treatment	Pre-count	Survival population 3 DAS/leaf			Survival population 7 DAS/leaf			Survival population 10 DAS/leaf			Overall		
			I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.
1.	Acephate 75SP	4.22 (2.17)	0.75 (1.12)	1.45 (1.39)	1.62 (1.45)	1.27 (1.32)	1.56 (1.44)	2.68 (1.78)	4.19 (2.17)	2.29 (1.66)	3.67 (2.03)	2.41 (1.67)		
2.	Buprofezin 25EC	4.28 (2.19)	0.60 (1.05)	0.72 (1.11)	0.78 (1.30)	0.70 (1.15)	0.96 (1.21)	1.15 (1.28)	1.40 (1.38)	1.17 (1.29)	1.52 (1.42)	1.13 (1.29)		
3.	Neem IEC	6.02 (2.55)	1.03 (1.24)	1.05 (1.24)	1.24 (1.32)	1.11 (1.27)	1.37 (1.36)	1.33 (1.35)	1.56 (1.44)	1.42 (1.38)	2.05 (1.60)	1.52 (1.42)		
4.	Fish oil rosin soap	5.34 (2.42)	2.13 (1.62)	2.70 (1.79)	2.51 (1.74)	2.45 (1.72)	2.57 (1.75)	3.29 (1.95)	3.51 (2.01)	3.12 (1.90)	3.74 (2.05) ^y	3.10 (1.89)		
5.	Mineral oil	3.74 (2.06)*	1.15 (1.28)	2.14 (1.63)	3.12 (1.90)	2.14 (1.60)	1.91 (1.55)	3.61 (2.03)	4.12 (2.15)	3.21 (1.91)	5.27 (2.38)	3.54 (1.97)		
6.	<i>V. lecanii</i>	4.54 (2.25)	3.55 (2.02)	4.17 (2.16)	4.97 (2.34)	4.23 (2.17)	3.02 (1.88)	3.54 (2.01)	4.25 (2.18)	3.60 (2.02)	2.02 (1.59)	3.29 (1.93)		
7.	Control	5.36 (2.42)	6.21 (2.59)	9.85 (3.22)	12.78 (3.65)	9.61 (3.15)	7.26 (2.79)	10.76 (3.36)	13.56 (3.75)	10.53 (3.30)	11.32 (3.42)	10.49 (3.29)		
	S.E.+	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	
	C.I.D. at 5%	0.09	0.08	0.08	0.08	0.08	0.06	0.07	0.08	0.07	0.06	0.06	0.06	0.07

DAS: Days after spraying

Figures in parentheses indicate square root transformed values $\sqrt{n + 0.5}$

Table 18. Comparative economics of different treatments against whitefly (*T. vaporariorum*) (5r area).

Sr. No.	Treatments	Dose / liter	Cost of insecticide (3 sprays) Rs.	Yield (No of flowers / 5r)			Increases in yield over control			Cost of 3 treatment (B) Rs.	Gross monetary benefit (A) (Rs.)			Net monetary returns (C)	C : B ratio
1	2	3	4	5			6			7	8			9	10
				A	B	Total	A	B	A		B	Total			
1.	Buprofezin25EC	2.5 ml	508	4464	685	5149	3610	-1580	598	10830	-3160	7670	7072.1	1:11.83	
2.	Neem IEC	5 ml	524.48	4083	898	4981	3229	-1367	614.48	9687	-2734	6953	6338.52	1:10.32	
3.	Accephate 75 SP	1 g	118	2598	753	3351	1744	-1512	208	5232	-3024	2208	2000	1:9.62	
4.	Fish oil rosin soap	5 g	194.67	2356	948	3304	1502	-1317	284.67	4506	-2634	1872	1587.33	5:58	
5.	Mineral oil	15ml	270	2258	1083	3341	1404	-1182	360	4212	-2364	1848	1488	1:4.13	
6.	<i>V. lecanii</i>	2 g	250	2487	944	3431	1633	-1321	340	4899	-2642	2257	1917	1:5.64	
7.	Control	-	-	854	2265	3119	-	-	-	-	-	-	-	-	

Concentration and prices of treatments are given in Table 2.

Cost : Benefit ratio (C:B)

The cost benefit ratio of different treatments were worked out on the basis of flower yield (5r area) from each treatments recorded for a period of one month and are presented in Table 18.

From the data, it is seen that the maximum net monetary returns of Rs. 7072.1 from 5r were obtained from the plot of buprofezin sprays. The next best treatment in this context was neem with net monetary returns of Rs. 6338.52 from 5r. The low net monetary returns were obtained from the treatment with mineral oil (Rs. 1488/5r).

The highest cost benefit ratio of 1:11.83 was emerged from the treatment with buprofezin sprays and was closely followed by treatment with neem with cost benefit ratio of 1:10.32. The lowest cost benefit ratio (1:4.13) was obtained from treatment with mineral oil.

It would be seen from the results that among the different treatments, cost benefit ratio was maximum in case of buprofezin (1:11.83). There is no work so far carried out earlier on *T.vaporariorum* infesting rose in polyhouses and hence present economics could not be compared.

4.5.7 Bioefficacy of different treatments against mealy bugs (*P.citri*)

The data on average number of mealy bug population recorded in pre and post counts are presented in Table 19.

The insecticides and biopesticides in combination with fish oil rosin soap @ 5 g per litre of water and the predator *C.montrouzieri* alone were evaluated against mealy bugs. The data recorded on 3rd day after treatment revealed that mealy bugs number varied from 16.82 to 54.80 in different treatments; while it was 93.53 in untreated control. All the treatments were significantly superior over control in reducing mealy bug population. The treatment with lambda cyhalothrin (0.002%) found to be significantly superior in reducing the mealy bug population (16.82). However, it was at par with buprofezin (17.98). The next best treatment were: imidacloprid (0.005%),

bifenthrin (0.06%), *V.lecanii* and *C.montrouzieri*; which recorded 20.16, 24.31, 31.44 and 54.80 mealy bugs per twig, respectively.

On the 7th day after application, imidacloprid was found to be the most effective and recorded significantly less mealy bugs i.e. 8.77 per twig and emerged as the significantly superior treatment, followed by buprofezin, lambda cyhalothrin, bifenthrin, *V.lecanii* and *C.montrouzieri*.

Similar trend of efficacy was observed on the 10th day after application in which, the treatment with imidacloprid was found to be superior and recorded significantly less number of mealy bugs (7.89). Buprofezin was emerged as second most effective treatment in reducing mealy bugs population (9.79) and it was followed by lambda cyhalothrin, bifenthrin and *V.lecanii*. The predator, *C.montrouzieri* was found least effective and recorded 36.20 mealy bugs per twig.

The data on overall effectiveness of different treatments in controlling the mealy bug revealed that the treatment with imidacloprid found to be most effective and recorded 12.27 mealy bugs per twig. It was followed by buprofezin (13.68 mealy bugs/twig) and lambda cyhalothrin (13.94 mealy bugs/twig), which were at par with each other. The efficacy of rest of the treatments was found to be in the order of: bifenthrin > *V.lecanii* > *C.montrouzieri*.

Earlier workers studied the effectiveness of *C.montrouzieri* and mentioned the grubs as very effective predator especially at high dense population of mealy bug. Adults also found to feed on mealy bugs. They recommended 3-4 releases at 2-3 weeks intervals @ 2-8 per 10 ft² or infested plant or @ 2 predators per yd² (2.4 predators/m²) or 2 beetles per small plant or 2 ft² (0.2 m²) of infested growing area. Further, they noted predators do best in warm, humid conditions. A single predator was known to consume 300-500 mealy bugs in its lifetime (Lindquist, 1997; Nelson, 1998; Singh 2000; Dreistadt, 2001 and Prabhakar, 2001).

Available reduced-risk insecticides include *B.bassiana*, imidacloprid, kinoprene, oil and soap, carbamates, organophosphates, pyrethroids and some botanicals also found to control mealy bugs (Lindquist, 1998; Nelson, 1998; Dreistadt, 2001).

Afore said scrutiny of literature revealed that the pesticides viz, imidacloprid, lambda cyhalothrin, buprofezin, bifenthrin, fish oil rosin soap, *V.lecanii* and predator *C.montrouziei*, were effective against mealy bugs. In present investigation, these components were also found effective in reducing mealy bugs at 3, 7 and 10 days after application.

4.5.8 Comparative economics of different treatments against *P.citri* in terms of flower yield.

It can be seen from the data (Table 20) that the flower yield is varied from 2192 to 3249 flowers per 5r in treated plots as against 3119 flowers per 5r in untreated control plots. The maximum yield 3249 flowers were obtained in plots treated with buprofezin followed by bifenthrin, imidacloprid, *V.lecanii*, lambda cyhalothrin, and *C.montrouzieri*.

In respect of the data on yield of 'A' grade flowers in the plots treated indicated that the yield ranged from 2364 to 1234 flowers as against 854 flowers from the untreated plots. Maximum numbers of 'A' grade flowers were obtained from plots receiving imidacloprid treatment (2364 flowers); while minimum number from plot receiving treatment with *C.montrouzieri* (1234 flowers).

As regards the data on yield of 'B' grade flowers ranged from 1104 to 685 flowers in treated plots as against 2265 flowers from untreated ones. Maximum numbers of 'B' grade flowers were obtained in untreated control plot (2265 flowers); while the plots treated with imidacloprid yielded less number of flowers (685).

Table 19. Comparative efficacy of different treatments against mealy bug (*P.citri*) infesting rose.

Sr. No.	Treatment	Pre-count	Survival population 3 DAS/twig				Survival population 7 DAS/twig				Survival population 10 DAS/twig				Overall	
			I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	Mean	
1.	Imidacloprid 17.8 SL+ FORS	88.40 (9.43)*	30.79 (5.59)	18.68 (4.38)	11.01 (3.39)	20.16 (4.45)	11.40 (3.44)	9.52 (3.16)	5.38 (2.42)	8.77 (3.01)	11.58 (3.47)	9.45 (3.15)	2.65 (1.77)	7.89 (2.80)	12.27 (3.42)	
2.	Buprofezin 25 EC+ FORS	64.56 (8.06)	20.54 (4.58)	20.88 (4.63)	12.53 (3.61)	17.98 (4.27)	16.20 (4.08)	13.93 (3.79)	9.64 (3.18)	13.26 (3.68)	16.20 (5.42)	8.36 (2.97)	4.82 (2.30)	9.79 (3.12)	13.68 (3.69)	
3.	Bifenthrin 10 EC+ FORS	81.56 (9.06)	39.60 (6.33)	19.71 (4.49)	13.61 (3.75)	24.31 (4.86)	23.30 (4.87)	18.21 (4.32)	11.42 (3.45)	17.64 (4.21)	21.32 (4.67)	12.83 (3.65)	6.14 (2.57)	13.43 (3.63)	18.46 (4.23)	
4.	Lambda cyhalothrin 5 EC+ FORS	55.04 (7.45)	21.46 (4.68)	15.77 (4.03)	13.24 (3.71)	16.82 (4.14)	17.06 (4.19)	13.56 (3.75)	10.64 (3.34)	13.75 (3.76)	15.57 (4.01)	9.84 (3.22)	8.34 (2.97)	11.25 (3.40)	13.94 (3.77)	
5.	<i>Verticillium</i> <i>lecanii</i> + FORS	46.92 (6.88)	40.34 (6.39)	31.33 (5.64)	22.64 (4.81)	31.44 (5.61)	33.87 (5.86)	23.60 (4.91)	17.42 (4.23)	24.96 (5.00)	22.15 (4.76)	13.98 (3.81)	13.28 (3.71)	16.47 (4.09)	24.29 (4.90)	
6.	<i>Cryptolaemus</i> <i>montrouzieri</i>	72.76 (8.56)	61.70 (7.89)	53.87 (7.37)	48.83 (7.03)	54.80 (7.43)	54.71 (7.43)	46.28 (6.84)	38.75 (6.26)	46.58 (6.84)	49.69 (7.08)	38.27 (6.23)	20.65 (4.60)	36.20 (5.97)	45.86 (6.75)	
7.	Control	73.64 (8.61)	77.58 (8.84)	92.98 (9.67)	110.04 (10.52)	93.53 (9.68)	80.84 (9.02)	96.63 (9.86)	112.25 (10.62)	96.57 (9.83)	83.15 (9.15)	100.85 (10.07)	119.13 (10.94)	101.04 (10.05)	97.05 (9.85)	
	S.E.+	0.11	0.07	0.06	0.07	0.07	0.09	0.09	0.07	0.08	0.07	0.07	0.08	0.07	0.07	
	C.D. at 5%	0.31	0.19	0.19	0.22	0.20	0.27	0.28	0.23	0.26	0.19	0.23	0.24	0.22	0.23	

DAS: Days after spraying

Figures in parentheses indicate square root transformed values $\sqrt{n + 0.5}$

Table 20. Comparative economics of different treatments against mealy bug (*P.citri*) (5r area).

Sr. No.	Treatment	Dose / liter	Cost of insecticide (3 sprays) Rs.	Yield (No of flowers / 5r)			Increases in yield over control			Cost of 3 treatment (B) Rs.	Gross monetary benefit (A) (Rs.)			Net monetary returns (C)	C : B ratio
				5			6				8				
				A	B	Total	A	B	A		B	Total			
1	2	3	4						7	A	B	Total	9	10	
1.	Imidacloprid 17.8 SL+ FORS	0.5ml + 5 g	455.7	2364	685	3049	1402	-442	545.7	4206	-884	3322	2776.3	1:5.09	
2.	Buprofezin 25 EC+ FORS	2.5ml + 5 g	702.6	2251	998	3249	1289	-129	792.6	3867	-258	3609	2816.4	1:3.55	
3.	Bifenthrin 10 EC+ FORS	0.6 ml + 5 g	483.7	2136	1017	3153	1174	-110	573.7	3522	-220	3302	2728.3	1:4.76	
4.	Lambda cyhalothrin 5 EC+ FORS	3.5 ml + 5 g	404.7	1987	948	2935	1025	-179	494.7	3075	-358	2717	2222.3	1:4.49	
5.	<i>V.lecanii</i> + FORS	2 g + 5 g	444.7	1906	1104	3010	944	-23	534.7	2832	-46	2786	2251.3	1:4.21	
6.	<i>C. montouzieri</i>	4 grubs / plant	45	1234	958	2192	272	-169	135	816	-338	478	343	1:2.54	
7.	Control	-	-	854	2265	3119	-	-	-	-	-	-	-	-	

Concentration and prices of treatments are given in Table 2.

Cost : Benefit ratio (C:B)

The cost benefit ratios of different treatments tried against *P.citri* were calculated (5r area). The cost benefit ratios were worked out based on flowers yield obtained for a period of one month.

It could be seen from the Table 20 that maximum net monetary returns of Rs. 2816.4 per 5r were obtained from the plots receiving buprofezin sprays. The next best treatments in this context were imidacloprid and bifenthrin. The net monetary returns obtained from these treatments were Rs. 2776.3 and Rs. 2728.3 per 5r. The net monetary returns obtained from the treatment with *C.montrouzieri* were Rs. 343 from 5r.

The highest cost benefit ratio of 1:5.09 was registered in treatment with imidacloprid; while in bifenthrin and lambda cyhalothrin treated plot they were 1:4.46 and 1:4.49. The lowest cost benefit ratio (1:2.54) was obtained from treatment with *C.montrouzieri*.

In the results, it is noteworthy to point out that the insecticide imidacloprid was found to be most effective treatment for controlling mealy bugs and exhibited the highest cost benefit ratio of 1:5.09. The treatment buprofezin even showed high monetary returns, but due to higher cost of insecticide and lower yield of 'A' grade flowers gave comparatively lower cost benefit ratio of 1:3.55. Comparative efficacy of buprofezin was also lower than imidacloprid. In absence of research work done on this pest on rose crop in polyhouse condition, the present work could not be compared.

4.5.9 Bioefficacy of different treatments against *H. armigera*.

The data on average number of larvae per plant recorded during pre and post counts are presented in Table 21. It could be seen from the data that pre-count in various treatments was ranged from 2.56 to 2.72 larvae per plant. These observations on incidence were statistically non-significant suggesting the uniform incidence of *H.armigera* on rose plots.

The data recorded on 3rd day after treatment indicated that the larval population ranged between 0.29 to 3.17 larvae per plant. All the treatments

were significantly superior over control in reducing pest population. The treatment with indoxacarb (0.014%) registered significantly fewer larvae per plant (0.29) and found to be most superior treatment. However, it was on par with deltamethrin (0.002%) and spinosad (0.015%) (0.47 larvae/plant). Amongst the microbial pesticides *HaNPV* was found superior (0.69 larvae/plant) over *B.thuringiensis* (1.39 larvae/plant).

The data taken on 7th day after treatment showed the larval population range of 0.20 to 3.23 per plant. The significantly lowest incidence was observed in plots treated with indoxacarb (0.014%) and has emerged as the significantly superior treatment. However, it was on par with spinosad (0.015%) and deltamethrin (0.002%) indicating larval population of 0.33 and 0.40, respectively. Similar trend of efficacy of these insecticides was also observed in past of 3rd day after application. As regards microbial insecticides *B.thuringiensis* (0.55 larvae/plant) emerged as superior over *HaNPV* (0.63 larvae/plant) in reducing larval population and they were on par with each other.

It is evident from the data that average survival larval population recorded 10th DAS varied from 0.12 to 3.13. All the treatments were significantly superior over control. The lowest incidence of 0.12 larvae per plant was observed in plots treated with indoxacarb (0.014%) and has emerged as the most significantly superior treatment and was on par with spinosad (0.015%) and deltamethrin (0.002%). In comparison to untreated control, the application of microbial insecticides viz., *B.thuringiensis*, showed significantly lower larval population (0.40 larvae/plant) and reported to be on par with *HaNPV* (0.49 larvae/plant).

Considering the overall efficacy, the treatment with indoxacarb reported to be the most promising insecticide in reducing larval population of *H.armigera* (0.20 larvae/plant). However, it was found to be on par with spinosad (0.33 larvae/plant) and deltamethrin (0.39 larvae/plant). In context of

microbial insecticide, *HaNPV* stood first in controlling the *H.armigera* (0.60 larvae/plant) followed by *B.thuringiensis* (0.78 larvae/plant).

The present findings are quite comparable with those of Srivastava and Sehgal (2002), Deole *et al.*, (2003), who reported deltamethrin and spinosad as effice against *H.armigera*. Further, the findings of Bhatt and Patel (2002) are also in agreement with present studies reporting the effectiveness of *HaNPV* and *B.thuringiensis* against *H.armigera* infesting chickpea.

4.5.10 Comparative economics of different treatments against *H.armigera* in terms of flower yield.

It can be seen from the data (Table 22) that the flower yield varied from 3311 to 4762 flowers per 5r in treated plots as against 2529 flowers per 5r in untreated control plots. The maximum yield 4762 flowers were obtained in the treatment with spinosad (0.015%) followed by indoxacarb (0.014%), *HaNPV*, *B.thuringiensis* and deltamethrin (0.002%).

The data on yield of 'A' grade flowers indicated that the yield ranged from 2517 to 3613 flowers as against 1046 flowers from the untreated plots. Maximum numbers of 'A' grade flowers were obtained from plot receiving indoxacarb treatment (3613 flowers); while minimum number from plot receiving treatment with *HaNPV* (2517 flowers).

It is evidenced that yield of 'B' grade flowers ranged from 763 to 1238 flowers per 5r as against 1483 flowers from untreated plots. Maximum numbers of 'B' grade flowers were obtained in the plot receiving *HaNPV* treatment (1238 flowers) and less number of grade 'B' flower were obtained from the plot receiving deltamethrin treatment (763 flowers).

Cost : Benefit ratio (C:B)

The cost benefit ratios of different treatments were worked out on the basis of yield of flower (5r area) from each treatments taken for a period of one month and are presented in Table 22.

Table 21. Comparative efficacy of different treatments against *H.armigera* infesting rose.

Sr. No.	Treatment	Pre-count	Survival population 3 DAS/plant				Survival population 7 DAS/plant				Survival population 10 DAS/plant				Overall Mean
			I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	
1.	Spinosad 45 SC	2.68 (1.78)*	0.60 (1.05)	0.44 (0.96)	0.36 (0.93)	0.47 (0.98)	0.48 (0.99)	0.36 (0.93)	0.16 (0.81)	0.33 (0.91)	0.24 (0.86)	0.16 (0.81)	0.12 (0.78)	0.17 (0.82)	0.33 (0.90)
2.	Deltamethrin 2.8 EC	2.60 (1.76)	0.64 (1.06)	0.56 (1.02)	0.20 (0.83)	0.47 (0.97)	0.56 (1.03)	0.52 (1.01)	0.12 (0.78)	0.40 (0.94)	0.48 (0.98)	0.36 (0.93)	0.08 (0.76)	0.31 (0.89)	0.39 (0.93)
3.	Indoxacarb 14.5 SC	2.68 (1.78)	0.48 (0.99)	0.32 (0.91)	0.08 (0.76)	0.29 (0.89)	0.40 (0.95)	0.16 (0.81)	0.04 (0.73)	0.20 (0.83)	0.20 (0.84)	0.16 (0.81)	0.00 (0.71)	0.12 (0.79)	0.20 (0.83)
4.	<i>Bacillus thuringiensis</i> 8L	2.56 (1.74)	1.80 (1.52)	1.52 (1.42)	0.84 (1.16)	1.39 (1.37)	0.84 (1.15)	0.60 (1.05)	0.20 (0.83)	0.55 (1.01)	0.56 (1.03)	0.48 (0.98)	0.16 (0.81)	0.40 (0.94)	0.78 (1.11)
5.	<i>Ita</i> NPV 500LE	2.72 (1.79)	0.96 (1.21)	0.76 (1.12)	0.36 (0.93)	0.69 (1.09)	0.88 (1.17)	0.64 (1.06)	0.36 (0.93)	0.63 (1.05)	0.68 (1.08)	0.56 (1.03)	0.24 (0.86)	0.49 (0.99)	0.60 (1.04)
6.	Control	2.72 (1.79)	2.64 (1.77)	3.16 (1.92)	3.72 (2.05)	3.17 (1.91)	2.88 (1.84)	3.16 (1.92)	3.64 (2.03)	3.23 (1.93)	2.48 (1.73)	3.24 (1.93)	3.68 (2.05)	3.13 (1.90)	3.18 (1.91)
	S.E.+	4.73	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.04
	C.D. at 5%	NS	0.12	0.15	0.11	0.13	0.11	0.12	0.12	0.12	0.12	0.09	0.10	0.10	0.12

DAS: Days after spraying

Figures in parentheses indicate square root transformed $\sqrt{n + 0.5}$

NS: Non-significant

Table 22. Comparative economics of different treatments against *H. armigera* (5r area).

Sr. No.	Treatment	Dose / liter	Cost of insecticide (3 sprays) Rs.	Yield (No of flowers / 5r)			Increases in yield over control		Cost of 3 treatment (B) Rs.	Gross monetary benefit (A) (Rs.)			Net monetary returns (C)	C : B ratio
1	2	3	4	5			6		7	8			9	10
				A	B	Total	A	B		A	B	Total		
1.	Spinosad 45 SC	0.33 ml	507.9	3536	1226	4762	2490	-257	597.9	6225	-514	5711	5113.1	1:8.55
2.	Deltamethrin 2.8 EC	0.7 ml	122.4	2548	763	3311	1502	-720	212.4	3755	-1440	2315	2102.6	1:9.90
3.	Indoxacarb 14.5 SC	1 ml	379	3613	1092	4705	2567	-391	469	6417.5	-782	5635.5	5166.5	1:11.02
4.	<i>B. thuringiensis</i> 8L	2 ml	492	2610	1121	3731	1564	-362	582	3910	-724	3186	2604	1:4.47
5.	<i>HaNPV</i> 500LE	1.5 ml	240	2517	1238	3755	1471	-245	330	3677.5	-490	3187.5	2857.5	1:8.66
6.	Control	-	-	1046	1483	2529	-	-	-	-	-	-	-	-

Concentration and prices of treatments are given in Table 2.

The maximum net monetary return of Rs. 5166.5 from 5r was obtained from the plot receiving indoxacarb sprays. The next best treatment in this context was spinosad with net monetary return of Rs. 5113.1 from 5r. The less net monetary return were obtained from the treatment with *B. thuringiensis* (Rs. 2604/5r).

The highest cost benefit ratio of 1:11.02 was recorded from the treatment with indoxacarb. It was followed by plots receiving sprays with deltamethrin and *HaNPV* with cost benefit ratio of 1:9.90 and 1:8.66, respectively. The least cost benefit ratio (1:4.47) was found to exhibit in treatment with *B.thuringiensis*.

The highest monetary returns per 5r of Rs. 5166.5 was obtained from treatment with indoxacarb and cost benefit ratio derived was highest i.e. 1:11.02. The next best treatment in terms of cost benefit ratio was deltamethrin (1:9.90) followed by *HaNPV* (1:8.66), spinosad (1:8.55) and *B.thuringiensis* (1:4.47).

Due to lack of research work on this line done on *H.armigera* in polyhouse, the present work and its economic could not be compared with other workers.

4.5.11 Bioefficacy of different treatments against *S.litura*

The data on pre and post count observations are presented in Table 23. It could be seen from data that pre-count observations in different treatments were ranged from 3.84 to 4.24 larvae per plant.

The data recorded on 3rd DAS revealed that *S.litura* larval number per plant varied from 0.69 to 4.16 in different treatment. All the treatments tried were significantly superior over control in reducing larval population. The treatment with indoxacarb (0.014%) emerged as the significantly superior to all other treatments and recorded significantly less number of larvae per plant (0.69). It was followed by abamectin (0.005%) and profenophos (0.20%), which were at par with each other and recorded 1.03 and 1.24 larval population

per plant, respectively. Amongst the microbial pesticides, *S/NPV* was found found to be superior (1.29 larvae/plant) over *N.rileyi* (2.51 larvae/plant) and *B.thuringiensis* (2.77 larvae/plant).

The data recorded 7th DAS on larval count showed the range of 0.47 to 4.25 larvae per plant. The treatment with indoxacarb (0.014%) sustained least infestation and it was found most effective treatment recording 0.47 larvae per plant. The treatment with abamectin (0.005%) and profenophos (0.20%) recorded 0.81 and 0.84 larvae per plant were found to be next best treatment and statistically on par with indoxacarb. It was followed by a microbial insecticide viz., *N.rileyi*, which recorded 1.08 larvae per plant and was found to be on par with *S/NPV* showing 1.12 larvae per plant. A bacterial insecticide *B.thuringiensis* was found to be least effective (2.61 larvae/plant) in controlling *S.litura*.

The observations on survival larval population of *S.litura* recorded 10 DAS observed to be 0.25 to 1.04 in treated plots and 4.25 in untreated plots. The superiority (0.25 larvae/plant) of indoxacarb (0.014%) was found persisted and found to be significantly superior over rest of the treatments except abamectin (0.43 larvae/plant) and profenophos (0.49 larvae/plant). The best microbial treatment in the order of merit was *N.rileyi*, which recorded 0.79 larvae per plant and was statistically on par with *S/NPV* showing 0.84 larvae per plant. The treatment with *B.thuringiensis* was least effective in controlling the pest harbouring 1.04 larvae per plant.

The overall efficacy of treatments tried indicated the superiority of indoxacarb 0.014% (0.47 larvae/plant) in controlling *S.litura*. The treatment with abamectin 0.005% and profenophos 0.20% were found equally effective (0.76, 0.86 larvae/plant) as compared to indoxacarb. Amongst microbial insecticides tested, *S/NPV* proved to be potent to reduce larval count followed by *N.rileyi* and *B.thuringiensis*.

The literature on efficacy of different pesticides for the control of *S.litura* infesting rose crop is lacking. Hence, the information pertaining to

S.litura on the crops like pulses, vegetables, fiber crops has also been employed to compare the results of present findings. In the present findings, *SINPV* was found to be most effective treatment controlling the *S.litura*, however; it was followed by *N.rileyi* and *B.thriungiensis*. These results corroborate with the studies carried out earlier by Jayaraj *et al.*, (1981), who reported the field application of *SINPV* @ 250 to 500 LE/ha on cotton resulted in 80.6 - 87.7% larval mortality. Further, similar workers found increased in yield in tune of 13.3 and 66.0% in black gram (*Phaseoleus mungo* L.) and groundnut (*Arachis hypogaea* L.), respectively.

Vimala Devi *et al.*, (1996) reported the *N. rileyi*, an entomopathogenic fungus of cosmopolitan occurrence, causes epizootics of major noctuid pests like *H.armigera* and *S.litura* on a variety of crops. Jayaraj *et al.*, (1981), Jayachadran and Chaudhari (1996), Satpathy *et al.*, (1998), Prasad and Kumar (2000) and Vimala Devi *et al.*, (2002) reported the *SINPV*, *B.thriungiensis* and *N.rileyi* as effective treatment against *S.litura* larvae on different crops.

Of the three chemical insecticides tested in present studies against *S.litura*, one insecticide, indoxacarb at 0.014% spray concentration was found most promising in controlling *S.litura*. Other workers also agreed regarding toxicity of indoxacarb where in they worked out toxicity against 9 days old larvae of *S.litura* in laboratory and found high degree of toxicity in terms of LC_{50} value (Pande and Srivastava, 2003).

4.5.12 Comparative economics of different treatments against *S.litura* in terms of flower yield.

It can be seen from the data (Table 24) that the flower yield is varied from 3398 to 5422 flowers per 5r in treated plots as against 3029 flowers per 5r in untreated control plots. The maximum yield 5422 flowers per 5r were obtained in the treatment with abamectin followed by indoxacarb (4447), *B.thriungiensis* (4229), *SINPV* (3778), profenophos (3521) and *N.rileyi* (3398).

Table 23. Comparative efficacy of different treatments against *S. litura* infesting rose.

Sr. No.	Treatment	Pre-count	Survival population 3 DAS/plant				Survival population 7 DAS/plant				Survival population 10 DAS/plant				Overall Mean
			I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	
1.	Abamectin 1.9 EC	4.24 (2.18)*	1.24 (1.31)	1.00 (1.21)	0.84 (1.14)	1.03 (1.22)	1.00 (1.21)	0.80 (1.13)	0.64 (1.06)	0.81 (1.13)	0.56 (1.02)	0.44 (0.96)	0.28 (0.88)	0.43 (0.95)	0.76 (1.10)
2.	Indoxacarb 14.5 SC	4.12 (2.15)	0.92 (1.18)	0.68 (1.08)	0.48 (0.98)	0.69 (1.08)	0.64 (1.06)	0.44 (0.97)	0.32 (0.90)	0.47 (0.98)	0.40 (0.94)	0.24 (0.86)	0.12 (0.79)	0.25 (0.86)	0.47 (0.97)
3.	Profenophos 50 EC	3.84 (2.08)	1.44 (1.38)	1.24 (1.32)	1.04 (1.24)	1.24 (1.31)	1.04 (1.23)	0.84 (1.15)	0.64 (1.07)	0.84 (1.15)	0.64 (1.05)	0.48 (0.99)	0.36 (0.93)	0.49 (0.99)	0.86 (1.15)
4.	<i>Nomuraea rileyi</i>	4.20 (2.17)	3.28 (1.94)	2.28 (1.66)	1.96 (1.56)	2.51 (1.72)	1.40 (1.36)	1.00 (1.20)	0.84 (1.15)	1.08 (1.24)	0.96 (1.20)	0.80 (1.14)	0.60 (1.05)	0.79 (1.13)	1.46 (1.36)
5.	SNPV 500 LE	3.92 (2.10)	1.64 (1.45)	1.20 (1.29)	1.04 (1.23)	1.29 (1.32)	1.44 (1.38)	1.04 (1.24)	0.88 (1.17)	1.12 (1.26)	1.04 (1.23)	0.84 (1.15)	0.64 (1.06)	0.84 (1.15)	1.08 (1.24)
6.	<i>Bacillus thuringiensis</i> 8L	4.28 (2.18)	3.28 (1.93)	2.84 (1.83)	2.20 (1.64)	2.77 (1.80)	2.64 (1.77)	3.40 (1.97)	1.80 (1.52)	2.61 (1.75)	1.24 (1.31)	1.00 (1.22)	0.88 (1.17)	1.04 (1.23)	2.14 (1.59)
7.	Control	3.96 (2.11)	3.96 (2.11)	4.60 (2.26)	3.92 (2.10)	4.16 (2.16)	4.16 (2.16)	4.56 (2.25)	4.04 (2.13)	4.25 (2.18)	4.36 (2.21)	4.28 (2.19)	4.12 (2.15)	4.25 (2.18)	4.22 (2.17)
	S.E.+	5.79	0.09	0.07	0.07	0.08	0.08	0.07	0.06	0.07	0.08	0.06	0.05	0.06	0.07
	C.D. at 5%	NS	0.26	0.22	0.22	0.23	0.24	0.21	0.18	0.21	0.23	0.17	0.13	0.18	0.21

DAS: Days after spraying

Figures in parentheses indicate square root transformed values $\sqrt{n + 0.5}$

NS: Non-significant

Table 24. Comparative economics of different treatments against *S.litura* (5r area).

Sr. No.	Treatment	Dose / liter	Cost of insecticide (3 sprays) Rs.	Yield (No of flowers / 5r)			Increases in yield over control		Cost of 3 treatment (B) Rs.	Gross monetary benefit (A) (Rs.)			Net monetary returns (C)	C : B ratio
				5			6			8				
				A	B	Total	A	B		A	B	Total		
1	2	3	4						7				9	10
1.	Abamectin 1.9 EC	0.25 ml	1300	3792	1630	5422	2546	-153	1390	7638	-306	7332	5942	1:4.27
2.	Indoxacarb 14.5 SC	1 ml	379	3947	500	4447	2701	-1283	469	8103	-2566	5537	5068	1:10.81
3.	Profenophos 50 EC	4 ml	250	2368	1153	3521	1122	-630	340	3366	-1260	2106	1766	1:5.19
4.	N. rileyi	2 g	150	2254	1144	3398	1008	-639	240	3024	-1278	1740	1506	1:6.28
5.	SNPV 500 I.E	1.5 ml	240	2630	1148	3778	1384	-635	330	4152	-1270	2882	2552	1:7.73
6.	B. thuringiensis 8L.	2 ml	492	2946	1283	4229	1700	-500	582	5100	-1000	4100	3518	1:6.04
7.	Control	-	-	1246	1783	3029	-	-	-	-	-	-	-	-

Concentration and prices of treatments are given in Table 2.

The yield range of 'A' grade flowers was found between 2254 to 3947 flowers as against 1246 flowers in untreated plots. Maximum number of 'A' grade flowers were obtained from plots receiving indoxacarb treatment (3947 flowers), while minimum number of flowers was obtained from plot receiving treatment with *N.rileyi* (2254 flowers). The treatment with abamectin, *B.thriungiensis*, *SINPV* and profenophos recorded 3792, 2946, 2630 and 2368 flowers from 5r, respectively.

The data on yield of 'B' grade flowers showed wide variation ranging from 500 to 1630 flowers as against 1783 flowers from untreated plots. Maximum numbers of 'B' grade flowers were produced in untreated control plots (2265 flowers); while less number of grade 'B' flower were obtained from the plot receiving indoxacarb treatment (500 flowers).

Cost : Benefit ratio (C:B)

The cost benefit ratio of different treatments tested against *S. litura* was calculated (5r area) and is presented in Table 24. The cost benefit ratios were worked out on the basis of yield of flower from each treatments for a period of one month.

It is seen from the Table 24 that a maximum net monetary return of Rs. 5942 from 5r was obtained from the plot receiving abamectin sprays. The next best treatment in this context was indoxacarb (Rs. 5068/5r). The less net monetary returns was obtained from the treatment with *N.rileyi* (Rs. 1506/5r).

The different cost benefit ratios were derived in different treatments .The highest cost benefit ratio was recorded from the treatment with indoxacarb (1:10.81); while *S/NPV* and profenophos treated plot registered the cost benefit ratios of 1:7.73 and 1:6.28. The least cost benefit (1:2.54) was obtained from treatment with abamectin being costly insecticide. In the present study, the insecticide indoxacarb found to be the most efficacious in controlling the *S.litura* and also generated highest CBR of 1:10.81.

The present findings could not be corroborated with others work, as so far no work on *S.litura* infesting rose in polyhouse seems to be carried out.

4.5.13 Bioefficacy of different treatments against mites (*T.urticae*)

The pre and post count observation were recorded and presented in Table 25. The data recorded on 2 DAS noticed that mite population per leaf varied from 8.73 to 76.16 in different treatments. All the treatments were significantly superior over control in reducing the mite population. The treatment with abamectin (0.005%) emerged as the significantly superior to all others recording significantly less number of larvae (8.73/plant) except milbemectin 0.009% (10.13 mites/leaf). The other treatments in order of merit of control were: fenazaquin (0.02%), fenpropathrin (0.02%), difenthiuron (0.15%) and mineral oil.

A wide range of survival population of mite was noticed when recorded on 7th DAS (3.56 to 81.80/leaf). The treatment with abamectin showed significant reduction in mite population (3.56 mites/leaf) as compared to other treatments. The rests of the treatments on their merit of control were: milbemectin > fenazaquin > fenpropathrin > difenthiuron > mineral oil.

The survival mite population recorded on 10th DAS was found to exist wide range (2.54 to 87.15 mites/leaf) in which abamectin was found to stand first showing significant superiority (2.54 mites/leaf) over rests of the treatments. The next best treatment in order of merit were: milbemectin > fenazaquin > fenpropathrin > difenthiuron > mineral oil (3.09 to 38.82 mites/leaf).

The data on overall effectiveness of different treatments enlightened on the superiority of abamectin which proved to be most promising miticide (4.94 mites/leaf). The acaricide, milbemectin was found to be on par with abamectin in reducing mite population (6.04 mite/leaf). The rests of the treatments in decreasing order of their efficacy were: fenazaquin > fenpropathrin > difenthiuron > mineral oil.

In present findings, the treatments *viz.*, abamectin 1.9 EC was found to be most promising in controlling mite populaton and it was followed by milbemectin, fenazaquin, fenpropathrin and difenthiuron. These findings corroborated with studies earlier carried out by Hoyt *et al.*, (1987). Further, these workers also reported the development of resistance by spider mites to broad range acaricides under polyhouse condition.

Earlier worker tested the efficacy of certain acaricides *viz.*, abamectin, milbemectin, difenthiuron, fenazaquin and these proved to be effective against mites in polyhouse conditions were Aguiar *et al.*, (1995), Jhansi Rani and Jaganmohan (1997), Wang-wenjer *et al.* (1997), Kharmate and Chandele (1997), Dhar *et al.*, (2000), Ghosh (2001), Jhansi Rani and Sridhar (2002), Jayachandran (2003) and Akashe *et al.*, (2003). Further, these workers reported non-phytotoxicity of these chemicals to plants, low mammalian toxicity, relatively low toxicity to beneficial fauna and quick degradability in the environment.

4.5.14 Comparative economics of different treatments against *T.urticae* in terms of flower yield.

It can be seen from the data (Table 26) that the flower yield is varied from 3073 to 5181 flowers from 5r in treated plots as against 2303 flowers per 5r in untreated control plots. The maximum yield of 5182 flowers was obtained in the treatment with abamectin followed by fenazaquin 0.02 per cent (4021 flowers), difenthiuron 0.15 per cent (3641 flowers), milbemectin 0.009 per cent (3541 flowers), fenpropathrin 0.02 per cent (3258) and mineral oil @ 15 ml per litre of water (3073 flowers).

The data on yield of 'A' grade flowers indicated the range of flowers between 1942 to 4035 as against 1058 flowers from the untreated plots. Maximum numbers of 'A' grade flowers were obtained from plot treated with abamectin (4035 flowers); while minimum from plot with mineral oil (1942 flowers).

Table 25. Comparative efficacy of different treatments against mites (*T. urticae*) infesting rose.

Sr. No.	Treatment	Pre-count	Survival population 2 DAS/leaf			Survival population 7 DAS/leaf			Survival population 10 DAS/leaf			Overall Mean
			I st spray	II nd spray	III rd spray	Av.	I st spray	II nd spray	III rd spray	Av.	I st spray	
1.	Milbemectin IEC	46.92 (6.89)*	12.37 (3.58)	10.32 (3.28)	7.69 (2.85)	10.13 (3.24)	6.51 (2.63)	4.67 (2.25)	3.50 (1.99)	4.89 (2.29)	3.09 (1.86)	6.04 (2.46)
2.	Abamectin 1.9 EC	44.25 (6.69)	10.55 (3.32)	9.36 (3.14)	6.28 (2.60)	8.73 (3.02)	4.39 (2.20)	3.55 (2.00)	2.75 (1.80)	3.56 (2.00)	2.54 (1.72)	4.94 (2.25)
3.	Difenthiuron 50 WP	41.04 (6.45)	37.28 (6.15)	32.50 (5.74)	29.50 (5.48)	33.09 (5.79)	31.43 (5.65)	26.58 (5.21)	29.49 (5.47)	29.17 (5.44)	29.49 (5.45)	30.58 (5.56)
4.	Fenazaquin 10 EC	51.16 (7.19)	19.79 (4.51)	16.17 (4.08)	9.88 (3.22)	15.28 (3.94)	15.19 (3.96)	15.57 (3.61)	7.69 (2.86)	12.82 (3.48)	8.84 (2.96)	12.31 (3.46)
5.	Fenpropathrin 30 EC	40.34 (7.19)	11.51 (3.46)	10.55 (3.32)	13.64 (3.76)	11.90 (3.51)	7.82 (2.88)	6.94 (2.72)	9.74 (3.20)	8.17 (2.93)	23.81 (4.94)	14.63 (3.80)
6.	Mineral oil	48.52 (7.00)	28.62 (5.38)	26.52 (5.18)	25.72 (5.12)	26.95 (5.23)	33.92 (5.86)	33.23 (5.81)	30.29 (5.55)	32.48 (5.74)	38.82 (6.26)	32.75 (5.74)
7.	Control	47.65 (6.94)	51.99 (7.25)	77.69 (8.84)	98.81 (9.96)	76.16 (8.68)	58.68 (7.69)	83.61 (9.17)	103.12 (10.18)	81.80 (9.01)	87.15 (9.31)	81.70 (9.00)
	S.E.+	0.06	0.09	0.11	0.08	0.09	0.11	0.09	0.08	0.09	0.09	0.09
	C.D. at 5%	0.17	0.27	0.32	0.23	0.27	0.31	0.27	0.23	0.27	0.27	0.27

DAS: Days after spraying

Figures in parentheses indicate square root transformed values $\sqrt{n} + 0.5$

Table 26. Comparative economics of different treatments against mites (*T. urticae*) (5r area).

Sr. No.	Treatment	Dose / liter	Cost of insecticide (3 sprays) Rs.	Yield (No of flowers / 5r)			Increases in yield over control		Cost of 3 treatment (B) Rs.	Gross monetary benefit (A) (Rs.)			Net monetary returns (C)	C : B ratio
				5			6			8				
				A	B	Total	A	B		A	B	Total		
1	2	3	4						7				9	10
1.	Milbemectin IEC	0.9 ml	486	2954	587	3541	1896	-658	576	5688	-1316	4372	3796	1:6.59
2.	Abamectin 1.9 EC	0.25 ml	1000	4035	1146	5181	2977	-99	1090	8931	-198	8733	7643	1:7.01
3.	Difenthiuron 50 WP	3 g	621	2687	954	3641	1629	-291	711	4887	-582	4305	3594	1:5.05
4.	Fenazaquin 10 EC	2 ml	750	2784	1237	4021	1726	-8	840	5178	-16	5162	4322	1:5.15
5.	Fenpropathrin 30 EC	0.7 ml	325	2364	894	3258	1306	-351	415	3918	-702	3216	2801	1:6.75
6.	Mineral oil	15 ml	270	1942	1131	3073	884	-114	360	2652	-228	2424	2064	1:5.73
7.	Control	-	-	1058	1245	2303	-	-	-	-	-	-	-	-

Concentration and prices of treatments are given in Table 2.

A wider range of variation in yields data of 'B' grade flowers was observed in treated plots (587 to 1237) as against 1245 flowers ripped in untreated plots. The highest numbers of flowers ('B; grade) were noted in plots treated with fenazaquin (1237); while lower in milbemectin treatment (587).

Cost : Benefit ratio (C:B)

The cost benefit ratios of different treatments were worked out on the basis of flower yield computed from 5r area from each treatments recorded for a period of one month and are presented in Table 26.

It is seen that maximum net monetary returns of Rs. 7643/- were obtained from the plot receiving abamectin sprays. The next best treatments in this context were fenazaquin with net monetary returns was Rs. 4322/-. The treatment of mineral oil sequenced at last in terms of net monetary return (2064).

The highest cost benefit ratio of 1:7.01 was recorded from the treatment with abamectin. It was followed by plots receiving sprays with fenpropathrin and milbemectin with cost benefit ratio of 1:6.75 and 1:6.59, respectively. The low cost benefit ratio (1:5.05) was derived from treatment with difenthiuron.

It could be seen from Table 26 that the treatment abamectin generated highest cost benefit ratio of 1:7.01 with higher net monetary returns (Rs.7643/-) The next best treatment in respect of CBR was fenpropathrin (1:6.75) followed by milbemectin (1:6.59), mineral oil (1:5.73), fenazaquin (1:5.15) and difenthiuron (1:5.05).

In view of absence of past research work on CBR rose mite in polyhouse, the present work could not be compared.

4.6 Effect of IPM Components on Flower Yield and CBR in Rose.

Studies were conducted to evaluate the relative efficacy of different IPM components against major pests of rose in two blocks comprising one with IPM technology and other without IPM. Two years data embodied in Table 27 revealed the superiority of the plot receiving IPM technology over untreated

control. The plots those received IPM technology recorded the lowest incidence of thrips (2.68/flower), aphids (16.29/shoot), white flies (2.50/leaves), mealy bugs (25.44/twig), *H.armigera* (0.66 larvae/plant), *S.litura* (1.37 larvae/plant) and mites (16.88/leaves) as compared to untreated control. The incidence thrips, aphids, white flies, mealy bugs, *H.armigera*, *S.litura* and mites in controlled plots was comparatively higher in tune of 11.17, 63.6, 10.49, 95.38, 3.16, 4.20 and 81.70, respectively. It can be seen from Table 27 that the flower yield of 9948 from 5r was obtained in the IPM plot as against 6076 flowers from 5r in untreated control plots. The data revealed that the yield obtained from IPM plot was higher over control. The cost benefit ratios of different treatments tried against different pests in both plots were computed (each plot of 5r area) and presented in Table 27. The marketable yield and quality parameters were recorded at harvest of flowers on gross plot basis. The cost benefit ratios were worked out on the basis of flowers yield from each plot recorded during 2004-05 and 2005-06. The overall performance of the IPM module was found to be encouraging when compared with the untreated control.

None of the treatments showed any phytotoxicity symptoms and off smell to flowers; which is desirable from commerce point of view. The phytotoxicity and dissipation study was undertaken by collecting the samples on 0, 1, 3, 7 and 15 days after spraying and analyzed in the laboratory of International Institute of Biotechnology and Toxicology (IIBAT), Kanchipuram Estate, Paddapai, Chennai.

There was a clear revelation from foregoing discussion that sequential application of bio-agents or bio-pesticides or neem product and chemical pesticides performed better in managing the pest population in rose than the sole use of biocontrol agents or biopesticides. These findings are in agreement with the results of Suganthi and Tej Kumar (2000); Patel *et al.*, (2002); Srinivasa Rao and Dharma Reddy (2003).

Table 27. Effect of IPM components on flower yield and CBR in rose (5r polyhouse)

Particular		IPM	Control
1.	Thrips/flower :	2.68	11.17
2.	Aphids/shoot :	16.29	63.6
3.	White flies/leaf :	2.50	10.49
4.	Mealy bugs/twig :	25.44	95.38
5.	<i>H.armigera</i> larvae/plant :	0.66	3.16
6.	<i>S. litura</i> larvae/plant :	1.37	4.20
7.	Mites/leaf :	16.88	81.70
Yield 'A' Grade flowers :		2706	1014
'B' Grade flowers :		915	1517
Total :		3621	2531
Gross return (Rs.) :		9948	6076
Cost of treatments (Rs.) :		466	-
Net return (Rs.) :		3406	-
Cost Benefit Ratio (CBR) :		1 : 7.31	-

Suganthy and Tej Kumar (2000) reported maximum yield of 11.7 q/ha obtained with IPM practices against *H.armigera* in chickpea as against 7.4 q/ha in the control plots. Further, Patel *et al.*, (2002) studied GAU IPM module (Installation of pheromone trap, spray of H₁aNPV @ 250LE/ha, spray of NSKE 5% and spray of monocrotophos 0.04% followed by endosulfan 0.07% spray) found effectively managed the population of *H. armigera*.

In support of present findings, the work carried out by Srinivasa Rao and Dharma Reddy (2003) could be cited, wherein they reported less pod and grain damage in IPM modules (8.6-9.6%) followed by endosulfan and NPV treatments. Further, worker also noted highest grain yield and CBR in IPM module with enhanced activities of predatory fauna of coccinellids and spiders.

On the basis of seasonal incidence of pest and prevalent weather condition during 2004-05 and 2005-06, the IPM module for management of pests infesting roses under polyhouse condition is formulated as under.

IPM Module for Management of Pests Infesting Roses Under Polyhouse Condition

Month	Target Pest	Management Practices
January	<i>H. armigera</i> Mealy bugs Aphids, thrips, whiteflies	- Spray <i>B. thuringiensis</i> (Btk) 2ml/lit + Triton 0.1% at 15 days interval. - Monitor the crawlers by traps made of sticky tapes - Spray <i>V. lecanii</i> @ 4 g/lit at 15 days interval. - Release <i>C. montrouzieri</i> @ 4 grubs/ plant. - Spray imidacloprid and thiamethoxam alternatively at 15 days interval.
February	<i>H. armigera</i> Mealy bugs Aphids, whiteflies Mites	- Spray deltamethrin and spinosad alternatively at 15 days interval. - Spray lambda cyhalothrin and bifenthrin alternatively at 15 days –interval. - Spray mineral oil at 15 days interval. - Monitor the population by inspecting middle to lower leaves with hand lens.
March	Mites Mites, thrips, <i>H. armigera</i> , Mealy bugs Thrips	- Give adequate irrigations and operate regularly overhead sprinklers / foggers. - Remove lower and dried leaves. - Spray mineral oil @ 15 ml/lit at 15 days interval - Spray indoxacarb and imidacloprid alternatively at 15 days interval. - Monitor the population with blue sticky cards.
April	Mites	- Spray fenpropathrin and milbemectin alternatively at 15 days interval.

	Mealy bugs	- Spray lambda cyhalothrin and buprofezin alternatively at 15 days interval.
	Thrips	- Spray fipronil and thiamethoxam alternatively at 15 days interval.
May	Mites	- Spray fenazaquin and abamectin alternatively at 15 days interval.
	Mealy bugs	- Spray bifenthrin and imidacloprid alternatively at 15 days interval.
	<i>S. litura</i> , whiteflies	- Monitor the population in pheromone traps / yellow sticky cards.
June	<i>S. litura</i>	- Collect and destroy egg masses and early instar caterpillars.
		- Spray SINPV @ 500LE /ha (2.25×10^{12} POBs/ml) + jaggery @ 0.5% + Triton @ 0.1% + UV protectant (fabric whitener-1ml/lit) at 15 days interval.
	Mites	- Spray difenthiuron and milbemectin alternatively at 15 days interval.
	Mealy bugs, whiteflies	- Spray lambda cyhalothrin and imidacloprid alternatively at 15 days interval.
July	<i>S. litura</i>	- Spray <i>B. thuringiensis</i> (Btk) 2ml/lit + Triton 0.1%
		- Spray <i>N. rileyi</i> @ 2g/lit.
	Mites	- Spray fenpropathrin and abamectin alternatively at 15 days interval.
	Whiteflies,	- Spray <i>V. lecanii</i> @ 4 g/ha at 15 days interval
	Mealy bugs,	
	Aphids	- Release <i>C. carnea</i> @ 4 grubs/ plant.
	Aphids	- Monitor the population with blue sticky cards/ yellow sticky cards.
	Thrips, aphids	
August	<i>S. litura</i>	- Spray profenophos and indoxacarb alternatively at 15 days interval.

	Aphids, mealy bugs, whiteflies, mealybugs, thrips Thrips Mites	- Spray buprofezin and imidacloprid alternatively at 15 days interval - Release <i>C. carnea</i> @ 4 grubs/ plant. - Monitor the population by inspecting middle to lower leaves with hand lens.
September	<i>S. litura</i> , mites White flies, mealy bugs, thrips Mealy bugs Aphids	- Spray abamectin and indoxacarb alternatively at 15 days interval. - Spray FORS and <i>V. lecanii</i> alternatively at 15 days interval. - Release <i>C. montrouzieri</i> @ 4 grubs/ plant. - Spray thiamethoxam and imidacloprid alternatively at 15 days interval.
October	<i>S. litura</i> White flies, mealy bugs, thrips Mites <i>H. armigera</i>	- Spray <i>N. rileyi</i> @ 2g/lit at 15 days interval. - Spray <i>V. lecanii</i> and imidacloprid alternatively at 15 days interval. - Spray abamectin and difenthiuron alternatively at 15 days interval. - Monitor the population with pheromone traps.
November	White flies Mealy bugs, aphids Mealy bugs Thrips Mites Aphids <i>H. armigera</i>	- Spray azadirachtin @ 5ml/lit and acephate alternatively at 15 days interval. - Spray <i>V. lecanii</i> @ 4 g/lit at 15 days interval. - Release <i>C. montrouzieri</i> @ 4 grubs/ plant. - Spray spinosad and fipronil alternatively at 15 days interval. - Spray fenazaquin and mineral oil alternatively at 15 days interval - Release <i>C. carnea</i> @ 4 larvae/ plant. - Release <i>T. chilonis</i> @ 1.5 lakh/ha at 15 days interval.

December	Whiteflies, mealy bugs <i>II. armigera</i>	- Spray bifenthrin and buprofezin alternatively at 15 days interval. - Spray HaNPV 500LE (2.25×10^{12} POBs/ml) + jaggery 0.5% + Triton 0.1% + UV protectant (fabric whitener-1ml/lit) per hectare at 15 days interval.
	Aphids, thrips	- Spray thiamethoxam and acetamiprid alternatively at 15 days interval.
	Mites	- Spray fenpropathrin and milbemectin alternatively at 15 days interval.

- Need based and timely application of pesticides was done.
- Fish oil rosin soap @ 5 g/lit mixed with insecticides against mealy bugs at every spraying.

**SUMMARY AND
CONCLUSION**

5. SUMMARY AND CONCLUSIONS

Rose (*Rossa* spp.) is one of the principal cut flowers grown under polyhouse condition. The different pests, thrips (*F.schultzei*), aphids (*M.rosae*), whiteflies (*T.vaporariorum*), mealy bugs (*P.citri*), foliage feeders/bud borers (*H.armigera*, *S.litura*), and mites (*T.urticae*) are of regular occurrence and cause severe damage. However, except biology, there is not much systematic information on other aspects of these pests is available. Hence, the present investigations were carried out to find out seasonal incidence of these pests and varietal reaction of thirty-five cultivars. Further, the efficacies of different components of IPM were evaluated and IPM module was formulated. These studies were undertaken at Pune and Maval during the year 2004-05 and 2005-06. The important findings are summarised below:

5.1 Seasonal Incidence

5.1.1 Thrips, *Frankliniella schultzei*

The thrip incidence at Pune was observed twice in a year first being from third week of June to second week of January and second in last week of February to last week of April. During this period the population gradually increased and reached to its peak in second week of November (52.5 thrips/trap) and second peak in first week of April (14.5thrips/trap) (Table 4). Thereafter, the pest activity slowly decreased and crop was free from incidence in the month of May and June. The meteorological parameters during this period were T_{max} , T_{min} , RH-I, RH-II and LI as 33.4°C, 17.2 °C, 62%, 43% and 70.5 klux that were very congenial to pest multiplication. The thrip population was positively correlated with LI and negatively with T_{max} .

At Maval, the incidence of thrips per flower ranged from 0.60 to 23.43 (Table 5). The maximum population was noticed in 43 MW (October), during this period T_{max} , T_{min} , RH-I, RH-II and LI were 38.7°C, 19.4°C, 66%, 57% and 57 klux, respectively; while the Ct_{min} , Ct_{max} , Crh-I and Crh-II were 24.3 °C, 31.5 °C, 68% and 64%, respectively.

The highly significant negative correlation of thrip population was found with humidity; while positive correlation was found with temperature.

5.1.2 Aphids, *Macrosiphum rosae*

There were two broods, first from July to September and second in November to February. At Pune, the incidence of aphids during experimental period ranged from 0.50 to 63.70 aphids per shoot. The maximum population was noticed in 4 MW, during this period $T_{\max}$ (32.5°C), $T_{\min}$ (13.3°C), RH-I (70%), RH-II (50%) and LI (64.9 klux); while the crop canopy $Ct_{\min}$, $Ct_{\max}$, Crh-I and Crh-II were 14.7°C, 28°C, 75% and 53%, respectively prevailed. A highly significant relationship was found existing between aphid incidence and meteorological parameters of temperature and humidity.

At Maval, significantly higher number of aphids (86.96 aphids/shoot) was observed in 5 MW. During this period temperature and humidity were ranged from 11.9 to 37.6°C and 56 to 84%. Aphid incidence was not noticed from March to June due to high temperature (34.3 to 41.6°C) and low humidity (60 to 71%). Aphid population was negatively correlated with temperature and humidity.

5.1.3 Whiteflies, *Trialeurodes vaporariorum*

Studies on influence of weather factors on the incidence of whitefly revealed positive correlation with $T_{\min}$ and humidity. $T_{\max}$ and LI had adverse effect on pest, indicating negative relationship between them. The peak population (12.13 whitefly/leaf) was recorded in 36 MW, when $T_{\max}$, $T_{\min}$, RH-I, RH-II and LI were 30°C, 24.4°C, 94%, 77% and 47.2 klux; while the canopy morning and noon temperature and humidity were 26.9°C, 28.4°C, 99% and 87%, respectively at Pune.

At Maval, the activity of pest was also governed by temperature and humidity. The prevailed condition at high incidence (19.66 whiteflies/leaf) was 34.2°C ($T_{\max}$), 21.5°C ($T_{\min}$), 65% (RH-I), 57% (RH-II) and 46 klux (LI); while the 21.8°C ($Ct_{\min}$), 28.1°C ($Ct_{\max}$), 74% (Crh-I) and 53% (Crh-II). There was

evidence of adverse effect of maximum temperature and high light intensity on population build up of whiteflies.

5.1.4. Mealy bugs, *Planococcus citri*

The infestation of mealy bugs was observed throughout the year at Maval; while it was very trace at Pune. The maximum population (144.28 mealy bugs/twig) was found in the month of March and minimum (1.52 mealy bugs/twig) in May. A negative correlation was found established between population build up and crop canopy temperature.

5.1.5 *Helicoverpa armigera*

The incidence of *H.armigera* was found to be once in a year i.e. from October to March. In general, incidence recorded at Maval was higher (2.04 to 2.52 larvae/plant) than recorded at Pune (1.33 to 1.84 larvae/plant). The incidence of *H.armigera* initiated in the first week of November and reached its peak in second fortnight of February at Pune. The $T_{\max}$ and $T_{\min}$ during this period were 29.9°C and 12.3°C. The pest showed negative correlation with $T_{\max}$ ($r = -0.37$) and canopy $Ct_{\max}$ ($r = -0.27$).

At Maval, incidence of *H.armigera* was started early i.e. last week of September and persisted late upto 4th week of March as compared to Pune. However, considerably higher number of larvae per plant was recorded (2.04 to 2.52) in the month of February. During this period temperature and humidity ranged between 13.1 to 39.2°C and 63 to 86%. Thus, the morning humidity was favourable, while the afternoon humidity had adverse effect.

5.1.6 *Spodoptera litura*

In general, higher incidence of *S.litura* was recorded at Maval as compared to Pune. The larval population increased from May and reached its peak during July (4.60 larvae/plant, Maval) and August (4.45 larvae/plant, Pune) and continued upto October. The temperature from 20.5 to 35.8°C, humidity 78 to 96% and light intensity 34.6 to 56.7 klux was found congenial for population build up of *S.litura*. The minimum temperature and morning humidity have positive correlation with *S.litura* infestation at Pune and Maval.

5.1.7 Mites, *Tetranychus urticae*

Mite infestation was noticed all the year round except in severe winter and mid-monsoon due to low temperature and high humidity. The average mite population per leaf ranged from 0.58 to 162.28 and 0.66 to 117.62 at Pune and Maval, respectively. The incidence of mite was higher at Pune than Maval. The population build up started during February and reached to its peak in the first week of May and declined thereafter. The mite incidence was found to be positively correlated with maximum temperature and negatively correlated with morning humidity. The higher temperature and lower humidity was found to be congenial for development of mite; while low temperature and high humidity showed adverse effect on growth.

5.2 Effect of Growth Media on The Incidence of Pest

The population of thrips, aphids, whiteflies, mealy bugs, *H.armigera*, *S.litura* and mite were found to be higher on the rose crop grown in soil medium as compared to sole cocopeat medium. The acidic pH (5.9) of cocopeat favour the crop growth due to availability of macro and micronutrients, which ultimately resist the development of pest population. The sole cocopeat makes avoidance to pests to take shelter, oviposition and hibernation.

5.3 Screening of Rose Cultivars

Thirty-five rose cultivars from various rose groups viz., Hybrid teas, Sweet heart and Floribundas were evaluated under polyhouse conditions against thrips, aphids, whiteflies, mealy bugs, *H.armigera*, *S.litura* and mites. None of which found completely immune except in case of mealy bugs. The cultivar 'Temptation' was found to be less susceptible to thrips. The morphological characters of plants like purple and pink flower colour with low flower yield ability showed susceptibility to thrips.

As regards to reaction with aphid, one cultivar viz., 'Saphir' exhibited consistent resistance through out the year harbouring lower aphid population. The cultivars with yellow and white flowers showed susceptibility to aphids.

The cultivars Merilan, Miracle, Grand gala, Eldorado and Pink Noblesse were found less susceptible to whitefly infestation. In general, the cultivars with yellow flowers tend to harbour higher whitefly population and showed susceptibility to whiteflies.

In studies undertaken on resistance of mealy bugs, the cultivars *viz.*, Naranga, Queensday and Eldorado were found completely immune to attack of mealy bug. The visual observations showed that the cultivars with shorter stem length were less susceptible to mealy bugs. The rose cultivars, Papillion was found to be comparatively less susceptible to mealy bugs.

Out of thirty-five cultivars screened against *H.armigera*, 19 cultivars were found to be less susceptible, 8 moderately susceptible, 5 susceptible and remaining 3 highly susceptible. The cultivar 'Teneki' recorded lowest larval population (0.11 larva/plant) and found to be less susceptible among the cultivars tested. The red flower colour cultivars were found more preferred by *H.armigera*. Among the thirty-five cultivars tested against *S.litura*, one cultivar 'Texas' was found to be less susceptible to *S.litura* followed by Konfetti and Akito. The cultivars with red and pink flowers were more susceptible to *S.litura* as more preference of larval feeding. Varied degrees of susceptibility to mite was noticed in thirty-five rose cultivars, in which cultivars *viz.*, Passion and First Lady were found to be less susceptible. It was noted that cultivars having white flowers always showed more incidence of mites.

5.4 Influence of Rose Genotypes on Parasitisation Efficiency of *T.chilonis* on Eggs of *H.armigera*.

The experiments were conducted on the effect of rose genotypes on the parasitisation efficiency of *T.chilonis* on eggs of *H.armigera*. Pooled analysis of data revealed significant difference in per cent parasitisation of *H.armigera* eggs by *T.chilonis* on five genotypes *viz.*, Pink Noblesse, Grand gala, Saphir, Passion and First red. Highest parasitisation was observed on First red (52.59%), followed by Passion (42.75%) and Grand gala (40.21%). Least

parasitisation was recorded on Saphir (37.28%) followed by Pink noblesse (29.74%).

5.5 Bioefficacy of Different Pesticides and Bioagents Against Pests Infesting Rose

The experiment to study the effectiveness of different pesticides and bioagents was laid out in RBD with 7 treatments and 5 replications during 2004-05 and 2005-06. Three insecticidal applications were given at 15 days interval whenever incidence of pests was noticed and the efficacy was judged by recording survival population of thrips, aphids, whiteflies, mealy bugs, *H.armigera*, *S.litura* and mites 2/3, 7 and 10 days after each spray.

The treatments viz., fipronil (0.01%), spinosad (0.015%), thiamethoxam (0.005%), mineral oil (15 ml/lit.), *V.lecanii* (2 g/lit.) and *C.carnea* (4 larvae/plant), were tried against thrips. Among the treatments, spinosad was significantly superior over rest followed by thiamethoxam, fipronil, mineral oil, *V.lecanii* and *C.carnea*. The maximum flower yield (5033) was obtained in treatment with spinosad followed by fipronil, mineral oil, thiamethoxam and *V.lecanii*. As regards 'A' grade flowers, the maximum yield (4614 flowers) was noticed in spinosad treated plots. The highest CBR was emerged in treatment with thiamethoxam (1:11.34) followed by spinosad (1:11.29).

The treatment of imidacloprid (0.005%), thiamethoxam (0.005%), acetamiprid (0.005%), mineral oil (15 ml/lit.), *V.lecanii* (2 g/lit.) and *C.carnea* (4 larvae/plant) were evaluated against rose aphids. Among all treatments, imidacloprid showed promise in reducing aphid population. The efficacy in reducing aphid population in remaining treatments was found to be in order of : thiamethoxam > acetamiprid > mineral oil > *V.lecanii* > *C.carnea*. The highest flower yield (3209) was noticed in imidacloprid followed by thiamethoxam (3010). However, highest CBR was obtained in treatment with thiamethoxam (1:12.49) followed by imidacloprid (1:11.14).

An experiment was conducted to evaluate the bio-efficacy of buprofezin (0.06%), neem (0.5%), acephate (0.075%), fish oil rosin soap (5 g/lit.), mineral

oil (15 ml/lit.) and *V.lecanii* (2 g/lit.) against whiteflies. Results indicated that the buprofezin (0.06%) was found to be most effective against whiteflies and recorded maximum flower yield (5149) and highest cost benefit ratio (1:11.83). The rest of the treatments in order of their CBR were neem, acephate, *V.lecanii*, mineral oil and fish oil rosin soap.

Insecticides and biopesticides in combination with fish oil rosin soap (5 g/lit.) and *C.montrouzieri* alone were evaluated against mealy bugs. The studies indicated that imidacloprid (0.005%) was most effective treatment for controlling mealy bug. It was followed by lambda cyhalothrin (0.0017%), buprofezin (0.06%), bifenthrin (0.06%), *V.lecanii* (4 g/lit.) and *C.carnea* (4 larvae/plant). The maximum flower yield (3249) was noticed in buprofezin with CBR of 1:3.55. The flower yield obtained from imidacloprid treated plots was 3049 with CBR of 1:5.09, which is an economical treatment for controlling mealy bugs on rose.

The bioefficacy of insecticide and biopesticides was evaluated on rose against *H.armigera*. The rose crop was sprayed thrice at 15 days interval with respective treatments during *Rabi* season of 2004 and 2005 when the pest population exceeded the economic threshold level. Among the different pesticides tested, indoxacarb (0.02%) was found significantly superior over rest of the treatments in controlling the larval population. The flower yield in respect of indoxacarb (0.02%) was 4705 with highest CBR of 1:11.02. However, the flower yield obtained from spinosad was comparatively higher (4762) with CBR of 1:8.55. The CBR derived from treatment with deltamethrin was 1:9.90 with flower yield of 3311. As regards *Ha*NPV treatment, flower yield was 3755 with CBR of 1:8.66, which is higher than spinosad.

Among the different synthetic insecticides tested, indoxacarb (0.02%), abamectin (0.005%) and profenophos (0.20%) were significantly superior over rest of the treatments in reducing the larval population of *S.litura*. There was reduction in flower damage and increase in the quality ('A' grade) flower yield in these treatments. Among the biopesticides, *S*/NPV (500 LE) and *N.rileyi*

(2 g/lit.) were significantly superior over control and at par with each other. However, *B.thuringiensis* was found less effective as compared to other biopesticides. The net CBR was found maximum in the treatment of indoxacarb (1:10.81) followed by *S/NPV* (1:7.73).

All the six acaricides were found effective in comparison with control in managing *T.urticae* on rose. The treatment abamectin was the most effective and recorded maximum flower yield (5181) with CBR of 1:7.01. It was found significantly superior over rest of the treatments except milbemectin. The mineral oil was least effective and not provided satisfactory control of mites.

5.6 Effect of IPM Components on Flower Yield and CBR in Rose

Studies were conducted to evaluate the relative efficacy of different IPM components against pests infesting roses revealed the superiority of IPM technology in reducing pest population over untreated control. The plot receiving IPM technology recorded lower incidence of pests (2.68 thrips/flower, 16.29 aphids/shoot, 2.50 whiteflies/leaf, 25.44 mealy bugs/twig, 0.66 *H.armigera* larvae/plant, 1.37 *S.litura* larvae/plant and 16.88 mites/leaf) as compared to untreated control (11.17 thrips/flower, 63.6 aphids/shoot, 10.49 whiteflies/leaf, 95.38 mealy bugs/twig, 3.16 *H.armigera* larvae/plant, 4.20 *S.litura* larvae/plant and 81.70 mites/leaf) with CBR of 1:7.31.

5.7 Conclusions

1. The variation between maximum and minimum temperatures, relative humidity in the morning and afternoon at Pune was fluctuating but was steady at Maval (Fig. 1, 2).
2. The incidence of aphid, whitefly, *H.armigera* and *S.litura* was found comparatively higher at Maval. However, incidence of thrips and mites was higher at Pune. The incidence of mealy bugs was found to be consistently severe for two years at Maval. The mite population was found active throughout the year except during severe cold and rainy season. The higher temperature and lower humidity were found to be

quite congenial for development of mites; while low temperature and high humidity showed adverse effect.

3. The reaction of rose cultivars to different pests showed varying degrees of infestation. The lower incidence of 1.39 thrips/flower (Temptation), 3.05 aphids/shoot (Saphir), 0.59 whiteflies/leaf (Merilan), 0.11 *H.armigera* larvae/plant (Teneki), 0.82 *S.litura* larvae/plant (Texas) and 13.10 mites/leaf (Passion) was recorded and these cultivars emerged as less susceptible. However, Mikado (17.21 thrips/flower), Suela (40.29 aphids/shoot), Golden gate (17.94 whiteflies/leaf), Pink Noblesse (81.72 mealy bugs/twig), Grand gala (2.12 *H.armigera* larvae/plant), Passion (3.12 *S.litura* larvae/plant and Teneki (82.85 mites/leaf) were found to be highly susceptible. The three cultivars viz., Naranga, Queensday and Eldorado were found completely immune to mealy bug infestation.
4. The rose crop grown in soil medium harboured comparatively more population of thrips, aphids, whiteflies, mealy bugs, *H.armigera*, *S.litura* and mite than in sole cocopeat medium. Hence, it could be suggested to use sole cocopeat medium for growing rose plants, which ultimately makes the plants resistant to pest and become cumbersome to pests to take shelter, oviposition and hibernation.
5. The IPM is a decision making process which is based on monitoring of pest population in prevailing climatic conditions. Based on the research findings, the probable activity period and population build up trend of pests alongwith control options are suggested below. The chemical pesticides found effective but needs to be used in rotation to avoid the development of resistance in target pest.
 - i. Thrip incidence was noticed during March and April. However, the population build up was initiated July onwards and reached its peak in the month of October and found persisted upto November. Thereafter, population was declined. The month of February was found to be thrip free period. These findings indicated the need of monitoring the thrips

(July onwards) with the help of blue sticky traps. It could be suggested that the control options such as use of *V.lecanii* entomopathogenic fungus and *C.carnea* predator can be initiated during the month of July. The use of insecticides viz., fipronil, thiamethoxam and spinosad during the month of October-November in rotation is recommended.

- ii. The incidence of aphid was noticed in the month of July to September with a peak activity during third week of August. However, the population started builds up from third week of October and reached the peak during first week of February. There was no incidence of aphid during March to June. It clearly showed the lower temperatures favoured the build up of aphid population. These findings alarmed the need of monitoring aphids with yellow sticky traps from third week of October onwards. This is the suitable period for release of predator *C.carnea* or use of entomopathogenic fungus *V.lecanii*. The insecticides viz., acetamiprid, thiamethoxam and imidacloprid can be used from January onwards in rotations to suppress the population build up.
- iii. The incidence of whitefly was noticed from second fortnight of January to February. The population was initiated June onwards and the peak activity period was found to be in the months of August and September. Thereafter, population was declined upto first fortnight of December. The climate during rainy season was found to favour for multiplication of whiteflies. The dry climate adversely affects the whitefly population. These findings indicated the need of monitoring with the help of yellow sticky traps from June onwards. It could be advocated that the control options such as use of *V.lecanii* and *C.carnea* can be initiated from the month of June. The use of insecticides viz., azadirachtin, FORS, mineral oil, buprofezin and acephate can be started from the month of August and September in rotation.
- iv. The mealy bugs were found active year around at Maval. The peak population (144.28 mealy bugs/twig) was observed in the month of

March and minimum (1.52 mealy bugs/twig) in May. It is inferred that the temperature in the range of 13.1 to 40.9°C favoured mealy bug multiplication; while the temperature above 41°C showed adverse effect. There were six peaks noticed in a year during 7, 12, 32, 35, 38 and 49 MWs. It could be suggested that besides monitoring the population of mealy bugs with the help of sticky tape traps, the use *V.lecanii* and *C.carnea* at low population density could be implemented. At high population density (February, March, August, September and December) spraying of insecticides viz., lambda cyhalothrin, bifenthrin, buprofezin, imidacloprid with mixing FORS in alternations be undertaken.

- v. The incidence of *H.armigera* was noticed from last week of September to March with a peak during February. The period from April to August was free from infestation. The low temperatures favoured the build up of *H.armigera* population. These findings suggested to monitor adult population with pheromone traps from fourth week of September onwards. This is the appropriate period for use of *T.chilonis*, *HaNPV* and *B.thuringiensis*. The insecticides viz., deltamethrin, spinosad and indoxacarb can also be recommended February onwards-in rotations to suppress the larval population.
- vi. The incidence of *S.litura* was noticed from third week of May to October with a peak during July and August. During November to April, there was no incidence of *S.litura*. The low temperatures adversely affect the development of *S.litura*. It could be suggested to monitor moth population with pheromone traps from third week of May onwards. This is the right period recommended for the application of *SINPV*, *N.rileyi* and *B.thuringiensis*. The insecticides viz., profenophos, indoxacarb and abamectin can be used July onwards in rotations to suppress the larval population.

vii. The mite population builds up started February onwards, reached to its peak in the first week of May and declined thereafter. There was no incidence during the second fortnight of January, first fortnight of February and August. The maximum temperature tends to favour the multiplication of mites. On this line, the control option of use of mineral oil can be initiated during the month of February. The use of acaricides *viz.*, fenpropathrin, difenthiuron, fenazaquin, milbemectin and abamectin during the month of March to May in rotation also advocated.

In IPM module none of the treatments showed any phytotoxic symptoms on the plants and off smell to the rose flowers; which are the important parameters of export quality. The guidelines suggested for implementation of IPM module will be useful for not only the sustainable control of the pests but also to reduce the costs on plant protection inputs. However, further studies on validation of IPM module for refinement is necessary.

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APPENDIX

APPENDIX – I

Weekly averages of meteorological parameters during experimental period in the polyhouse (Pune:2004-2005)

MSW	Month	Temperature (°C)		Relative Humidity (%)		Crop canopy Temp. (°C)		Crop canopy RH (%)		LI Inside (klux)
		Tmax	Tmin	RH -I	RH-II	Ct _{min}	Ct _{max}	Crh-I	Crh-II	
1	Jan.	31.5	13.2	73	57	13.9	28.2	79	61	70.5
2		32.1	11.7	76	59	12.5	29.1	84	64	63.1
3		31.6	9.5	72	53	10.3	27.8	77	55	64.5
4		32.5	13.3	70	50	14.7	28	75	53	64.9
5	Feb.	31.7	10.8	60	46	11.4	28.1	72	48	73.9
6		30.1	11.9	64	44	13	29.3	74	52	76.3
7		29.9	12.3	65	42	13.9	28.1	76	47	41.9
8		31.1	12.9	64	46	14.7	29.7	73	54	30.5
9	Mar.	32.2	13.9	60	42	15.6	31.3	71	46	30.9
10		34.4	15.7	59	31	16.6	32.9	69	40	43.7
11		35.2	18.6	53	33	19.5	33.8	65	38	35.1
12		36.8	18.6	54	34	20.4	34.6	67	36	31.2
13		36.9	19.2	56	36	21	34.9	69	37	30.8
14	April	37	18.9	53	33	22.7	35.6	66	34	34
15		37.3	19.2	52	32	23.4	35.7	64	33	31.4
16		37.7	21.5	58	38	24.2	36.2	68	39	27.5
17		38.8	22.9	61	40	24.9	36.7	70	48	33.8
18	May	39.6	23.5	58	39	25.3	37.1	68	46	30.
19		39.3	25.8	71	50	26.6	36.8	83	55	36.8
20		39.4	25.6	69	48	27.2	36.9	78	59	32.5
21		40.2	26	62	41	28.1	37.2	71	46	34.4
22		41.4	26.7	61	42	29.3	37.3	68	47	47.1
23	June	40.7	27.9	60	39	28.4	36.4	66	43	56.5
24		36.6	27	79	58	27.8	32.4	86	69	51.4
25		35.3	26.8	83	61	27.1	30.1	95	71	59.1
26		35	26.9	81	65	29.6	29.4	97	73	49.5
27	July	34.6	26.8	85	65	30.8	30.8	98	75	68.8
28		33.4	25.8	92	73	29.4	29.6	99	78	58.6
29		31.2	25.5	96	78	28.4	28.3	99	80	78.7
30		30.3	25.2	98	82	27.9	27.6	98	85	34.6
31	Aug.	30.4	25.3	96	78	28.9	28.2	98	80	56.7
32		29.9	24.9	92	77	27.8	28	97	82	41.2
33		31.7	25.4	92	75	28.5	28.5	98	85	29.9
34		32.1	25.2	87	68	27.8	29.5	99	83	22.7
35		30.8	24.7	97	79	27.1	28.7	98	81	35.5
36	Sept.	30	24.4	94	77	26.9	28.4	99	87	47.2
37		31.8	24.6	84	71	27.4	30.5	90	85	34.8
38		32.6	23.6	79	65	25.5	30.5	85	78	34.4
39		34.5	23.7	76	62	25.8	31.3	82	72	55
40	Oct.	35.7	22.8	68	56	23.4	31.4	81	64	49.6
41		36.6	21.9	64	54	22.3	31.8	78	61	63
42		35	20.5	68	52	21.4	32	80	59	68.9
43		33.8	19.5	70	57	23.5	33.1	82	60	53.6
44	Nov.	34.2	18	76	58	20.7	33.4	85	64	60.4
45		33.4	17.2	62	43	19.6	30.6	76	53	70.5
46		32.5	15.8	64	45	18.4	30.9	77	55	78.1
47		31	14.6	66	48	16.5	29.5	79	57	81.9
48		31.1	13.8	85	54	15.6	30.7	93	70	82.7
49	Dec.	30.5	12.4	68	42	14.9	29.2	80	55	78.4
50		28.7	10.4	71	43	12.1	27.8	86	57	69.9
51		29.8	11.3	73	42	14.5	28.5	84	58	82.4
52		28.6	12.7	75	55	16.2	26.9	87	65	58.3

APPENDIX – II

Weekly averages of meteorological parameters during experimental period in the polyhouse (Maval:2004-2005)

MSW	Month	Temperature (°C)		Relative Humidity (%)		Crop canopy Temp. (°C)		Crop canopy RH (%)		LI Inside (klux)
		T _{max}	T _{min}	RH-I	RH-II	Ct _{min}	Ct _{max}	Crh-I	Crh-II	
1	Jan.	36.7	10.6	84	53	14.9	25.6	82	63	65
2		37.1	10.9	82	58	13.3	25.2	86	66	62.8
3		39.6	12.5	79	62	12.7	26.2	87	64	65.9
4		36.7	11.5	84	52	11.1	24.9	88	62	61.2
5	Feb.	37.6	11.9	84	56	10.9	24.3	89	61	74.9
6		38.5	12.5	81	59	12.5	25.5	90	59	77.1
7		39.2	13.1	86	63	13.4	26.3	95	75	41.5
8		38.9	13.4	79	64	14.8	26.8	90	66	31.4
9	Mar.	39.7	14.4	84	67	15.1	27.5	94	71	31.4
10		40.9	15.3	82	60	17.2	29.1	92	68	43.4
11		41.6	16.8	84	63	18.3	29.9	94	75	35.8
12		40.4	16.2	78	60	19.9	30.2	98	77	31.4
13		41.1	16.5	82	62	20.2	30.7	97	85	31.2
14	April	41.6	15.5	77	61	20.7	31.2	98	83	27.6
15		42.1	16.9	71	63	21	31.6	97	77	32.3
16		42.8	17.5	68	72	22.3	33.3	93	83	27.5
17		43.1	18.6	80	71	24.7	33.9	93	82	34.9
18	May	42.5	19.4	74	62	26.4	34.4	97	89	30.1
19		41.1	20.2	73	69	25.1	33.1	97	81	35.3
20		40.3	21.1	77	74	26.6	33.5	99	86	31.6
21		39.8	20.8	83	79	25.4	32.7	98	92	31.3
22		40.6	19.4	71	66	24.2	32.4	96	78	44.5
23	June	41.2	21.1	75	67	25.9	33.5	98	71	53.4
24		40.2	22.2	78	71	26.8	33.7	97	75	51.8
25		39.6	22.3	92	74	27.6	33.6	97	78	49.4
26		37.7	22.4	86	64	27.8	32.7	98	68	33
27	July	36.7	21.6	91	69	26.1	31.4	99	72	32.6
28		35.8	20.5	93	78	24.8	30.3	98	79	34.6
29		34.3	20.9	88	79	25.1	29.7	99	77	73.3
30		36.1	21.1	90	77	25.7	30.9	98	78	24.5
31	Aug.	36	21.3	93	71	24.6	30.3	97	73	24.8
32		37.9	21.8	95	64	23.8	30.8	96	65	29.2
33		37.6	21	96	62	23.2	30.4	98	64	25.2
34		38	20.9	98	57	22.8	29.5	99	67	22.4
35		37.9	21.2	97	59	22.1	29.3	99	61	33.3
36	Sept.	34.2	21.5	65	57	21.8	28.1	74	53	46
37		34.8	21.7	69	55	22.6	28.7	77	55	34.8
38		36.5	21.9	68	55	22.1	29.2	73	56	36
39		31.5	22.2	70	58	22.4	28.2	72	58	53.9
40	Oct.	36.8	22.7	72	54	22.9	29.8	77	52	50.3
41		37.5	21.4	69	60	23.8	30.6	72	62	63
42		38	20.7	68	59	25.4	31.7	74	65	71.6
43		38.7	19.4	66	57	24.3	31.5	68	64	57
44	Nov.	37.8	18.5	78	72	23.3	30.5	77	77	59.8
45		38.5	17.8	72	60	22.7	30.6	74	61	73.7
46		38.7	16.6	72	53	21.5	30.1	78	60	80
47		37.5	15.3	73	57	20.8	29.2	81	63	81
48		38	16.8	79	40	18.9	28.3	84	45	79.1
49	Dec.	36.4	14.2	76	46	17.3	26.8	83	52	77.5
50		35.6	13.7	82	49	16.6	26.1	85	54	69.9
51		36.4	12.1	81	54	16.1	25.8	84	58	75.1
52		36	11.3	79	52	15.7	25.7	83	59	59

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