POPULATION DYNAMICS AND SOME MANAGEMENT ASPECTS OF MANGO HOPPER

A

THESIS

SUBMITTED TO THE

FACULTY OF AGRICULTURE

NAVSARI AGRICULTURAL UNIVERSITY

NAVSARI

IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS

FOR THE AWARD OF THE DEGREE

OF

DOCTOR OF PHILOSOPHY

(AGRICULTURE)

IN

AGRICULTURAL ENTOMOLOGY

BY

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JANUARY-2006

Registration No. 04-4692-2000

POPULATION DYNAMICS AND SOME MANAGEMENT ASPECTS OF MANGO HOPPER

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ABSTRACT

Studies on **Population dynamics and some management aspects of mango hopper** were conducted at Agriculture Experimental Station, Gujarat Agricultural University (now Navsari Agricultural University), Paria, Valsad, Gujarat-396145 during January 2002 – June 2004.

The study on population dynamics of mango hopper on the basis of survey carried out during January 2002 – December 2003 revealed peak incidence of *Amritodus atkinsoni* (Lethierry) on tree trunk (3.29 hoppers per sq. ft.) and tree twig (0.41 hoppers per twig) during 43rd (22 October -28 October) and 22-26 (3 July – 12 August) standard weeks, respectively along with peak population of *Idioscopus clypealis* (Lethierry) on tree trunk (0.94 hoppers per sq. ft. or 0.11 sq. m.) and tree twig (2.84 hoppers per twig) during 5th (29 January – 4 February) and 16th (16-22 April) standard weeks, respectively and have been identified as predominant species under South Gujarat, whereas other two species of mango hopper which have been recorded and identified are *I. niveosparsus* and *Amrasca splendens* but with lower population.

The total hopper population (irrespective of species or tree location) peaked (5.49 per tree) on 15th standard week (9-15 April) coinciding with stone sized fruit stage of crop growth when maximum temperature, relative humidity (morning, evening

and average) and sun shine were 35.21 ºC, 81.57, 40.28, 60.93 per cent and 10.10 hours per day, respectively. Correlation and regression studies of total hopper population with weather factors indicated that maximum temperature and sun shine directly (positively) influenced the population build-up of mango hoppers, whereas relative humidity, rainfall and rainy days had negative impact. Inter-specific relationship between trunk and twig hopper populations revealed that higher the predominant hopper *A. atkinsoni* on tree trunk, lesser the predominant hopper *I. clypealis* on twig and vice-versa.

Peak period of hopper egg laying (8.99 per cent) and sooty mold (2.25 sooty mold grade) damage was recorded during 14-18 (2 April – 6 May) and 6-18 (5 February – 6 May) standard weeks, respectively and they had significant positive and negative correlations with twig and trunk hopper populations, respectively.

Abundance of predatory spiders and coccinellids peaked (0.53 and 0.35 per panicle, respectively) during 12-17 standard weeks (19 March – 29 April) and both were significant and positively correlated with hopper population on tree twig.

Spatial distribution (intra tree) distribution of mango hopper in four different directions of tree trunk (both on lower and upper side) indicated uniform distribution on the basis of various statistical parameters *viz*; mean, variance-mean ratio, mean crowding, Morista indices and Chi square (X^2).

Reaction of fifteen mango cultivars to mango hopper and its associated damages indicated that Totapuri cultivar was least susceptible to the pest (1.61 per twig), whereas Alphonso was most susceptible to mango hopper (7.52 per twig). Relationship of abundance of hopper and sooty mold with morphological characters of mango trees was found non-significant. So, Totapuri and Alphonso were categorized as resistant and susceptible varieties, respectively.

Abundance of hopper population (5.45 per panicle), hopper egg laying (9.46 per cent) and sooty mold (2.60 SM grade) damages was found higher on recurrent than on non-recurrent flowers (4.41 per panicle, 9.00 per cent and 2.25 SM grade, respectively) during 14-15 (2 April - 15 April) standard weeks when the crop was in stone sized fruit stage. Similar observations were recorded in case of natural enemies (predatory spiders and coccinellids) proving their synchronization with the pest.

High density plantation or closer spacing (10 x 2.5 m.) in mango cv. Kesar, invited higher abundance of hopper population (6.05 per twig), hopper egg laying (5.16 per cent) and sooty mold (2.74 SM grade) damages as compared to normal planting (10 x 10 m.) *i.e.* 3.70 per twig, 3.42 per cent and 1.78 SM grade, respectively.

Abundance of hopper population (5.08 per twig), egg laying (4.76 per cent) and sooty mold (3.65 SM grade) damages were highest in $N_2P_2K_2$ level of NPK (150, 100 and 150 gms. per tree at the time of planting), whereas, it was lowest in $N_0P_0K_0$ (control) (2.22 per twig, 2.84 per cent and 1.64 SM grade). Natural enemies also synchronized with hopper population, thus higher doze of NPK particularly nitrogen provided favourable platform for the attack of the pest as it was responsible for increased chlorophyll content and higher succulence in leaves.

Early induction of flowering by one month using paclobutrazol (PBZ) as plant growth regulator in mango (cv. 'Alphonso') has also caused early arrival of mango hopper. Overall, hopper abundance in PBZ treated trees was higher (3.10-13.60 per twig) than in non PBZ trees (3.00-4.65 hoppers per twig). Hopper associated damages as well as natural enemies also remained higher in PBZ trees. Correlation of crop stage with abundance of hopper population in paclobutrazol and its associated damages was significant and positive.

Among the various insecticides tested against mango hopper, imidacloprid 0.005 per cent was most effective and statistically superior over rest of the treatment. It recorded lowest, hopper population (2.22 per panicle) and sooty mold damage (2.39 SM grade), highest fruit setting at pea, marble and harvest (518.43, 311.73 and 210.62 fruits per hundred panicles per tree) stages, comparatively higher fruit retention at marble (over pea) (45.63 per cent) and harvest (over marble stage) (48.16 per cent), tree bearing (240.00 fruits per tree) and yield (60.00 Kg per tree or 6000.00 Kg per ha.) stages, followed by thiamethoxam 0.0084 per cent, monocrotophos 0.04 per cent and acetaprimid 0.004 per cent. Imidacloprid 0.005 per cent was also the most economical treatment wherein it provided highest, net realization (Rs 83520.00 per ha.) and ICBR (1:8.39), followed by thiamethoxam 0.0084 per cent (ICBR 1:7.63), monocrotophos 0.04 per cent (1:6.59). Abundance of natural enemies *viz*; predatory spiders and coccinellids were higher in control followed by endosulfan 0.07 per cent and imidacloprid 0.005 per cent treatments.

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CERTIFICATE

This is to certify that the thesis entitled **"Population dynamics and some management aspects of mango hopper"** submitted by **Shri Sushil Kumar** in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY (Agriculture)** in the **Agricultural Entomology** of the **Navsari Agricultural University, Navsari** is a record of bonafide research carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or any other similar title.

Place : Navsari **(M. S. Purohit)**

Date : 20th January, 2006 Major Advisor

DECLARATION

This is to declare that the whole of the research work reported in this thesis in partial fulfilment of the requirements for the award of **Doctor of Philosophy (Agriculture)** in **Agricultural Entomology** by the undersigned is the result of investigation carried out by me under direct guidance and supervision of **Dr. M. S. Purohit**, Professor (Plant Protection), T & V Scheme, Office of the Director of Extension Education, Navsari Agricultural University, Navsari and that no part of the work has been submitted for any other degree so far.

Place : Navsari

Date : 20th January, 2006 **(Sushil Kumar)**

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ACKNOWLEDGEMENT

I take this opportunity to express my heartfelt, sincere and deep sense of gratitude to my major advisor, Dr. M. S. Purohit, Professo (Plant Protection), T and V scheme, Office of the Director of Extension Education, Navsari Agricultural University, Navsari, for his learned counsel, valuable and inspiring guidance, constant encouragement and constructive criticism throughout the course of this investigation and preparation of this manuscript.

I am highly thankful to Dr. R. I. Bhatt, Research Scientist (retired) and Dr. B. N. Patel, Research Scientist (I/C), Agriculture Experimental Station, Navsari Agricultural University, Paria for providing necessary facilities during the course of investigation. I am also thankful to Dr. P. N. Upadhyaya, Principal, N.M. College of Agriculture, Navsari Agricultural University, Navsari for providing library and other facilities during the course of study and investigation.

Sincere thanks and gratefulness are also expressed to the members of my advisory committee viz; Dr. K. U. Solanky, Minor Advisor and Professor of Plant Pathology, Dr. M. B. Patel, Professor of Agricultural Entomology, Dr. R. K. Parikh, Associate Professor of Agricultural Statistics; N.M. College of Agriculture, NAU; Navsari and Dr. Z. P. Patel, Associate Professor of Entomology, Fruit Research Station, NAU; Gandevi, District Navsari, for their valuable suggestions and necessary guidance during the course of this study.

I am specially grateful to Dr. R. M. Desai, Associate Professor of Agricultural Chemistry and Shri G. G. Patel, Agricultural Officer for helping me during the chemical analysis and Shri J. R. Naik, Assistant Professor of Agricultural Statistics, N.M. College of Agriculture, NAU; Navsari for helping me in statistical analysis during the course of investigation.

I am sincerely thankful to Dr. R. C. Jhala, Professor of Agricultural Entomology, Anand Agricultural University, Anand and Dr. B.R. Raghvani, Associate Research Scientist (Entomology), Pulse Research Station, Junagadh Agricultural University, Junagadh for giving me valuable suggestions in the selection of topic of research leading to Ph.D. I can not forget the required help given by DR. G. G. Radadia, Shri K. A. Bandhania, Shri A. A. Shah, Shri M. M. Naik, Dr. H. R. Desai, Shri H. M. Patel, Shri S.N. Sarvaiya, Dr. A. N. Sabalpara, Dr. B. P. Mehta and other staff members of the departments of Agricultural Entomology and Plant Pathology, N.M. College of Agriculture, NAU; Navsari for their direct and indirect help.

I would be untalented if I don't express my sincere and cordial thanks to Shri J.J. Pastagia, Assistant Professor of Entomology, Dr. D. M. Joshi, Professor of Plant

Pathology and Shri H. N. Chatrola, Assistant Professor of Statistics, Aspee College of Horticulture and Forestry, NAU; Navsari, Shri H.V.Pandya and Shri M.B. Patel of Regional Sugarcane Research Station, NAU; Navsari for their continuous help and keen cooperation during the course of study.

I am also thankful to my colleagues viz; Shri J. C. Patel, Dr. P.K..Shrivastava, Shri Taslim Ahmad, Shri S.N.Patel, Shri B.G.Patel, Shri J.L. Patel, Shri Y. I. Shihora, Shri L. K. Arwadiya, Shri P.M. Mistry, Shri J.P.Makati, Shri H.R.Ganvit and Shri L.J. Navadia of Agriculture Experimental Station, NAU; Paria for their valuable suggestions and constant encouragement during the course of this investigation.

On my personal note, I would like to express my deepest gratitude and respect to my father Late Shri Prem Kumar Saksena and mother Mrs. Shakuntala Saksena, my better half Mrs. Manjushree and my sons Mr. Abhishek Kumar and Mr. Vivek Kumar for their everlasting love, encouragement, strong moral support and providing opportunity for building up my educational career i.e. title degree.

Finally, I am thankful to the authorities of Navsari Agricultural University (part of erstwhile Gujarat Agricultural University) and specially Dr.R.P.S.Ahlawat, Vice Chancellor, Navsari Agricultural University for registering me for in-service higher study leading to Ph.D. degree in Agricultural Entomology.

Place : Navsari

Date : 20th January, 2006 **(Sushil Kumar)**

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I INTRODUCTION

Mango word comes from Malayalam, ‘man-ka’. In Kerala, people call mango tree as ‘Ma’ or ‘Mavu’. The first mention of mango (Manga) appeared in English in 1582 AD. in Lichefield’s translation of Castaneda’s conq. E. Indies (1. XVI: 42).

Mango is the main fruit of Asia and this fruit has developed its own importance all over the world. *Mangifera indica* Lin. is the national fruit of Indian and since long it is the choicest fruit in India. This fruit has been in cultivation in India sub-continent for well over 4000 years and has been the favourite of the kings and commoners because of its nutritive value, taste, attractive fragrance and health promoting qualities. In many parts of the country mango serves as staple food for several months during the year because of its fine quality and taste as raw fruit. It is now recognized as one of the best fruits in the world market; hence it is called as the ‘King of the fruits’. It occupies relatively the same position in the tropical region as is enjoyed by Apple in temperate region.

Ripe fruit is canned in various forms. It is also made into pickles, curries and chutneys of all sorts. The kernel is dried roasted and then eaten during the scarcity period; the same is ground into flour and eaten as gruel. The bark is used in tanning leather, while timber is being utilized in various ways. Besides these uses, mango tree also possess good medicinal value.

The genus *Mangifera* comprised of 41 species (Mukherjee, 1985), however, the total number of valid species now stands at 39

(Mukherjee and Stolon, 1989). Likewise, five species *viz. Mangifera indica*, *M. khasiana*, *M. sylvatica*, *M. andamanica* and *M. comptosperma* have been reported from India (Yadav and Rajan, 1993). All the edible cultivars of mango belong to the single species *Mangifera indica* Lin. originated in the Indian sub-continent.

In consideration of area, production and productivity of various states in the Indian Union, Uttar Pradesh stands at the top considering the area (0.266 million ha) under mango cultivation. Andhra Pradesh tops the list considering total production (3.071 million tonnes) as well as productivity (12 tonnes/ha). The other important mango growing states are Bihar, Tamil Nadu, Maharashtra, West Bengal, Gujarat, Madhya Pradesh, Orissa and Kerala (Srivastava, 1998).

In Gujarat the area under mango cultivation was 32,000 ha (Anonymous, 1991) has now risen to about 56,600 ha with annual production of 3,66,032 tonnes and productivity of 6.467 t./ha. (Chundawat, 1998 and 2003). There are two major pockets of mango cultivation *viz;* south Gujarat (Valsad, Navsari and Surat districts mainly accounts for nearly 80 % of the total area in Gujarat) and parts of Saurashtra particularly Junagadh, Bhavnagar and parts of Amreli districts. The scattered plantation is however, available in other districts of the state.

In Gujarat the commercial activities are confined to the cultivation of ‘Alphonso’, ‘Kesar’, ‘Rajapuri’ and ‘Langra’ of which ‘Alphonso’ occupies about 50 per cent of the area under mango in the state, which is estimated to be 16,000 hectares. This variety is mainly cultivated in the districts of Valsad, Navsari and Surat, locally known as ‘Haphus’. This is an export quality cultivar of India because of its excellent keeping quality.

Another very important and popular cultivar of Gujarat is 'Kesar' which though originated in Junagadh region of Gujarat, is not only rapidly gaining popularity in rest of the Gujarat but also in other major mango growing centers of this country.

Besides being a popular fruit with the masses in India, mango is gradually gaining ground as good source of earning foreign exchange in way of export. Out of total 39,352 tonnes world's share in the mango products, India accounts for 22,740 tonnes worth 299.268 million rupees. Maximum quantity of fresh mangoes (10,900 tonnes) are being exported to UAE from India, while in Europe, it is the U.K. which is getting the highest share of fresh mangoes (1,270 tonnes) which values as high as 26.197 million rupees (Anonymous, 2004). This increased demand of mango and mango products has created the demand for increasing the yield as well as quality of mango fruits. The most limiting factor which limits increase in mango productivity is year round occurrence of high to very high level of incidence of various pests and diseases besides problem of irregular bearing and low productivity. Of various pests, attack of insect-pests is of colossal nature. Lately, incidence of mites as well as nematodes has also complicated the mango farming.

About 492 species of insects, 17 species of mites and 26 species of nematodes have been reported from mango crop the world over (Butani, 1974). Of these, over 188 species have been reported in India (Tandon and Verghese, 1985) and hardly half a dozen are of major importance (Tandon and Srivastava, 1982). As per Butani (1974), these are mango hoppers, *Idioscopus clypealis* Lethierry and *Amritodus atkinsoni* Lethierry, mango mealy bug, *Drosicha mangiferae* Green, mango fruit fly, *Bactrocera* (syn. *Dacus) dorsalis* Hendel, bark eating caterpillar, *Indarbela* spp; stem borer, *Batocera* spp; and scale insect, *Aspidiotus destructor* Signoret, while insect-pests of minor importance are *viz*; mango stem weevil, *Sternochetus mangiferae* Fab; mango leaf weevil, *Deporaus marginatus* Pascal, mango shoot gall, *Apsylla cistellata* Buckton, termite, *Odontotermes obesus* Rambur and amongst non-insect pests, mite, *Oligonychus mangiferus* Rahman and Sapra, *Tetranychus cucurbitae* Rahman and Sapra and mango bud mite, *Aceria mangiferae* Sayed are commonly found. Whereas, insect-pests which came into prominence as mango pests during the last decade are thrips, *Rhipiphorothrips cruentatus* Hood, *Scirtothrips mangiferae* Priesner, mango gall midges, *Erosomyia indica* Grover, *Dasyneura amaramanjarae* Grover and *Protocontarinia matteiana* Kieffer and Cecconi, fruit borers, *Dichcrocis punctiferalis* Guenee and *Virachola isocrates* Fab; shoot borer, *Chlumetia transversa* Walker, mango leaf webber (syn. Tent caterpillar), *Orthaga euadrusalis* Walker and leaf miner, *Acrocercops syngramma* Meyrick, whereas, status of ants, O*ecophylla smaragdina* Fab. is yet to be confirmed either as a pest or natural enemy (Srivastava, 1998).

Among the insect-pests listed above, mango hoppers are the number one serious and destructive pest of mango which was first reported by Distant in 1908. Apart from causing menace in various states of India, the hopper pests have been found prevalent in most of the tropical and sub-tropical countries in South East Asia. Damage is caused by the nymphs and adults by sucking sap from inflorescence as a consequence of which inflorescence and fruit if any set, fall prematurely. Heavy puncturing of buds and midrib of the leaves lead to distortion and dryness of the buds while leaves get curled up (Plate 4-5). Ballard (1915) observed great loss by secreting honey dew which facilitates the development of sooty mold on the leaves, twigs and inflorescence. This damage caused by hoppers is known as ‘Honey Dew Disease’ or ‘Theni Manzu’ in many parts of Andhra Pradesh as reported by Ramakrishnan Ayyar (1963). Due to sooty mold the photosynthetic activity is affected and ultimately fruit setting is also adversely affected. When there is an infestation, the entire garden presents a sickly sight (Plate 5 and 7).

In India, the greatest damage to the mango crop is caused by these hoppers and at times they are responsible for its total failure (Singh, 1968). Not much work has been done on the quantification of losses caused by mango hoppers. However, according to Rao (1930) the hoppers cause a loss of 20 to 100 per cent of inflorescences. Cheema *et al.* (1954) and Gangolly *et al.* (1967) have reported the losses due to hopper to the tune of 25-60 per cent, whereas, Bap Reddy (1968) has recorded the losses up to 60 per cent. This is a specific pest of mango (Wagle, 1928) and in some years population reaches as much high that 150 hoppers are reported on a single leaf (Singh and Mishra, 1976).

Of the three mango hoppers viz; *Idioscopus clypealis* (Lethierry), *I. niveosparsus* (Lethierry) and *Amritodus atkinsoni* (Lethierry) reported in South Gujarat (Anonymous, 2000), *I. clypealis* has been the most prolific breeder but it breeds only once in a year during January-February.

South Gujarat is a hot bed of mango hoppers due to its humid climate, availability of variety of susceptible mango cultivars and old mango trees which serve as breeding centers of various species of mango hopper. Further, indiscriminate use of conventional insecticides and particularly second/third generation synthetic pyrethroids (Sushil Kumar *et al*; 2002) has created problem of development of mango hopper resistance. Another area of concern which has compounded the problem of occurrence of mango hopper repeatedly in this region is the probable development of different biotypes of mango hopper.

Apart from high incidence of hopper and development of resistance to most of the second and third insecticides, the problem of irregular bearing is also very important in south Gujarat particularly in Alphonso variety which has a maximum area in this region of the state. This has opened a new market of plant growth regulators in the mango industry. One such molecule is a newly developed growth retardant paclobutrazol appears to fit in this concept. On the basis of multilocational trials one application of paclobutrazol (Cultar 25 SC) at the rate of 16-20 ml per tree has been recommended as soil treatment during middle of August in Alphonso mango (Burondkar and Gunjate, 1991, 1993; Desai and Chundawat, 1994 and Bhatt and Sushil Kumar, 1997). Due to early induction of flowering and fruiting, about 50 to 60 per cent of mango farmers of Konkan and South Gujarat regions of Maharashtra and Gujarat, respectively, growing Alphonso mango have started using paclobutrazol. This has brought a big revolution in mango industry during the last decade. Not only their old orchards have been rejuvenated but productivity has also been optimized in the bargain.

However, this concept of induction of early flowering in mango has also resulted in early arrival of hopper and other important sucking pests on foliage and newly emerged panicles. Extent of advancement of mango hopper incidence and its impact on both quality and quantity of mango fruits are required to be tackled with more emphasis. Hence, relationship of paclobutrazol (Cultar) application on arrival of hopper in mango has been studied in detail in this investigation.

Another reason of continuous hopper damage in flowering season is presence of recurrent flowering and or recurrent damage by the hoppers. Some orchards even fail to blossom or fruit set, hence impact of recurrent flowers on continuous incidence of various species of mango hoppers needs investigation (Plate 2).

In south Gujarat, mango varieties which are basically consumed either as table, pickle or juice purpose also suffers from mango hopper incidence apart from various other insect-pests and diseases. Hence, reaction of different cultivars to various species of mango hopper has been studied in detail in this investigation so as to categorize them as resistant, moderately resistant and susceptible entries.

Land availability is becoming a limiting factor for the mango/ fruit cultivation. To deal with problem scientists have recommended high density plantation so as to optimize crop productivity per unit area. However, this practice, largely adopted by the farmers invites probably higher population of mango hopper. Hence, role of crop geometry on incidence of mango hopper needs to be ascertained.

Role of primary nutrients (NPK) with special emphasis on nitrogen and their relationship with abundance of hopper population has also been studied in this investigation.

Similarly, to tackle problem of mango hopper and other important insect-pests, many new insecticides and molecules have come in the market. The broad spectrum activity of these insecticides at a very low application rate coupled with low mammalian toxicity have led them to emerge as alternative to the highly effective conventional insecticides currently in use and as such an attempt has been made to compare the effectiveness of these available newer products vis-à-vis conventional insecticides for the control of mango hoppers on need basis.

The survey has been made to study the impact of abiotic factors and crop stages on abundance of various species of mango hoppers throughout the year and reported in this thesis.

Objectives of the present investigation are as under :

1. To record species wise (indigenous species) abundance of mango hopper in relation to weather parameters as well as mango crop stages.
2. To screen important mango cultivars against mango hopper.
3. To assess the impact of recurrent flowering on abundance of mango hopper.
4. To study the impact of high density plantation on the pest density.
5. To study the effect of NPK fertilization of mango trees on the incidence of mango hopper.
6. To study the time of appearance and abundance of mango hopper on mango trees treated with growth retardant (Paclobutrazol).
7. To evaluate the efficacy of newer insecticides against mango hopper.

II REVIEW OF LITERATURE

Mango hopper is the most widespread pest however; adequate attention has not been paid on the studies related to the impact of environmental factors, crop phenology, ecology and major crop nutrients on abundance of various species of mango hopper. Besides, roles of recurrent flowers and application of paclobutrazol on abundance and arrival of mango hopper has not been reported any where in India and abroad. As well, efficacy of newer insecticides, products and molecules has not been studied much on insect-pests of mango. In view of its importance and to systematize the studies, literature pertaining to hoppers particularly in relation to the present investigations has been compiled and presented here under the following heads.

2.1 Geographical distribution

2.1.1 Species record

There are three species of these hoppers which were first recorded from Saharanpur (Uttar Pradesh, India) and described by Lethierry (1889) as *Idiocerus atkinsoni, Idiocerus clypealis* and *Idiocerus niveosparsus*. Similarly, Distant (1908) also reported this hopper, while Baker (1915) erected a new genus *Idioscopus* and placed *clypealis* under this genus. Later, Maldonada-Copriles (1964) transferred *atkinsoni* and *niveosparsus* also under *Idioscopus.* Anufriev (1970) shifted *atkinsoni* and placed it under a new genus *Amritodus*. So now they are *Amritodus atkinsoni* (Lethierry), *Idioscopus clypealis* (Lerthierry) and *Idioscopus niveosparsus* (Lethierry).

Ghauri (1967) described two more species of Cicadellid leaf hoppers, *Amrasca splendens* from India and *Meganeura reticulata* Ghauri from Malaysia. Similarly, Viraktamath and Murphy (1980) found two more species, *Idioscopus nigroclypealis* and *Idioscopus clarosignatus* on mango in Singapore. Lastly, Viraktamath and Viraktamath (1985) reported three new species of mango hoppers namely *Busoniominus manjunathi* and *Idioscopus jayshriae* breeding on mango in Karnataka.

2.1.2 Distribution

Mango hoppers, *Idiocerus clypealis*, apart from India, have also been reported from Pakistan, Bangladesh, Taiwan, Burma (Myanmar), Sri Lanka and the Philippines (Baker, 1915; Kato, 1926; Jepson, 1935; Palo and Grecia, 1935; Alam, 1962 and Ghauri, 1967). Vanhall (1924) has recorded *Idiocerus niveosparsus* as a pest on mango in Indonesia. The two species, *Idiocerus clypealis* and *Idiocerus niveosparsus* were reported causing damage to mango orchards in Formosa (Kayashima, 1934).

Reports have been made on the occurrence of *Amritodus atkinsoni* in Bihar, Gujarat, Maharashtra, Orissa, Punjab and Uttar Pradesh, while *I. clypealis* was reported from Bihar, Maharashtra, Mysore, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal and *I. niveosparsus* from Gujarat, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal (Anonymous, 1917).

However, within India, wide distribution of *Amritodus atkinsoni* and *Idioscopus clypealis* have been reported in Bihar (Sen and Prashad,1954) and in North West India (Chopra, 1926; Rehman, 1939; Pruthi and Batra, 1960), whereas, *A. atkinsoni* and *I. clypealis* have been found to more serious in Punjab (Atwal, 1963). Tandon and Lal (1979) found *I. clypealis* more severe in Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

In Gujarat, besides the above reports, Patel *et al.*(1997) and Jhala *et al.*(1989) found abundance of *Amritodus atkinsoni* in old mango orchards, whereas, Shah *et al.*(1989) indicated presence of *A. atkinsoni* and *Idioscopus clypealis* in serious form in south Gujarat. Similarly, Patel *et al.*

(1994) and Sushil Kumar and Bhatt (1999) reported abundance of *A. atkinsoni* in the South Gujarat. Recently, *I. niveosparsus* has also been reported from all mango growing areas of south Gujarat (Anonymous, 2002).

2.2 Population dynamics of mango hopper

2.2.1 In relation to weather parameters

Butani as early as 1979 reported that mango hoppers start egg laying around end of January or early February and continues till March. He further revealed that in north India, there are two distinct generations of mango hopper in a year; spring generation in February to April and summer generation during June to August. Similarly, Dwivedi *et al.* (2003) found peak intensity (87.9/10 leaves) of mango hoppers in June. While, Tandon *et al.* (1983) found peak population of *Idioscopus clypealis* during March-April and were smallest during December-January. They further stated that maximum and minimum temperatures and relative humidity contributed 89 percent of the population variation. Similarly, Kudagamage *et al.* (2001) noticed peak population of *I. niveosparsus* and *Amrasca brevistylus* in March-April in Sri Lanka.

Shekh *et al.*(1993) predicted outbreaks of mango hoppers when the minimum temperature and vapour pressure ranged between 20-25 °C and 16-25 mm. Hg. respectively, whereas, Patel *et al*. (1994) indicated a positive correlation of minimum temperature and vapour pressure with mango hopper, *Amritodus atkinsoni* population. Xie Guao Gan and Xie Bing Qing (2000) observed that high temperature (18-28 °C) and humidity (more than 95 %) favoured multiplication of mango leaf hopper (Cicadellidae).

Pandey *et al.* (2003) observed highest hopper population with higher temperature (more than 28 °C). They further stated that fortnightly rainfalls of more than 100 mm. had washing effect although the temperatures were optimum. The total contribution of abiotic factors ranged between 36 and 61 percent.

2.2.2 In relation to crop stages

Idioscopus niveosparsus has been found to breed throughout the flowering season. *Amritodus atkinsoni* on the other hand has been reported to be a shy breeder found on vegetative shoots rarely on blossoms (Anonymous, 1917) under North Indian conditions. Similar trend of this pest species was reported in middle Gujarat by Patel *et al.* (1994).

Verghese and Rao (1987) reported population of this pest at post bloom stage. Similarly, higher population build-up and rapid multiplication of mango hoppers, *A. atkinsoni* and *Idioscopus* spp. have been reported during flower initiation and full-bloom stage of the crop (Srivastava, 1998; Bharat Babu *et al;* 2001 and Sushil Kumar *et al;* 2002).

Talpur *et al.* (2002) reported that population density of mango hopper had positive correlation with inflorescence phenology in all the mango cultivars; however population of hoppers had negative correlation with fruit development.

2.3 Spatial distribution of mango hopper

Verghese *et al.* (1985) while studying the sequential sampling plan for mango hopper; *Idioscopus clypealis* Lethierry, indicated uniform distribution of the pest species on mango trees irrespective of direction or height of mango trees. Similarly, Tandon *et al.* (1989) while studying distribution of *Idioscopus niveosparsus* on 'Totapuri' cultivar of mango recorded that there was no significant difference in the distribution of nymphs between the north, south, east and west portions of the tree or between the upper and lower canopies. In a similar study on mango leaf gall midge carried out in south Gujarat, no significant difference in distribution of leaf galls has been found amongst various tree sections (Anonymous, 2002).

2.4 Screening of mango cultivars against mango hopper

Nachiappan and Bhaskaran (1984) on the basis of natural population during flowering season on inflorescence categorized Baneshan, Chinarasam, Banglora and Khadar as resistant and Padiri, Neelam, Mulgoa, Peter and Sindura as highly susceptible varieties to hopper infestation. Similarly, Khaire (1987) found Rajmana and Vanraj least susceptible to *I. clypealis*.

Srivastava (1995) observed Amrapalli, Dashehari and Neelam as highly susceptible and Banglora as highly resistant to mango hoppers on the basis of natural incidence of the pest.

Anonymous (2000, 2002) found Alphonso as most susceptible variety to all the species of mango hopper in south Gujarat. They further stated that in case of outbreak of hopper, Alphonso suffers the most leading to lot of economic loss. Similarly, Sushil Kumar *et al*. (2002) evaluated various mango hybrids on the basis of natural infestation of hopper in field conditions and categorized Arka Punit, Mehmud Bahar and Neleshan-Gujarat as least and Sonpari as highly susceptible to mango hoppers.

Talpur and Khuhro (2003) in Pakistan indicated higher incidence of mango hopper species, A*mritodus atkinsoni*, *Idioscopus niveosparsus, I. clypealis* on Langra and Sarolee varieties. They further stated Neelam, Zafran and Dashehari harbored less numbers of mango hopper per shoot.

2.5 Impact of high density plantation on incidence of mango hopper

Srivastava *et al.* (1987) found that spacing of mango trees in orchards also play an important role to facilitate breeding of these hoppers. The orchards with close plantation having tall plants with vigorous growth having shade attract high hopper population and cause lot of damage. They further observed that lesser the spacing between plants higher was the incidence of hoppers. Similarly, Weng Hung Chich (2000) observed higher incidence of *Idioscopus clypealis* (Lethierry) on taller mango plants.

2.6 Impact of NPK fertilization on incidence of mango hopper

Fertilizers particularly nitrogenous one has been found to increase the abundance of insect-pests. These fertilizers increase cell turgidity thereby invite more attack of sucking pests. There have been hardly any reports on the importance of nitrogenous and other fertilizers in population build-up of important pests of mango except by that of Nachiappan (1982) who indicated low incidence of mango hopper with presence of less nitrogen, more of phosphorus and calcium and less of reducing sugar.

2.7 Natural/biological control

Srivastava *et al.* (1979) recorded *Coccinella septumpunctata*, *C. transversalis* and *Menochilus sexmaculatus* preying upon *I. clypealis*. They also observed one species of mantids and one species of neuroptera i.e. *Mallada boninensis* and *Chrysopa lacciperda* preying upon nymphs and adults of *I. nitidulus.* Similarly, *C. septumpunctata, Menochilus sexmaculatus* and *Chrysoperla carnea* were found predating on *A. atkinsoni*, *I. clypealis* and *I. niveosparsus* during flowering season in south Gujarat (Anonymous, 2004).

Srivastava *et al.* (1979) recorded twelve species of spiders belonging to eight families namely *Phiddipus* spp; *Rhene indicus, Marpisa* spp; *Oxyopes shweta, Cyrtophora* spp; *C. cicatrasa, Araneus sinhagadensis, Cheiracanthium donicli, Linphia* spp; *Stegodyphes sarsihorum, Uloborus* spp; *Hersilia sarigryi* and *Theridion indica.* Similarly, predatory efficiency of *Plexippus paykulli* was confirmed by Cao (1986), Miah *et al.* (1986) and Jackson and Macnab (1989) on mango. These findings were later confirmed by Sushil Kumar and Bhatt (1998) on *Amritodus atkinsoni* (Lethierry) in south Gujarat. More precisely, three species of salticid spiders *viz; Marpisa tigrina*, *Lyssomanes sikkimiensis* and *Plexippus paykulli* were reported as voracious feeder on *Idioscopus clypealis* on mango in Punjab and south India (Meena Kumari, 1986; Sadana, 1991 and Venkateshan *et al;* 1992).

2.8 Chemical control

2.8.1 Conventional insecticides

Diazinon (0.02 per cent), DDT (0.1 %) and endrin (0.02 %) have been found effective against various mango hoppers (Patel and Handi, 1953; Tirumala Rao, 1953; Sen and Prashad, 1954; Gangolly *et al;* 1967 and Pruthi and Batra, 1960).

Chari *et al.* (1969) reported that 0.02 per cent parathion followed by 0.1 per cent endosulphan, and carbaryl to be more effective under North Indian climate. Similarly, Gajendra Singh *et al.* (1974) reported 0.1 per cent carbaryl, 0.1 per cent fenitrothion and 0.03 per cent dimethoate to be better than nine other treatments in U.P. Jagtap *et al.* (1976) reported the use of 0.1 per cent carbaryl with sulphur, 0.02 per cent methyl demeton, 0.1 per cent orthene, 0.02 per cent dicrotophos and monocrotophos for the control of hoppers in Maharashtra. Gandhali *et al.* (1975) found 0.03 per cent dimethoate, 0.03 per cent fenitrothion, 0.1 per cent mixture of carbaryl and sulphur (1:1) or 0.2 per cent of mixture of DDT and sulphur as effective chemicals when applied four times at the interval of 21 days staring from pre-flowering. Similarly, carbaryl 0.1 per cent has been found most effective against *Amritodus atkinsoni* (Singh *et al*; 1974; Sarma *et al*; 1981; Shah and Valand, 1981; Patel *et al;* 1987; Pingle and Patil, 1988). Shah *et al.* (1979) in Gujarat recommended 0.03 per cent monocrotophos, 0.075 per cent endosulphan and 0.2 per cent carbaryl quite effective in controlling hopper population. Prashad and Bagle (1979) also recommended 0.2 per cent carbaryl, 0.05 per cent monocrotophos, 0.05 per cent phenthoate and 0.05 per cent phosalone to control mango leaf hoppers, whereas, Tandon and Lal (1979) on the other hand screened 19 insecticides against *Idioscopus cypealis* in U.P. and found 0.15 per cent carbaryl, 0.04 per cent monocrotophos, 0.05 per cent phosphamidon and 0.05 per cent methyl parathion to be the most effective. Shah and Valand (1981) however, observed that continuous application of carbaryl for controlling mango hoppers invariably increased population of two spotted spider mite (*Tetranychus urticae* Koch). They further stated that this could be due to an increased reproductive potential of its predators, Yazdani and

Mehto (1980) found dimethoate at 0.5 Kg/ha more efficacious than methyl parathion against *A. atkinsoni* which was later confirmed by Dakshinamurthy (1984) who found lowest nymph population of *A. atkinsoni* with 0.03 per cent dimethoate. Whereas, Nachiappan (1982) found 0.035 per cent endosulphan most effective followed by 0.08 per cent phosphamidon and 0.1 per cent carbaryl. They further observed that endosulphan resulted in maximum retention of fruits and hence, gave a better yield.

Kumar *et al.* (1985) found methyl-o-demeton causing rapid knock down of *A. atkinsoni* in laboratory as well as field trials. Abbas *et al.* (1987) found 0.2 per cent carbaryl, 0.063 per cent quinalphos, 0.054 per cent monocrotophos, 0.04 per cent chlorpyriphos, 0.075 per cent fenitrothion and 0.06 per cent dimethoate as most effective insecticides against *I. nitidulus* and *I. clypealis*, whereas, Srivastava *et al*. (1987) succeeded against another mango hopper species *A. atkinsoni* using 0.063 per cent quinalphos, 0.2 per cent carbaryl and 0.04 per cent chlorpyriphos.

Srivastava and Verghese (1989) recommended 0.04 per cent monocrotophos and 0.05 per cent Voltan for the control of *I. clypealis.* They further found phosxin (Voltan) least toxic to the parasite, *Tetrastichus* spp. of the hoppers. Similar results were reported by Mishra and Choudhary (1996) against *I. clypealis*.

Sarma *et al.* (1981) obtained cent percent knock down of *Idioscopus* spp. on mango using BPMC {2-(1-methyl propyl) phenyl methyl carbamate} or isoprocarb (MIPC).

2.8.2 Synthetic pyrethroids

Shukla and Prasad (1984) indicated effectiveness of permethrin, cypermethrin and fenvalerate at 0.02 per cent concentration each for the control of *Idioscopus clypealis* on mango, whereas Datar (1985) found similar result of fenvalerate at lower dose (0.01 per cent) to control *Amritodus atkinsoni*. Pingle and Patil (1988) found 0.01 per cent permethrin reduced the population of both the species.

Gajendra Singh (1989) found 0.005 per cent fenvalerate and cypermethrin and 0.002 per cent decamethrin (deltamethrin) to be very effective against *A. atkinsoni*, while Shah *et al*. (1989) showed that permethrin and fenvalerate at 20 p.p.m. and cypermethrin at 10 p.p.m. very effective against this pest species for over two months. Similar findings were reported by Srivastava and Verghese (1989) using 0.02 per cent cypermethrin and 0.05 per cent permethrin and by Singh and Chopra (1997) using cypermethrin and fenvalerate at 0.005 per cent concentration each on another hopper species, *I. clypealis.*

Deltamethrin 0.01 per cent was found least toxic to the parasite, *Tetrastichus* spp. on hoppers (Verghese and Srivastava, 1989).

Ragini *et al.* (2001) indicated effectiveness of fluvalinate (Mavrik) at 0.016 and 0.02 per cent concentrations to bring down the population of mango hoppers below the economic threshold level.

Verghese (2000) found effectiveness of lambdacyhalothrin at 0.5 ml./lit. as effective as monocrotophos (0.05 per cent) against *I. niveosparsus.* These results were later on confirmed by Pusphalatha *et al.*

(2002) and Anonymous (2003) on *A. atkinsoni* and other hoppers, respectively.

Synthetic pyrethroids are broad spectrum insecticides who on one hand have quick knock down effect but there are reports that their repeated applications results in resurgence of sucking pests in particular. Repeated applications of same insecticides resulted in resurgence of mango hopper in south Gujarat (Sushil Kumar and Bhatt, 2002). They further found toxicity on *Menochilus sexmaculatus* and predatory spiders due to their repeated applications.

2.8.3 Newer insecticides

Indiscriminate use of present day conventional insecticides has resulted into their ineffectiveness on mango hopper complex. This may be due to insecticide resistance to these insects or may be due to possible resurgence of the pest owing to their repeated use or may due to insect resistance to these insecticides due to development of new biotypes of the pest. So, there is a strong need of evaluating new insecticides in the form of new molecules or products on mango hopper and other important insect-pests of mango. Though relevent literature on these products is very scarce, however, available references are mentioned here under.

A new generation systemic insecticide having low mammalian toxicity was reported to be highly effective for the control of homopteran pests (Elbert *et al;* 1991). The effectiveness of imidacloprid at 3 and 4 ml/10 lit. of water has been reported by Dattatraya (1998), Godase (1998), Godase and Bhole, (2002), and Sushil Kumar *et al*. (1998) against mango hoppers. Imidacloprid at doses ranged from 0.2-1.6 ml/lit. found effective for a period of 21 days against the hoppers, *I. nagpurensis* and *I.*

niveosparsus (Verghese, 1998; Anonymous, 1999) and at the rate of 0.2 ml/lit. against another species, *I. niveosparsus*, (Verghese, 2000). Similar observations were noticed by Kudagamage *et al.* (2001) against mango hoppers*, I. clypealis* and *A. brevistylus* in Sri Lanka during February-March. Indumathi and Savithri (2003) also proved that imidacloprid resulted in the highest reduction of the mango hopper in Andhra Pradesh.

Two applications of thiamethoxam, a thianicotyl compound (Actara 25 WG) once at the beginning of flowering and another at the full bloom stage at 50 and 100 g. a.i checked the mango hopper (*Idioscopus niveosparsus*) infestation (Murugan and Ramchandran, 2001). Similarly, bioefficacy of thiamethoxam (Actara 25 WG) at 50 g a.i./ha. was proved in comparison to conventional insecticides against hopper, *Amritodus atkinsoni* infesting mango in Gujarat by Patel *et al.* (2003).

Similarly, Krishna Kumar *et al.* (2001) indicated that thiamethoxam 25 WG at the rate of 12 ml/Kg. of seed was effective in reducing the hopper infestation of okra, whereas, Vadodaria *et al;* (2001) proved its efficacy as cotton seed treatment at 2.8 and 4.3 g/Kg seeds on aphids, jassids and thrips up to 50 days.

Acetamiprid has a highly systemic and translaminar activity and hence gives excellent efficacy against sucking pest complex. Superiority of acetamiprid against jassids and aphids of cotton in comparison to conventional insecticides was proved by Kumar *et al*. (1999) and Patel *et al*. (2001). Similarly, Kendappa *et al*. (2002) revealed that two applications of acetamiprid at 20 g a.i./ha. were highly effective in suppressing heavy infestation of green peach aphid, *Myzus persicae* on tobacco.

Two sprays of profenofos at 0.05, 0.1 and 0.2 per cent doses found to give protection against mango hoppers throughout the flowering season (Ragini *et al*; 2001), whereas ready to mix formulation of profenofos with cypermethrin (Polytrin-C) at 2 ml/lit. has checked hopper infestation significantly higher than other treatments (Vijay Bhaskar and Purushottam, 2004).

2.8.4 Insect growth regulators

Though, diflubenzuron has never been tested on mango hoppers, but its effectiveness has already been proved in cotton (Plapp, 1976; Abbas *et al;* 1987; Wilkinson, 1976; Sundramurthy, 1978; Nateshan and Bala Subramaniam, 1980).

III MATERIALS AND METHODS

The present investigation on the “Population dynamics and some management aspects of mango hopper” was carried out during 2002, 2003 and 2004 at the Agriculture Experimental Station, Gujarat Agricultural University (now Navsari Agricultural University), Paria which is situated in Valsad district of Gujarat state at an elevation of 10 meters above mean sea level. The place lies at 20° 51’ N latitude and 72° 54’ E longitude. It is about 10 km east of the Arabian Sea shore.

The climate of the area is tropical and monsonic; the monsonic rains commence from second week of June and last up to first week of October and confines mostly to the southwest monsoon. The average rainfall is 2000 mm. The lowest temperature occurs in January during which the mean weekly minimum temperature fluctuates between 7 to 13.5 °C. The summer season starts from March and temperatures rise up to 45 °C in the month of May. However, the average maximum temperature is 27 °C. The meteorological data in respect of maximum and minimum temperatures, relative humidity and rainfall distribution, recorded at the meteorological observatory of Agriculture Experimental Station, Gujarat Agricultural University, Paria during the course of experimental period from 2002-2004 have been presented in Appendix I-IV.

The soil of the experimental fields was well-drained, medium black with more than two meters of soil depth. The land was leveled with a gentle slope from north - south.

EXPERIMENTAL DETAILS

During the course of study seven different experiments were undertaken. The details of the experimental materials used, methods followed and the techniques adopted during the course of the investigation are described hereunder.

All the field experiments were conducted at Agriculture Experimental Station, Gujarat Agricultural University (now Navsari Agricultural University) at Paria consecutively for two and a half years during January 2002 to June 2003 as well as during July 2003 to June 2004.

3.1 Population dynamics of mango hopper

3.1.1 In relation to weather parameters

In order to study the population dynamics of hoppers, *Amritodus atkinsoni*, *Idioscopus clypealis*, *Idioscopus niveosparsus* and *Amrasca splendens* in relation to weather parameters, a study was carried in the form of fixed plot survey for two consecutive years viz; January 2002 to December 2003. For this purpose ten mature mango (cv. 'Alphonso') trees of uniform age were selected randomly in one-hectare plot.

3.1.2 Method of recording observations

Observations were recorded during morning hours between 8-9 A.M. at weekly (standard week wise) interval throughout the experimental period spread over two years in the following manner.

(a) On tree trunk

Mango hopper (nymphs and or adults) population was recorded on tree trunk throughout the year at weekly (standard week wise) interval (Plate 3). For recording observations, four spots of one sq. ft. were randomly selected on main tree trunk of each selected tree (ten trees in one hectare plot) and species wise hopper population was recorded from each spot visually.

(b) Before and after flowering

Ten twigs on each of the ten experimental trees were selected randomly during vegetative stage (April-June and October-December) and mango hopper population (nymphs and or adults or both) was recorded weekly interval (standard week wise).

(c) Flowering stage

Hundred panicles were selected randomly on each of the ten trees during flowering stage and mango hopper was recorded at weekly interval each year (Plate 1).

(d) Hopper egg laying injury

Hopper egg laying injury was observed on ten terminal leaves of each of the ten twigs selected randomly on each experimental tree throughout the year at weekly interval. Damage was thus assessed on percent basis (Plate 4-5).

(e) Sooty mold

The sticky appearance of the trees as caused by honey dew excretions of hoppers and black sooty mold development (Plate 5 and 7) was visually graded on ten terminally mature leaves on each of the ten twigs and hundred panicles on each of ten experimental trees during vegetative (April-June and October-December) and flowering stages (January - March), respectively using a 0-4 scale as described below.

Grade scale	Description
0	No visual appearance of black mold development
1	Development of black mold on less than 25 per cent of leaves or panicles.
2	Development of black mold on less than 26 - 50 per cent of leaves or panicles.
3	Development of black mold on less than 51 - 75 per cent of leaves or panicles.
4	Development of black mold on more than 75 per cent of leaves or panicles.

(f) Natural enemies

Population of predatory spiders and Cocinellids was observed on ten twigs and hundred panicles on each of ten experimental trees during vegetative (April-June and October-December) and flowering stages (January - March) at weekly (standard week wise) interval, respectively, each year.

3.1.3 Correlation and regression

In order to study the effect of weather parameters *viz*; temperature (maximum, minimum and average), relative humidity (morning, evening and average), rainfall, rainy days and sun shine on the population of various species of mango hopper, correlation coefficients and regression equations were worked out by taking average hopper population (both on trunk and twig or panicle) as dependent variable (Y) and weekly meteorological data as independent variables (X_1 to X_9).

3.1.4 In relation to crop stages

Hopper population (nymphs and or adults) was observed at various crop growth stages of mango viz; vegetative, flowering, fruit set (at pea, marble and stone formation) and harvest stages of the crop. The method of recording observations was same as mentioned in 3.1.2 (b) and (c).

3.1.5 Spatial distribution of mango hopper

Mango hopper (nymphs and or adults) population on tree trunk was recorded from four spots each of 1 sq. ft. direction wise viz; North, South, East and West on lower (at 2 ft. height above the ground level) and upper trunk (more than 2 ft. above ground level but not after its division into primary branches) on ten trees selected randomly in a fixed plot survey at weekly interval and observations were later on summed up and their average values were considered for studying spatial distribution (Plate 3). The procedure outlined by Southwood (1978) was followed for determining the distribution pattern. Three dispersion indices *viz*; variance mean ratio, mean crowding and Lloyd's index of patchiness were worked out.

Lloyd's index of patchiness is the ratio of mean crowding (X*) to mean density was also calculated for each set of observation. The value of mean crowding (X*) with estimates was calculated by the formula as under :

$$X* = X + \left(\frac{S^2}{\overline{X}} - 1 \right)$$

Where $\overline{X}$ = Mean density

S^2 = Variance

The value of index equals unity in a random distribution, but is greater and smaller than unity in contagious and regular distributions, respectively. Amongst the model of uniform distribution, the negative binomial is perhaps the most widely applied to insect populations (Anscombe, 1949; Bliss and Owen, 1958; Evans, 1953 and Waters, 1959).

Index of clumping was calculated by substracting mean values from mean crowding.

After finding the distribution trend from dispersion parameters, the data were fitted to χ^2 - Chisquare departure from Poisson distribution.

$$\chi^2 = S^2 \frac{(N-1)}{\overline{X}}$$

Where $\overline{X}$ = Mean density

S^2 = Variance

N = Number of observations

Higher the value of χ^2, more is the aggregation among the insects and vice-versa.

To study the distribution further, Morista's indices of dispersion as suggested by Morista (1962) were calculated for each set of observation. The value of Morista indices (I) was calculated by the formula:

$$I = N - \frac{\sum X^2 - \sum X}{(\sum X)^2 - \sum X}$$

Where N = Total number of samples (80)

X = Sum of number of individuals found in the samples

3.2 Screening of mango cultivars against mango hopper

To study the varietal resistance or susceptibility of mango against mango hoppers, a field experiment was conducted during July 2002 to June 2004. For the purpose, mango germplasm planted in 1967 was taken advantage. The experimental details are as under:

(a) Statistical design : Row based

(b) Spacing : 10 x 10 m.

(c) Replication : 2 (one tree considered as one replication)

(d) Treatment : 15 varieties

1. Alphonso (Check)
2. Kesar (Check)
3. Baneshan
4. Chausa
5. Dadamio
6. Dashehari
7. Jamadar
8. Langra
9. Neelum
10. Pairi
11. Rajapuri
12. Makaram
13. Suvarnrekha
14. Totapuri
15. Vashibadami

All the experimental trees were kept free from insecticidal spray during the course of investigation.

3.2.1 Method of recording observations

Observations were recorded on thirty experimental trees at fortnightly interval throughout the experimental period of two years i.e. 2002-2003 and 2003-2004 crop seasons.

The methodology for screening mango cultivars was same as mentioned in 3.1.2 (b) to (f).

3.2.2 Morphological characters

To examine the role of morphological characters of the tree on abundance of hopper population following observations were made.

(a) Height of mango tree

Height of each selected tree (representing various cultivars) was measured by a measuring tape in the beginning as well as at the end of the experimentation.

(b) Unit leaf area

In order to determine actual leaf area hundred leaves from ten twigs were selected randomly from all the four main compass points of each tree canopy. The average fortnightly leaf area of different flushes (i.e. February - April for spring season, June - July for rainy season and October – January for autumn season) was calculated and summed up on monthly basis. The samples were immediately shifted in the laboratory. The length of the leaf (excluding petiole) from base to top and breadth at the widest point was measured. The product of length and breadth was thus calculated. The actual leaf area was measured using a CI-203 portable laser meter.

(c) Leaf shape

Ten mature leaves (more than six months old) were sampled for studying the leaf shape of each cultivar and categorized as per their shape (Table -22) before and after the end of the experimentation.

(d) Colour of newly emerged leaves

Ten newly emerged leaves (less than six months old) were sampled for studying the leaf colour of each cultivar and categorized as per their colour *viz.* light green, light brown, purple brown, coppery brown or

Bud initiation stage

Panicle emergence stage

Pre-anthesis stage

Peak flowering stage

PLATE 1 : CROP STAGES IN MANGO

Initiation of recurrent flowering

Recurrent flowers and mature inflorescence on the same twig

Recurrent flowers encircled by mature inflorescence

PLATE 2 : RECURRENT FLOWERING IN MANGO

orange, purple and brick red (Table -22) before and after the end of the experimentation.

(e) Length and colour of inflorescence

Twenty-five panicles from each tree were selected randomly during February 2003 and 2004. Length of the inflorescence was measured using a measuring scale. These inflorescences of different cultivars were grouped on the basis of their individual colour *viz;* yellowish green, crimson, copper, coral red and cornithan red (Table 23).

(f) Hair on inflorescence rachis

Twenty-five panicles from each tree were randomly sampled during February 2003 and 2004 to examine the presence or absence of hairs on inflorescence rachis (Table 23).

3.2.3 Fruit yield

(i) Number of fruits per tree

For recording the fruit setting per tree, the total number of fruits per tree was counted at harvest stage (physiologically mature fruits). These results were expressed as number of fruits or fruit bearing per tree.

(ii) Weight of fruits per tree

For recording the yield the total produce that was earlier observed for counting number of fruits was subsequently weighed at harvest. These results were expressed as yield in Kilograms per tree.

3.2.4 Analysis of data

Relationships between hopper population and each morphological character in each cultivar were worked out using correlation analysis.

3.2.5 Categorization of varieties

The incidence of damage by mango hopper was measured on 0-5 scale and the test varieties were categorized as under:

(i) Categorization on the basis of hopper population

Grade	Hopper population	Categorization
0	Nil	Free
1	1-2 hoppers/twig or panicle	Highly Resistant
2	Up to 5 hoppers/twig or panicle	Resistant
3	6-10 hoppers /twig or panicle	Susceptible
4	> 10 hoppers /twig or panicle	Highly susceptible

(ii) Categorization on the basis of black sooty mold

Grade	Description	Categorization
0	No visual appearance of black mold	Free
1	Development of black mold on less than 25 percent of leaves	Highly resistant
2	Development of black mold on 26-50 percent of leaves	Resistant
3	Development of black mold on	Susceptible

	51-75 percent of leaves	
4	Development of black mold on > 75 percent of leaves	Highly susceptible

3.3 Influence of recurrent flowering on incidence of mango hopper

Recurrent flowers are those new flowers, which emerge from the base points of previously emerged panicles (Plate 2). This recurrent flowering is mostly observed during 45-60 days after the emergence of main panicle. It is also responsible for attracting additional population of hoppers causing late damages at marble and stone size fruit stages of crop growth. So as to assess the crop damage during flowering as well as during post flowering stage this experiment was conducted. For this purpose, ten mango trees (cv. Alphonso) planted in 1987 were utilized for recording observations.

Method of recording observations

Observations were recorded at bud initiation, pre-anthesis, 50 percent panicle emergence, pea, marble, stone and harvest stages of crop growth during 2002 and 2003 years.

(a) Hopper population (nymphs and or adults) was recorded on 100 panicles (50 non-recurrent as well as 50 recurrent flowers originating from lower canopy of each selected tree) on each of the ten trees selected randomly.

(b) Observations based on hopper egg laying injury (Plate 4-5), sooty mold (Plate 5 and 6) and natural enemies were recorded as per 3.1.2 (d) to (f) and 3.2.3.

3.4 Impact of high density plantation on incidence of mango hopper

Trees planted at normal (recommended) distance were compared with the trees of closer spacing planted in single hedge row plantation for abundance of hoppers. This was done with a view to examine the role of microclimate between and within trees on the abundance of hopper complex in mango. Mango (cv. Kesar) trees planted in 1991 were used for recording observations.

The experimental details are as under:

(a)	Statistical design	:	Randomized Block Design
(b)	Replication	:	10 (Each tree was considered as unit replicate)
(c)	Spacing	:	As per the treatment
(d)	**Treatment** (based on spacing)	**:**	**Normal/ Recommended (10 x 10 m)** Single hedge row (10 x 5 m) Single hedge row (10 x 2.5 m)

All the experimental trees were kept free from insecticidal spray during the course of investigation.

Method of recording observations

Observations were recorded on thirty experimental trees at fortnightly interval throughout the experimental period of two years i.e. 2002-2003 and 2003-2004 crop seasons. The methodology for recording observations was same as mentioned in 3.1.2 (b) to (f) and 3.2.3.

3.5 Impact of NPK fertlization on incidence of mango hopper

With an objective to study the effect of different levels of NPK fertilizers to mango trees on abundance of hopper, the field experiment was conducted during 2002-2003 and 2003-2004. For this purpose mango (cv. Kesar) trees planted in 1997 were utilized for taking observations.

The experimental details are as under:

(a) Type of soil : Medium black with more than 2 meters of soil depth

(b) Statistical design : Randomized Block Design

(c) Replication : 3 (One tree considered as one replication)

(d) Spacing : 10 x 10 m

(e) Treatment : Nutrients in gm/tree/year of plantation

(i) Main treatment :

Nitrogen : 1. N_0 - 0 Phosphorus : P_0 - 0 Potash : K_0 - 0

2. N_1 - 75 P_1 - 50 K_1 - 75

3. N_2 - 150 P_2 - 100 K_2 - 150

(ii) Treatment combinations

1.	$N_0P_0K_0$ (Control)	10.	$N_1P_0K_0$	19.	$N_2P_0K_o$
2.	$N_0P_0K_1$	11.	$N_1P_0K_1$	20.	$N_2P_0K_1$
3.	$N_0P_0K_2$	12.	$N_1P_0K_2$	21.	$N_2P_0K_2$
4.	$N_0P_1K_0$	13.	$N_1P_1K_0$	22.	$N_2P_1K_0$
5.	$N_0P_1K_1$	14.	$N_1P_1K_1$	23.	$N_2P_1K_1$
6.	$N_0P_1K_2$	15.	$N_1P_1K_2$	24.	$N_2P_1K_2$
7.	$N_0P_2K_0$	16.	$N_1P_2K_0$	25.	$N_2P_2K_o$
8.	$N_0P_2K_1$	17.	$N_1P_2K_1$	26.	$N_2P_2K_1$
9.	$N_0P_2K_2$	18.	$N_1P_2K_2$	27.	$N_2P_2K_2$

(j) Date of fertilizer application. : 30.6.2002 and 29.6.2003

3.5.1 Method and time of application of fertilizer

NPK nutrients in different quantities (as per different combinations) were applied in the form of chemical fertilizers viz; Urea, Single super phosphate and Muriate of potash at a time around tree trunk at about 1 meter away from tree trunk with the onset of monsoon (during June each year).

All the experimental trees were kept free from insecticidal spray during the course of investigation

3.5.2 Method of recording observations

Observations were recorded on eighty one experimental trees at fortnightly interval throughout the experimental period of two years i.e. 2002-2003 and 2003-2004 crop seasons. The methodology for recording observations was same as mentioned in 3.1.2 (b) to (f) and 3.2.3.

3.6 Mango hopper incidence as influenced by plant growth regulator and different doses of NPK

This experiment primarily dealt with the impact of paclobutrazol and fertilizer application on seasonal cyclicity of mango hoppers. For the purpose, mango trees (cv. Alphonso) planted in 1987 were utilized for recording observations.

The experimental details are as under

(a) Statistical design : Randomised Block Design

(b) Spacing : 10 x 10 m.

(c) Replication : Three (one tree was considered as unit replicate)

(d) Treatment : 8

(i) Paclobutrazol at the rate of 4 g a.i./tree/year with recommended dose of fertilizer.

(ii) Paclobutrazol at the rate of 4 g a.i./tree/year with half of the recommended dose of fertilizer.

(iii) Paclobutrazol at the rate of 4 g a.i./tree (I year) and 2 g a.i./tree (II year) with recommended dose of fertilizer.

(iv) Paclobutrazol at the rate of 4 g a.i./tree (I year) and 2 g a.i./tree (II year) with half of the recommended dose of fertilizer.

(v) Paclobutrazol at the rate of 4 g a.i./tree (I year) and 3 g a.i./tree (II year) with recommended dose of fertilizer.

(vi) Paclobutrazol at the rate of 4 g a. i./tree (I year) and 3 g a.i./tree (II year) with half of the recommended dose of fertilizer.

(vii) Control (untreated) with recommended dose of fertilizer.

(Viii) Control (untreated) with half of the recommended dose of fertilizer.

Date of Paclobutrazol application: 16.8.2002 and 15.8.2003

3.6.1 Method of paclobutrazol (Cultar) application

Treatments of paclobutrazol were applied by trunk soil line pour method at collar region (0.5 m. from tree trunk) to Alphonso trees in different doses mixed with 5 litres of water.

All the experimental trees were kept free from insecticidal spray during the course of investigation.

3.6.2 Method of recording observations

Observations were recorded on twenty four experimental trees at fortnightly interval throughout the experimental period of two years i.e. 2002-2003 and 2003-2004 crop seasons. The methodology for recording observations was same as mentioned in 3.1.2 (b) to (f). Observations on date of flower initiation, full bloom were also recorded at appropriate crop stages.

3.6.3 Yield attributes

Observations based on fruit setting at pea and marble stages of crop growth along with other yield parameters were recorded as per 3.2.3.

3.7 Evaluation of newer insecticides against mango hopper

Efficacy of newer insecticides was tested on mango hopper during 2002, 2003 and 2004 crop seasons. For this purpose mango trees (cv. Alphonso) planted in 1967 were utilized for taking observations. The experimental details of the trial are as under:

(a)	Statistical design	:	Randomised Block Design
(b)	Replication	:	3 (One tree considered as one replication)
(c)	Spacing	:	10 x 10 m.
(d)	Treatment	:	12

1.	Control (untreated)	NIL
2.	Imidacloprid 17.8 EC	0.005 per cent
3.	Thiamethoxam 25 WG	0.0084 per cent
4.	Acetamiprid 20 SP	0.004 per cent
5.	Fipronil 5 EC	0.005 per cent
6.	Profenofos 50 EC	0.1 per cent
7.	Diflubenzuron 25 WP	0.02 per cent
8.	Lambdacyhalothrin 5 EC	0.003 per cent
9.	Carbosulfan 25 EC	0.05 per cent
10.	Fenubucarb 50 EC	0.05 per cent
11.	Endosulfan 35 EC	0.07 per cent
12.	Monocrotophos 36 WSC	0.04 per cent

Note : Technical details are given in Appendix- X

3.7.1 Method of insecticide application

Three trees were randomly selected from each line having 8-10 trees for giving treatment and the observations were taken on them considering one tree as one replication. The treatments were randomized and data on hopper population were recorded before as well as 1, 7, 10, 15 and 21 days after each spray application. In each treatment except control, the need based applications of insecticides were given.The hopper population of five or exceeding five (nymphs and or adults) on each of the hundred panicles selected randomly per experimental tree for taking pre and post spray observations for hopper count was considered as the need (economic threshold level) for insecticide application. This assessment of hopper population was done before initiation of first spray.The details regarding date and number of insecticide application during experimental period (2002, 2003 and 2004 years) are given in vide Table 1-3. For the control of diseases blanket spray of fungicides was done commonly in all the treatments. The Maruti sprayer with triple action nozzle attached to bamboo lance was used to apply the insecticide and fungicide solutions. Twenty-five liters of spray solution was used per tree.

3.7.2 Method of recording observations

The observations were recorded before as well as 1, 7, 10, 15 and 21 days after each spray.

(i) Hopper population

Hopper (nymphs and adult) population was recorded on 100 panicles selected randomly on each tree before spray as well as at each post spray interval.

(ii) Observations on sooty mold, natural enemies and ancillary data were recorded along with hopper population from the same panicles at each spray interval.

3.7.3 Fruit set observations

For taking observations on fruit setting, 100 panicles selected per tree earlier for recording hopper population were used. Number of fruits at peanut, marble and harvest stages of the crop was recorded on each of the tagged panicles on each experimental tree in all the treatments during all the three years of experimentation.

3.7.4 Fruit retention

Number of fruits retained was counted at marble stage (over pea stage) and harvest stage (over marble stage) on 100 panicles (selected for recording hopper population).

3.7.5 Number of fruits and yield at harvest

Methodology of number of fruits and yield at harvest was as per 3.2.3 and expressed in number and Kilogram, respectively during all the three years of experimentation.

3.7.6 Incremental Cost Benefit Ratio (ICBR)

To know the economics of chemical control of mango hoppers, Incremental Cost Benefit Ratio (ICBR) was worked out and presented in Table 50.

First of all, total cost of treatment including the cost of insecticide per tree for each treatment based on the prevailing market price and the labour cost involved for chemical control in treatments during the experiment was taken into account. The value of average yield of mango fruits per tree for each treatment was calculated on the basis of pooled value of the yield obtained during the experimental years (2002, 2003 and 2004) and was considered as total receipt per tree. Thereafter, gross realization was worked out for each treatment after deducting the cost of insecticides and cost of labour. The additional profit due to the use of insecticides for each treatment was worked out by subtracting the value realized in the control treatment from the gross realization for each treatment. The percent increase over control was also worked out based on additional profit divided by the value realized in control and multiplied by a hundred.

Net gain per rupee cost (I.C.B.R.) was worked out based on additional profit after deducting realization in control divided by total cost i.e. cost of insecticide plus cost of labour.

3.7.7 Rank method

First of all, the rank was given on the basis of individual character. Thereafter, these ranks for each treatment were summed up and overall rank of each treatment was calculated.

3.8 Analysis of data

Data of hopper population, sooty mould and egg injury were analyzed after subjecting them to $\sqrt{x+0.5}$ transformations. Similarly, data of fruit set at pea, marble, harvest and yield stages were analyzed after subjecting them to $\sqrt{x+0.5}$ transformations. The data were analyzed using analysis of variance technique in Randomised Block Design. Thereafter, different treatments under test were compared on the basis of various parameters considered for investigation during the years of investigation.

The data on seasonal abundance, varietal screening, effect of recurrent flowering and paclobutrazol were compared on the basis of correlation and regression studies.

Table -1: Details regarding date of spraying in the field experiment to study the effectiveness of insecticides against mango hoppers (2002)

Sr. No.	Name of the insecticide	Date and month of the year (2002)						
		21 Jan.	31 Jan.	5 Feb.	11 Feb.	21 Feb.	26 Feb.	4
1.	Imidacloprid 0.005 %	*	--	--	*	--	--	
2.	Thiamethoxam 0.0084 %	*	--	--	*	--	*	
3.	Acetamiprid 0.004 %	*	--	*	--	*	--	
4.	Fipronil 0.005 %	*	--	*	--	*	--	
5.	Profenofos 0.1 %	*	--	*	--	*	--	
6.	Diflubenzuron 0.02 %	*	*	--	*	*	*	
7.	Lambdacyhalothrin 0.005 %	*	*	--	*	*	*	
8.	Carbosulfan 0.05 %	*	*	--	*	*	*	
9.	Fenubucarb 0.05 %	*	--	*	--	*	--	
10.	Endosulfan 0.07 %	*	*	--	*	*	*	
11.	Monocrotophos 0.04 %	*	--	*	--	*	--	

Table -2 : Details regarding date of spraying in the field experiment to study the effectiveness of insecticides against mango hoppers (2003)

Sr. No.	Name of the insecticide	Date and month of the year (2003)						
		23 Jan.	2 Feb.	7 Feb.	13 Feb.	23 Feb.	28 Feb.	6
1.	Imidacloprid 0.005 %	*	--	--	*	--	--	
2.	Thiamethoxam 0.0084 %	*	--	--	*	--	*	
3.	Acetamiprid 0.004 %	*	--	*	--	*	--	
4.	Fipronil 0.005 %	*	--	*	--	*	--	
5.	Profenofos 0.1 %	*	--	*	--	*	--	
6.	Diflubenzuron 0.02 %	*	*	--	*	*	*	
7.	Lambdacyhalothrin 0.005 %	*	*	--	*	*	*	
8.	Carbosulfan 0.05 %	*	*	--	*	*	*	
9.	Fenubucarb 0.05 %	*	--	*	--	*	--	
10.	Endosulfan 0.07 %	*	*	--	*	*	*	
11.	Monocrotophos 0.04 %	*	--	*	--	*	--	

Table- 3 : Details regarding date of spraying in the field experiment to study the effectiveness of insecticides against mango hoppers (2004)

Sr. No.	Name of the insecticide	Date and month of the year (2004)						
		31 Jan.	10 Feb.	15 Feb.	21 Feb.	3 Mar.	8 Mar.	M
1.	Imidacloprid 0.005 %	*	--	--	*	--	--	
2.	Thiamethoxam 0.0084 %	*	--	--	*	--	*	
3.	Acetamiprid 0.004 %	*	--	*	--	*	--	
4.	Fipronil 0.005 %	*	--	*	--	*	--	
5.	Profenofos 0.1 %	*	--	*	--	*	--	
6.	Diflubenzuron 0.02 %	*	*	--	*	*	*	
7.	Lambdacyhalothrin 0.005 %	*	*	--	*	*	*	
8.	Carbosulfan 0.05 %	*	*	--	*	*	*	
9.	Fenubucarb 0.05 %	*	--	*	--	*	--	
10.	Endosulfan 0.07 %	*	*	--	*	*	*	
11.	Monocrotophos 0.04 %	*	--	*	--	*	--	

IV RESULTS AND DISCUSSION

The results of the present investigation on mango hopper carried out in the field conditions are presented and discussed as below.

4.1 Population studies of mango hopper

Four species of mango hopper *viz*; *Amritodus atkinsoni* Lethierry, *Idioscopus clypealis* Lethierry, *I. niveosparsus* Lethierry and *Amrasca splendens* Ghauri both on tree trunk and twig or panicle appeared either simultaneously or in succession at different stages of crop growth of mango during 2002 and 2003. Incidence of all the hoppers associated with mango is presented in Table 4-7 and depicted in Fig. 1-5. The population build-up of any insect-pest varies closely with weather conditions prevailing during the preceding and corresponding periods. The year wise and pooled relationship between incidence of mango hoppers and weather parameters is presented below. Whereas, results on inter-specefic correlation, associated damage, natural enemies along with spatial distribution studies have also been discussed in this chapter.

4.1.1 Abundance of various species of mango hopper in relation to weather parameters

4.1.1.1 Abundance of hopper population

***Amritodus atkinsoni* (Lethierry)**

A. atkinsoni appeared throughout both the years on different crop stages. The density on tree trunk was very low during flowering and fruiting season of the crop i.e. 0.01 to 0.36, 0.03 to 0.73 and 0.02 to 0.54 hoppers per sq. ft. tree trunk area during 2002, 2003 and pooled analysis, respectively. The population multiplied further and reached the peak count of 3.34, 3.24 and 3.29 hoppers per sq. ft. trunk area in the 43rd standard week (SW) i.e. during emergence of new flush of 2002, 2003 and pooled analysis, respectively. (Table 4-6).

Similarly, the twig population of the pest density peaked (0.29 per twig) during 31-32 standard weeks i.e. vegetative stage of the crop in 2002. In the subsequent year, the pest peaked (0.56 per twig) on the 43rd standard week i.e. emergence of new flush stage, whereas, in the pooled analysis the population on tree twig peaked (0.41 per twig) on 42nd standard week i.e. emergence of new flush. Population of *A. atkinsoni* however, remained zero during 22-26 standard weeks in 2003 (Table 4-6) (Fig.1).

***Idioscopus clypealis* (Lethierry)**

Relatively high incidence of the mango hopper *I. clypealis* was observed on tree trunk during flowering season of 2002. The peak population was 1.46 hoppers per sq. ft. trunk in the 5th SW (29 January-4 February), whereas during fruiting season, it was very low and for rest of the period it was nil in 2002. Similar trend of population but in lower form was noticed in the subsequent year and in pooled analysis. The peak population was 0.60 per sq. ft. tree trunk in 12th standard week i.e. stone sized fruit stage in 2003 and 0.94 per sq. ft tree trunk in 5th standard week at peak flowering in pooled analysis. However, there were no hoppers of *I. clypealis* during 23-48, 27-50 and 27-48 standard weeks of 2002, 2003 and mean of two years, respectively (Table 4-6).

The pest population on tree twig or panicle was comparatively higher during marble/stone sized fruit stage of the crop during both the years and pooled analysis reaching its peak of 4.14, 1.69 and 2.84 hoppers per panicle in the 15 (9-15 April) and 16 (16-22 April) standard weeks of 2002, 2003 and pooled analysis, respectively. For rest of the period of both years and pooled analysis population was negligible to nil (Table 4-6) (Fig. 1).

***Idioscopus niveosparsus* (Lethierry)**

Incidence of the mango hopper, *I. niveosparsus* remained very low with peak population of only 0.21 (2nd standard week), 0.16 (6th standard week) and 0.15 (22nd standard week) hoppers per sq. ft. tree trunk during 2002, 2003 and pooled analysis, respectively on tree trunk coinciding with flowering stage of the crop. Population was nil consecutively between 22-34 and 48, 24 and 28-42 and 24 and 28-34 standard weeks of 2002, 2003 and mean of two years, respectively (Table 4-6).

Likewise, twig population of the pest species attained peak status of 2.91, 0.61 and 1.75 hoppers per panicle on 15 , 16 and 16th standard weeks of 2002, 2003 and pooled analysis, respectively which coincided with stone sized fruit stage of crop growth, whereas, no hopper population of *I. niveosparsus* was recorded during 26-30 and 33-38, 24-25 and 27-48 and 27-30 and 33-38 standard weeks of 2002, 2003 and mean of two years, respectively (Table 4-6) (Fig. 1).

***Amrasca splendens* Ghauri**

A very low population density of the mango hopper, *splendens* was observed (0.00 to 0.18, 0.00 to 0.13 and 0.00 to 0.13 hoppers per sq. ft. trunk during 2002, 2003 and pooled analysis, respectively). However, there was no hopper population during 9, 20-29 and 31-32 standard weeks of 2002, 21, 23-24 standard weeks of 2003 and 21 and 23-24 standard weeks in mean values. Whereas, pest density on tree

Table - 4: Fluctuation of species wise hopper population during 2002

St. wk.	Std. period	Crop stage	Hopper/ sq. ft trunk area/					Hopper/ twig or panicle				
			Aa	Ic	In	As	Tot	Aa	Ic	In	As	Tot
1	1-7 Jan.	In. Flowering	0.36	1.01	0.18	0.08	1.63	0.10	0.35	0.24	0.09	0.78
2	8-14 Jan.	In. Flowering	0.29	1.08	0.21	0.05	1.63	0.10	0.39	0.27	0.11	0.87
3	15-21 Jan.	In. Flowering	0.21	1.05	0.10	0.05	1.41	0.08	0.31	0.20	0.07	0.66
4	22-28 Jan.	In. Flowering	0.20	1.13	0.13	0.05	1.51	0.08	0.39	0.24	0.09	0.80
5	29 Jan.- 4 Feb.	Peak flowering	0.08	1.46	0.10	0.01	1.65	0.06	0.44	0.27	0.11	0.88
6	5-11 Feb.	Peak flowering	0.20	1.13	0.10	0.04	1.47	0.06	0.44	0.31	0.11	0.92
7	12-18 Feb.	Pea/marble	0.11	0.99	0.05	0.01	1.16	0.05	0.84	0.49	0.13	1.51
8	19-25 Feb.	Pea/marble	0.08	1	0.04	0.01	1.13	0.04	0.89	0.56	0.11	1.60
9	26 Feb.- 4 Mar.	Pea/marble	0.06	1.05	0.01	0	1.12	0.05	0.99	0.59	0.17	1.80
10	5-11 Mar.	Pea/marble	0.06	1	0.01	0.01	1.08	0.06	1.14	0.79	0.26	2.25
11	12-18 Mar.	Stone size	0.06	1	0.09	0.04	1.19	0.06	1.94	1.14	0.29	3.43
12	19-25 Mar.	Stone size	0.05	0.95	0.09	0.05	1.14	0.06	2.09	1.66	0.29	4.10
13	26 Mar.- 1 Apr.	Stone size	0.05	0.83	0.05	0.02	0.95	0.05	2.31	2.01	0.26	4.63
14	2-8 Apr.	Stone size	0.05	0.81	0.05	0.01	0.92	0.05	3.91	2.44	0.21	6.61
15	9-15 Apr.	Stone size	0.05	0.75	0.05	0.01	0.86	0.05	4.14	2.91	0.16	7.26
16	16-22 Apr.	Stone size	0.05	0.45	0.05	0.01	0.56	0.05	3.99	2.90	0.14	7.08
17	23-29 Apr.	Stone size	0.03	0.47	0.01	0.01	0.52	0.05	3.99	1.66	0.11	5.81
18	30 Apr.- 6 May	Stone size	0.03	0.45	0.01	0.01	0.50	0.04	2.67	1.44	0.09	4.24
19	7-13 May	Fruiting	0.03	0.36	0.02	0.01	0.42	0.03	2.19	1.14	0.08	3.44
20	14-30 May	Fruiting	0.03	0.26	0.01	0	0.30	0.03	1.66	0.97	0.06	2.72
21	21-27 May	In. Ripening	0.03	0.07	0.01	0	0.11	0.03	0.91	0.49	0.01	1.44
22	28 May- 3 June	In. Ripening	0.02	0.01	0	0	0.03	0.02	0.56	0.40	0	0.98
23	4-10 June	Rip./harvest	0.01	0	0	0	0.01	0.04	0.14	0.07	0	0.25
24	11-17 June	Harvest	0.03	0	0	0	0.03	0.04	0.09	0.06	0	0.19
25	18-24 June	Harvest	0.06	0	0	0	0.06	0.07	0.03	0.01	0	0.11
26	25 June-1 Jul.	Harvest	0.06	0	0	0	0.06	0.09	0.01	0	0	0.10
27	2-8 Jul.	Vegetative	0.20	0	0	0	0.20	0.13	0.01	0	0	0.14
28	9-15 Jul.	Vegetative	0.66	0	0	0	0.66	0.17	0.01	0	0	0.18
29	16-22 Jul.	Vegetative	0.83	0	0	0	0.83	0.19	0.01	0	0	0.20
30	23-29 Jul.	Vegetative	1.11	0	0	0.03	1.14	0.24	0.01	0	0	0.25
31	30 Jul.- 5 Aug.	Vegetative	1.01	0	0	0	1.01	0.29	0.02	0.01	0	0.32
32	6-12 Aug.	Vegetative	2.13	0	0	0	2.13	0.29	0.02	0.02	0	0.33
33	13-19 Aug.	Vegetative	2.23	0	0	0.04	2.27	0.26	0.01	0	0	0.27
34	20-26 Aug.	Vegetative	2.36	0	0	0.10	2.46	0.23	0	0	0	0.23
35	27 Aug.- 2 Sep.	Emr. New flush	2.70	0	0.08	0.13	2.91	0.24	0.01	0	0	0.25
36	3-9 Sep.	Emr. New flush	2.75	0	0.08	0.10	2.93	0.24	0.01	0	0	0.25
37	10-16 sep.	Emr. New flush	2.86	0	0.05	0.10	3.01	0.21	0.01	0	0	0.22
38	17-23 Sep.	Emr. New flush	2.88	0	0.06	0.09	3.03	0.19	0.01	0	0	0.20
39	24-30 Sep.	Emr. New flush	2.90	0	0.04	0.08	3.02	0.23	0.01	0.01	0	0.25
40	1-7 Oct.	Emr. New flush	2.91	0	0.04	0.08	3.03	0.23	0.01	0.01	0	0.25
41	8-14 Oct.	Emr. New flush	2.93	0	0.03	0.08	3.04	0.27	0.01	0.01	0	0.29
42	15-21 Oct.	Emr. New flush	3.08	0	0.03	0.08	3.19	0.27	0.01	0.01	0	0.29
43	22-28 Oct.	Emr. New flush	3.34	0	0.04	0.18	3.56	0.24	0.01	0.01	0	0.26
44	29 Oct.- 4 Nov.	New twigs	2.94	0	0.03	0.14	3.11	0.24	0.03	0.01	0	0.28
45	5-11 Nov.	New twigs	2.41	0	0.03	0.10	2.54	0.21	0.03	0.01	0	0.25
46	12-18 Nov.	New twigs	2.30	0	0.01	0.06	2.37	0.21	0.04	0.02	0	0.27
47	19-25 Nov.	New twigs	2.23	0	0.01	0.06	2.30	0.19	0.03	0.02	0	0.24

48	26 Nov.- 2 Dec.	Bud/bud burst	2.08	0	0	0.05	2.13	0.16	0.04	0.03	0	0.23
49	3-9 Dec.	Bud/bud burst	1.71	0.13	0.01	0.04	1.89	0.14	0.03	0.03	0	0.20
50	10-16 Dec.	Bud/bud burst	1.43	0.14	0.03	0.04	1.64	0.16	0.04	0.03	0	0.23
51	17-23 Dec.	Bud/bud burst	1	0.14	0.03	0.04	1.21	0.19	0.05	0.03	0	0.27
52	24 Dec- 31 Dec.	Bud/bud burst	0.80	0.14	0.04	0.04	1.02	0.19	0.04	0.03	0	0.26

Aa : *Amritodus atkinsoni* Ic : *Idioscopus clypealis* In : *I. niveosparsus* As : *Amrasca splendens* Nil population Period of low activity Lowest activity Active period Peak period

Table - 5: Fluctuation of species wise hopper population during 2003

St. wk.	Std. period	Crop stage	Hopper/sq. ft trunk area					Hopper/ twig or panicle				
			Aa	Ic	In	As	Tot	Aa	Ic	In	As	Tot
1	1-7 Jan.	In. Flowering	0.73	0.18	0.08	0.01	1.00	0.20	0.06	0.03	0	0.29
2	8-14 Jan.	In. Flowering	0.73	0.26	0.08	0.03	1.12	0.26	0.06	0.03	0	0.29
3	15-21 Jan.	In. Flowering	0.60	0.30	0.08	0.05	1.03	0.21	0.07	0.03	0.04	0.35
4	22-28 Jan.	In. Flowering	0.55	0.38	0.08	0.05	1.06	0.22	0.08	0.03	0.04	0.37
5	29 Jan.- 4 Feb.	Peak flowering	0.30	0.43	0.14	0.09	0.96	0.22	0.10	0.03	0.06	0.41
6	5-11 Feb.	Peak flowering	0.30	0.43	0.16	0.09	0.98	0.23	0.10	0.03	0.06	0.42
7	12-18 Feb.	Pea/marble	0.26	0.49	0.13	0.09	0.97	0.19	0.11	0.04	0.07	0.41
8	19-25 Feb.	Pea/marble	0.26	0.49	0.09	0.09	0.93	0.19	0.11	0.04	0.01	0.35
9	26 Feb.- 4 Mar.	Pea/marble	0.18	0.51	0.11	0.04	0.84	0.17	0.13	0.06	0.01	0.37
10	5-11 Mar.	Pea/marble	0.18	0.51	0.05	0.03	0.77	0.14	0.16	0.07	0.01	0.38
11	12-18 Mar.	Stone size	0.18	0.54	0.08	0.08	0.88	0.19	0.29	0.11	0.11	0.70
12	19-25 Mar.	Stone size	0.16	0.60	0.06	0.01	0.83	0.16	0.44	0.13	0.11	0.84
13	26 Mar.- 1 Apr.	Stone size	0.14	0.38	0.05	0.01	0.58	0.13	0.71	0.21	0.13	1.18
14	2-8 Apr.	Stone size	0.11	0.41	0.05	0.01	0.58	0.11	1.13	0.39	0.29	1.92
15	9-15 Apr.	Stone size	0.10	0.45	0.03	0.01	0.59	0.11	1.44	0.44	0.31	2.30
16	16-22 Apr.	Stone size	0.10	0.43	0.01	0.01	0.55	0.11	1.69	0.61	0.39	2.80
17	23-29 Apr.	Stone size	0.09	0.43	0.10	0.05	0.67	0.09	1.44	0.40	0.29	2.22
18	30 Apr.- 6 May	Stone size	0.08	0.28	0.05	0.05	0.43	0.06	1.01	0.21	0.16	1.44
19	7-13 May	Fruiting	0.08	0.26	0.03	0.01	0.38	0.03	0.69	0.17	0.09	0.98
20	14-30 May	Fruiting	0.06	0.25	0.01	0.01	0.33	0.03	0.51	0.11	0.06	0.71
21	21-27 May	In. Ripening	0.04	0.20	0.01	0	0.25	0.01	0.39	0.09	0.03	0.52
22	28 May- 3 June	In. Ripening	0.03	0.18	0.03	0.01	0.25	0	0.24	0.06	0.01	0.31
23	4-10 June	Rip./harvest	0.03	0.10	0.03	0	0.16	0	0.16	0.01	0	0.17
24	11-17 June	Harvest	0.03	0.08	0	0	0.11	0	0.13	0	0	0.13
25	18-24 June	Harvest	0.03	0.14	0.01	0.01	0.19	0	0.11	0	0	0.11
26	25 June-1 Jul.	Harvest	0.03	0.16	0.01	0.01	0.21	0	0.09	0.01	0	0.10
27	2-8 Jul.	Vegetative	0.30	0	0.04	0.08	0.42	0.02	0.03	0	0	0.05
28	9-15 Jul.	Vegetative	0.38	0	0	0.08	0.46	0.03	0	0	0	0.03
29	16-22 Jul.	Vegetative	0.74	0	0	0.04	0.78	0.06	0	0	0	0.06
30	23-29 Jul.	Vegetative	0.76	0	0	0.09	0.85	0.09	0	0	0	0.09
31	30 Jul.- 5 Aug.	Vegetative	0.80	0	0	0.09	0.89	0.17	0	0	0	0.17
32	6-12 Aug.	Vegetative	0.86	0	0	0.05	0.91	0.26	0	0	0	0.26
33	13-19 Aug.	Vegetative	1.04	0	0	0.06	1.10	0.21	0	0	0	0.21
34	20-26 Aug.	Vegetative	1.08	0	0	0.04	1.12	0.23	0	0	0	0.23
35	27 Aug.- 2 Sep.	Emr. New flush	1.30	0	0	0.08	1.38	0.29	0	0	0	0.29
36	3-9 Sep.	Emr. New flush	1.88	0	0	0.11	1.99	0.34	0	0	0	0.34
37	10-16 sep.	Emr. New flush	2.36	0	0	0.11	2.47	0.41	0	0	0	0.41

38	17-23 Sep.	Emr. New flush	2.49	0	0	0.09	2.57	0.44	0	0	0	0.44
39	24-30 Sep.	Emr. New flush	2.98	0	0	0.08	3.06	0.41	0	0	0	0.41
40	1-7 Oct.	Emr. New flush	2.84	0	0	0.06	2.90	0.44	0	0	0	0.44
41	8-14 Oct.	Emr. New flush	2.91	0	0	0.06	2.97	0.49	0	0	0.01	0.50
42	15-21 Oct.	Emr. New flush	2.95	0	0	0.08	3.03	0.56	0	0	0.01	0.57
43	22-28 Oct.	Emr. New flush	3.24	0	0.04	0.08	3.36	0.46	0	0	0.02	0.48
44	29 Oct.- 4 Nov.	New twigs	2.73	0	0.05	0.11	2.89	0.41	0	0	0.03	0.44
45	5-11 Nov.	New twigs	2.44	0	0.05	0.13	2.62	0.36	0	0	0.02	0.38
46	12-18 Nov.	New twigs	1.71	0	0.05	0.13	1.89	0.36	0	0	0.02	0.38
47	19-25 Nov.	New twigs	1.54	0	0.09	0.08	1.71	0.31	0	0	0.01	0.32
48	26 Nov.- 2 Dec.	Bud/bud burst	1.30	0	0.09	0.09	1.48	0.26	0	0	0.01	0.27
49	3-9 Dec.	Bud/bud burst	1.38	0	0.10	0.08	1.56	0.21	0.01	0.01	0.01	0.24
50	10-16 Dec.	Bud/bud burst	0.95	0	0.09	0.08	1.12	0.20	0.03	0.01	0.01	0.25
51	17-23 Dec.	Bud/bud burst	0.59	0.11	0.08	0.08	0.86	0.14	0.07	0.03	0.01	0.25
52	24 Dec- 31 Dec.	Bud/bud burst	0.30	0.14	0.08	0.09	0.61	0.11	0.09	0.04	0.03	0.27

Aa : ***Amritodus atkinsoni*** **Ic** : ***Idioscopus clypealis*** **In** : ***I. niveosparsus*** **As** : ***Amrasca splendens***

Nil population **Period of low activity** **Lowest activity** **Active period** **Peak period**

Table - 6: Fluctuation of species wise hopper population during 2002-2003

St. wk.	Std. period	Crop stage	Hopper/ sq. ft trunk					Hopper/ twig or panicle				
			Aa	Ic	In	As	Tot	Aa	Ic	In	As	Tot
1	1-7 Jan.	In. Flowering	0.54	0.59	0.13	0.04	1.30	0.15	0.20	0.13	0.04	0.52
2	8-14 Jan.	In. Flowering	0.51	0.67	0.14	0.04	1.36	0.15	0.22	0.15	0.05	0.57
3	15-21 Jan.	In. Flowering	0.40	0.67	0.09	0.05	1.21	0.14	0.19	0.11	0.05	0.49
4	22-28 Jan.	In. Flowering	0.37	0.75	0.10	0.05	1.27	0.15	0.23	0.13	0.06	0.57
5	29 Jan.- 4 Feb.	Peak flowering	0.19	0.94	0.12	0.05	1.30	0.14	0.27	0.15	0.08	0.64
6	5-11 Feb.	Peak flowering	0.25	0.78	0.13	0.06	1.22	0.14	0.27	0.17	0.08	0.66
7	12-18 Feb.	Pea/marble	0.18	0.74	0.09	0.05	1.06	0.12	0.47	0.26	0.10	0.95
8	19-25 Feb.	Pea/marble	0.17	0.74	0.06	0.05	1.02	0.11	0.50	0.30	0.06	0.97
9	26 Feb.- 4 Mar.	Pea/marble	0.12	0.78	0.06	0.02	0.98	0.11	0.56	0.32	0.09	1.08
10	5-11 Mar.	Pea/marble	0.12	0.75	0.03	0.02	0.92	0.10	0.65	0.43	0.13	1.31
11	12-18 Mar.	Stone size	0.12	0.77	0.08	0.06	1.03	0.12	1.11	0.62	0.20	2.05
12	19-25 Mar.	Stone size	0.10	0.77	0.07	0.03	0.97	0.11	1.26	0.89	0.02	2.46
13	26 Mar.- 1 Apr.	Stone size	0.09	0.60	0.05	0.01	0.75	0.09	1.51	1.11	0.19	2.90
14	2-8 Apr.	Stone size	0.08	0.61	0.05	0.01	0.75	0.08	2.52	1.41	0.25	4.71
15	9-15 Apr.	Stone size	0.07	0.60	0.04	0.01	0.72	0.08	2.79	1.67	0.23	4.77
16	16-22 Apr.	Stone size	0.07	0.44	0.03	0.01	0.55	0.08	2.84	1.75	0.26	4.93
17	23-29 Apr.	Stone size	0.06	0.45	0.05	0.03	0.59	0.07	2.71	1.03	0.20	4.01
18	30 Apr.- 6 May	Stone size	0.05	0.36	0.03	0.03	0.47	0.05	1.84	0.82	0.12	2.83
19	7-13 May	Fruiting	0.05	0.31	0.02	0.01	0.39	0.03	1.44	0.65	0.08	2.20
20	14-30 May	Fruiting	0.04	0.25	0.01	0.05	0.35	0.03	1.08	0.54	0.06	1.71
21	21-27 May	In. Ripening	0.03	0.13	0.01	0	0.17	0.02	0.65	0.29	0.02	0.98
22	28 May- 3 June	In. Ripening	0.02	0.09	0.15	0.05	0.31	0.01	0.40	0.23	0.05	0.69
23	4-10 June	Rip./harvest	0.02	0.05	0.01	0	0.08	0.02	0.15	0.04	0	0.21
24	11-17 June	Harvest	0.03	0.04	0	0	0.07	0.02	0.11	0.03	0	0.16
25	18-24 June	Harvest	0.04	0.07	0.05	0.01	0.17	0.03	0.07	0.01	0	0.11

26	25 June-1 Jul.	Harvest	0.04	0.08	0.01	0.01	0.14	0.04	0.05	0.01	0	0.10
27	2-8 Jul.	Vegetative	0.25	0	0.02	0.04	0.31	0.07	0.02	0	0	0.10
28	9-15 Jul.	Vegetative	0.52	0	0	0.04	0.56	0.10	0.01	0	0	0.11
29	16-22 Jul.	Vegetative	0.78	0	0	0.02	0.80	0.12	0.01	0	0	0.13
30	23-29 Jul.	Vegetative	0.93	0	0	0.06	0.99	0.16	0.01	0	0	0.17
31	30 Jul.- 5 Aug.	Vegetative	0.90	0	0	0.04	0.94	0.23	0.01	0.01	0	0.25
32	6-12 Aug.	Vegetative	1.49	0	0	0.02	1.51	0.27	0.01	0.01	0	0.29
33	13-19 Aug.	Vegetative	1.63	0	0	0.05	1.68	0.23	0.01	0	0	0.24
34	20-26 Aug.	Vegetative	1.72	0	0	0.07	1.79	0.23	0	0	0	0.23
35	27 Aug.- 2 Sep.	Emr. New flush	2.00	0	0.04	0.10	2.10	0.26	0.01	0	0	0.27
36	3-9 Sep.	Emr. New flush	2.31	0	0.04	0.10	2.45	0.29	0.01	0	0	0.30
37	10-16 sep.	Emr. New flush	2.61	0	0.02	0.10	2.73	0.31	0.01	0	0	0.32
38	17-23 Sep.	Emr. New flush	2.68	0	0.03	0.09	2.80	0.31	0.01	0	0	0.32
39	24-30 Sep.	Emr. New flush	2.94	0	0.02	0.08	3.04	0.32	0.01	0.01	0	0.34
40	1-7 Oct.	Emr. New flush	2.87	0	0.02	0.07	2.96	0.33	0.01	0.01	0	0.35
41	8-14 Oct.	Emr. New flush	2.92	0	0.01	0.07	3.00	0.38	0.01	0	0.01	0.39
42	15-21 Oct.	Emr. New flush	3.01	0	0.01	0.08	3.10	0.41	0.01	0.01	0.01	0.44
43	22-28 Oct.	Emr. New flush	3.29	0	0.04	0.13	3.46	0.35	0.01	0.01	0.01	0.38
44	29 Oct.- 4 Nov.	New twigs	2.83	0	0.04	0.12	2.99	0.32	0.01	0.01	0.01	0.35
45	5-11 Nov.	New twigs	2.42	0	0.04	0.11	2.57	0.28	0.01	0.01	0.01	0.31
46	12-18 Nov.	New twigs	2.00	0	0.03	0.09	2.12	0.28	0.02	0.01	0.01	0.32
47	19-25 Nov.	New twigs	1.88	0	0.05	0.07	2.00	0.25	0.01	0.01	0.01	0.28
48	26 Nov.- 2 Dec.	Bud/bud burst	1.69	0	0.04	0.07	1.80	0.21	0.02	0.01	0.01	0.25
49	3-9 Dec.	Bud/bud burst	1.54	0.06	0.05	0.06	1.71	0.17	0.02	0.02	0.01	0.22
50	10-16 Dec.	Bud/bud burst	1.19	0.07	0.06	0.06	1.38	0.18	0.03	0.02	0.01	0.24
51	17-23 Dec.	Bud/bud burst	0.79	0.12	0.05	0.06	1.02	0.16	0.06	0.03	0.01	0.26
52	24 Dec- 31 Dec.	Bud/bud burst	0.55	0.14	0.06	0.06	0.81	0.15	0.06	0.03	0.01	0.25

Aa : ***Amritodus atkinsoni*** **Ic :** ***Idioscopus clypealis*** **In :** ***I. niveosparsus*** **As :** ***Amrasca splendens***

Nil population Period of low activity Lowest activity Active period Peak period

twig or panicle was highest i.e. 0.29, 0.39 and 0.26 per panicle) on 11, 16 and 16th standard weeks in 2002, 2003 and pooled analysis, respectively, though no hoppers were observed during 23-52, 1-2 and 23-40 and 23-40 standard weeks of 2002, 2003 and mean observations, respectively (Table 4-6) (Fig. 1).

Overall hopper population (irrespective of species wise distribution) on tree trunk was highest during 43 (3.56 hopper per sq. ft.), 43 (3.36 hoppers per sq. ft.) and 43 rd standard weeks (3.46 hoppers per sq. ft.) in 2002, 2003 and mean of two years, respectively. Similarly, Overall, peak activity of mango hopper (irrespective of species) on tree twigs was noticed during 15 (7.26 hoppers per panicle), 16 (2.80 hoppers per panicle) and 16 standard weeks (4.93 hoppers per panicle) of 2002, 2003 and mean of two years, respectively (Table 4-6).

The total hopper population (irrespective of species as well as tree location i.e. trunk or twig) was highest (8.12, 3.84 and 5.49) on 15, 43 and 15th standard weeks of 2002, 2003 and pooled analysis, respectively coinciding with stone sized fruit and emergence of new flush stages of crop growth, Higher activity was observed during, 1-20 and 32-49 standard weeks in 2002 (2.07-8.12 hoppers per tree), 14-17 and 36-47 standard weeks (2.03-3.84 hoppers per tree) in 2003 and 7, 9-20 and 34-48 standard weeks (2.01-5.49 hoppers per tree) in pooled analysis. However, lower activity (< 2 hoppers per tree) of the pest was noticed during 21-31 and 50-52 standard weeks in 2002, 1-13, 18-35 and 48-52 standard weeks in 2003 and 1-6, 7, 21-33 and 49-52 standard weeks in pooled analysis indicating lowest populations of the pest on 26 (0.16 hoppers per tree), 24 (0.24 hoppers per tree) and 24 (0.23 hoppers per tree) standard weeks in 2002, 2003 and pooled analysis, respectively (Table 7) (Fig. 1).

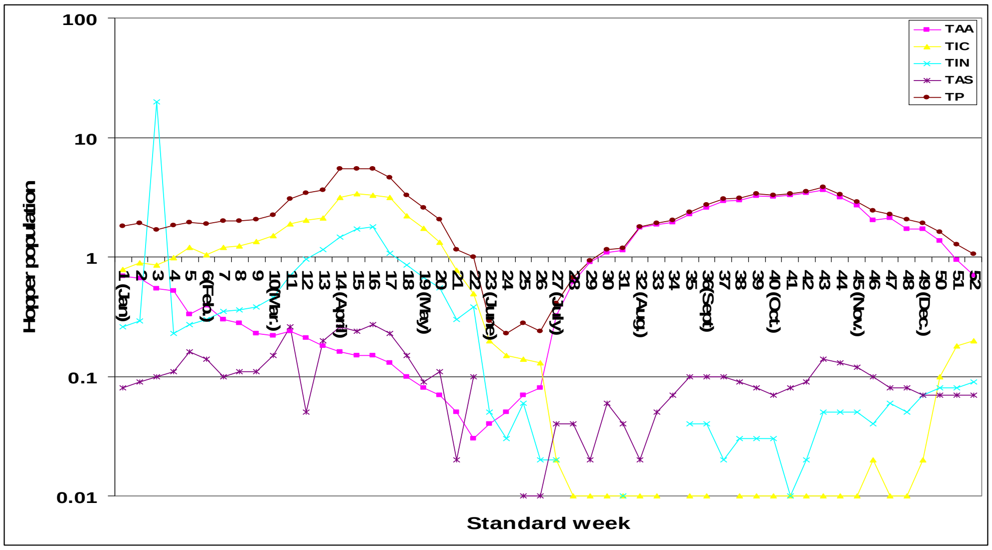
Table - 7: Fluctuation of total hopper population (irrespective of species)

St. wk.	Std. period	Crop stage	Total hopper population/tree*		
			2002	2003	Pooled
1	1-7 Jan.	In. Flowering	2.41	1.30	1.82
2	8-14 Jan.	In. Flowering	2.50	1.41	1.93
3	15-21 Jan.	In. Flowering	2.07	1.38	1.70
4	22-28 Jan.	In. Flowering	2.31	1.43	1.84
5	29 Jan.- 4 Feb.	Peak flowering	2.53	1.37	1.94
6	5-11 Feb.	Peak flowering	2.39	1.40	1.88
7	12-18 Feb.	Pea/marble	2.67	1.38	2.01
8	19-25 Feb.	Pea/marble	2.73	1.28	1.99
9	26 Feb.- 4 Mar.	Pea/marble	2.92	1.21	2.06
10	5-11 Mar.	Pea/marble	3.33	1.15	2.23
11	12-18 Mar.	Stone size	4.62	1.58	3.08
12	19-25 Mar.	Stone size	5.24	1.67	3.43
13	26 Mar.- 1 Apr.	Stone size	5.58	1.76	3.65
14	2-8 Apr.	Stone size	7.53	2.50	5.46
15	9-15 Apr.	Stone size	8.12	2.89	5.49
16	16-22 Apr.	Stone size	7.64	3.35	5.48
17	23-29 Apr.	Stone size	6.33	2.89	4.60
18	30 Apr.- 6 May	Stone size	4.74	1.87	3.30
19	7-13 May	Fruiting	3.86	1.36	2.59
20	14-30 May	Fruiting	3.02	1.04	2.06
21	21-27 May	In. Ripening	1.55	0.77	1.15
22	28 May- 3 June	In. Ripening	1.01	0.56	1.00
23	4-10 June	Rip./harvest	0.26	0.33	0.29
24	11-17 June	Harvest	0.22	0.24	0.23
25	18-24 June	Harvest	0.17	0.30	0.28
26	25 June-1 Jul.	Harvest	0.16	0.31	0.24
27	2-8 Jul.	Vegetative	0.34	0.47	0.41
28	9-15 Jul.	Vegetative	0.84	0.49	0.67
29	16-22 Jul.	Vegetative	1.03	0.84	0.93
30	23-29 Jul.	Vegetative	1.39	0.94	1.16
31	30 Jul.- 5 Aug.	Vegetative	1.33	1.06	1.19
32	6-12 Aug.	Vegetative	2.46	1.17	1.80
33	13-19 Aug.	Vegetative	2.54	1.31	1.92
34	20-26 Aug.	Vegetative	2.69	1.35	2.02
35	27 Aug.- 2 Sep.	Emr. New flush	3.16	1.67	2.37
36	3-9 Sep.	Emr. New flush	3.18	2.33	2.75
37	10-16 sep.	Emr. New flush	3.23	2.88	3.05
38	17-23 Sep.	Emr. New flush	3.23	3.01	3.12
39	24-30 Sep.	Emr. New flush	3.27	3.47	3.38
40	1-7 Oct.	Emr. New flush	3.28	3.34	3.31
41	8-14 Oct.	Emr. New flush	3.33	3.47	3.39
42	15-21 Oct.	Emr. New flush	3.48	3.60	3.54
43	22-28 Oct.	Emr. New flush	3.82	3.84	3.84
44	29 Oct.- 4 Nov.	New twigs	3.39	3.33	3.34
45	5-11 Nov.	New twigs	2.79	3.30	2.88
46	12-18 Nov.	New twigs	2.64	2.27	2.44
47	19-25 Nov.	New twigs	2.54	2.03	2.28

48	26 Nov.- 2 Dec.	Bud/bud burst	2.36	1.75	2.05
49	3-9 Dec.	Bud/bud burst	2.09	1.80	1.93
50	10-16 Dec.	Bud/bud burst	1.87	1.37	1.62
51	17-23 Dec.	Bud/bud burst	1.48	1.11	1.28
52	24 Dec- 31 Dec.	Bud/bud burst	1.28	0.88	1.06

*** Includes trunk + twig population per tree**

Period of low activity **Lowest activity** **Active period** **Peak period**



TAA : *Amritodus atkinsoni*
TIC: *Idioscopus clypealis*
TIN: *Idioscopus niveosparsus* **TAS: *Amrasca splendens***
TP: Total population

Fig. 1: Abundance of species wise mango hopper population

Plate3-adult hoppers in resting stage

Thus, in the entire period of study, there were two active periods of hopper activity, first between 1-20 standard weeks (1 January -30 May) which had its peak (5.49 hoppers per tree in pooled observation) on 15th standard week (9-15 April) coinciding with stone sized fruit stage of the crop. This period had majority population of *I. clypealis* and *I. niveosparsus* (Table 4-6), whereas, second active period was between 32-49 standard weeks (6 August-9 December) coinciding with vegetative, new flush and bud burst stages of crop growth which subsequently indicated its peak (3.84 hoppers per tree) on 43rd standard week (22-28 October in pooled observation) which was witnessed predominantly by *A. atkinsoni* (Table 4-6). Thus, it is proved that the predominant hopper species on tree trunk was *A. atkinsoni* (0.01-3.34, 0.03-3.24 and 0.02-3.29 hoppers per sq. ft tree trunk in 2002, 2003 and pooled analysis, respectively), while on tree twig or panicle it was *I. clypealis* (0-4.14, 0-1.69 and 0-2.84 hoppers per panicle in 2002, 2003 and pooled analysis, respectively) (Table 4-6) (Fig. 1). Hopper population (except trunk population of *A. atkinsoni*) remained either very low or nil during 21-52 standard weeks (21 May – 31 Dec.), thus it could be the hibernation or inactive period of the pest species. Butani (1979) reported that mango hopper start egg laying around end of January or early February while, Tandon *et al.* (1983) specifically indicated peak of *I. clypealis* during March-April. Similarly, Kudagamage *et* al. (2001) noticed peak population of *I. niveosparsus* in March-April. However, Dwivedi *et al*. (2003) found peak intensity (87.9/10 leaves) of hopper in June. In majority of these reports, peak population of mango hoppers (*I. clypealis* and *I. niveosparsus*) has been recorded during January-April. Similar observations were recorded in the present investigation (Table 4-6) thus, confirms the present findings.

4.1.1.2 Correlation and regression

In order to study the effect of different abiotic factors such as temperature, relative humidity, rainfall, rainy days and sun shine hours on the overall population (inclusive of tree trunk and twig population) build-up of mango hopper (irrespective of species) during different seasons, correlation analysis was carried out. The results obtained are presented in Table 8. With a view to study the combined quantitative impact of different weather parameters on mango hopper complex during different crop seasons, a multi linear regression model was tested and fitted well with all the abiotic factors as independent variables whereas, overall population of mango hopper as dependent variable and multiple regression coefficient (R^2) for each case was also calculated. The results obtained have been summarized in the Table 8.

On the basis of results based on overall population of mango hopper (irrespective of species or tree location), it is revealed that correlation between hopper population (Y) and weather parameters (X_1 to X_9) was consistent for two years of study. During the year 2002, the hopper population (Y) showed significant positive correlation with maximum temperature (X_1) ('r' = 0.4718) and sun shine (X_9) ('r' = 0.3476) but significant negative correlation with evening relative humidity (X_5)('r' = -0.3595), average relative humidity (X_6)('r' = -0.3631) and rainy days (X_8)('r' = -0.3864), whereas in the subsequent year, the population build-up of hopper (Y) indicated significant positive correlation with sun shine

(X_9)(‘r’ = 0.2766) but negative with rainfall (X_7)(‘r’ = -0.4224) (Table 8) (Fig. 2).

In pooled analysis, overall population build-up of mango hopper (irrespective of species wise population)(Y) showed significant and highly positive correlation with maximum temperature (X_1)(‘r’ = 0.4764) and sun shine (X_9)(‘r’ = 0.3929) but significant negative correlation with morning relative humidity (X_4)(‘r’= -0.3145), evening relative humidity (X_5)(‘r’ = -0.3853), average relative humidity (X_6)(‘r’ = -0.4021), rainfall (X_7)(‘r’ = -0.4092) and rainy days (X_8)(‘r’ = -0.4054) (Table 8) (Fig. 2).

The multiple correlation coefficient (R) was significant in 2002 (R = 0.5337), 2003 (R = 0.4286) as well as in pooled analysis (R = 0.5416). The regression equations developed for build-up of overall hopper population were:

2002 : $\hat{Y} = -9.5183 + 0.3709 (X_1) – 0.0512 (X_5) + 0.0757 (X_6) – 1.4588 (X_8) – 0.2318 (X_9)$

2003 : $\hat{Y} = 2.2863 – 0.0336 (X_7) – 0.0374 (X_9)$

Pooled : $\hat{Y} = -10.0371 + 0.2958 (X_1) + 0.0645 (X_4) – 0.0082 (X_5) – 0.0084 (X_6) – 0.0210 (X_7) – 0.7259 (X_8) – 0.1844 (X_9)$

where,

$\hat{Y}$ = Overall hopper population (irrespective of species or tree location)

X_1 = Maximum temperature

X_4 = Morning relative humidity

X_5 = Evening relative humidity

X_6 = Average relative humidity

X_7 = Rainfall

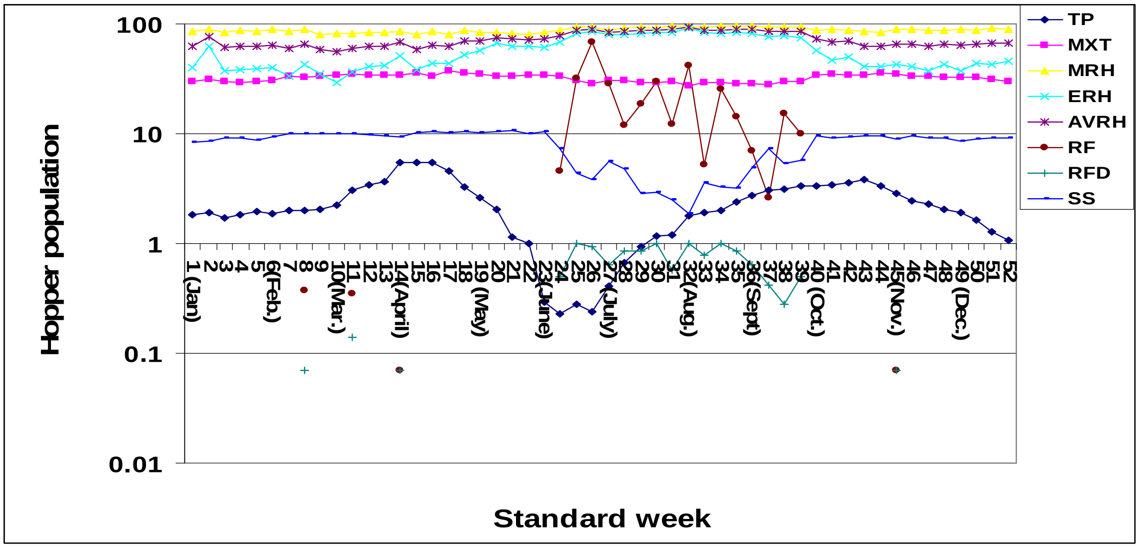
X_8 = Rainy days

X_9 = Sun shine hours

Table – 8 : Correlation and Regression analysis of total mango hopper population with meteorological factors

Total mango hopper (Y)/ Meteorological factors	Correlation coefficient ('r')			Regression coefficient		
	2002	2003	Pooled	2002	2003	Pooled
Max. temp. (X_1)	0.4718**	0.2487	.4764**	0.3709	--	0.2958
Min. temp. (X_2)	-0.1191	-0.0752	-0.1250	--	--	--
Av. temp. (X_3)	0.0963	0.0417	0.0877	--	--	--
Mor. R.H. (X_4)	-0.1977	-0.0559	-0.3145*	--	--	0.0645
Eve. R. H. (X_5)	-0.3595**	-0.2689	-0.3853**	-0.0512	--	-0.0082
Av. R. H. (X_6)	-0.3631**	-0.2344	-0.4021**	0.0757	--	-0.0084
Rainfall (X_7)	-0.2654	-0.4224**	-0.4092**	--	-0.0336	-0.0210
Rainy days (X_8)	-0.3864**	-0.2608	-0.4054**	-1.4588	--	-0.7259
Sun shine (X_9)	0.3476*	0.2766*	0.3929**	-0.2318	-0.0374	-0.1844
R^2	--	--	--	0.2071	0.1504	0.1809
Variation explained (%)	--	--	--	20.71	15.04	18.09
R value	--	--	--	0.5337	0.4286	0.5416
Constant (A value)	--	--	--	-9.5183	2.2863	-10.0371

* Significant at 5 % level ** Significant at 1 % level



TP: Total hopper population
MXT : Maximum temp.

MRH : Morning R.H. **ERH : Evening R.H.**
AVRH : Average R.H.

RF : Rainfall **RFD : Rainy days**
SS : Sun shine

Fig. 2: Influence of weather factors on population build up of mango hopper

The regression analysis also explained 20.71, 15.04 and 18.09 per cent variations in the overall population build-up of mango hopper due to weather factors in 2002, 2003 and pooled observations, respectively (Table 8).

So, looking to the relationship of abiotic factors on overall abundance of mango hopper complex, it may be concluded that hopper population was directly influenced by maximum temperature and sun shine, whereas, relative humidity (morning, evening and average), rainfall and rainy days had negative bearing on its abundance. This implies that as the temperature and sun shine increased hopper population increased further and vice-versa, whereas, hopper population decreased as relative humidity, rainfall and rainy days increased or vice-versa. This interpretation is substantiated by the fact that hopper population was higher in abundance i.e. 2.07-8.12, 2.50-3.35 and 2.01-5.49 hoppers per tree during 1-20, 14-17 and 7-20 standard weeks in 2002, 2002 and mean observations, respectively coinciding with pea and fruiting stages of crop growth when maximum temperature and sun shine were in the range of 26.77 - 38.14 ºC and 7.71 – 10.85 hours, respectively and there were no rains or rainy period, whereas, total hopper population increased from 2.46 to 3.82, 2.33 to 3.84 and 2.02 to 3.84 hoppers per tree during 32-49 (2002), 36-47 (2003) and 34-48 standard weeks when morning relative humidity, evening relative humidity, average relative humidity, rainfall and rainy days decreased from 94.71 to 77.28, 89.85 to 29.00, 93.13 to 57.43 per cent, 57.29 to 0 mm. and 1 to 0 days, respectively (Table 7)(Appendix-I to IV).

Tandon *et al*. (1983) reported that temperature (maximum and minimum) and relative humidity which contributed 89 per cent of the population variation had significant impact on population build-up of mango hopper. Similarly, Shekh *et al.* (1993) and Patel *et al*. (1994) predicted outbreak of mango hoppers (*Amritodus atkinsoni*) when minimum temperature and vapour pressure ranged between 20-25 ºC and 16 mm. Hg; respectively, while Xie Guo Gan and Xie Bing Qing (2000) observed temperature range of 18 – 28 ºC and more than 95 per cent humidity favourable for the multiplication of leaf hopper. Pandey *et al.* (2003) on the other hand recorded highest hopper population when temperature was more than 28 ºC. They further stated that fortnightly rainfall of more than 100 mm. had washing effect on hopper population although temperatures were optimum with total contribution of abiotic factors in the range of 36 to 61 per cent. In the present investigation, higher abundance of hopper was observed when temperatures and relative humidity ranged between 26.77 to 38.14 ºC and 93.13 to 57.43 per cent, respectively, whereas, joint impact of abiotic factors on abundance of hoppers varied from 15.04 to 20.71 per cent is more or less the same what has been observed in the above reports, hence confirms the present investigation. However, slight variations in results could be due to variation in the periods of mango flowering across the country.

4.1.2 Inter-specific correlation of mango hopper

Inter-specific competition between various species of mango hopper *viz*; *Amritodus atkinsoni, Idioscopus clypealis, I. niveosparsus* and *Amrasca splendens* was studied in the form of correlation studies on tree trunk and tree twig. Correlation between trunk and twig population was also carried out so as to show some light on migration pattern of trunk population to twig and vice-versa throughout the crop seasons of 2002, 2003 and pooled analysis (Table 9-11).

4.1.2.1 Inter-specific correlation of mango hopper complex on tree trunk

Data presented in Table 9 reveal that *A. atkinsoni* had significant positive correlation with *A. splendens* during 2002 (‘r’ = 0.8010), 2003 (‘r’ = 0.5798) and pooled analysis (‘r’ = 0.8339) but exhibited significant negative correlation with those of *I. clypealis* (‘r’ = -0.5985, -0.6281 and -0.6061) and *I. niveosparsus* (‘r’ = -0.2891 in 2003) on tree trunk.

Similarly, trunk population of *I. clypealis* population showed significant positive correlation (‘r’ = 0.6452, 0.5409 and 0.7397) with that of I*. niveosparsus* but significant negative correlation (‘r = - 0.3917 and -0.3340 in 2003 and pooled analysis, respectively) with *A splendens* population, whereas, population build-up of *I. niveosparsus* had significant positive relationship (‘r’ = 0.3042 in 2002) with *A splendens* population.

It is evident from the data presented in Table 6 that concentration of *A. atkinsoni* increased from 1.49 to 3.29 hoppers per sq. ft on trunk area in pooled analysis during 32-49 standard weeks (6 August – 9 December), populations of *I. clypealis* (0-0.06 hoppers per sq.ft trunk area) and *I. niveosparsus* (0-0.06 hoppers per sq. ft. trunk area) was very low or nil during the same period not only confirmed the predominant position of the former on tree trunk but also confirmed the negative relationship between *A. atkinsoni* and *I. clypealis* as well as *I. niveosparsus*. Another reason could be that *A. atkinsoni* was higher during rainy season or immediately after the withdrawl of monsonic rains

(August – December) when humidity was higher whereas population of *I. clypealis* and *I. niveosparsus* was lower during the same period indicating negative and positive correlations of the former and latter with relative humidity, respectively, whereas, population of *A. atkinsoni* decreased from 0.54 to 0.02 hoppers per sq. trunk area (pooled analysis) during 1- 23 standard week (1 January – 10 June) when populations of *I. clypealis* and *I. niveosparsus* was higher in number i.e. 0.05 – 0.94 and 0.01 – 0.14 hoppers per sq. ft. trunk area. There was not much variation in the population of *A. splendens*, however, it was found higher in number (0.02 - 0.13 hoppers per sq. trunk area in pooled analysis) during 32-49 standard weeks when population of *A. atkinsoni* was also higher confirming the positive relationship between the two species.

Thus, in the foregoing discussion it may be concluded that population of *A. atkinsoni* increased with an increase of *A splendens* population on tree trunk and vice-versa as there existed significant positive correlation between the population of two species, while it decreased with an increase of *I. clypealis* and *I. niveosparsus* populations on tree trunk and vice-versa as there was a significant negative correlation between *A. atkinsoni* and *I. clypealis* as well as *I. niveosparsus.*

4.1.2.2 Inter-specific correlation of mango hopper complex on twig

Results presented in Table 10 indicate that twig population of *A. atkinsoni* had significant negative correlation with those of *I. clypealis* ('r' = - 0.5904, -0.3827 and -0.4841 in 2002, 2003 and pooled anlysis, respectively), *I. niveosparsus* ('r' = -0.5788, -0.3184 and -0.4571) and

A. splendens ('r' = -0.6080 and -0.4214 in 2002 and pooled analysis, respectively) populations.

Similarly, *I. clypealis* population on twig showed significant positive correlation with *I. niveosparsus* ('r' = 0.9728, 0.9800 and 0.9753 in 2002, 2003 and pooled analysis, respectively) and *A. splendens* ('r' =

Table - 9: Inter-specific correlation of mango hopper complex on tree trunk

Hopper species on tree trunk/sq ft.	Correlation coefficient ('r')											
	2002				2003				Pooled			
	Aa	Ic	In	As	Aa	Ic	In	As	Aa	Ic	In	As
A. atkinsoni	1.0000	-0.5985**	-0.1112	0.8010**	1.0000	-0.6281**	-0.2891*	0.5798**	1.0000	-0.6081**	0.2285	0.8339**
I. clypealis	-0.5985**	1.0000	0.6452**	-0.2423	-0.6281**	1.0000	0.5409**	0.3917**	-0.6081**	1.0000	0.7397**	-0.3340*
I. niveosparsus	-0.1112	0.6452**	1.0000	0.3042*	-0.2891*	0.5409**	1.0000	0.1913	-0.2285	0.7397**	1.0000	0.1340
A. splendens	0.8010**	-0.2423	0.3042*	1.0000	0.5798**	-0.3917**	0.1913	1.0000	0.8339**	-0.3340*	0.1340	1.0000

Table - 10: Inter-specific correlation of mango hopper complex on tree twig

Hopper species on tree trunk/ sq. ft	Correlation coefficient ('r')											
	2002				2003				Pooled			
	Aa	Ic	In	As	Aa	Ic	In	As	Aa	Ic	In	As
A. atkinsoni	1.0000	-0.5904**	0.5788**	-0.6080	1.0000	-0.3827**	-0.3184*	-0.2417	1.0000	-0.4841**	-0.4571**	-0.4214**

I. clypealis	-0.5904**	1.0000	0.9728**	0.6726**	-0.3827**	1.0000	0.9800**	0.9579**	-0.4841**	1.0000	0.9753**	0.9031**
I. niveosparsus	-0.5788**	0.9728**	1.0000	0.7327**	-0.3184*	0.9800**	1.0000	0.9769**	-0.4571**	0.9753**	1.0000	0.9391**
A. splendens	-0.6080**	0.6726**	0.7327**	1.0000	-0.2417	0.9579**	0.9769**	1.0000	-0.4214**	0.9031**	0.9391**	1.0000

* Significant at 5 % level ** Significant at 1 % level

Aa : *Amritodus atkinsoni* Ic : *Idioscopus clypealis* In : *Idioscopus niveosparsus* As : *Amrasca splendens*

0.6726, 0.9579 and 0.9031) populations, whereas, population of *I. niveosparsus* was positively correlated (‘r’ = 0.7327, 0.9769 and 0.9391) with that of *A. splendens*.

The results mentioned in Table 6 indicate that population of *I. clypealis* was higher (0.01- 2.84 per panicle in pooled analysis) than rest of the three species of mango hopper *viz*; *A. atkinsoni* (0.01-0.41 per panicle), *I. niveosparsus* (0.01-1.75 per panicle) and *A. splendens* (0.01-0.26 per panicle) on tree twig, thus confirming the predominance of the species.

Positive correlationship of predominant species *I. clypealis* with *I. niveosparsus* and *A. splendens* can be proved by the data mentioned in Table 6 which indicate higher population of *I. clypealis* (1.08-2.84 per panicle) during 11-20 standard weeks (12 March – 30 May) when

I. niveosparsus (0.54-1.75 per panicle) and *A. splendens* (0.06-0.26 per panicle) were comparatively lower in number, whereas, lower population (0.02-0.12 per panicle) of *A. atkinsoni* during the same period confirms its negative correlation with *I. clypealis*, the predominant mango hopper on tree twig. Higher population of *I. clypealis* during the flowering and fruit set period i.e. 1- 20 standard weeks (1 January – 30 May) not only indicates its affinity towards inflorescence and newly set fruits but also towards bright sun shine (8.41-10.47 hours per day) and comparatively lower humidity (average relative humidity 55.74-75.89 per cent) as well as less or no rainfall and rainy days, thus confirms positive correlation with sun shine and negative correlation with relative humidity, rainfall and rainy days, respectively (Appendix I-II).

Thus, above findings confirm that population of *I. clypealis*, the predominant species increased with an increase in *I. niveosparsus* and *A. splendens* populations and decreased with an increase in population of *A. atkinsoni* and vice-versa.

4.1.2.3 Inter-specific correlation between mango hopper on tree trunk and twig

Results of the present investigation mentioned in Table 11 indicate highly significant positive correlation between trunk and twig populations of *A. atkinsoni* ('r' = 0.8746, 0.9121 and 0.9502 in 2002, 2003 and pooled analysis, respectively), whereas, the same species on tree trunk had significant negative correlation with twig population of *I.* clypealis ('r' = - 0.5162, -0.4428 and -0.4960), *I. niveosparsus* ('r' = -0.5094, -0.4058 and -0.4884) and A*. splendens* ('r' = -0.5675, -0.3543 and -0.5175).

Similarly, trunk population of *I. clypealis* was found to increase with an increase in population of the same species (“r’ = 0.4284, 0.5542 and 0.4841 in 2002, 2003 and pooled analysis, respectively), *I. niveosparsus* (‘r’ = 0.4571, 0.5709 and 0.5283) and *A. splendens* (‘r’ = 0.8082, 0.5772 and 0.7270) on twig, however, it was found to decrease with an increase of twig populations of *A. atkinsoni* (‘r’ = -0.6191, -0.3600 and -0.4300) (Table 11).

Population build-up of *I. niveosparsus* on tree trunk showed significant positive correlation with *A. splendens* (‘r’ = 0.3805 and 0.3428 in 2002 and pooled analysis, respectively) on twig (Table 11).

Trunk population of *A. splendens* was found positively correlated with twig populations of *A. atkinsoni* (‘r’ = 0.6000, 0.6190 and 0.8505 in 2002, 2003 and pooled analysis, respectively), whereas, it exhibited significant negative correlations with twig populations of. *I. clypealis* (‘r’ = -0.3629, -0.4863 and -0.4832), *I. niveosparsus* (‘r’ =

Table – 11: Tree trunk and twig wise inter specific correlation of mango hopper

Hopper species on tree trunk/ sq.ft → -------------------- **Hopper species/ tree twig or panicle ↓**	**Correlation coefficient ('r')**											
	2002				**2003**				**Pooled**			
	Aa	**Ic**	**In**	**As**	**Aa**	**Ic**	**In**	**As**	**Aa**	**Ic**	**In**	**As**
A. atkinsoni	0.8746**	-0.6191**	-0.1627	0.6000**	0.9121**	-0.3600**	-0.0498	0.6190**	0.9502**	-0.4300**	-0.0648	0.8503**
I. clypealis	-0.5162**	0.4284**	0.0627	-0.3629**	-0.4428**	0.5542**	0.0380	-0.4863**	-0.4960**	0.4844**	0.0910	-0.4832**
I.niveosparsus	-0.5094**	0.4571**	0.1117	-0.3417*	-0.4058**	0.5709**	0.0620	-0.4424**	-0.4884**	0.5283**	0.1225	-0.4730**
A. splendens	-0.5675**	0.8082**	0.3805**	-0.2729*	-0.3543**	0.5772**	0.1405	-0.3342*	-0.5175**	0.7270**	0.3428*	-0.3933**

* Significant at 5 % level   ** Significant at 1 % level

Aa: *Amritodus atkinsoni* Ic: *Idioscopus clypealis* In: *Idioscopus niveosparsus* As: *Amrasca splendens*

-0.3417, -0.4424 and -0.4730) and *A. splendens* ('r' = -0.2729, -0.3342 and -0.3933) (Table 11).

It is evident from the data presented in Table 11 that higher population of *A. atkinsoni* on tree trunk always corresponded with higher population of the same species on tree twig, thereby confirming the positive correlation, whereas, it exhibited negative trend with populations of *I. clypealis, I. niveosparsus* and *A. splendens* on tree twig. Similarly, trunk population of *I. clypealis* was found to increase with increase in the populations of *I. niveosparsus* and *A. splendens* on tree twig thereby confirmed positive correlation. Likewise, trunk population of *I. niveosparsus* was found to increase with increase in the twig population of *A. splendens* proving the positive relationship between the two populations. Lastly, trunk population of *A. splendens* increased with increase in twig population of *A. atkinsoni* and decreased with increase in the twig populations of *I. clypealis*, *I. niveosparsus* and *A. splendens* confirming the positive and negative correlations between respective populations.

Looking to the overall trend of species wise differentiation of tree trunk and twig populations, it is clear that *A. atkinsoni* was the predominant species on tree trunk as it always dominated in terms of higher population over remaining three mango hopper species and was found higher in proportion either during the rainy period (August – September) or immediately after the withdrwal of monsonic rains confirming its affinity towards higher relative humidity, rainfall and rainy days, whereas, its population was found in low intensity both on tree trunk and twig during dry season i.e. flowering (January-March) and post flowering (April-June), the period of bright sun shine. During the rainy season (July-September), populations of *I. clypealis* and *I. niveosparsus* was very low. However, as flowering season initiated and panicle emergence commenced i.e. 1-4 standard weeks (1 January- 28 January), population of *A. atkinsoni* decreased gradually or sometimes abruptly and was replaced by populations of *I. clypealis* and *I. niveosparsus* both on tree and twig. This could be due to later affinity towards flowering and newly set fruits but also towards bright sun shine thereby confirming positive relationship. On the other hand population of *A. splendens* was very low both on tree trunk as well as twig throughout both the years and in pooled analysis.

Thus, in the light of foregoing discussion, it may be concluded that displacement of *A. atkinsoni* took place mainly by *I. clypealis* and to a lesser extent by *I. niveosparsus* from tree trunk to tree twig as the vegetative/new flush/bud burst stages culminated into initiation of flowering/pea/marble/stone stages of crop growth. Thereafter, immediately after the harvest and with the initiation of rainy season higher populations of *I. clypealis* and *I. niveosparsus* were gradually or abruptly displaced by *A. atkinsoni* both on tree trunk and twig. So, there were two phases of displacement, first with the initiation of flowering (*A. atkinsoni* by *I. clypealis* and *I. niveosparsus*) and second with the completion of harvest and commencement of rainy season (*I. clypealis* and *I. niveosparsus* by *A. atkinsoni*). The present findings are supported by Anonymous (1967) and Srivastava (1998) who reported that *I. clypealis* and *I. niveosparsus* were found to breed preferably during January-

February or throughout the flowering season; *A. atkinsoni* on the other hand has been reported to be a shy breeder on flowered shoots and rarely on blossoms.

4.1.3 Hopper associated damage

4.1.3.1 Hopper egg laying damage

During 2002 crop season, hopper egg laying damage on leaves was found more or less throughout the year, however it was higher during flowering season and stone size formation stage (1-18 standard weeks) of the crop with peak damage of 10.85 per cent during 14th standard week (2-8 April). For rest of the period, hopper egg laying damage was neglible. In the subsequent year also, the hopper egg laying damage was observed throughout the year, but in lower form as compared to year 2002. Higher egg laying damage on leaves occurred during 13-21 standard weeks with peak of 8.90 per cent on 18th standard week (30 April - 6 May) and thereafter, the damage declined gradually. Thus, the hopper egg laying injury was more during stone size fruit formation stage of the mango (Table 12).

In pooled analysis, higher level of damage (> 5 per cent) was observed during 1-21 standard weeks (1 January - 27 May) which ultimately coincided with the flowering, pea, marble, stone and initiation of ripening stages of the crop growth. The highest damage (8.99 per cent) was observed on 16th standard week (16-22 April) (Table 12) (Fig. 3) (Plate 4-5).

Das *et al*. (1969) and Kangane and Patil (1989) while working on the biology of *Amrasca splendens* noticed that egg were laid into the midrib or side veins of tender leaves in longitudinal rows resulting in curling and distortion of leaves. Srivastava (1998) reported heavy egg laying on underside of leaves resulting in withering of affected parts. These results confirm occurrence of hopper egg laying damage due to oviposition by mango hopper on leaves, however, there are no reports available on occurrence of hopper egg laying damage with respect to various standard weeks or periods.

4.1.3.2 Sooty mold damage

Besides hopper egg laying damage, development of sooty mold is another type of hopper associated damage observed in mango particularly on foliage, twigs and florets which restrict the photosynthetic activity of the crop (Plate 5 and 7). During 2002, 1-22 standard weeks (1 January - 3 June) was the most conducive period for the development of sooty mold coinciding with the active period of hopper incidence as well as preferred crop stage i.e. flowering and fruit set stages (Table 7) wherein peak incidence of 3.10 sooty mold grade was observed during 6-8 standard weeks (5-25 February) as well as during 12-14 standard weeks (19 March - 8 April). No sooty mold occurred (0 grade) during 25-45 standard weeks and thereafter it was in negligbe form at the later part of the year. In the next season, sooty mold was in low intensity showing peak incidence of 2.10 (SM grade) on the 18th standard week (30 April - 6 May), thereafter, it declined gradually. The period of 28-38 standard weeks (9 July – 23 September) was noticed as sooty mold free duration of the year, thereafter, the damage started appearing again reaching to the level of 1.90 SM grade on 52nd standard week (Table 12) which not only coincided with hopper multiplication period (Table 7) but also with bud burst, the stage preferred by mango hopper for its emergence and multiplication leading to the occurrence of sooty mold damage (Plate 1).

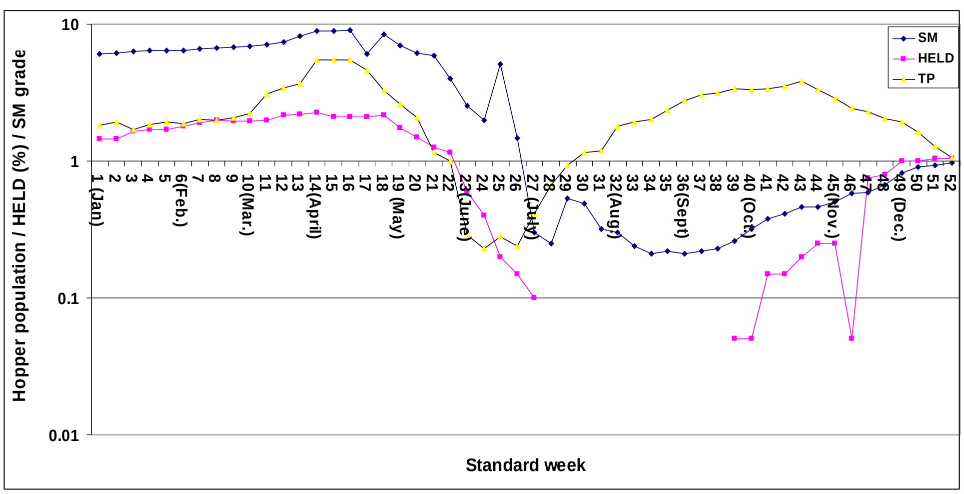
In pooled analysis, 1-18 standard weeks (1 January - 6 May) was most conducive for the development of sooty mold indicating peak incidence of 2.25 SM grade on 14th standard week (2-8 April) as the damage was fully associated with not only active period of mango hopper

Table-12: Hopper associated damage during 2002 and 2003

Std. wk.	Std. period	Crop stage	Hopper egg laying damage (%)			Sooty mold grade		
			2002	2003	Pooled	2002	2003	Pooled
1	1-7 Jan.	In. Flowering	9.96	2.20	6.08	2.50	0.40	1.45
2	8-14 Jan.	In. Flowering	9.99	2.40	6.19	2.50	0.40	1.45
3	15-21 Jan.	In. Flowering	9.99	2.60	6.29	2.90	0.40	1.65
4	22-28 Jan.	In. Flowering	9.99	2.90	6.44	2.90	0.50	1.70
5	29 Jan.- 4 Feb.	Peak flowering	10.01	2.90	6.45	2.90	0.50	1.70
6	5-11 Feb.	Peak flowering	10.01	2.90	6.45	3.10	0.50	1.80
7	12-18 Feb.	Pea/marble	10.09	3.10	6.59	3.10	0.70	1.90
8	19-25 Feb.	Pea/marble	10.12	3.20	6.66	3.10	0.90	2.00
9	26 Feb.- 4 Mar.	Pea/marble	10.12	3.40	6.76	3.00	0.90	1.95
10	5-11 Mar.	Pea/marble	10.14	3.60	6.87	3.00	0.90	1.95
11	12-18 Mar.	Stone size	10.29	3.90	7.09	3.00	1.00	2.00
12	19-25 Mar.	Stone size	10.71	4.10	7.40	3.10	1.20	2.15
13	26 Mar.- 1 Apr.	Stone size	10.79	5.60	8.19	3.10	1.30	2.20
14	2-8 Apr.	Stone size	10.85	6.90	8.87	3.10	1.40	2.25
15	9-15 Apr.	Stone size	10.14	7.60	8.87	2.60	1.60	2.10
16	16-22 Apr.	Stone size	9.89	8.10	8.99	2.40	1.80	2.10
17	23-29 Apr.	Stone size	8.14	8.40	6.02	2.40	1.80	2.10
18	30 Apr.- 6 May	Stone size	7.86	8.90	8.38	2.20	2.10	2.15
19	7-13 May	Fruiting	6.14	7.90	7.02	1.60	1.90	1.75
20	14-30 May	Fruiting	5.14	7.10	6.12	1.40	1.60	1.50
21	21-27 May	In. Ripening	4.86	6.90	5.88	1.20	1.30	1.25
22	28 May- 3 June	In. Ripening	3.14	4.90	4.02	1.20	1.10	1.15
23	4-10 June	Rip./harvest	1.44	3.60	2.52	0.60	0.60	0.60
24	11-17 June	Harvest	0.91	3.10	2.00	0.30	0.50	0.40
25	18-24 June	Harvest (R)	0.76	2.60	5.10	0	0.40	0.20
26	25 June-1 Jul.	Harvest (R)	0.56	2.40	1.48	0	0.30	0.15
27	2-8 Jul.	Vegetative (R)	0.43	0.17	0.30	0	0.10	0.05
28	9-15 Jul.	Vegetative (R)	0.39	0.11	0.25	0	0	0
29	16-22 Jul.	Vegetative (R)	0.46	0.61	0.53	0	0	0
30	23-29 Jul.	Vegetative (R)	0.49	0.49	0.49	0	0	0

31	30 Jul.- 5 Aug.	Vegetative (R)	0.31	0.34	0.32	0	0	0
32	6-12 Aug.	Vegetative (R)	0.32	0.29	0.30	0	0	0
33	13-19 Aug.	Vegetative (R)	0.26	0.23	0.24	0	0	0
34	20-26 Aug.	Vegetative (R)	0.21	0.21	0.21	0	0	0
35	27 Aug.- 2 Sep.	Emr. New flush	0.16	0.29	0.22	0	0	0
36	3-9 Sep.	Emr. New flush	0.14	0.29	0.21	0	0	0
37	10-16 sep.	Emr. New flush	0.14	0.31	0.22	0	0	0
38	17-23 Sep.	Emr. New flush	0.13	0.33	0.23	0	0	0
39	24-30 Sep.	Emr. New flush	0.19	0.34	0.26	0	0.10	0.05
40	1-7 Oct.	Emr. New flush	0.19	0.46	0.32	0	0.10	0.05
41	8-14 Oct.	Emr. New flush	0.19	0.57	0.38	0	0.30	0.15
42	15-21 Oct.	Emr. New flush	0.19	0.64	0.41	0	0.30	0.15
43	22-28 Oct.	Emr. New flush	0.23	0.69	0.46	0	0.40	0.20
44	29 Oct.- 4 Nov.	New twigs	0.23	0.69	0.46	0.10	0.40	0.25
45	5-11 Nov.	New twigs	0.24	0.76	0.50	0.10	0.40	0.25
46	12-18 Nov.	New twigs	0.27	0.89	0.58	0.10	0.90	0.05
47	19-25 Nov.	New twigs	0.21	0.97	0.59	0.20	1.30	0.75
48	26 Nov.- 2 Dec.	Bud/bud burst	0.21	1.14	0.67	0.20	1.40	0.80
49	3-9 Dec.	Bud/bud burst	0.24	1.41	0.82	0.40	1.60	1.00
50	10-16 Dec.	Bud/bud burst	0.26	1.56	0.91	0.40	1.60	1.00
51	17-23 Dec.	Bud/bud burst	0.21	1.66	0.93	0.40	1.70	1.05
52	24 Dec- 31 Dec.	Bud/bud burst	0.21	1.74	0.97	0.40	1.90	1.05

Nil damage   Period of low damage   Lowest damage   Higher damage   Peak damage



TP: Total hopper population

HELD : Hopper egg laying damage (%) SM : Sooty mould grade

Fig. 3: Hopper associated damage influenced by abundance of hopper population

Plate-4:Mango HOPPER EGGs LAYING INJURY

PLATE-5 :Mango HOPPER EGGs LAYING INJURY

PLATE-6:HOPPER ATTACKS ON NEW TWIGS OF MANGO

PLATE-7:HOPPER DEMAGE AT FLOWERING AND FRIUTING STAGE

but also its peak status (5.49 hoppers) which was attained on 14th standard week leading to the occurrence and establishment of sooty mold damage. The peak status on the other hand was observed during 1-18th standard weeks which also coincided with flowering, pea, marble and stone formation, the stages preferred by mango hopper for emergence, survival and multiplication leading to the occurrence of sooty mold later on (Table 7 and 12) (Fig. 3) (Plate 5 and 7).

The findings of Ballard (1915), Wagle (1928), Butani (1979) and Srivastava (1998) who recorded development of sooty mold on leaf, twig and inflorescence, whereas, Hussain and Pruthi (1921) identified the sooty mold species as *Capnodium mangiferum* and *Meliola mangiferae* leading to the confirmation of occurrence of sooty mold damage on foliage and blossoms due to abundance of mango hopper, thus confirms the present investigation, however no reports on comparative occurrence of sooty mold damage with respect to various standard weeks are available.

4.1.3.3 Correlation between hopper associated damage and hopper population

Result presented in Table 13 indicated positive correlation between hopper egg laying damage (Y_1) and hopper population on twig (X_2) (‘r’ = 0.6856, 0.7633 and 0.7426 in 2002, 2003 and pooled analysis, respectively) and significant negative correlation (‘r’ = -0.3800, -0.5418 and -0.5395) with hopper population on trunk (X_1) during both the years of investigation and pooled analysis. Similarly, sooty mold damage (Y_2) had significant positive correlation (‘r’ = 0.6554, 0.5783 and 0.7251) with hopper population on twig (X_2) and significant negative correlation (‘r’ = -0.3760, -0.3743 and -0.4754) with hopper population on trunk (X_1) during both the years of investigation and pooled analysis.

Table -13 : Correlation of hopper associated damage with abundance of mango hopper

Mango hopper complex	Correlation coefficient ('r')					
	Hopper egg laying damage (%) (Y_1)			Sooty mold grade (Y_2)		
	2002	2003	Pooled	2002	2003	Pooled
Trunk population (X_1)	-0.3800*	-0.5418**	-0.5395**	-0.3760**	-0.3743*	-0.4754**
Population on twig or panicle (X_2)	0.6856**	0.7633**	0.7426**	0.6554**	0.5783**	0.7251**

* Significant at 5 % level ** Significant at 1 % level

Thus, in the light of present investigation, it may be concluded that hopper egg laying damage observed in the form of distorted and curled leaves due to insertion of eggs in the leaf midrib (Plate 4) is not directly influenced by hopper population on trunk but as soon as hopper migrates on twig, its population had a direct bearing on the occurrence of this type of damage. Similarly, sooty mold which appears on leaves and inflorescence (Plate 5) is not directly influenced by trunk hopper population but get directly influenced by hopper settlement on foliage, twig and inflorescence.

4.1.4 Abundance of natural enemies in relation to mango hopper

Three species of predatory spiders viz; *Plexippus paykulli*, *Lyssomanes sikkimiensis* and *Harpissa tigrina* along with coccinellid complex consisting of *Coccinella septumpunctata* and *Menochilus sexmaculata* were found as natural enemies of mango hopper during the study period. Abundance of all these natural enemies associated with mango hopper is mentioned in Table 14.

4.1.4.1 Abundance of predatory spiders

Predatory spiders appeared in low density throughout the crop season and at every stage of crop growth (except during 25-28, 31-40 standard weeks when their population was zero) but their population was higher during flowering and fruit set period of the crop exhibiting its peak of 0.64 spiders per panicle on 12th standard week (19-25 April) in 2002, whereas in the next season, appearance of these spiders were slightly delayed and had their (0.43 spiders per panicle) on 14th standard week (2-8 April).

In pooled analysis, highest abundance (0.53 spiders per panicle) was observed on 14th standard week (2-8 April) (Table 14).

These findings are in close agreement with those of Srivastava *et al*. (1979) who recorded *Harpissa* sp. and eleven other species of predatory spiders in mango. Predatory efficiency of *Plexippus paykulli* was later confirmed by Cao (1986), Miah *et al*. (1986) and Jackson and Macnab (1989), whereas, reports of Meena Kumari (1986), Sadana (1991) and Venkateshan *et al*. (1992) on occurrence of three salticid spiders viz; *Harpissa tigrina*, *Lyssomanes siikkimiensis* and *Plexippus paykulli* on mango hopper, *Idioscopus clypealis* confirm the present investigation

as the present findings also recorded their peak occurrence particularly during active period (11-20 standard weeks) of mango hopper, *I. clypealis* (Table 6).

4.1.4.2 Abundance of coccinellid complex

Coccinellid complex was found in low intensity throughout the crop season except during the rainy season period. The peak population status of 0.51 coccinellids per panicle was recorded during 14-15 SW (2-15 April) of 2002, whereas in 2003, highest abundance (0.21 per panicle) was recorded during 16-17 SW (16-29 April). In pooled analysis, highest population of coccinellids (0.35 per panicle) was observed on 15th SW (9-15 April) (Table 14).

Report of Srivastava *et al*. (1979) on abundance of various cocinellids viz; *Coccinella septumpunctata*, *C. transversalis* and *Menochilus sexmaculata* preying upon *I. clypealis* was in line with the present investigation wherein higher activity of cocinellids was witnessed during the period (11-20 standard week) of higher activity of mango hopper, *I. clypealis* thus confirms the present investigation.

Table- 14 : Natural enemies of mango hopper

Std. wk.	Std. period	Crop stage	Predatory spider/twig*			Coccinellid complex/twig**		
			2002	2003	Pooled	2002	2003	Pooled
1	1-7 Jan.	In. Flowering	0.09	0.04	0.06	0.13	0.03	0.08
2	8-14 Jan.	In. Flowering	0.09	0.04	0.06	0.14	0.03	0.08
3	15-21 Jan.	In. Flowering	0.10	0.05	0.07	0.17	0.03	0.10
4	22-28 Jan.	In. Flowering	0.10	0.05	0.07	0.18	0.04	0.11
5	29 Jan.- 4 Feb.	Peak flowering	0.16	0.06	0.11	0.17	0.04	0.10
6	5-11 Feb.	Peak flowering	0.16	0.06	0.11	0.17	0.04	0.10
7	12-18 Feb.	Pea/marble	0.24	0.07	0.15	0.19	0.05	0.12
8	19-25 Feb.	Pea/marble	0.24	0.07	0.15	0.19	0.05	0.12
9	26 Feb.- 4 Mar.	Pea/marble	0.31	0.08	0.19	0.21	0.05	0.13
10	5-11 Mar.	Pea/marble	0.33	0.08	0.20	0.24	0.06	0.15
11	12-18 Mar.	Stone size	0.46	0.16	0.31	0.36	0.06	0.21
12	19-25 Mar.	Stone size	0.64	0.17	0.40	0.41	0.09	0.25
13	26 Mar.- 1 Apr.	Stone size	0.59	0.29	0.44	0.46	0.14	0.30
14	2-8 Apr.	Stone size	0.63	0.43	0.53	0.51	0.16	0.33
15	9-15 Apr.	Stone size	0.59	0.31	0.45	0.51	0.19	0.35
16	16-22 Apr.	Stone size	0.56	0.31	0.43	0.47	0.21	0.34
17	23-29 Apr.	Stone size	0.48	0.32	0.40	0.36	0.21	0.28
18	30 Apr.- 6 May	Stone size	0.43	0.26	0.34	0.31	0.19	0.25
19	7-13 May	Fruiting	0.36	0.24	0.30	0.16	0.16	0.16
20	14-30 May	Fruiting	0.31	0.21	0.26	0.09	0.13	0.11
21	21-27 May	In. Ripening	0.26	0.19	0.22	0.03	0.06	0.04
22	28 May- 3 June	In. Ripening	0.19	0.17	0.13	0	0.06	0.03
23	4-10 June	Rip./harvest	0.16	0.13	0.14	0	0.03	0.01
24	11-17 June	Harvest	0.11	0.13	0.07	0	0.03	0.01
25	18-24 June	Harvest (R)	0	0.11	0.05	0	0.03	0.01
26	25 June-1 Jul.	Harvest (R)	0	0.11	0.05	0	0.03	0.01
27	2-8 Jul.	Vegetative (R)	0	0.08	0.04	0	0.01	0.01
28	9-15 Jul.	Vegetative (R)	0	0.06	0.03	0	0	0
29	16-22 Jul.	Vegetative (R)	0.04	0.06	0.05	0	0	0
30	23-29 Jul.	Vegetative (R)	0.07	0.06	0.06	0	0	0
31	30 Jul.- 5 Aug.	Vegetative (R)	0	0.04	0.02	0	0	0
32	6-12 Aug.	Vegetative (R)	0	0.03	0.01	0	0	0
33	13-19 Aug.	Vegetative (R)	0	0.03	0.01	0	0	0
34	20-26 Aug.	Vegetative (R)	0	0.03	0.01	0	0	0

35	27 Aug.- 2 Sep.	Emr. New flush	0	0.04	0.02	0	0	0
36	3-9 Sep.	Emr. New flush	0	0.04	0.02	0	0	0
37	10-16 sep.	Emr. New flush	0	0.04	0.02	0	0	0
38	17-23 Sep.	Emr. New flush	0	0.07	0.03	0	0	0
39	24-30 Sep.	Emr. New flush	0	0.09	0.04	0	0.01	0.01
40	1-7 Oct.	Emr. New flush	0	0.10	0.05	0	0.02	0.01
41	8-14 Oct.	Emr. New flush	0.01	0.11	0.06	0	0.03	0.01
42	15-21 Oct.	Emr. New flush	0.01	0.11	0.06	0	0.04	0.02
43	22-28 Oct.	Emr. New flush	0.01	0.11	0.06	0	0.05	0.02
44	29 Oct.- 4 Nov.	New twigs	0.01	0.11	0.06	0.10	0.05	0.02
45	5-11 Nov.	New twigs	0.01	0.13	0.07	0.10	0.06	0.03
46	12-18 Nov.	New twigs	0.02	0.13	0.07	0.10	0.06	0.03
47	19-25 Nov.	New twigs	0.01	0.14	0.07	0.20	0.09	0.05
48	26 Nov.- 2 Dec.	Bud/bud burst	0.02	0.14	0.08	0.20	0.09	0.05
49	3-9 Dec.	Bud/bud burst	0.03	0.23	0.13	0.40	0.06	0.03
50	10-16 Dec.	Bud/bud burst	0.03	0.28	0.15	0.40	0.07	0.04
51	17-23 Dec.	Bud/bud burst	0.03	0.34	0.18	0.40	0.09	0.06
52	24 Dec- 31 Dec.	Bud/bumd burst	0.03	0.36	0.19	0.40	0.13	0.07

*** *Plexippus paykulli* , *Lyssomanes sikkimiensis* and *Harpissa tigrina***

**** *Menochilus sexmaculata, Coccinella septumpunctata* and *C. transversalis***

Nil population Low population Lowest population Peak population

4.1.4.3 Correlation between abundance of natural enemies and hopper population

Population build-up of predatory spiders (Y_1) ('r' = 0.8175, 0.3422 and 0.9261 in 2002, 2003 and pooled analysis, respectively) as well as coccinellids (Y_2) (0.7200, 0.8421 and 0.9335) was positively correlated with hopper population. So, it is very clear that higher the population of predatory spiders and coccinellids, higher was the hopper population and vice-versa (Table 15).

These findings are supported by Srivastava *et al*. (1979), Cao (1986), Meena kumari (1986), Miah *et al*. (1986), Jackson and Macnab (1989), Sadana (1991) and Venkateshan *et al*. (1992) who reported active period of predatory spiders and coccinellid complex when mango hopper, *A. atkinsoni, I. clypealis* and *I. niveosparsus* were also in higher proportion, thus proving positive association between the two. These findings ultimately became confirmatory to the present investigation.

4.1.5 Abundance of hopper population in relation to various crop stages

To study the effect of various stages of mango crop on appearance of hopper complex, the observations recorded for different crop stages were grouped together as vegetative, flowering, fruit set (at pea, marble and stone formation) and harvest stages of the crop. The data on total hopper population (irrespective of species or tree location) with respect to various crop stages are presented in Table 16 and depicted in Fig. 4.

Abundance of hopper population was observed comparatively higher during flowering, pea and marble stages of crop growth leading to

Table -15: Correlation of natural enemies with abundance of mango hopper

Mango hopper complex	Correlation coefficient ('r')					
	Predatory spiders/ twig (Y_1)			Coccinellid complex/ twig (Y_2)		
	2002	2003	Pooled	2002	2003	Pooled
Population on twig or panicle (X_1)	0.8175**	0.3422*	0.9261**	0.7200**	0.8421**	0.9335**

* Significant at 5 % level ** Significant at 1 % level

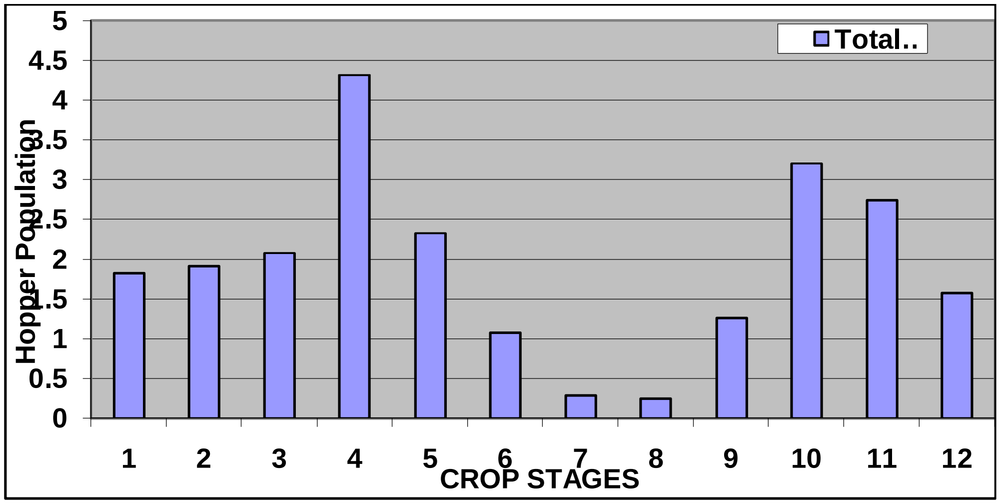
the peak status (6.46, and 4.31 hoppers per panicle in 2002 and pooled analysis, respectively) at stone sized fruit stage of the crop growth which coincided with 11-18 standard weeks, however, in 2003, peak abundance of hopper (3.07 hoppers per panicle) was noticed at emergence of new flush. Besides peak population at stone formation stage, another peak of 3.44 hoppers per panicle was observed at fruiting stage (19-20 standard weeks) in 2002, whereas, in the subsequent year, the second peak of 2.66 hoppers per panicle was noticed at new twig (44-47 standard weeks). In pooled analysis, highest population of hoppers (4.31 per panicle) was observed at stone sized fruit stage (11-18 standard weeks) whereas, second peak of 3.20 hoppers per panicle was observed at emergence of new flush (35-43 standard weeks) (Table 16). After attaining peak status, population declined gradually (3.44-0.18, 1.21-0.28 and 2.33-0.25 hoppers per panicle in 2002, 2003 and pooled analysis, respectively) upto harvest stage of the crop growth. Thereafter, either during the later half of the rainy season or immediately after the withdrwal of monsoon, hopper population rose abruptly (1.58-3.33, 0.96- 3.07 and 1.26-3.20 hoppers per panicle), due to the availability of new leaves and twigs, the preferred ovipositional site of trunk hoppers predominated by *A. atkinsoni* (Table 4-6). After attaining second peak at new flush initiation stage, hoppers once again declined gradually (3.33-1.82, 3.07-1.39 and 3.20-1.58 hoppers per panicle) upto the bud burst stage (Table 4-7 and 16).

Thus, on the basis of foregoing discussion on abundance of hopper complex at various stages of crop growth, it may be concluded that there were two peaks of hopper abundance *viz*; stone formation stage and emergence of new flush (Plate 3-7). Stone formation was the stage when panicles became fully mature, whereas the newly set fruits were immature.

Table -16: Abundance of hopper population with respect to various crop stages

Crop stage	Standard week	Total hopper population (Trunk + twig)		
		2002	2003	Pooled
Vegetative/Vegetative (R)	27-34	0.18	0.28	0.25
Emergence of new flush	35-43	3.33	3.07	3.20
New twig	44-47	2.84	2.66	2.74
Bud/bud burst	48-52	1.82	1.39	1.58
Initiation of flowering	1-4	2.33*	1.38*	1.83*
Peak flowering	5-6	2.46*	1.39*	1.91*
Pea/Marble	7-10	2.93*	1.26*	2.08*
Stone size	11-18	6.46*	2.32*	4.31*
Fruiting	19-20	3.44	1.21	2.33
Initiation of ripening	21-22	1.28	0.67	1.08
Ripening/harvest	23	0.26	0.33	0.29
Harvest/harvest (R)	24-26	0.18	0.28	0.25

R: Rainy period * (Trunk + Panicle population)



1 : Initiation of flowering (1-4 Standard week) 2: Peak flowering (5-6 Standard week) 3: Pea/Marble (7-10 Standard week)

4: Stone size fruits (11-18 Standard week) 5: Fruiting (19-20 Standard week) 6: Initiation of ripening (21-22 Standard week)

7: Ripening/Harvest (23 Standard week) 8: Harvest/Harvest (Rainy period) (24-26 Standard week)

9: Vegetative/Vegetative (Rainy season)(27-34 standard week) 9: Emergence of new flush (35-46 Standard week)

10: New twig (44-47 Standard week) 11: Bud/Bud burst (48-52 Standard week)

Fig. 4: Abundance of mango hopper complex at various stages of crop growth

After damaging panicles, hopper population shifted towards newly set fruits which were in the process of initiation of fruiting or the stone formation stage. At this stage, hopper nymphs as well as adults not only attained peak population (Table 7) but their excessive gummy secretion led to highest sooty mold damage (Table 12) (Plate 7). Another peak was noticed immediately after the cessation of rains which witnessed emergence of new flush. These newly emerged leaves as well as twigs became soft target of adult as well as nymph hoppers leading to their second peak in the crop season which ultimately led to excessive hopper egg laying in newly emerged leaves indicated by hopper egg egg laying damage in the form of curled and distorted leaves (Plate 4). These findings are supported by report from Verghese and Rao (1987) and Bharati Babu *et al*. (2001) who found occurrence of *Idioscopus* sp. at post bloom stage. Talpur *et al*. (2002) in Pakistan found positive correlation between occurrence of mango hopper and inflorescence phenology. The present findings also recorded peak abundance of mango hopper at stone formation or post bloom stage (Table 16) which is more or less the same as reported by the above workers, thus confirms the investigation.

4.1.6 Spatial distribution of mango hopper

The results on the spatial distribution pattern of mango hopper (nymph and adult) based on various characters are summarized in Table 17-19.

4.1.6.1 Vegetative stage

As shown in Table 17-19 and depicted in Fig.5, hopper population was in low density amongst all the tree sections. It was significantly highest (1.691 per sq. ft. tree trunk) in south lower direction (at par with 1.663, 1.649, 1.627, 1.596 and 1.583 in west upper, west lower, east upper, south upper and east lower directions, respectively) in 2002, whereas, distribution was uniform (hopper population did not differ significantly) amongst various tree sections in 2003 and in pooled analysis.

The mean values exceeded the variance in all the tree sections during both the years of investigation and in pooled analysis. The variance-mean ratio has been the simplest method of showing distribution pattern (Taylor, 1961; Utida *et al;* 1952). The variance to mean ratios was invariably less than unity (0.006 to 0.027, 0.008 to 0.031 and 0.001 to 0.097 during both the years and pooled analysis, respectively). Since, these ratios were less than unity in all the tree sections, this implies that distribution pattern was uniform. However, mean values in 2002 were separated significantly. It might be due to the role of some abiotic or biotic factors in that particular year which was not part of this investigation; otherwise data on uniform distribution were consistent in the subsequent year as well as in pooled analysis.

Likewise, the index of mean crowding (X*) was less than mean density in all the cases and thereby the Lloyd's indices of patchiness (which is the ratio of mean crowding to mean density) became lower than unity (0.536 to 0.681, 0.220 to 0.277 and 0.283 to 0.383) in all the cases. According to Lloyd's index of patchiness (Lloyd, 1967), the value of index equals unity in a random distribution, but is greater and smaller than unity in contagious and regular or uniform distributions, respectively. The values of the indices in the present investigation were less than unity in all the cases thereby confirming the finding that mango hopper population was uniform.

The total distribution can also be adequately expressed by clumping index (difference between mean crowding and mean density), which was less than unity (-0.900 to -0.994, -0.969 to -0.992 and -0.903 to -0.999) in all the cases (tree sections). According to David and Moore (1954), the index equals unity in a random distribution, but is greater and smaller than unity in contagious and uniform distributions, respectively. In the present investigation, all the data indicate values less than unity, thus confirms uniform distribution of the pest.

To study the distribution further, Morista's indices of dispersion suggested by Morista (1962) were calculated which were more or less similar in all the entire tree sections (9.560 to 9.963, 9.970 to 9.976 and 9.964 to 9.700 during both the years of investigation as well as in pooled analysis, respectively). The values pertaining to Morista indices were more or less similar (Table 17-19) thus, indicating uniform distribution of the population. The values of X^2 (Chi square) and possibility of fit for negative binomial distribution as shown in Table 23-25 indicate values (0.056 to 0.243, 0.069 to 0.278 and 0.012 to 0.866) which were less than unity. In the current investigation of intra tree distribution of mango hopper during vegetative stage, values were not only low but also near to the unit value (1.00) leading to their less departure from Poisson distribution. According to Poisson distribution, the values which are close to 1.00 indicate uniform distribution, whereas, more than 8.00 leads to contagious distribution. In the current trend all the values were less than unity as well as their departure from Poisson distribution was very less, thus it was a case of uniform distribution.

The above findings on the basis of various statistical parameters thus revealed uniform distribution of mango hopper in various tree sections of mango during vegetative stage of crop growth.

4.1.6.2 Flowering stage

Result presented in Table 17-19 and depicted in Fig. 5 reveal that population was uniformly distributed amongst various tree sections during flowering stage of the crop growth in 2002 and in pooled analysis, however, the population differed significantly in the subsequent year exhibiting highest population of 1.014 hoppers per sq. ft. tree trunk area in north upper direction. The population distribution was uniform and consistent in 2002 as well as in pooled analysis; however, significant difference in 2003 might be due to high population variation at flowering stage in a particular year owing to the factors not considered in the present investigation

Similarly, mean values exceeded variance in all the cases during both the years and pooled analysis; the variance-mean ratios were invariably less than unity (0.025 to 0.075, 0.012 to 0.038 and 0.010 to

0.023) in all the cases which implies that the population was more or less same during flowering stage of the crop.

Likewise, values of mean crowding (X*) were less than unity thereby Lloyd's index of patchiness became lower than unity (0.183 to 0.339, 0.043 to 0.233 and 0.002 to 0.203) in all the tree sections, thus indicating uniform distribution.

Clumping index which measures the amount of aggregation was less than unity in 2002 (-0.925 to -0.975), 2003 (-0.598 to -0.887) and in pooled analysis (-0.977 to - 0.986) thereby confirmed the uniform distribution of the pest.

Morista's indices of dispersion (I) did not vary much in all the tree sections in 2002 (9.964 to 9.980), 2003 (9.995 to 10.027) and pooled analysis (9.978 to 10.000), thus, indicated uniform distribution of the population.

The value of X^2 (Chi-square) and possibility of fit for negative binomial distribution indicated lower values (less than unity) in 2002 (0.226 to 0.675), 2003 (0.193 to 0.346) and pooled analysis (0.002 to 0.090) corresponding to less departure from Poisson distribution or in other words the population was uniform.

On the basis of above statistical parameters, the above findings thus indicate uniform distribution of the pest in all the tree sections during flowering stage of the crop growth.

4.1.6.3 Throughout the crop season

The values of various indices are presented in Table 17-19. In all the cases the variance-mean ratio being lower than unity suggesting that the hopper population was uniform in distribution. The values ranged from 0.006 to 0.020, 0.008 to 0.027 and 0.002 to 0.018 in all the cases of 2002, 2003 and pooled data, respectively.

Likewise, the values of mean crowding (X*) were less than mean hopper population in all the tree sections thereby Lloyd's index of patchiness became lower than unity in all the cases (0.330-0.361, 0.137-0.175 and 0.247-0.268 in 2002, 2003 and pooled data, respectively) confirming the finding that the hopper population was uniform in distribution (Table 17-19).

The clumping parameter or index ranged from -0.980 to -0.994, -0.973 to -0.992 and -0.982 to -0.998 during both the years of investigation and pooled analysis, respectively. In these cases low and uniform values indicate a fairly high degree of uniform distribution. These findings are in accordance with the statement of David and Moore (1954)

Table- 17: Spatial distribution of mango hopper during 2002

Tree section	Vegetative stage							
	$\bar{X}$ (Hoppers / sq.ft. tree trunk)	Variance (S^2)	($S^2/\bar{X}$)	Mean crowding (X*)	Lloyd's index of patchin-ess	Clump-ing index	Mori-sta index (I)	Chi Sq. (X^2)
North Upper	1.483	0.040	0.027	0.583	0.393	-0.900	9.963	0.243
North Lower	1.516	0.030	0.020	0.536	0.354	-0.980	9.962	0.178
South upper	1.596	0.010	0.006	0.602	0.377	-0.994	9.957	0.056
South lower	1.691	0.020	0.012	0.703	0.416	-0.988	9.56	0.106

East Lower	1.583	0.040	0.025	0.608	0.384	-0.975	9.959	0.227
East Upper	1.627	0.020	0.012	0.639	0.393	-0.988	9.58	0.111
West Lower	1.649	0.040	0.024	0.673	0.408	-0.976	9.957	0.218
West Upper	1.663	0.030	0.018	0.681	0.410	-0.982	9.956	0.162
S Em ±	0.0416							
CD at 5 %	0.117							
CV (%)	8.22							
Tree section	**Flowering stage**							
North Upper	1.439	0.070	0.049	0.0488	0.339	-0.951	9.964	0.438
North Lower	1.367	0.080	0.059	0.426	0.311	-0.941	9.966	0.527
South upper	1.254	0.070	0.056	0.310	0.247	-0.944	9.973	0.502
South lower	1.200	0.090	0.075	0.275	0.229	--0.925	9.975	0.675
East Lower	1.226	0.090	0.073	0.299	0.244	-0.927	9.974	0.661
East Upper	1.186	0.070	0.059	0.245	0.207	-0.941	9.977	0.531
West Lower	1.287	0.060	0.047	0.334	0.259	-0.953	9.972	0.420
West Upper	1.193	0.030	0.025	0.218	0.183	-0.975	9.980	0.226
S Em ±	0.0758							
CD at 5 %	NS							
CV (%)	18.88							
Tree section	**Throughout the year**							
North Upper	1.470	0.030	0.020	0.490	0.333	-0.980	9.964	0.184
North Lower	1.472	0.020	0.014	0.486	0.330	-0.986	9.965	0.183
South upper	1.498	0.010	0.007	0.505	0.337	-0.993	9.964	0.060
South lower	1.549	0.010	0.006	0.555	0.358	-0.994	9.961	0.058
East Lower	1.481	0.020	0.014	0.495	0.334	-0.986	9.964	0.122
East Upper	1.501	0.020	0.013	0.514	0.342	-0.987	9.963	0.120
West Lower	1.544	0.020	0.013	0.557	0.361	-0.987	9.962	0.117
West Upper	1.528	0.010	0.007	0.537	0.350	-0.993	9.962	0.059
S Em ±	0.034							
CD at 5 %	NS							
CV (%)	7.20							

Table- 18: Spatial distribution of mango hopper during 2003

Tree section	Vegetative stage							
	$\bar{X}$ (Hoppers/ sq. ft. tree trunk)	Variance (S^2)	($S^2/\bar{X}$)	Mean crowding (X*)	Lloyd's index of patchin-ess	Clump-ing index	Mori-sta index (I)	Chi Sq. (X^2)
North Upper	1.261	0.020	0.016	0.277	0.220	-0.984	9.976	0.143
North Lower	1.297	0.040	0.031	0.328	0.253	-0.969	9.973	0.278
South upper	1.339	0.020	0.015	0.354	0.264	-0.985	9.972	0.134
South lower	1.311	0.010	0.008	0.319	0.243	-0.992	9.974	0.069
East Lower	1.341	0.040	0.030	0.371	0.277	-0.970	9.970	0.268
East Upper	1.299	0.040	0.031	0.330	0.254	-0.969	9.973	0.277
West Lower	1.298	0.040	0.031	0.329	0.253	-0.969	9.973	0.277
West Upper	1.271	0.040	0.031	0.302	0.238	-0.969	9.974	0.283
S Em ±	0.052							
CD at 5 %	NS							
CV (%)	12.72							
Tree section	**Flowering stage**							
North Upper	1.014*	0.030	0.030	0.044	0.043	-0.70	9.995	0.266
North Lower	0.933	0.020	0.021	-0.046	-0.049	-0.887	10.005	0.193
South upper	0.835	0.020	0.024	-0.141	-0.169	-0.694	10.020	0.216
South lower	0.821	0.020	0.024	-0.155	-0.188	-0.666	10.022	0.219
East Lower	0.835	0.020	0.024	-0.141	-0.169	-0.694	10.019	0.216
East Upper	0.819	0.010	0.012	-0.169	-0.206	-0.650	10.023	0.110
West Lower	0.812	0.020	0.025	-0.163	-0.201	0.649	10.023	0.222
West Upper	0.780	0.030	0.038	-0.182	-0.233	-0.598	10.027	0.346
S Em ±	0.047							
CD at 5 %	0.135							
C.V. (%)	17.70							
Tree section	**Throughout the year**							
North Upper	1.188	0.010	0.008	0.196	0.165	-0.992	9.982	0.076
North Lower	1.191	0.020	0.017	0.208	0.175	-0.983	9.981	0.151
South upper	1.192	0.010	0.008	0.200	0.168	-0.992	9.982	0.076
South lower	1.170	0.010	0.009	0.179	0.153	-0.991	9.984	0.077
East Lower	1.196	0.020	0.017	0.213	0.178	-0.983	9.981	0.151
East Upper	1.160	0.020	0.017	0.177	0.153	-0.983	9.983	0.155
West Lower	1.159	0.020	0.017	0.176	0.152	-0.983	9.983	0.155
West Upper	1.128	0.030	0.027	0.155	0.137	-0.973	9.985	0.239
S Em ±	0.039							
CD at 5 %	NS							
CV (%)	10.57							

Table-19: Spatial distribution of mango hopper during 2002-2003 (Pooled analysis)

Tree section	**Vegetative stage**							
	$\bar{X}$ (Hoppers/ sq. ft. tree trunk)	Variance (S^2)	($S^2/\bar{X}$)	Mean crowding (X^*)	Lloyd's index of patchiness	Clumping index	Morista index (I)	Chi Sq. (X^2)
North Upper	1.374	0.020	0.015	0.389	0.283	-0.985	9.970	0.131
North Lower	1.410	0.020	0.014	0.424	0.301	-0.986	9.968	0.128
South upper	1.470	0.002	0.001	0.471	0.320	-0.999	9.966	0.012
South lower	1.504	0.091	0.061	0.565	0.376	-0.939	9.964	0.545
East Lower	1.464	0.133	0.091	0.555	0.379	-0.909	9.965	0.818
East Upper	1.466	0.141	0.096	0.562	0.383	-0.904	9.965	0.866
West Lower	1.476	0.029	0.020	0.496	0.336	-0.980	9.964	0.177
West Upper	1.468	0.142	0.097	0.565	0.385	-0.903	9.965	0.871
S Em ± (T) S Em ± (YxT)	0.0336 0.0473							
CD at 5 % (T) CD at 5 % (YxT)	NS NS							
CV (%)	10.30							
Tree section	**Flowering stage**							
North Upper	1.229*	0.025	0.020	0.249	0.203	-0.980	9.978	0.090
North Lower	1.152	0.027	0.023	0.175	0.152	--0.977	9.983	0.061
South upper	1.046	0.021	0.020	0.066	0.063	-0.980	9.993	0.020
South lower	1.012	0.021	0.021	0.033	0.032	-0.979	9.996	0.005
East Lower	1.033	0.020	0.019	0.052	0.051	-0.981	9.994	0.014
East Upper	1.004	0.015	0.015	0.019	0.019	-0.985	9.998	0.002
West Lower	1.068	0.023	0.022	0.090	0.084	-0.978	9.991	0.029
West Upper	0.988	0.010	0.010	-0.002	-0.002	-0.986	10.00	0.005
S Em ± (T) S Em ± (YxT)	0.043 0.063							
CD at 5 % (T) CD at 5 % (YxT)	0.122 NS							
CV (%)	18.87							
Tree section	**Throughout the year**							
North Upper	1.331	0.012	0.009	0.340	0.255	-0.991	9.972	0.081
North Lower	1.335	0.010	0.007	0.342	0.256	-0.993	9.972	0.067
South upper	1.348	0.003	0.002	0.350	0.260	-0.998	9.972	0.020
South lower	1.362	0.005	0.003	0.365	0.268	-0.997	9.971	0.033
East Lower	1.341	0.008	0.006	0.347	0.259	-0.994	9.972	0.054
East Upper	1.332	0.013	0.010	0.342	0.257	-0.990	9.972	0.088
West Lower	1.304	0.023	0.018	0.322	0.247	-0.982	9.973	0.159
West Upper	1.332	0.011	0.008	0.340	0.255	-0.992	9.972	0.074

S Em ± (T) S Em ± (YxT)	0.026 0.036	
CD at 5 % (T) CD at 5 % (YxT)	NS NS	
CV (%)	8.69	

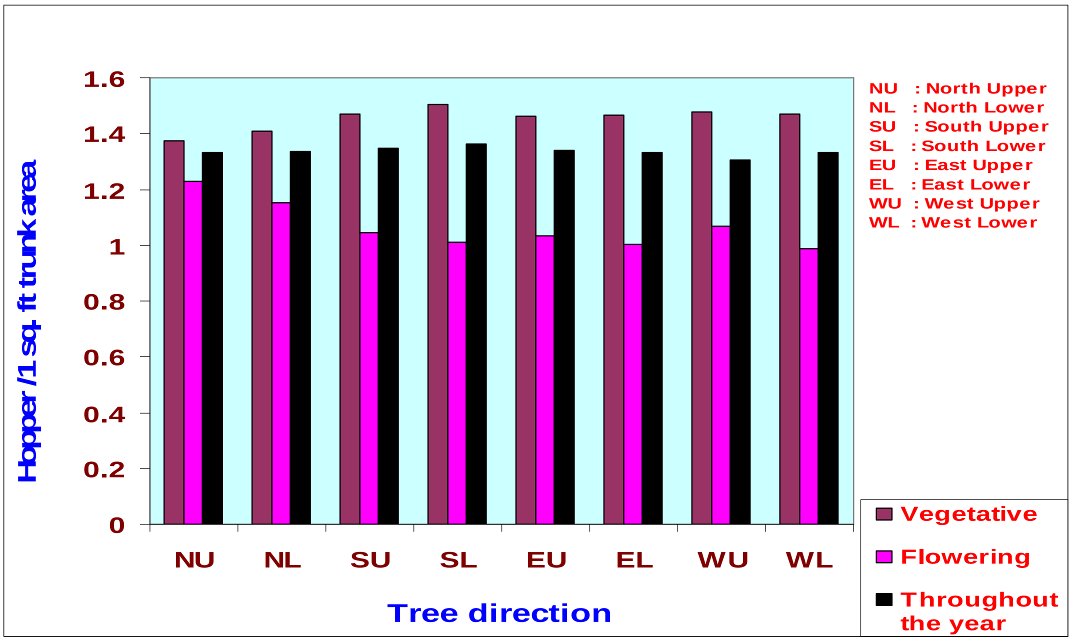


Fig. 5: Intra tree distribution of mango hopper during 2002 and 2003

who reported that if the index is < 8, population is uniformly distributed (Table 17-19).

Morista indices of dispersion (I) were more or less similar in all the tree sections in 2002 (9.961 to 9.65), 2003 (9.981 to 9.985) and pooled data (9.971 to 9.973), thus confirms uniform distribution of the population as the values being more or less similar in all the cases (Table 17-19).

The values of χ^2 (Chi-square) and probability of fit for negative binomial distribution shown in Table 23-25 indicated very low values (less than unity) in 2002 (0.117 to 0.184), 2003 (0.076 to 0.239) and pooled analysis (0.020 to 0.159) corresponded to low departure from Poisson distribution (Table 17-19).

Hence, on the basis of various statistical parameters *viz*; variance-mean ratio, mean crowding (X*) and Lloyd's index of patchiness, it may be concluded that the hoppers were uniformly distributed in all the tree sections.

This was further confirmed by clumping index (measure of aggregation) and Morista's indices of dispersion which indicated uniform distribution of the pest. Further, low values of χ^2- (Chi square) also indicated low aggregation and low departure from Poisson distribution, thus confirm uniformity in the pest distribution.

Thus, on the basis of above indices of dispersion, it may be concluded that the population of mango hopper was uniformly distributed in all the tree sections during vegetative, flowering and the entire crop season of both the years and pooled analysis and there was no discrimination in various tree sections as well as in upper and lower sections of the tree canopy.

These findings are in close agreement with the reports of Verghese *et al.* (1985) who studied the sequential sampling plan for mango hopper, *Idioscopus clypealis* and further reported uniform distribution of the pest species on mango trees irrespective of direction or height of mango tree. Similarly, Tandon *et al*. (1989) recorded that there was no significant difference in distribution of nymphs between north, south, east or west portions of the mango (cv. 'Totapuri') tree or between the upper and lower canopies.

4.2 Screening of mango cultivars against mango hopper

Fifteen mango cultivars were screened against mango hopper and its associated damage on the basis following characters:

4.2.1 Hopper population

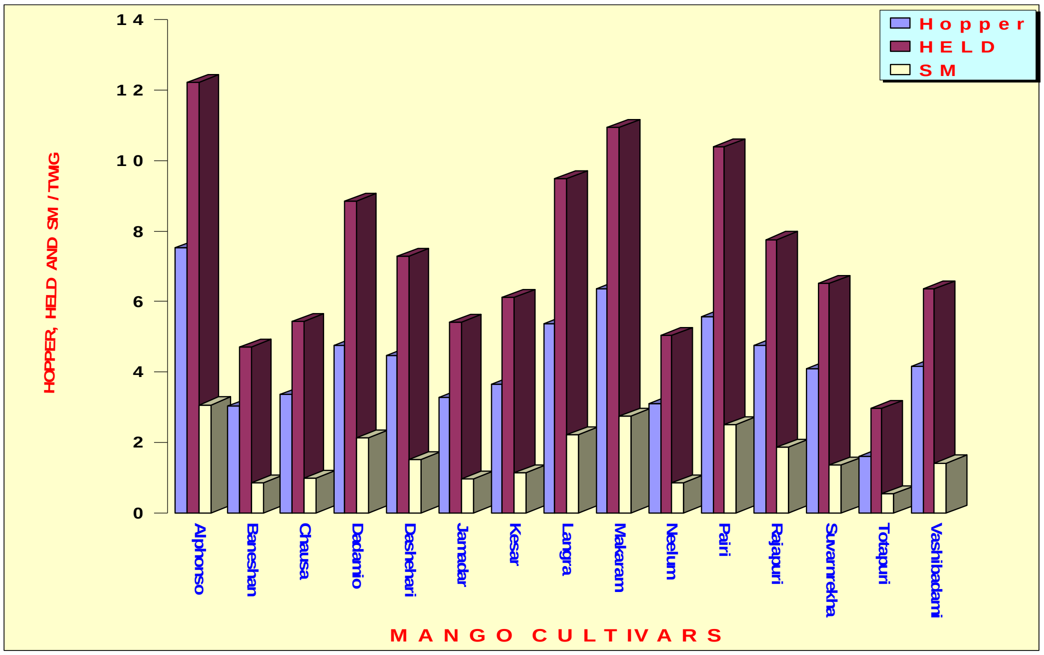
Year wise and pooled data of two years presented in Table 20 and depicted in Fig. 6 regarding the average hopper population revealed that the lowest hopper population was observed in Totapuri (2.32, 1.00 and 1.61 hoppers per twig in 2002-2003, 2003-2004 years and pooled data, respectively) and it was significantly less than the rest of the entries. The highest hopper population was observed in Alphonso (6.64, 8.46 and 7.52 hoppers per twig in both the years of investigation and pooled analysis, respectively) followed by Makaram (6.41, 6.31 and 6.36 hoppers per twig) which were at par with it, whereas, hopper population in the remaining entries *viz;* Makaram, Pairi, Langra, Dadamio, Dashehari, Vashibadami, Suvarnrekha, Kesar, Chausa, Jamadar, Neelum and Baneshan ranged from 6.31 to 6.41, 5.40 to 5.73, 5.15 to 5.59, 4.72 to 4.77, 4.09 to 4.87, 3.75 to 4.61, 3.64 to 4.57, 3.00 to 4.35, 2.58 to 4.24, 2.71 to 3.90, 2.39 to 3.90 and 2.11 to 3.83 hoppers per twig, respectively.

Table 20: Screening of mango cultivars to mango hopper and its associated damage

Sr. No.	Name of the cultivar	Hopper/twig			Hopper egg laying injury/twig (%)			Sooty mold grade/twig		
		2002-2003	**2003-2004**	**Pooled**	**2002-2003**	**2003-2004**	**Pooled**	**2002-2003**	**2003-2004**	**Pooled**
1	Alphonso	2.67* (6.64)	2.99* (8.44)	2.83* (7.52) a	3.68* 13.11)	3.44* (11.36)	3.56* (12.22)a	1.91* (3.15)	1.87* (3.00)	1.89* (3.07) a
2	Baneshan	2.07 (3.83)	1.67 (2.11)	1.87 (3.03) hijklmn	2.51 (5.81)	2.05 (3.73)	2.28 (4.72) jklmn	1.35 (1.35)	0.97 (0.45)	1.16 (0.86) jklm
3	Chausa	2.17 (4.24)	1.75 (2.58)	1.96 (3.36) ghijk	2.67 (6.64)	2.20 (4.34)	2.43 (5.44) hijk	1.42 (1.54)	1.01 (0.53)	1.22 (0.99) jk
4	Dadamio	2.28 (4.72)	2.29 (4.77)	2.29 (4.75) bcde	3.18 (9.61)	2.93 (8.10)	3.05 (8.84) cde	1.73 (2.51)	1.51 (1.79)	1.62 (2.14) cde
5	Dashehari	2.31 (4.87)	2.14 (4.09)	2.22 (4.47) cdefg	2.84 (7.57)	2.73 (7.00)	2.78 (7.28) efg	1.58 (2.02)	1.24 (1.05)	1.41 (1.51) fg
6	Jamadar	2.09 (3.90)	1.79 (2.71)	1.94 (3.28) ghijkl	2.60 (6.26)	2.26 (4.64)	2.43 (5.42) hijkl	1.31 (1.24)	1.11 (0.73)	1.21 (0.97) jkl
7	Kesar	2.20 (4.35)	1.87 (3.00)	2.03 (3.65) ghij	2.72 (6.94)	2.41 (5.33)	2.57 (6.11) hij	1.43 (1.57)	1.13 (0.78)	1.28 (1.15) ghij
8	Langra	2.46 (5.59)	2.37 (5.15)	2.42 (5.37) bcd	3.34 (11.40)	2.97 (8.35)	3.15 (9.48) bcd	1.77 (2.66)	1.52 (1.82)	1.65 (2.23) cd
9	Makaram	2.62 (6.41)	2.60 (6.31)	2.61(6.36) ab	3.52 (11.92)	3.24 (10.01)	3.38 (10.94) ab	1.87 (3.00)	1.73 (2.51)	1.80 (2.75) ab
10	Neelum	2.09 (3.90)	1.69 (2.39)	1.89 (3.10) hijlkm	2.57 (6.15)	2.13 (4.04)	2.35 (5.05) ijklm	1.33 (1.27)	0.99 (0.49)	1.16 (0.85) jklmn
11	Pairi	2.42 (5.40)	2.49 (5.73)	2.46 (5.56) bc	3.51 (11.89)	3.07 (8.98)	3.29 (10.39) abc	1.81 (2.81)	1.64 (2.22)	1.73 (2.51) bc
12	Rajapuri	2.42 (5.36)	2.16 (4.18)	2.29 (4.75) bcde	2.93 (8.14)	2.81 (7.40)	2.87 (7.76) def	1.67 (2.32)	1.39 (1.45)	1.53 (1.87) def
13	Suvarnrekha	2.25 (4.57)	2.03 (3.64)	2.14 (4.09) cdefghi	2.76 (7.12)	2.53 (5.95)	2.65 (6.52) fgh	1.51 (1.80)	1.21 (0.97)	1.36 (1.36) ghi
14	Totapuri	1.68 (2.32)	1.22 (1.00)	1.45 (1.61) o	2.24 (4.53)	1.48 (1.72)	1.86 (2.98) o	1.14 (0.82)	0.90 (0.32)	1.02 (0.55) o
15	Vashibadami	2.26 (4.61)	2.06 (3.75)	2.16 (4.17) cdefgh	2.57 (6.15)	2.66 (6.60)	2.62 (6.37) fghi	1.54 (1.87)	1.23 (1.01)	1.38 (1.42) gh
S.Em. ± (T) S.Em. ± (YxT)		0.020 --	0.050 --	0.108 0.038	0.094 --	0.065 --	0.097 0.081	0.027 --	0.088 --	0.047 0.065
C.D. at 5 % (T) C.D. at 5 % (YxT)		0.061 --	0.153 --	0.329 0.116	0.287 --	0.199 --	0.295 0.236	0.084 --	0.267 --	0.134 NS
C.V. (%)		1.260	3.430	2.500	4.610	3.580	4.190	2.520	9.580	6.450

* $\sqrt{x + 0.5}$ values   Figures in parenthesis indicate original values (mean of fortnightly observations)

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)



HELD: Hopper egg laying damage (%)   SM: Sooty mold grade

Fig. 6: Hopper and its associated damages on mango cultivars

4.2.2 Hopper egg laying damage

In respect of hopper egg laying damage minimum (4.53, 1.72 and 2.98 per cent on ten terminally mature leaves per twig in 2002-2003, 2003-2004 and in pooled data, respectively) was observed in Totapuri which was significantly less than the rest of the entries. The maximum damage was observed in Alphonso (13.11, 11.36 and 12.22 per cent during both the years of investigation and in pooled data, respectively) (Table 20) (Fig. 6).

4.2.3 Sooty mold

The data with respect to sooty mold grade revealed that the lowest sooty mold grade was observed in Totapuri (0.82, 0.32 and 0.55 in Sooty mold grade of 0-5 in 2002-2003, 2003-2004 and pooled data, respectively) and it was significantly less than the rest of the entries. Highest sooty mold grade was observed in Alphonso (3.15, 3.00 and 3.07) followed by Makaram (2.75 in pooled data) which were at par with it (Table 20) (Fig.6).

4.2.4 Natural enemies

The average predatory spider population was lowest in Totapuri (1.99, 1.65 and 1.81 per twig in 2002-2003, 2003-2004 and pooled data, respectively) and it was significantly less than the rest of the entries. Highest predatory spiders were recorded in Alphonso (7.12, 7.37 and 7.25 per twig) followed by Makaram (5.61 per twig in pooled data).

Similarly, average population of coccinellids was lowest in Totapuri (1.65, 0.58 and 1.07 per twig) and it was significantly less than the rest of the cultivars. Whereas, maximum was recorded in Alphonso

Table 21: Screening of mango cultivars to natural enemies of mango hopper

Sr. No.	Name of the cultivar	Predatory spiders/twig			Coccinellids/twig		
		2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled
1	Alphonso	2.76* (7.12)	2.80* (7.37)	2.78* (7.25) a	2.38* (5.21)	2.39* (5.21)	2.38* (5.21) a
2	Baneshan	1.97 (3.41)	1.78 (2.70)	1.88 (3.05) klm	1.79 (2.74)	1.47 (1.69)	1.63 (2.19) jklm
3	Chausa	2.05 (3.71)	1.87 (3.01)	1.96 (3.35) ijk	1.88 (3.04)	1.41 (1.50)	1.64 (2.22) ijk
4	Dadamio	2.42 (5.36)	2.34 (5.02)	2.38 (5.19) de	2.11 (3.96)	1.90 (3.11)	2.00 (3.53) cd
5	Dashehari	2.33 (4.94)	2.12 (4.04)	2.23 (4.48) fg	1.96 (3.37)	1.70 (2.40)	1.83 (2.87) efg
6	Jamadar	1.99 (3.49)	1.83 (2.85)	1.91 (3.16) jkl	1.79 (2.74)	1.49 (1.72)	1.64 (2.21) ijkl
7	Kesar	2.09 (3.90)	1.91 (3.17)	2.00 (3.53) ij	1.90 (3.11)	1.55 (1.92)	1.72 (2.49) ghij
8	Langra	2.48 (5.66)	2.45 (5.55)	2.47 (5.61) cd	2.05 (3.71)	1.87 (3.02)	1.96 (3.36) cde
9	Makaram	2.62 (6.37)	2.63 (6.45)	2.62 (6.41) b	2.31 (4.87)	2.12 (4.00)	2.22 (4.43) b
10	Neelum	1.97 (3.41)	1.78 (2.68)	1.88 (3.04) klmn	1.73 (2.51)	1.44 (1.60)	1.59 (2.03) jklmn
11	Pairi	2.53 (5.92)	2.49 (5.72)	2.51 (5.82) c	2.17 (4.22)	1.98 (3.44)	2.07 (3.82) c
12	Rajapuri	2.29 (4.75)	2.25 (4.60)	2.27 (4.68) f	2.08 (3.86)	1.78 (2.70)	1.93 (3.26) def
13	Suvarnrekha	2.14 (4.09)	1.98 (3.45)	2.06 (3.76) hi	1.91 (3.15)	1.64 (2.20)	1.77 (2.66) ghi
14	Totapuri	1.57 (1.99)	1.46 (1.65)	1.52 (1.81) o	1.46 (1.65)	1.04 (0.58)	1.25 (1.07) o
15	Vashibadami	2.21 (4.39)	2.03 (3.66)	2.12 (4.02) h	1.93 (3.26)	1.65 (2.24)	1.79 (2.73) gh
S.Em. ± (T) S.Em. ± (YxT)		0.034 --	0.058 --	0.037 0.048	0.037 --	0.077 --	0.047 0.060
C.D. at 5 % (T) C.D. at 5 % (YxT)		0.105 --	0.1777 --	0.105 NS	0.113 --	0.233 --	0.134 NS
C.V. (%)		2.200	3.910	3.130	2.680	6.410	4.660

$\sqrt{x + 0.5}$ values

Figures in parenthesis indicate original values (mean of fortnightly observations)

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

(5.21, 5.21 and 5.21 per twig) followed by Makaram (4.43 per twig in pooled data) (Table 21).

4.2.5 Abundance of hopper population in relation to morphological characters of mango

Abundance of hopper on various cultivars of mango has been studied on the basis of morphological characters or physical impediments of the crop so as to prove non-preference basis of host plant resistance, if any.

The observations were recorded on morphological characters of the plant such as height of the tree, unit leaf area, actual leaf area, leaf shape, colour of newly emerged leaves, length and colour of inflorescence and presence or absence of hair on inflorescence rachis and the results are described here under:

(a) Height of mango trees

Maximum height (8.50 m.) was recorded in Rajapuri and Pairi varieties while, it was minimum (4.47 m.) in Neelum. In rest of the varieties (Jamadar, Totapuri, Dashehari, Langra, Chausa, Vashibadami, Alphonso, Baneshan, Kesar, Suvarnrekgha, Dadamio and Makaram, though there was no meaningful or significant correlation existed between hopper population ('r' = 0.1112) as well as hopper egg laying damage ('r' = 0.1719) and height of mango trees (Table 22).

(b) Unit leaf area

The results indicated in Table 22 indicated lowest (100.73 cm^2) and highest leaf area (281.43 cm^2) in Chausa and Rajapuri, respectively, whereas in remaining varieties *viz*; Jamadar, Langra, Kesar, Pairi, Suvarnrekha, Makaram, Vashibadami, Totapuri, Dadamio, Dashehari, Neelum, Baneshan and Alphonso ranged from 114.18 to 223.55 cm^2. However, there was no significant difference between hopper population ('r' = 0.0785) as well as hopper egg laying damage ('r' = 0.0942) and unit leaf area in these varieties.

(c) Actual leaf area

Actual leaf area measured by portable leaf area meter (CI-203) in the test varieties was highest (149.17 cm^2) in Rajapuri and lowest (53.18 cm^2) in Chausa, whereas in rest of the varieties *viz*; Jamadar, Langra, Kesar, Pairi, Suvarnrekha, Makaram, Vashibadami, Totapuri, Dadamio, Dashehari, Neelum, Baneshan and Alphonso, it ranged from 60.49 to 118.34 cm^2). Correlation between hopper population ('r' = 0.0777) and hopper egg laying damage ('r' = 0.0941) was however found non-significant (Table 22).

(d) Leaf shape

Various types of leaf shapes have been observed in test varieties. It was ovate lanceolate in Alphonso, Langra, Makaram, Pairi, Rajapuri, Totapuri and Vashibadami with or without wavy margin, however in varieties *viz*; Baneshan, Chausa, Dashehari Jamadar and Kesar leaves were oval lanceolate with either twisted or sub-acuminate apex. Similarly, Dadamio and Suvarnrekha in leaves were folded with acuminate or sub-acuminate apex, whereas, leaves in Neelum were of irregular shape with slight fold and acute apex. However, hopper population ('r' = 0.1935) as well as its egg laying damage ('r' = 0.1393) did not indicate significant correlation with various leaf shapes in these varieties (Table 22).

Table 22: Correlation of hopper and its associated damage with tree height and leaf characters

Sr. No.	Name of the Cultivar	Hopper and HELD/twig	Height of tree (m.)	Leaf area (cm^2)		Leaf shape	Colour of new leaves
				Unit leaf area	Actual leaf area		
1	Alphonso	7.52 12.22	6.00	114.18	60.49	Ovate lanceolate, twisted, apex acuminate	Brick red
2	Baneshan	3.03/4.72	6.00	117.50	62.20	Oval lanceolate, flat, apex acute	Light green
3	Chausa	3.03/4.72	7.00	100.73	53.18	Oval lanceolate, twisted, apex acuminate	Light brown
4	Dadamio	3.36/5.44	4.67	122.48	64.82	Folded, slightly wavy margin, apex acuminate	Purple
5	Dashehari	4.75/8.84	7.67	121.65	60.62	Oval lanceolate, flat, wavy apex sub-acuminate	Light green
6	Jamadar	4.27/7.28	8.07	223.55	118.34	Flat, wavy margin, oval lanceolate, apex-acute	Light green
7	Kesar	3.65/6.11	5.70	207.53	109.88	Flat, wavy margin, oval lanceolate, apex sub-acuminate	Light green
8	Langra	5.37/9.48	7.17	214.68	113.60	Ovate lanceolate, flat, apex sub-acuminate	Light purple or brown
9	Makaram	6.36/10.94	4.67	141.93	75.06	Wavy, ovate lanceolate, apex acuminate	Light green
10	Neelum	3.10/5.05	4.47	117.59	62.15	Irregular shape, slightly folding, twisted, apex acute	Purple brown
11	Pairi	5.56/10.39	8.50	169.13	89.54	Ovate lanceolate, apex acuminate	Coppery brown
12	Rajapuri	4.75/7.76	8.50	281.43	149.17	Ovate lanceolate, wavy margin, apex acuminate	Orange
13	Suvarnrekha	4.09/6.52	5.10	154.75	81.93	Reflexed, folded, apex sub- acuminate	Rainette green
14	Totapuri	1.61/2.98	7.33	124.01	65.60	Ovate lanceolate, almost flat with twist, apex sub-acuminate	Light green With brick red tinge
15	Vashibadami	4.17/6.37	6.67	132.45	70.04	Ovate lanceolate, wavy margin, apex- sub-acuminate	Light green
	Corr. Coeff ('r') (Hopper)	1.0000	0.1112 (NS)	0.0785 (NS)	0.0777 (NS)	0.1935 (NS)	0.4483 (NS)
	Corr. Coeff ('r') (HELD)	1.0000	0.1719 (NS)	0.0942 (NS)	0.0941 (NS)	0.1393 (NS)	0.4604 (NS)

HELD: Hopper egg laying damage (%)

(e) Colour of new leaf

Results indicated in Table 22 reveal varied colour of new leaves in test varieties. It was light green in Baneshan, Dashehari, Jamadar, Kesar, Makaram, Totapuri (with brick red tinge) and Vashibadami, whereas, new leaves of Suvarnrekha exhibited rainette green color. Similarly, new leaves of Chausa and Langra were of light brown colour. New leaves emerged out in Neelum and Pairi were purple brown and coppery brown in colour. New leaves emerged out in Dadamio, Rajapuri, Alphonso were of purple, orange and brick red colours, but colours of new leaves could not orient hopper population towards these varieties significantly, hence correlation of hopper population ('r' = 0.4483) and hopper egg laying damage ('r' = 0.4604) with colour variation of newly emerged leaves was found non-significant.

(f) Appearance and length of inflorescence

Appearance of mango inflorescence in test varieties was recorded in the form of shape and colour. It was pyramidical in Alphonso, Baneshan, Chausa, Dadamio, Dashehari, Jamadar, Kesar, Langra, Makaram, Pairi, Rajapuri, Totapuri and Vashibadami, whereas, it was conical in Neelum and large in Suvarnrekha. Mango inflorescence in Baneshan and Chausa were of yellowish colour while they were yellowish green in varieties *viz*; Alphonso, Dashehari, Jamadar, Kesar, Langra, Makaram, Totapuri and Vashibadami. Similarly, crimson coloured inflorescence was observed in Dadamio and Neelum. Copper, coral red and cornithan red coloured mango inflorescence were observed in Pairi, Rajapuri and Suvarnrekha. Length of mango inflorescence was maximum (31cm.) in Suvarnrekha followed by 30.15, 27.94, 27.90, 26.10, 26, 25.40, 24.17, 24.10 cms in Rajapuri, Dashehari (also in Neelum and Totapuri), Baneshan, Jamadar (also in Vashibadami), Kesar (also in Dadamio), Alphonso (also in Langra), Makaram and Pairi, respectively, while it was minimum in Chausa (24 cm.). Hopper population ('r' = -0.4082) or hopper egg laying damage ('r' = 0.4652) did not exhibit significant correlation with appearance as well as length of mango inflorescence in test varieties (Table 23).

(g) Presence of hairs on inflorescence rachis

All the test varieties had presence of hairs on their inflorescence rachis, though they were fine in case of Alphonso, Baneshan, Chausa, Dadamio, Dashehari, Jamadar, Kesar, Langra, Makaram, Rajapuri, Suvarnrekha, Totapuri and Vashibadami, whereas, they were of moderate and coarse type in Pairi and Neelum, respectively. Hopper population ('r' = 0.0855) as well as hopper egg laying damage ('r' = 0.0773) did not exhibit significant correlation with presence or type of hairs on inflorescence rachis.

It is evident from results indicated in Table 23 that there was no significant correlation of hopper population and hopper egg laying damage with any plant character taken into consideration, although hopper population on twig exhibited positive correlation with all the plant characters except length and colour of inflorescence which had negative (but non-significant) relationship with it. Similarly, hopper egg laying damage which occurs after landing of female hoppers on under side of mango leaves or freshly emerged inflorescence resulting into oviposition also had positive (but non-significant) correlation with all the plant characters taken into consideration. Hence, it may be concluded that orientation of mango hoppers and their subsequent ovipositional damage was not directly or indirectly influenced (significantly) by any of

Table 23: Correlation of hopper and its associated damage with mango inflorescence characters

Sr. No.	Name of the cultivar	Hopper and HELD/twig	Inflorescence		
			Length (cm.)	Shape and Colour	Hairyness
1	Alphonso	7.52 12.22	25.40	Pyramidal, yellowish green	Hairy, fine hairs
2	Baneshan	3.03/4.72	27.90	Pyramidal, yellowish	Hairy, fine hairs
3	Chausa	3.03/4.72	24.00	Pyramidal, yellowish	Hairy, fine hairs
4	Dadamio	3.36/5.44	26.00	Pyramidal, crimson	Hairy, fine hairs
5	Dashehari	4.75/8.84	27.94	Pyramidal, yellowish green	Hairy, fine hairs
6	Jamadar	4.27/7.28	26.10	Pyramidal, yellowish green	Hairy, fine hairs
7	Kesar	3.65/6.11	26.00	Pyramidal, yellowish green	Hairy, fine hairs
8	Langra	5.37/9.48	25.40	Pyramidal, yellowish green	Hairy, fine hairs
9	Makaram	6.36/10.94	24.17	Pyramidal, yellowish green	Hairy, fine hairs
10	Neelum	3.10/5.05	27.94	Conocal deep crimson	Hairy, coarse hairs
11	Pairi	5.56/10.39	24.10	Pyramidal, copper	Hairy, moderate hairs
12	Rajapuri	4.75/7.76	30.15	Pyramidal, coral red	Hairy, fine hairs
13	Suvarnrekha	4.09/6.52	31.00	Large cornithan red	Hairy, fine hairs
14	Totapuri	1.61/2.98	27.94	Pyramidal, yellowish green	Hairy, fine hairs
15	Vashibadami	4.17/6.37	26.10	Pyramidal, yellowish green	Hairy, fine hairs
	Corr. Coeff ('r') (Hopper)	1.0000	-0.4082 (NS)		0.0855 (NS)
	Corr. Coeff ('r') (HELD)	1.0000	0.4652 (NS)		0.0773 (NS)

HELD: Hopper egg laying damage (%)

the morphological character of mango trees of select varieties taken into consideration in this investigation (Table 23).

4.2.6 Impact of abundance of hopper on mango production

The statistical analysis of yield data indicated in Table 24 showed that variety Totapuri gave highest yield (221.50, 312.50 and 263.24 Kg per tree in 2002-2003, 2003-2004 and pooled data, respectively) followed by Rajapuri, Langra, Vashibadami, Kesar, Dadamio and Alphonso reporting 252.39, 244.42, 239.35, 235.30, 234.30 and 230.79 Kg per tree yield in pooled data, respectively, which were at par with it. The variety Chausa gave the lowest yield (132.50, 178.00 and 154.31 Kg per tree). However, the yield was not significantly correlated with abundance of hopper population on these varieties thus indicating that the yield of these varieties did not increase or decrease according to hopper population but the characters like differential yielding ability coupled with ability to recover the damage caused by the pest may be the possible reason for differences in yield of different varieties taken into present investigations.

4.2.7 Categorization of mango cultivars

Fifteen mango cultivars screened against mango hopper and its associated damage have been categorized as highly resistant, resistant and susceptible entries, while none of the entry was found highly susceptible to the insect-pest (Table 25).

On the basis of hopper population, Totapuri has been categorized as highly resistant, Baneshan, Neelum, Jamadar, Chausa, Kesar, Suvarnrekha, Vashibadami, Dashehari, Dadamio and Rajapuri as resistant and Langra, Pairi, Makaram and Alphonso as susceptible entries.

Table 24: Fruit yield of mango cultivars influenced by hopper incidence

Sr. No.	Cultivars	Yield (Kg/tree)			Hopper /twig
		2002-2003	2003-2004	Pooled	
1	Alphonso	12.95* (167.50)	12.45* (304.50)	15.20* abcdefg (230.79)	7.52
2	Baneshan	11.63 (135.00)	13.61 (185.00)	12.62 ab (158.92)	3.03
3	Chausa	11.53 (132.50)	13.35 (178.00)	12.44 o (154.31)	3.36
4	Dadamio	13.20 (174.00)	17.40 (302.50)	15.30 abcdef (234.30)	4.75
5	Dashehari	12.14 (147.00)	17.41 (208.50)	13.27 hi (175.82)	4.47
6	Jamadar	12.03 (144.50)	13.81 (190.50)	12.92 hijk (166.63)	3.28
7	Kesar	13.55 (183.50)	17.16 (294.00)	15.35 abcde (235.30)	3.65
8	Langra	13.72 (188.00)	17.57 (308.50)	15.64 abc (244.42)	5.37
9	Makaram	12.72 (161.50)	15.70 (248.00)	14.21 h (201.61)	6.36
10	Neelum	11.61 (134.50)	13.69 (187.00)	12.65 ijkl (159.64)	3.10
11	Pairi	11.70 (136.50)	13.37 (178.50)	12.53 ijklmn (156.66)	5.56
12	Rajapuri	14.01 (196.50)	17.78 (316.00)	15.90 ab (252.39)	4.75
13	Suvarnrekha	12.24 (149.50)	13.82 (191.00)	13.03 hij (169.48)	4.09
14	Totapuri	14.88 (221.50)	17.59 (312.50)	16.24 a (263.24)	1.61
15	Vashibadami	14.15 (200.00)	16.81 (285.00)	15.48 abcd (239.35)	4.17
S.Em. ± (T)		0.404	0.815	0.469	0.108
S.Em. ± (YxT)		--	--	0.643	0.038
C.D. at 5 % (T)		1.227	2.473	1.340	0.329
C.D. at 5 % (YxT)		--	--	NS	0.116
C.V. (%)		4.47	7.41	6.41	2.500
Corr. Coeff (‘r’)		--	--	1.0000	0.1355 (NS)

$\sqrt{x+0.5}$ values   Figures in parenthesis indicate original values

Figures followed by the same letters do not differ significantly as per Duncan’s multiple range test (DMRT)

Table - 25: Categorization of mango varieties

Sr. No.	Name of the cultivar	Hopper /twig	Rank index	Categorization (on the basis of hopper population/twig)	Sooty Mold Grade /twig	Rank index	Categorization (on the basis of sooty mold grade/twig)	Mean Rank index	Overall Rank (in terms of susce-ptibility)
1	**Alphonso**	7.52	1	**Susceptible**	3.07	1	**Susceptible**	1	**1**
2	**Baneshan**	3.03	13	**Resistant**	0.86	13	**Highly resistant**	13	**13**
3	**Chausa**	3.36	10	**Resistant**	0.99	11	**Highly resistant**	10.5	**11**
4	**Dadamio**	4.75	5	**Resistant**	2.14	5	**Susceptible**	5	**5**
5	**Dashehari**	4.47	6	**Resistant**	1.51	7	**Resistant**	6.5	**7**
6	**Jamadar**	3.28	11	**Resistant**	0.97	12	**Highly resistant**	11.5	**12**
7	**Kesar**	3.65	9	**Resistant**	1.15	10	**Resistant**	9.5	**10**
8	**Langra**	5.37	4	**Susceptible**	2.23	4	**Susceptible**	4	**4**
9	**Makaram**	6.36	2	**Susceptible**	2.75	2	**Susceptible**	2	**2**
10	**Neelum**	3.10	12	**Resistant**	0.85	14	**Highly resistant**	13	**13**
11	**Pairi**	5.56	3	**Susceptible**	2.51	3	**Susceptible**	3	**3**
12	**Rajapuri**	4.75	5	**Resistant**	1.87	6	**Resistant**	5.5	**6**
13	**Suvarnr-ekha**	4.09	8	**Resistant**	1.36	9	**Resistant**	8.5	**9**
14	**Totapuri**	1.61	14	**Highly resistant**	0.55	15	**Highly resistant**	14.5	**14**
15	**Vashiba-dami**	4.17	7	**Resistant**	1.42	8	**Resistant**	7.5	**8**

MOST SUSCEPTIBLE VARIETY: ALPHONSO **LEAST SUSCEPTIBLE VARIETY: TOTAPURI**

Hopper population	**Rating**	**Sooty mold index**	**Rating**
Nil	Free	No visual appearance of black mold	Free
1-2 hoppers/twig or panicle	Highly resistant	< 25 per cent on leaves	Highly resistant

Up to 5 hoppers/twig or panicle	Resistant	25 - 60 per cent on leaves	Resistant
6-10 hoppers /twig or panicle	Susceptible	51-75 per cent black mold on leaves	Susceptible
> 10 hoppers /twig or panicle	Highly susceptible	> 75 per cent on leaves	Highly susceptible

Similarly, on the basis of sooty mold grade, Totapuri, Nelum, Baneshan, Jamadar and Chausa were categorized highly resistant, Kesar, Suvarnrekha, Vashibadami, Dashehari and Rajapuri resistant and Dadamio, Langra, Pairi, Makaram and Alphonso susceptible entries.

No entry has been found either free or highly susceptible to the insect-pest on the basis of sooty mold grade.

Thus, on the basis of both the parameters, it may be concluded that Totapuri has been found least susceptible entry (Table 25), and was categorized as highly resistant only, whereas Alphonso was the most susceptible entry and was categorized as susceptible entry. These findings are in close agreement with the reports of Nachiappan and Bhaskaran (1984) and Srivastava (1995) who categorized Baneshan, Chinarasam, Banglora (syn. Totapuri) as resistant varieties and Alphonso has been found most susceptible and categorized as susceptible entry. Alphonso, Langra and Makaram have been proved as susceptible to highly susceptible entries to mango hopper complex consisting of *A. atkinsoni, I. clypealis* and *I. niveosparsus* (Anonymous, 1999 and Talpur and Khuhro, 2003). They further stated that Neelum and Dashehari harboured less number of mango hopper per shoot. The present investigation has already indicated similar findings in Table 20-22 and thus confirming the study.

So, it is evident from the results that significant role of morphological characters of mango could not be established, hence, there could be some other factors which were not taken into present consideration might have led to the establishment of non-preference basis of host plant resistance.

4.3 Influence of recurrent flowering on incidence of mango hopper

Recurrent flowers are those new flowers which emerge from the base points of previously emerged panicles (Plate 2). This type of flowering is mostly observed during 45-60 days after the emergence of main panicle. Emergence of recurrent flowering may be physiological in nature and emerge due to natural phenomenon. Influence of recurrent flowers on abundance of hopper, its associated damage and natural enemies was investigated on fifty recurrent and fifty non-recurrent flowers per tree (ten trees were randomly selected in the trial) on the basis of following parameters.

4.3.1 Influence of recurrent flowering on abundance of hopper complex

Results presented in Table 26 and depicted in Fig. 7 reveal that hopper abundance was higher on recurrent flowers in 2002 with peak population of 8.60 hoppers per panicle at stone sized fruit stage of the crop (stone –III) coinciding with 14-15 SW (2-15 April) wherein during the same period highest abundance of 6.89 hoppers was recorded on non-recurrent flowers. In the next season, highest populations of 3.25 and 2.91 hoppers per panicle was observed during the same period on recurrent and non-recurrent flowers, respectively.

In pooled analysis, highest abundance of hopper on recurrent and non-recurrent flowers during the same period was 5.45 and 4.41 hoppers per panicle, respectively.

Thus, on the basis of foregoing discussion it may be concluded that this difference in hopper population could be due to the reason that hopper prefer fresh panicles and its population started declining as panicle approach full maturity owing to reduction in cell sap content in the old panicles, whereas emergence of new flowers at the base of main panicle i.e. recurrent flowers (Plate 2) hosted higher abundance of hopper as compared to the old mature inflorescence.

4.3.2 Influence of recurrent flowering on abundance of hopper egg laying damage

During 2002, highest damage (11.96 per cent) was observed on recurrent flowers at stone sized fruit stage of crop growth (stone-I) which coincided with 10-11 SW (5-18 March) whereas, on non-recurrent flowers highest damage was 10.85 per cent at stone sized fruit stage of crop growth (stone-III) coinciding with 14-15 SW (2-15 April). The damage remained low in 2003 as compared to the preceding year, however, highest damages of 9.2 and 8.9 per cent were observed at the same stage of crop growth on recurrent and non-recurrent flowers, respectively, coinciding with 18 SW (14-20 May). In pooled analysis, recurrent and non-recurrent flowers respectively had higher damage of 9.46 and 9.00 per cent recorded at the same stage of crop growth coinciding with 16-17 SW (16-29 April) (Table 26).

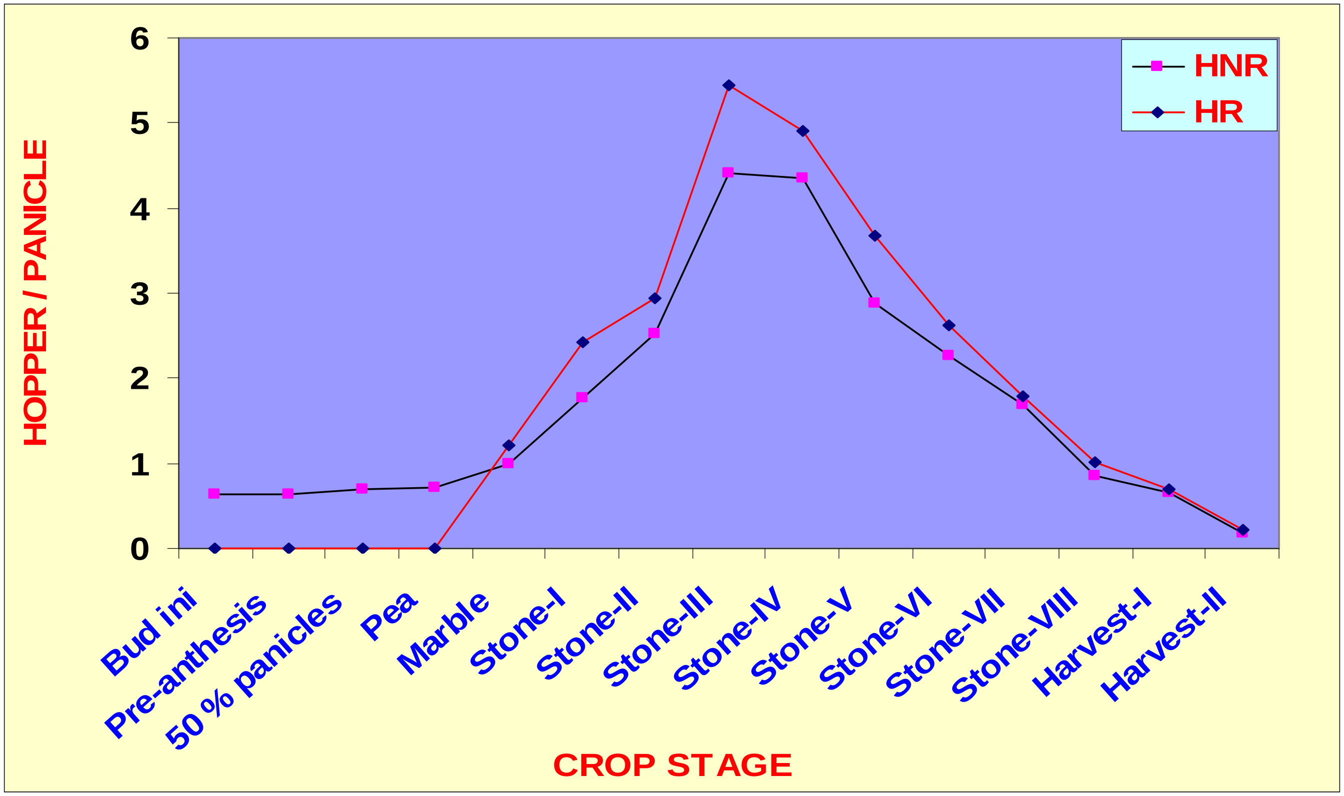
So, above results very clearly reflect higher abundance of hopper egg laying damage on recurrent flowers as compared to that on non-recurrent flowers. This could be due to higher abundance of hopper population leading to higher oviposition on recurrent flowers as compared to that on non-recurrent flowers (Plate 1-2).

Table 26: Impact of recurrent flowering on abundance of mango hopper and associated damage

Crop stage	SW	Hopper/panicle						Hopper egg laying damage (%)						Sooty mold grade					
		2002		2003		Pooled		2002		2003		Pooled		2002		2003		Pooled	
		NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R
Bud ini.	**1-2**	0.89	--	0.37	--	0.64	--	9.99	--	2.60	--	6.30	--	2.50	--	0.40	--	1.45	--
Pre-anthesis	**3-4**	0.90	--	0.37	--	0.64	--	9.99	--	2.90	--	6.45	--	2.50	--	0.50	--	1.50	--
50 % panicles	**5**	0.95	--	0.43	--	0.69	--	10.10	--	2.90	--	6.50	--	2.90	--	0.50	--	1.70	--
Pea stage	**6-7**	1.01	--	0.41	--	0.71	--	10.05	--	3.10	--	6.58	--	3.10	--	0.70	--	1.90	--
Marble stage	**8-9**	1.64	2.02	0.35	0.39	1.00	1.21	10.12	10.24	3.20	3.40	6.66	6.71	3.10	3.70	0.90	1.10	2.00	2.40
Stone-I	**10-11**	3.15	4.15	0.39	0.70	1.77	2.43	10.26	11.96	3.60	3.90	6.93	7.93	3.00	3.90	0.90	1.10	1.95	2.50
Stone-II	**12-13**	4.15	4.78	0.88	1.09	2.52	2.94	10.29	10.49	4.10	4.90	7.20	7.70	3.10	3.60	1.20	1.40	2.15	2.50
Stone-III	**14-15**	6.89	8.60	1.92	2.30	4.41	5.45	10.85	11.15	6.90	7.60	8.88	9.38	3.10	3.60	1.40	1.60	2.25	2.60
Stone-IV	**16-17**	5.81	6.55	2.91	3.25	4.36	4.90	9.89	10.01	8.10	8.90	9.00	9.46	2.40	2.90	1.80	2.00	2.10	2.45
Stone-V	**18**	4.33	4.80	1.44	2.53	2.89	3.67	7.89	8.16	8.90	9.20	8.40	8.68	2.20	2.90	2.10	2.30	2.15	2.60
Stone-VI	**19**	3.54	4.12	1.00	1.12	2.27	2.62	6.24	6.64	7.90	8.10	7.07	7.37	1.60	1.70	1.90	1.90	1.75	1.80
Stone-VII	**20**	2.65	2.82	0.71	0.74	1.68	1.78	5.17	5.56	7.10	7.30	6.14	6.43	1.40	1.90	1.60	1.70	1.50	1.80
Stone-VIII	**21**	1.31	1.51	0.41	0.50	0.86	1.01	3.14	3.46	6.90	7.60	5.02	5.53	1.20	1.20	1.30	1.40	1.25	1.30
Harvest-I	**22**	0.98	1.03	0.31	0.34	0.65	0.69	3.16	3.39	4.90	5.10	4.03	4.25	1.20	1.20	1.10	1.20	1.15	1.20
Harvest-II	**23-24**	0.19	0.20	0.17	0.21	0.18	0.21	0.86	0.89	3.60	3.10	2.23	2.00	0.30	0.30	0.60	0.50	0.15	0.40

NR: Non-recurrent flowers (average based on fifty panicles)

R : Recurrent flowers (average based on fifty panicles)



HNR : Hopper on non-recurrent flowers **HR : Hopper on recurrent flowers**

Fig. 7: Impact of recurrent flowering on abundance of mango hopper

Table 27: Impact of recurrent flowering on abundance of natural enemies of mango hopper

Crop stage	SW	Predatory spiders/twig						Coccinellids/twig					
		2002		2003		Pooled		2002		2003		Pooled	
		NR	R	NR	R	NR	R	NR	R	NR	R	NR	R
Bud ini.	**1-2**	0.09	--	0.05	--	0.07	--	0.14	--	0.04	--	0.09	--
Pre-anthesis	**3-4**	0.11	--	0.05	--	0.08	--	0.18	--	0.04	--	0.11	--
50 % panicles	**5**	0.16	--	0.07	--	0.12	--	0.18	--	0.05	--	0.12	--
Pea stage	**6-7**	0.24	--	0.07	--	0.16	--	0.19	--	0.06	--	0.13	--
Marble stage	**8-9**	0.24	0.25	0.07	0.07	0.16	0.16	0.19	0.19	0.05	0.06	0.12	0.13
Stone-I	**10-11**	0.33	0.46	0.08	0.16	0.21	0.31	0.24	0.36	0.06	0.06	0.15	0.21
Stone-II	**12-13**	0.64	0.69	0.17	0.24	0.41	0.47	0.49	0.56	0.09	0.10	0.29	0.33
Stone-III	**14-15**	0.66	0.69	0.43	0.44	0.55	0.57	0.53	0.66	0.16	0.17	0.35	0.42
Stone-IV	**16-17**	0.56	0.64	0.32	0.34	0.44	0.49	0.49	0.61	0.24	0.29	0.37	0.45
Stone-V	**18**	0.43	0.49	0.26	0.29	0.35	0.39	0.36	0.41	0.19	0.21	0.28	0.31
Stone-VI	**19**	0.39	0.40	0.24	0.25	0.32	0.33	0.19	0.24	0.16	0.17	0.18	0.21
Stone-VII	**20**	0.37	0.39	0.21	0.22	0.29	0.31	0.09	0.10	0.13	0.13	0.11	0.12
Stone-VIII	**21**	0.26	0.27	0.19	0.21	0.23	0.24	0.03	0.03	0.06	0.07	0.05	0.05
Harvest-I	**22**	0.19	0.19	0.17	0.17	0.18	0.18	0	0	0.06	0.09	0.03	0.05
Harvest-II	**23-24**	0.11	0.13	0.13	0.14	0.12	0.14	0	0	0.03	0.03	0.02	0.02

NR : Non-recurrent flowers (average based on fifty panicles)

R : Recurrent flowers (average based on fifty panicles)

4.3.3 Influence of recurrent flowering on sooty mold damage

Recurrent flowers had highest sooty mold damage of 3.9 (SM grade) at stone sized fruit stage of crop growth coinciding with 10-11 SW (5-18 March), whereas, highest sooty mold damage of 3.10 (SM grade) on non-recurrent flowers was observed at pea, marble and stone (stone-II and III) sized fruit crop stages in 2002, whereas in the subsequent year, it was late in appearance exhibiting peaks of 2.3 and 2.1 (SM grades) on recurrent and non-recurrent flowers, respectively at the similar stage of crop growth coinciding with 18^{th} SW (30 April-6 May).

In pooled analysis, recurrent and non-recurrent flowers had highest sooty mold grades of 2.60 and 2.25, respectively at the same crop stage coinciding with 14-15 SW (2-15 April) and 18 SW (30 April-6 May) (Table 26).

Thus, on the basis of comparative grades at marble (2.40 SM grade), stone (I-VIII) (1.30-2.50 SM grades), Harvest (I-II) (0.40-1.20 SM grades) stages, it is evident that higher damage in terms of higher SM grades were observed on recurrent flowers than on non-recurrent flowers i.e. 2.00, 1.25-2.15 and 0.15-1.15 SM grades at marble, stone and harvest stages, respectively during the same period and stages of crop growth. It may be due to relatively higher abundance of hoppers on recurrent flowers as compared to that on non-recurrent flowers.

4.3.4 Abundance of natural enemies on recurrent and non-recurrent flowers

During 2002, results presented in Table 27 reveal comparatively higher abundance of predatory spiders on recurrent flowers (0.69 per panicle) than on non-recurrent flowers (0.66 per panicle) at stone sized fruit stage of crop growth (stone-II and III) coinciding with 12-15 SW (19 March – 15 April). In the subsequent year, highest population of predatory spiders on recurrent flowers was 0.44 as compared to those of 0.43 spiders per panicle on non-recurrent flowers. This was recorded at stone sized fruit stage of crop growth (stone-III) coinciding with 14-15 SW (2-15 April). In pooled analysis, highest predatory spider populations of 0.57 and 0.55 per panicle was observed in recurrent and non-recurrent flowers, respectively at stone sized fruit stage of crop growth coinciding with 14-15 SW (2-15 April).

Similarly, comparatively higher abundance of coccinellids was observed on recurrent flowers (0.66, 0.29 and 0.45 per panicle in 2002, 2003 and pooled analysis, respectively) as compared to those on non-recurrent flowers (0.53, 0.24 and 037 per panicle in 2002, 2003 and pooled analysis, respectively) at stone sized fruit stage of crop growth (stone-III and IV) coinciding with 14-17 SW (2-29 April) (Table 27).

Thus, on the basis of above results, it may be concluded that higher abundance of both the natural enemies was observed on recurrent flowers as compared to those on non-recurrent flowers. This difference in level of natural enemies' population could be due to difference in abundance of mango hopper. It has already been proved in the earlier section of the result (refer 4.14) that higher abundance of natural enemies of hopper is directly proportional to the higher activity of hopper. So, higher abundance of hoppers on recurrent flowers leads to higher population of natural enemies as compared to those on non-recurrent flowers.

4.3.5 Correlation and regression of hopper (on recurrent and non-recurrent flowers) and its damage with crop stage

During 2002**,** hopper populations on non-recurrent and recurrent flowers were not significantly correlated with crop stage, however, hopper egg laying damage and sooty mold on non-recurrent flowers indicated significant negative correlation with crop stage. This implies that as the crop stage moved from stone to harvest stages of crop growth, hopper egg laying damage and sooty mold grades declined gradually from 10.85 to 0.86 per cent and 3.10-0.30 SM grades, respectively. However, in the subsequent year, hopper egg laying and sooty mold damages on both non-recurrent and recurrent flowers were positively correlated with crop stages of mango i.e. proportion of both the damages increased as the crop stage moved from marble to stone to harvest stages, whereas, in pooled analysis none of the parameter could establish any significant correlation with crop stage of mango (Table 28).

The linear regression equations of significant parameters were:

2002 **HELD (NR)** : $\hat{Y} = 12.8949 + 0.6285\,(X_3)$

SM (NR) : $\hat{Y} = 3.5342 + 0.1617\,(X_5)$

2003 **HELD (NR)** : $\hat{Y} = 2.7219 + 0.2989\,(X_3)$

HELD (R) : $\hat{Y} = 0.3723 + 0.5292\,(X_4)$

SM (NR) : $\hat{Y} = 0.5952 + 0.0664\,(X_5)$

SM (R) : $\hat{Y} = 0.2257 + 0.1067\,(X_6)$

Where,

$\hat{Y}$ = Crop stage

X_3 = Hopper egg laying damage (%) on non-recurrent flowers

X_4 = Hopper egg laying damage (%) on recurrent flowers

Table 28: Correlation and regression of crop stage with hopper and its damage on non-recurrent and recurrent flowers

Year/Crop stage (Y)	Hoppper /panicle		Hopper egg laying damage (%)		Sooty mold grade	
	NR	R	NR	R	NR	R
	X_1	X_2	X_3	X_4	X_5	X_6
Correlation coefficient ('r')						
2002	0.107	0.211	-0.853*	0.162	-0.809*	0.148
2003	0.114	0.264	0.594*	0.686*	0.541*	0.599*
Pooled	0.111	0.231	0.419	0.426	0.456	0.323
Regression coefficient						
2002						
A value	---	---	12.8949	---	3.5342	---
b value	---	---	0.6285	---	0.1617	---
2003						
A value	---	---	2.7219	0.3723	0.5952	0.2257
b value	---	---	0.2989	0.5292	0.0664	0.1067
Regression coefficient Pooled	---	---	---	---	---	---

* Significant at 5 % level

NR : Non-recurrent flowers

R : Recurrent flowers

X_5 = Sooty mold grade on non-recurrent flowers

X_6 = Sooty mold grade on recurrent flowers

HELD (NR) = Hopper egg laying damage (%) on non-recurrent flowers

HELD (R) = Hopper egg laying damage (%) on recurrent flowers

SM (NR) = Sooty mold grade on non-recurrent flowers

SM (R) = Sooty mold grade on recurrent flowers

Results on correlation studies reveal that there was no significant relationship of hopper population both on non-recurrent and recurrent flowers with crop stage, however, hopper egg laying damage and sooty mold were significantly correlated with crop stage in individual years (2002 and 2003); this proves higher damages as the crop approach recurrent flowering stage. However, in pooled analysis, none of the parameter exhibited any significant correlation both on non-recurrent and recurrent flowers with the crop stage. This variation in results in respective years could be due to abiotic or any other factor responsible for the transformation of various crop stages which was not taken into consideration (Table 28).

Hence, on the basis of results indicated in Table 26-28, it may be concluded that hopper population as well as its associated damage has remained higher on recurrent flowers. This could be due to higher availability of fresh panicles (also fresh cell sap) on recurrent flowers than those on non-recurrent or ageing or old inflorescence which may not be preferred by mango hopper for oviposition and subsequent damage.

4.4 Impact of high density plantation on incidence of mango hopper

High density plantation in mango is being often used by farmers now days so as to optimize crop productivity per unit area. However, in this exercise of reduced spacing, status of insect-pests needs to be ascertained. Therefore, influence of different planting densities on incidence of mango hopper has been studied on the basis of following characters.

4.4.1 Hopper population

The results presented in Table 29 and depicted in Fig. 8 revealed that hopper population during 2002-2003 was found highest in 10 x 5 m. (5.50 per twig) and lowest in 10 x 2.5 m. spacing (3.30 per twig), whereas, highest hopper population in the subsequent year was found in 10 x 2.5 m. (5.45 per twig) and lowest in 10 x 10 m. spacing (2.89 per twig). However, hopper population did not differ significantly among various planting densities in pooled analysis, though; it was highest (6.05 per twig) in 10 x 2.5 m. and lowest (3.70 per twig) in 10 x 10 m. spacings. The interaction between year and treatment was found significant because of year wise variation in results.

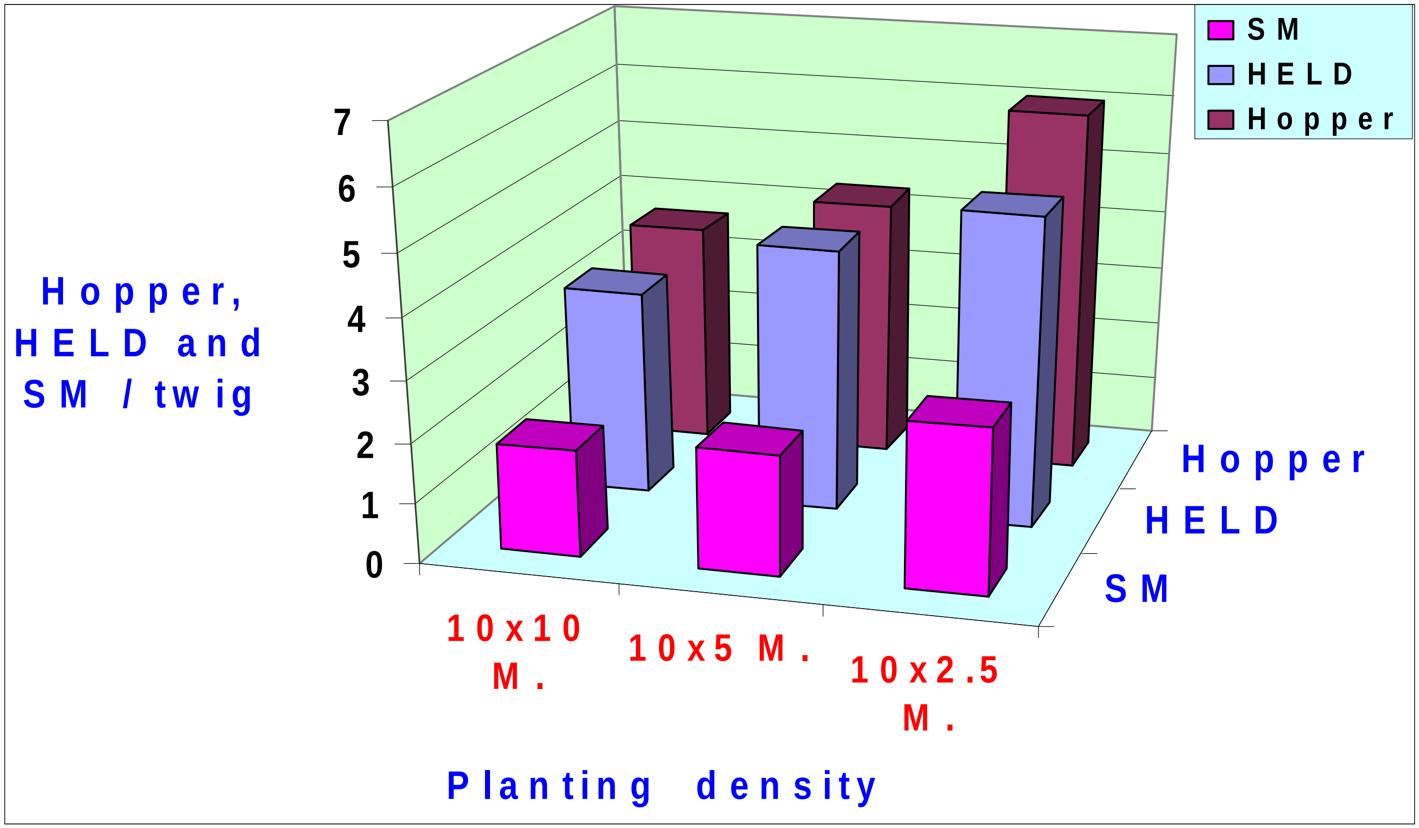
4.4.2 Hopper egg laying damage

In respect of oviposition damage, it also differed significantly during 2002-2003, 2003-2004 and pooled analysis. It was significant highest in 10 x 2.5 m. spacing (5.66, 5.26 and 5.16 per cent per twig in 2002-2003, 2003-2004 and in pooled data, respectively). However, significant lowest injury (3.22, 3.58 and 3.42 per cent per twig) was recorded in 10 x10 m. spacing (Table 29) (Fig. 8) followed by 10 x 5 m.

Table 29: Impact of high density plantation on incidence of mango hopper and its associated damage

Sr. No.	Treatment (based on spacing)	Hopper/twig			Hopper egg laying damage (%)			Sooty mold grade		
		2002-2003	2003-2003	Pooled	2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled
1	10 x 10 M.	2.27* (4.65)	1.84* (2.89)	2.05* (3.70)	1.93* (3.22)	2.02* (3.58)	1.98* (c) (3.42)	1.39* (1.43)	1.62* (2.12)	1.51* (c) (1.78)
2	10 x 5 M.	2.45 (5.50)	1.95 (3.30)	2.20 (4.34)	2.21 (4.38)	2.20 (4.34)	2.21 (b) (4.38)	1.51 (1.78)	1.65 (2.22)	1.58 (b) (2.00)
3	10 x 2.5 M.	1.95 (3.30)	2.44 (5.45)	2.56 (6.05)	2.38 (5.66)	2.40 (5.26)	2.38 (a) (5.16)	1.71 (2.42)	1.89 (3.07)	1.80 (a) (2.74)
S Em ± (T) S Em ± (Y X T)		0.031 --	0.022 --	0.071 0.026	0.037 --	0.023 --	0.022 0.031	0.023 --	0.028 --	0.018 0.052
CD at 5 % (T) CD at 5% (Y x T)		0.092 --	0.065 --	NS 0.077	0.11 --	0.070 --	0.063 NS	0.068 --	0.083 --	0.025 NS
CV (%)		3.97	3.34	3.73	5.38	3.41	4.49	4.72	5.17	4.98

* $\sqrt{x + 0.5}$ values Figures in parenthesis indicate original values (mean of fortnightly observations)



HELD: Hopper egg laying damage (%) / twig   SM: Sooty mold grade / twig

Fig. 8: Impact of high density plantation on incidence of mango hopper

spacing (4.38, 4.34 and 4.38 per cent per twig in respective years) (Table 29) (Fig. 8).

4.4.3 Sooty mold

Another type of damage associated with abundance of mango hopper is development of sooty mold on leaves, twigs and inflorescence recorded in the form of sooty mold grade. Significantly highest grade of 2.42, 3.07 and 2.74 per twig was observed in 10 x 2.5 m. spacing during 2002-2003, 2003-2004 and in pooled data, respectively, while it remained lowest in 10 x 10 m. spacing (1.43, 2.12 and 1.78 per twig) (Table 29) (Fig. 8).

4.4.4 Natural enemies

Results presented in Table 30 revealed highest population 5.02, 4.47 and 4.74 per twig of predatory spiders in 2002-2003, 2003-2004 and pooled data in 10 x 2.5 m. spacing, while, it was lowest (2.92, 2.60 and 2.74 per twig) in 10 x 10 m. spacing. Similarly, coccinellids remained highest (4.52, 4.34 and 4.43 per twig) in 10 x 2.5 m. spacing and lowest (2.53, 2.63 and 2.60 per twig) in 10 x 10 m. spacing.

Thus, in the ongoing discussion on influence of high density plantation on abundance of hopper, it is clear that closer spacing (10 x 2.5 or 10 x 5 m.) has relatively higher and wider spacing (10 x 10 m.) (Plate 8) has lower abundance of hopper population, respectively. So, this ultimately led to higher associated damage in the former than in later. It could be due to the fact that reduced plant to plant distance had taller plants with vigorous growth as compared to wider spacing which led to higher shady area and dampness in the microclimate of the tree canopy because of reduced penetration of sun light, thereby attracted higher hopper

Table 30: Impact of high density plantation on abundance of natural enemies

Sr. No.	Treatment (based on spacing)	Predatory spiders/ twig			Coccinellids/ twig		
		2002-2003	2003 - 2004	Pooled	2002 - 2003	2003-2004	Pooled
1	10 x 10 M.	1.85* (2.92)	1.76* (2.60)	1.80* c) (2.74)	1.74* (2.53)	1.77* (2.63)	1.76* (c) (2.60)
2	10 x 5 M.	2.13 (4.04)	2.04 (3.66)	2.09 (b) (3.87)	2.04 (3.66)	1.98 (3.42)	2.01 (b) (3.54)
3	10 x 2.5 M.	2.35 (5.02)	2.23 (4.47)	2.29 (a) (4.74)	2.24 (4.52)	2.20 (4.34)	2.22 (a) (4.43)
	S Em ± (T) S Em ± (Y X T)	0.050 --	0.042 --	0.032 0.092	0.037 --	0.058 --	0.034 0.049
	CD at 5 % (T) CD at 5% (Y x T)	0.150 --	0.127 --	0.042 NS	0.111 --	0.172 --	0.097 NS
	CV (%)	7.55	6.73	7.17	5.92	9.25	7.75

* $\sqrt{x + 0.5}$ values

Figures in parenthesis indicate original values (mean of fortnightly observations)

population causing higher damage in high density. Thus, role of crop geometry has been significant in this investigation.

Srivastava *et al.* (1987) and Weng Hung Chich (2000) found that close plantation having tall plants with vigorous growth having shade attract high hopper population (*I. clypealis*) and facilitate their breeding which ultimately leads to lot of damage. Present investigation is in close agreement with that of these workers.

4.5 Impact of NPK fertilization on incidence of mango hopper

4.5.1 Hopper population

The data presented in Table 31 and depicted in Fig. 9 revealed that hopper population differed significantly in different levels of NPK fertilization during both the years of investigation as well as in pooled analysis. During 2002-2003, lowest hopper population (2.13 per twig) was noticed in $N_0P_0K_0$ (control), followed by $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$, $N_0P_2K_2$, $N_1P_0K_0$, $N_1P_0K_1$, $N_1P_0K_2$, $N_1P_1K_0$, $N_1P_1K_1$, $N_1P_1K_2$, $N_1P_2K_0$ and $N_1P_2K_1$, which were were at par with it, whereas, highest (4.01 per twig) was observed in $N_2P_2K_2$ though, it did not differ significantly with $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$ and $N_2P_0K_2$. In the subsequent year similar trend was observed indicating lowest hoppers (2.31 per twig) in $N_0P_0K_0$ (control) followed by $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$ and $N_0P_2K_2$ which indicated statistically similar population. The highest population (6.26 per twig) was however, recorded in $N_2P_2K_2$ though it did not differ significantly in $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$ and $N_2P_0K_2$.

In pooled analysis, lowest population (2.22 per twig) was reported in $N_0P_0K_0$ (control) followed by $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$,

Table 31: Impact of NPK fertilization on incidence of mango hopper

Sr. No.	Treatment	Hopper /twig		
		2002- 2003	2003-2004	Pooled
1	$N_0P_0K_0$ (Control)	1.62* (2.13)	1.67* (2.31)	1.64* (2.22)
2	$N_0P_0K_1$	1.62 (2.13)	1.72 (2.49)	1.67 (2.31)
3	$N_0P_oK_2$	1.63 (2.17)	1.76 (2.63)	1.70 (2.40)
4	$N_0P_1K_0$	1.64 (2.19)	1.75 (2.57)	1.69 (3.33)
5	$N_0P_1K_1$	1.65 (2.22)	1.79 (2.74)	1.72 (2.48)
6	$N_0P_1K_2$	1.65 (2.22)	1.69 (2.36)	1.67 (2.29)
7	$N_0P_2K_0$	1.66 (2.26)	1.80 (2.77)	1.73 (2.51)
8	$N_0P_2K_1$	1.66 (2.26)	1.76 (2.62)	1.71 (2.43)
9	$N_0P_2K_2$	1.66 (2.26)	1.83 (2.87)	1.74 (2.55)
10	$N_1P_0K_0$	1.72 (2.48)	1.92 (3.21)	1.82 (2.83)
11	$N_1P_0K_1$	1.74 (2.54)	2.01 (3.56)	1.87 (3.03)
12	$N_1P_0K_2$	1.76 (2.61)	2.04 (3.69)	1.90 (3.13)
13	$N_1P_1K_0$	1.77 (2.63)	1.98 (3.45)	1.87 (3.02)
14	$N_1P_1K_1$	1.78 (2.68)	2.10 (3.93)	1.94 (3.28)
15	$N_1P_1K_2$	1.80 (2.77)	2.20 (4.38)	2.00 (3.53)
16	$N_1P_2K_0$	1.80 (2.76)	2.22 (4.45)	2.01 (3.56)
17	$N_1P_2K_1$	1.81 (2.78)	2.24 (4.52)	2.02 (3.61)
18	$N_1P_2K_2$	1.82 (2.83)	2.26 (4.61)	2.04 (3.68)
19	$N_2P_0K_0$	1.90 (3.12)	2.36 (5.11)	2.13 (4.06)
20	$N_2P_0K_1$	1.92 (3.20)	2.42 (5.40)	2.17 (4.24)
21	$N_2P_0K_2$	1.93 (3.26)	2.42 (5.36)	2.18 (4.26)
22	$N_2P_1K_0$	1.98 (3.43)	2.47 (5.62)	2.22 (4.46)
23	$N_2P_1K_1$	2.01 (3.55)	2.50 (5.78)	2.25 (4.60)
24	$N_2P_1K_2$	2.02 (3.61)	2.41 (5.32)	2.21 (4.43)

25	$N_2P_2K_0$	2.07 (3.82)	2.44 (5.48)	2.26 (4.62)
26	$N_2P_2K_1$	2.07 (3.79)	2.51 (5.83)	2.29 (4.76)
27	$N_2P_2K_2$	2.12 (4.01)	2.60 (6.26)	2.36 (5.08)
SEm $\pm$ (T) SEm $\pm$ (YxT)		0.065 --	0.074 --	0.0788 0.0703
CD at 5 % (T) CD at 5 % (YxT)		0.186 --	0.212 --	0.229 0.197
CV (%)		6.27	6.13	6.21

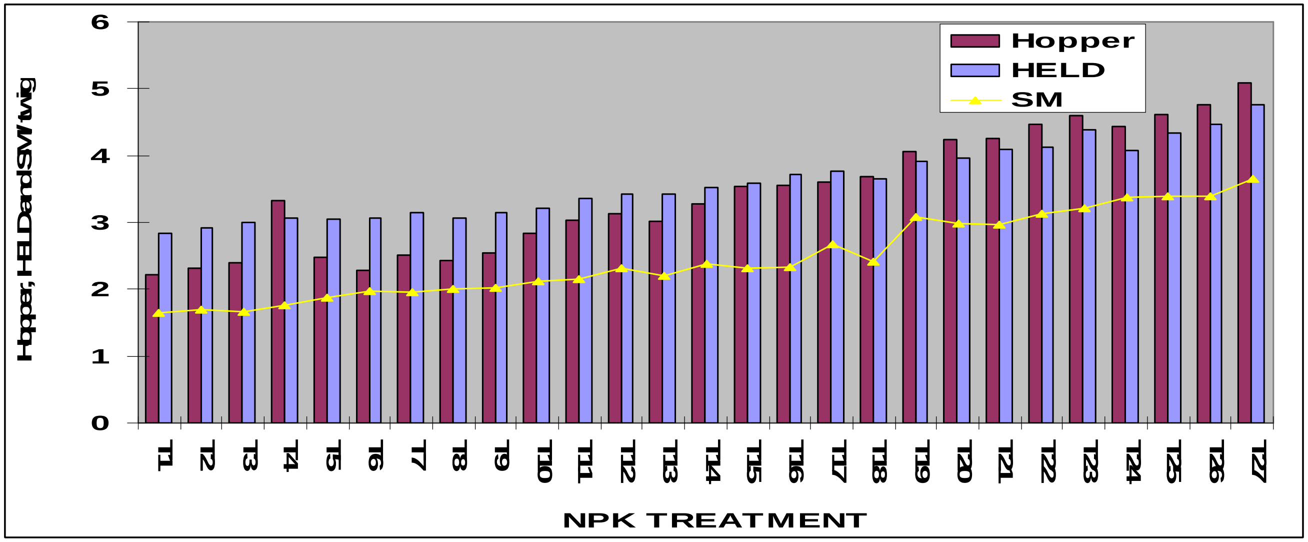
* √x + 0.5 values Figures in parenthesis indicate original values

(mean of fortnightly observations)

Nitrogen : 1. N_0 – 0 Phosphorus :1. P_0 – 0 Potash : 1. K_0 – 0

(gm/tree) 2. N_1 –75 (gm/tree) 2. P_1 --50. (gm/tree) 2. K_1-- 75

3. N_2 –150 3. P_2 –100 3. K_{2--} 150



T1 : $N_0P_0K_0$ T2 : $N_0P_0K_1$ T3 : $N_0P_0K_2$ T4 : $N_0P_1K_0$ T5 : $N_0P_1K_1$ T6 : $N_0P_1K_2$ T7 : $N_0P_2K_0$ T8 : $N_0P_2K_1$

T9 : $N_0P_2K_2$ T10: $N_1P_0K_0$ T11: $N_1P_0K_1$ T12: $N_1P_0K_2$ T13: $N_1P_1K_0$ T14: $N_1P_1K_1$ T15: $N_1P_1K_2$ T16: $N_1P_2K_0$

T17: $N_1P_2K_1$ T18: $N_1P_2K_2$ T19: $N_2P_0K_0$ T20: $N_2P_0K_1$ T21: $N_2P_0K_2$ T22: $N_2P_1K_0$ T23: $N_2P_1K_1$ T24: $N_2P_1K_2$

T25: $N_2P_2K_0$ T26: $N_2P_2K_1$ T27: $N_2P_2K_2$

Nitrogen : (gm/tree) 1. N_0 – 0 2. N_1 –75 3. N_2 –150

Phosphorus : (gm/tree) 1. P_0 – 0 2. P_1 --50. 3. P_2 –100

Potash : (gm/tree) 1. K_0 – 0 2. K_1 – 75 3. K_2 –150

HELD : Hopper egg laying damage (%)

SM : Sooty mold grade

Fig. 9: Impact of NPK fertilization on incidence of mango hopper

$N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$, $N_0P_2K_2$, $N_1P_0K_0$, $N_1P_0K_1$, $N_1P_0K_2$ and $N_1P_1K_0$ which did not differ significantly with it. Highest number of hoppers (5.08 per twig) was recorded in $N_2P_2K_2$, though NPK treatments of $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$, $N_2P_0K_2$, $N_2P_0K_1$ and $N_2P_0K_0$ also reported statistically similar data (Table 31).

So, from the results reported in Table 31 it may be concluded that application of $N_2P_2K_2$ (150, 100 and 150 gm per tree) level of NPK resulted in highest population of hoppers (4.01, 6.26 and 5.08 per twig), whereas, least population was observed in $N_0P_0K_0$ (control. The interaction of year and treatment was however, found significant because of slight variation in year wise results, though sequence of treatments in both the years of investigation as well as in pooled analysis was more or less the same) (Table 31) (Fig. 9).

4.5.2 Hopper egg laying damage

Hopper egg laying damage similar to hopper population varied significantly among different levels of NPK fertilization. It was lowest (2.92 per cent) in $N_0P_0K_0$ in 2002-2003, followed by $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$ and $N_0P_2K_2$ which indicated statistically similar population. Highest damage (4.58 per cent) was noticed in $N_2P_2K_2$ followed by $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$ and $N_2P_1K_1$. In the year 2003-2004, lowest damage (2.77 per cent) by hoppers was recorded in $N_0P_0K_0$ and treatments of $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$, $N_0P_2K_2$ and $N_1P_0K_0$ were statistically similar to it. However, highest damage (4.93 per cent) was recorded in $N_2P_2K_2$ followed by $N_2P_2K_1$ which was statistically similat to it in terms of damage (Table 32) (Fig. 9).

In pooled analysis, lowest damage (2.84 per cent) was again noticed in $N_0P_0K_0$ and was not statistically apart from the treatments of $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$ and $N_0P_2K_1$, whereas, highest damage (4.76 per cent) was recorded in $N_2P_2K_2$ (Table 32) (Fig. 9).

Thus, it can be summarized that highest egg laying damage (4.58, 4.93 and 4.76 percent) caused by hoppers was recorded in $N_2P_2K_2$ (150, 100 and 150 gm per tree) (Table 54) and lowest (2.92, 2.77 and 2.84 per cent) was indicated in the control ($N_0P_0K_0$).

4.5.3 Sooty mold

During 2002-2003, impact of hopper population on the development of sooty mold was found lowest (1.75 SM grade) in $N_0P_0K_0$ (untreated control) though, it was at par with $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$ and $N_0P_2K_2$, $N_1P_0K_0$ and $N_1P_0K_1$ in terms of sooty mold damage, but it remained highest (3.65 SM grade) on trees which received $N_2P_2K_2$ application and was followed by $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$ and $N_2P_1K_1$, which were at par with it. In the subsequent year, the lowest damage (1.54 SM grade) was observed in $N_0P_0K_0$, however, it did not differ significantly with $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$, $N_0P_2K_2$, $N_1P_0K_0$, $N_1P_0K_1$, $N_1P_0K_2$, $N_1P_1K_0$, $N_1P_1K_1$, $N_1P_1K_2$ and $N_1P_2K_0$. The highest sooty mold damage (3.65 SM grade) was however recorded in $N_2P_2K_2$ (at par with $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$,

Table 32: Impact of NPK fertilization on abundance of mango hopper associated damage

Sr. No.	Treat-ment	Hopper egg laying damage /twig (%)			Sooty mold grade /twig		
		2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled
1	$N_0P_0K_0$ (Control)	1.84* (2.92)	1.80 (2.77)	1.82*(2.84)	1.49*(1.75)	1.42*(1.54)	1.46*(1.64)
2	$N_0P_0K_1$	1.86 (2.97)	1.83 (2.88)	1.85 (2.92)	1.50 (1.77)	1.45 (1.61)	1.47 (1.69)
3	$N_0P_oK_2$	1.86 (2.98)	1.87 (3.01)	1.86 (3.00)	1.50 (1.77)	1.42 (1.54)	1.46 (1.66)
4	$N_0P_1K_0$	1.90 (3.12)	1.87 (3.03)	1.89 (3.07)	1.51 (1.81)	1.48 (1.72)	1.50 (1.76)
5	$N_0P_1K_1$	1.90 (3.12)	1.86 (2.99)	1.88 (3.05)	1.51 (1.80)	1.56 (1.96)	1.54 (1.88)
6	$N_0P_1K_2$	1.90 (3.13)	1.86 (2.99)	1.88 (3.06)	1.55 (1.91)	1.59 (2.03)	1.57 (1.97)
7	$N_0P_2K_0$	1.91 (3.17)	1.90 (3.12)	1.90 (3.14)	1.53 (1.85)	1.60 (2.08)	1.56 (1.96)
8	$N_0P_2K_1$	1.92 (3.19)	1.85 (2.94)	1.88 (3.06)	1.53 (1.84)	1.63 (2.16)	1.58 (2.00)
9	$N_0P_2K_2$	1.92 (3.19)	1.89 (3.10)	1.90 (3.15)	1.54 (1.89)	1.62 (2.15)	1.58 (2.02)
10	$N_1P_0K_0$	1.96 (3.35)	1.89 (3.08)	1.92 (3.22)	1.60 (2.07)	1.63 (2.16)	1.61 (2.12)
11	$N_1P_0K_1$	1.98 (3.43)	1.94 (3.30)	1.96 (3.36)	1.60 (2.08)	1.65 (2.24)	1.63 (2.16)
12	$N_1P_0K_2$	1.98 (3.43)	1.98 (3.43)	1.98 (3.43)	1.65 (2.24)	1.70 (2.41)	1.68 (2.32)
13	$N_1P_1K_0$	1.98 (3.45)	1.97 (3.42)	1.98 (3.43)	1.66 (2.26)	1.62 (2.14)	1.64 (2.20)
14	$N_1P_1K_1$	2.01 (3.55)	1.99 (3.49)	2.00 (3.52)	1.66 (2.26)	1.73 (2.51)	1.69 (2.38)
15	$N_1P_1K_2$	2.02 (3.60)	2.01 (3.56)	2.01 (3.58)	1.68 (2.35)	1.66 (2.29)	1.67 (2.32)
16	$N_1P_2K_0$	2.06 (3.77)	2.04 (3.68)	2.05 (3.72)	1.69 (2.36)	1.67 (2.30)	1.68 (2.33)
17	$N_1P_2K_1$	2.07 (3.80)	2.05 (3.71)	2.06 (3.76)	1.69 (2.39)	1.86 (2.98)	1.78 (2.68)
18	$N_1P_2K_2$	2.04 (3.70)	2.02 (3.61)	2.03 (3.65)	1.70 (2.40)	1.71 (2.44)	1.70 (2.42)
19	$N_2P_0K_0$	2.10 (3.95)	2.08 (3.87)	2.09 (3.91)	1.83 (2.85)	1.95 (3.32)	1.89 (3.08)
20	$N_2P_0K_1$	2.12 (4.00)	2.10 (3.93)	2.11 (3.97)	1.84 (2.90)	1.89 (3.09)	1.86 (2.99)
21	$N_2P_0K_2$	2.13 (4.07)	2.15 (4.13)	2.14 (4.10)	1.85 (2.94)	1.86 (2.97)	1.85 (2.96)
22	$N_2P_1K_0$	2.15 (4.15)	2.14 (4.11)	2.15 (4.13)	1.89 (3.09)	1.91 (3.18)	1.90 (3.13)
23	$N_2P_1K_1$	2.17 (4.23)	2.24 (4.54)	2.21 (4.39)	1.90 (3.13)	1.95 (3.32)	1.92 (3.22)
24	$N_2P_1K_2$	2.18 (4.28)	2.09 (3.89)	2.14 (4.08)	1.93 (3.23)	2.00 (3.52)	1.96 (3.37)
25	$N_2P_2K_0$	2.19 (4.31)	2.20 (4.35)	2.19 (4.33)	1.94 (3.29)	1.99 (3.49)	1.97 (3.39)
26	$N_2P_2K_1$	2.21 (4.39)	2.24 (4.54)	2.22 (4.46)	1.97 (3.39)	1.97 (3.40)	1.97 (3.39)
27	$N_2P_2K_2$	2.25 (4.58)	2.33 (4.93)	2.29 (4.76)	2.03 (3.65)	2.03 (3.65)	2.03 (3.65)
SEm ± (T) SEm ± (YxT)		0.030 --	0.038 --	0.023 0.034	0.039 --	0.108 --	0.053 0.081
CD at 5 % (T) CD at 5 % (YxT)		0.086 --	0.109 --	0.065 NS	0.112 --	0.307 --	0.148 NS
CV (%)		2.60	3.32	2.98	4.05	10.84	8.24

* $\sqrt{x + 0.5}$ values

Figures in parenthesis indicate original values (mean of fortnightly observations)

Nitrogen : (gm/tree) 1. N_0 – 0 2. N_1 –75 3. N_2 –150

Phosphorus : (gm/tree) 1. P_0 – 0 2. P_1 --50. 3. P_2 –100

Potash : (gm/tree) 1. K_0 – 0 2. K_1-- 75 3. K_2-- 150

$N_2P_1K_1$, $N_2P_1K_0$, $N_2P_0K_2$, $N_2P_0K_1$, $N_2P_0K_0$, $N_1P_2K_1$ and $N_1P_1K_1$) (Table 32) (Fig. 9).

In pooled analysis, the lowest damage (1.64 SM grade) was observed in $N_0P_0K_0$ (untreated control), but it was at par with $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$, $N_0P_2K_2$ and $N_1P_0K_0$ in terms of sooty mold damage. On the other hand, the highest damage (3.65 SM grade) was recorded in $N_2P_2K_2$, although NPK treatments of $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$ and $N_2P_0K_0$ were statistically similar to it (Table 32) (Fig. 9).

4.5.4 Natural enemies

Predatory spiders and coccinellids were recorded as natural enemies of mango hopper on trees which received various levels of NPK fertilization.

Lowest population (0 per twig) of predatory spiders was observed in $N_0P_0K_0$ (control plot) and $N_0P_0K_1$ treatments during 2002-2003, whereas, maximum predatory spiders (5.49 per twig) were observed in $N_2P_2K_2$ and were followed by $N_2P_2K_1$ which did not differ significantly with the highest population. In the year 2003-2004, lowest number of spiders (0.91 per twig) was seen in $N_0P_0K_0$ (untreated control) followed by $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_2K_0$, $N_0P_2K_1$, $N_0P_2K_2$, $N_1P_0K_0$ and $N_1P_0K_2$ which were were at par with it, whereas, highest number of spiders (4.62 per twig) were recorded in $N_2P_2K_2$, though, it was at par with $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$, $N_2P_0K_2$, $N_2P_0K_1$ and $N_2P_0K_0$. Similarly in pooled analysis, untreated control ($N_0P_0K_0$) trees had lowest population (0.40 per twig) of spiders and was at par with $N_0P_0K_1$, $N_0P_0K_2$ and $N_0P_1K_0$ treatments, while NPK treatment of $N_2P_2K_2$

recorded highest population of spiders (5.05 per twig) and was statistically similar to $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$ and $N_2P_1K_0$ (Table 33).

Cocinellids were the other predators or natural enemies of mango hopper observed in various levels of NPK fertilization. During 2002-2003, lowest population (0.16 per twig) was observed in $N_0P_0K_o$ (control Plots), followed by $N_0P_0K_{1,}$ $N_0P_0K_2$ and $N_0P_1K_0$ which were at par with it, whereas, highest population (5.42 per twig) was recorded in $N_2P_2K_2$, followed by $N_2P_2K_1$, $N_2P_2K_0$ and $N_2P_1K_2$ which did not differ

Table 33: Impact of NPK fertilization on abundance of natural enemies of mango hopper

Sr. No.	Treat-ment	Predatory spiders/twig			Coccinellids /twig		
		2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled
1	$N_0P_0K_0$ (Control)	0.70* (0)	1.18*(0.91)	0.94*(0.40)	0.81*(0.16)	1.10*(0.73)	0.96*(0.42)
2	$N_0P_0K_1$	0.70 (0)	1.32 (1.25)	1.01 (0.53)	0.86 (0.25)	1.11 (0.74)	0.99 (0.48)
3	$N_0P_oK_2$	1.00 (0.50)	1.8 (1.41)	1.19 (0.92)	0.86 (0.25)	1.21 (0.98)	1.04 (0.58)
4	$N_0P_1K_0$	1.07 (0.66)	1.35 (1.33)	1.21 (0.98)	0.95 (0.40)	1.25 (1.08)	1.10 (0.72)
5	$N_0P_1K_1$	1.15 (0.83)	1.46 (1.66)	1.31 (1.22)	1.03 (0.58)	1.32 (1.24)	1.18 (0.89)
6	$N_0P_1K_2$	1.22 (0.99)	1.57 (1.98)	1.39 (1.46)	1.03 (0.56)	1.20 (0.94)	1.11 (0.74)
7	$N_0P_2K_0$	1.32 (1.25)	1.47 (1.68)	1.40 (1.46)	1.11 (0.74)	1.43 (1.55)	1.27 (1.12)
8	$N_0P_2K_1$	1.25 (1.07)	1.52 (1.83)	1.39 (1.43)	1.25 (1.08)	1.35 (1.33)	1.30 (1.20)
9	$N_0P_2K_2$	1.43 (1.57)	1.51 (1.79)	1.47 (1.68)	1.28 (1.15)	1.50 (1.77)	1.39 (1.45)
10	$N_1P_0K_0$	1.46 (1.66)	1.52 (1.83)	1.49 (1.74)	1.37 (1.38)	1.49 (1.75)	1.43 (1.56)
11	$N_1P_0K_1$	1.55 (1.91)	1.55 (1.93)	1.55 (1.92)	1.41 (1.50)	1.60 (2.08)	1.51 (1.78)
12	$N_1P_0K_2$	1.67 (2.32)	1.53 (1.87)	1.60 (2.09)	1.57 (1.98)	1.52 (1.83)	1.55 (1.91)
13	$N_1P_1K_0$	1.77 (2.66)	1.64 (2.20)	1.71 (2.42)	1.65 (2.25)	1.65 (2.24)	1.65 (2.24)
14	$N_1P_1K_1$	1.77 (2.66)	1.82 (2.83)	1.80 (2.75)	1.60 (2.07)	1.58 (2.02)	1.59 (2.05)
15	$N_1P_1K_2$	1.75 (2.58)	1.61 (2.11)	1.68 (2.34)	1.70 (2.42)	1.57 (1.98)	1.64 (2.19)
16	$N_1P_2K_0$	1.86 (2.99)	1.83 (2.86)	1.85 (2.92)	1.82 (2.82)	1.65 (2.22)	1.73 (2.51)
17	$N_1P_2K_1$	1.80 (2.74)	1.97 (3.40)	1.88 (3.06)	1.88 (3.07)	1.73 (2.50)	1.81 (2.78)
18	$N_1P_2K_2$	1.89 (3.08)	1.90 (3.14)	1.90 (3.11)	1.95 (3.33)	1.79 (2.71)	1.87 (3.01)
19	$N_2P_0K_0$	2.02 (3.58)	1.92 (3.21)	1.97 (3.39)	2.04 (3.66)	1.78 (2.70)	1.91 (3.16)
20	$N_2P_0K_1$	2.01 (3.58)	1.92 (3.20)	1.97 (3.39)	2.05 (3.74)	1.91 (3.15)	1.98 (3.44)
21	$N_2P_0K_2$	1.93 (3.24)	1.93 (3.25)	1.93 (3.24)	2.16 (4.17)	2.01 (3.57)	2.08 (3.86)
22	$N_2P_1K_0$	2.12 (4.00)	1.97 (3.39)	2.04 (3.69)	2.17 (4.25)	1.96 (3.36)	2.07 (3.79)
23	$N_2P_1K_1$	2.14 (4.08)	2.03 (3.63)	2.08 (3.85)	2.23 (4.50)	2.11 (3.96)	2.17 (4.23)
24	$N_2P_1K_2$	2.23 (4.49)	1.99 (3.49)	2.11 (3.98)	2.30 (4.82)	2.23 (4.50)	2.27 (4.66)
25	$N_2P_2K_0$	2.28 (4.74)	2.15 (4.16)	2.22 (4.44)	2.30 (4.83)	2.17 (4.22)	2.24 (4.52)
26	$N_2P_2K_1$	2.34 (4.99)	2.20 (4.37)	2.27 (4.67)	2.32 (4.91)	2.09 (3.91)	2.21 (4.40)
27	$N_2P_2K_2$	2.44 (5.49)	2.26 (4.62)	2.35 (5.05)	2.43 (5.42)	2.29 (4.74)	2.36 (5.07)
SEm $\pm$ (T)		0.053	0.128	0.113	0.060	0.122	0.100
SEm $\pm$ (YxT)		--	--	0.098	--	--	0.096

CD at 5 % (T) CD at 5 % (YxT)	0.150 --	0.364 --	0.328 0.278	0.172 --	0.346 --	0.291 0.273
CV (%)	5.51	12.85	10.01	6.41	12.76	10.12

√x + 0.5 values

Figures in parenthesis indicate original values (mean of fortnightly observations)

Nitrogen :	1. N_0 – 0	Phosphorus :	1. P_0 – 0	Potash :	1. K_0 – 0
(gm/tree)	2. N_1 –75	(gm/tree)	2. P_1 --50.	(gm/tree)	2. K_1-- 75
	3. N_2 –150		3. P_2 –100		3. K_2-- 150

significantly with the highest population. In the subsequent year, lowest population of coccinellids (0.73 per twig) was seen in $N_0P_0K_o$ (control Plots) followed by $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$ and $N_0P_2K_1$ and was not statistically different. The highest coccinellids (4.74 per twig) however, were reported from trees which received $N_2P_2K_2$ treatment and were followed by $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$ and $N_2P_0K_2$ which were statistically similar to it. Similarly, in pooled analysis, lowest coccinellids (0.42 per twig) were reported in $N_0P_0K_o$ (control Plots) and the population was statistically similar to that recorded in $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$ and $N_0P_1K_2$. On the other hand, highest number of coccinellids (5.07 per twig) was again reported on trees which received NPK treatment of $N_2P_2K_2$, though it was statistically similar to that observed in $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$ and $N_2P_1K_0$ (Table 33).

Thus, the present results indicated higher incidence of hopper (> 5 hoppers per twig) and its associated damage (hopper egg laying and sooty mold) in the higher levels of NPK (more than recommended doses i.e. $N_2P_2K_2$, $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$, $N_2P_0K_2$, $N_2P_0K_1$ and $N_2P_0K_0$) suggesting positive role of nitrogen in population build up of hopper and vice-versa.

Higher levels of NPK fertilization particularly nitrogen levels resulted in higher incidence of hopper which could be due to increased chlorophyll content and higher succulency in the leaves and other parts of the mango trees thereby providing suitable platform for higher longevity and multiplication of mango hopper, whereas, its population by and large remained low in control plot ($N_0P_0K_0$) as well as in doses where level of nitrogen was either nil or low. However, role of phosphorus and potash could not be established in the present investigation. Higher population of natural enemies was observed in higher level of NPK. It could be due to the fact that natural enemy population synchronized with abundance of hopper in all the levels of NPK. Various levels of NPK however, did not seem to influence their population in any way.The report of Nachiappan (1982) who indicated low incidence of mango hopper (less than threshold level i.e. 5 hoppers per twig with presence of less nitrogen (upto recommended doze) and vice-versa, thus confirms the present investigation as the data obtained in the present investigation indicate lower hopper population (< 2 hoppers per twig) on trees which received either no nitrogen i.e. $N_0P_0K_0$, $N_0P_0K_1$, $N_0P_0K_2$, $N_0P_1K_0$, $N_0P_1K_1$, $N_0P_1K_2$, $N_0P_2K_0$, $N_0P_2K_1$ and $N_0P_2K_2$ or the recommended level of nitrogen (< 4 hoppers per twig) i.e. $N_1P_0K_0$, $N_1P_0K_1$, $N_1P_0K_2$, $N_1P_1K_0$, $N_1P_1K_1$, $N_1P_1K_2$, $N_1P_2K_0$, $N_1P_2K_1$ and $N_1P_2K_2$, whereas, higher population (> 5 hoppers per twig) was recorded in NPK treatments of higher nitrogen i.e. $N_2P_2K_2$, $N_2P_2K_1$, $N_2P_2K_0$, $N_2P_1K_2$, $N_2P_1K_1$, $N_2P_1K_0$, $N_2P_0K_2$, $N_2P_0K_1$ and $N_2P_0K_0$ during both the years of investigation as well as in pooled analysis (Table 33). Highest level of NPK doses also gave highest yield (APPENDIX - VIII) which could have been possible due to the recovery factor involved in damaged plants resulting in better vegetative growth as they received higher doses of nitrogen which is responsible for crop growth.

4.6 Mango hopper incidence as influenced by plant growth regulator and different doses of NPK

Impact of paclobutrazol an antigibberlin based plant growth regulator on incidence of mango hopper has been assessed on the basis of following parameters:

4.6.1 Hopper population

Hoppers were recorded in varying densities in different paclobutrazol (PBZ) treatments. During 2002-2003, highest population of hoppers (8.40 per twig) was noticed in PBZ at the rate of 4 g. a. i. (I year) + 3 g.a.i (II year) per tree with recommended doze of fertilizer (RDF) followed by the same doze of PBZ but with half of the recommended doze of fertilizer (½ RDF) which did not differ significantly with it. However, the lowest number of mango hoppers (3.92 per twig) was recorded on control trees which received ½ RDF, though control trees which received RDF (4.32 per twig) had statistically similar population. Similarly in the subsequent year, highest hoppers (6.88 per twig) were observed in PBZ at the rate of 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + RDF followed by the same doze of PBZ but with ½ RDF (6.71 per twig), PBZ at 4 g. a. i. (I year) + 2 g.a.i (II year) + RDF (6.52 per twig) and PBZ 4 g.a.i. + RDF (6.47 per twig) which were statistically at par with it in terms of hopper population, whereas lowest number of hoppers were observed on control + ½ RDF trees (3.60 per twig), though it was statistically similar with control having RDF application (3.80 per twig) (Table 34) (Fig. 10). In the pooled analysis, highest population of mango hoppers (7.64 per twig) was noticed on trees which received PBZ at 4 g.a.i. (I year) + 3 g.a.i. (II year) + RDF, whereas next in line was the same doze of PBZ but with ½ RDF (7.42 per twig) and PBZ at 4 g.a.i. (I year) + 2 g.a.i. (II year) + RDF (7.10

per twig), which were at par with it. On the other hand, lowest population of mango hoppers (3.76 per twig) was observed in control + ½ RDF, though control + RDF treatment had statistically similar hoppers (4.06 per twig) (Table 34) (Fig. 10).

Hopper population on mango trees which received recommended doze of fertilizer (4.06, 6.80, 7.10 and 7.64 per twig) did not differ significantly with those which had half of the recommended doze of fertilizer (3.76, 6.68, 6.77 and 7.42 per twig) (Table 34) (Fig. 10).

4.6.2 Hopper associated damage

4.6.2.1 Hopper egg laying damage

Highest hopper egg laying damage (9.02 %) was recorded in PBZ at the rate of 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + RDF during 2002-2003 followed by the same doze of PBZ + ½ RDF (8.86 %) which did not differ significantly, whereas, the lowest damage (4.82 %) was recorded on control trees which received RDF, though control trees which had ½ RDF indicated statistically similar damage (4.95 %). Similarly in the subsequent year, the highest damage (7.98 %) was observed in PBZ at 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + RDF, though trees which had ½ RDF having the same doze of PBZ indicated statistically similar damage (7.48 %). The lowest damage (4.07 %) was recorded in control + ½ RDF and did not differ significantly with that of control + RDF trees (4.42 %) (Table 34).

Likewise, in pooled analysis, highest damage (8.50 %) was recorded in PBZ at 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + RDF followed by the same doze of PBZ + ½ RDF (8.17 %), whereas, the lowest damage (4.51 %) was observed in control + RDF, though it was at par with ½ RDF trees

(4.62 %). The interaction of year and treatment was found non-significant indicating consistency in year wise results (Table 34).

Hopper egg laying damage on RDF trees (4.62, 6.31, 7.37 and 8.50 %) was statistically similar to that on trees which had half of the recommended doze of fertilizer (4.51, 6.16, 7.52 and 8.17) (Table 34).

4.6.2.2. Sooty mold damage

Sooty mold damage caused by hopper secretion remained highest (2.50 SM grade) on trees which received treatment of PBZ at 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + ½ RDF in 2002-2003, but it did not differ significantly with PBZ at the rate of 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + RDF (2.39 SM grade per twig), PBZ at the rate of 4 g. a. i. (I year) + 2 g.a.i (II year) per tree + RDF (2.25 SM grade per twig) and PBZ at 4 g. a. i. (I year) + 2 g.a.i (II year) per tree + ½ RDF (2.18 SM grade per twig) whereas, the lowest damage (1.40 SM grade per twig) was indicated on control + ½ RDF trees and it was at par with control + RDF trees (1.52 SM grade per twig). Similarly in 2003-2004, highest damage (2.37 SM grade per twig) was noticed in PBZ at the rate of 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + RDF, though the damage was statistically at par with PBZ at 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + ½ RDF (2.30 SM grade per twig), PBZ at 4 g. a. i. (I year) + 2 g.a.i (II year) per tree + RDF (2.30 SM grade per twig), PBZ at 4 g. a. i. (I year) + 2 g.a.i (II year) per tree + ½ RDF (2.15 SM grade per twig) and PBZ at 4 g.a.i. per tree (2.15 SM grade per twig). The lowest damage (1.42 SM grade) however was observed in control + ½ RDF trees (at par with control + RDF) (1.42 SM grade per twig) (Table 34).

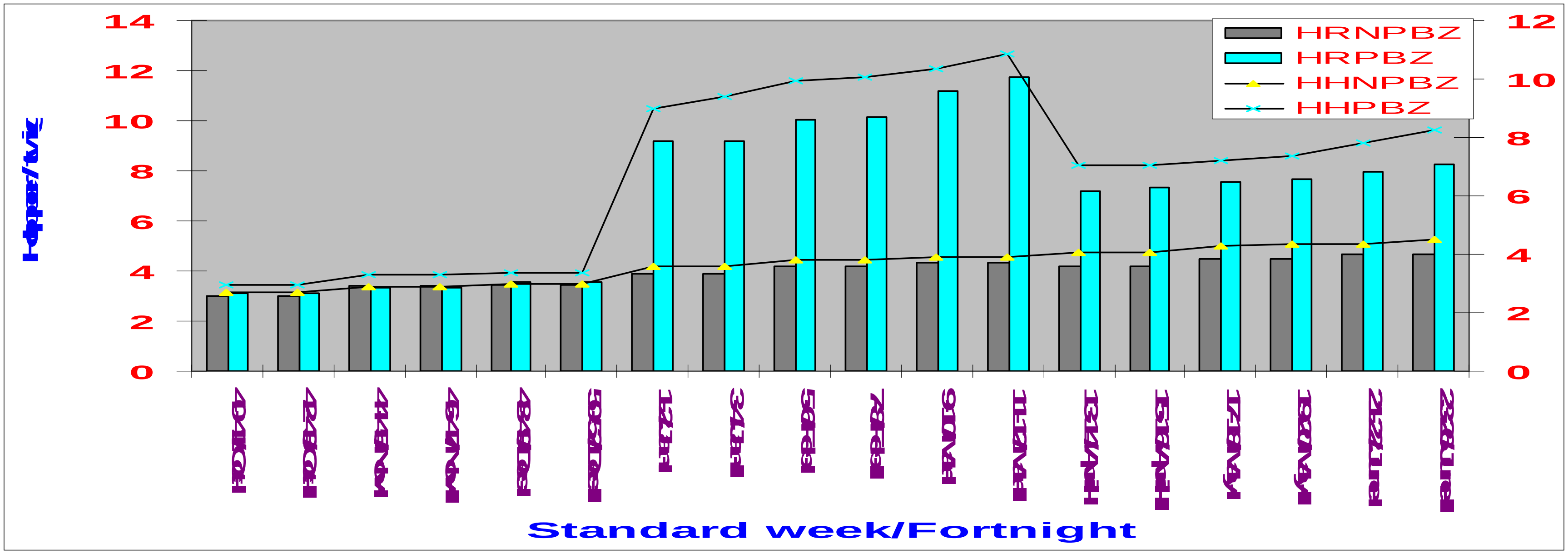
In pooled analysis, highest damage of 2.40 SM grade was recorded in PBZ at 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + ½ RDF followed by PBZ at 4 g. a. i. (I year) + 3 g.a.i (II year) per tree + RDF (2.38 SM grade per twig) and PBZ at 4 g. a. i. (I year) + 2 g.a.i (II year)

Table 34: Influence of paclobutrazol + fertilization on incidence of mango hopper and its associated damage

Sr. No.	Treatment	Hopper/twig			Hopper egg laying damage/twig (%)			Sooty mold grade/twig		
		2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled
1	PBZ 4 g.a.i./tree + RDF	7.12*	6.47*	6.80 (bcd)	6.62*	6.00*	6.31 (e)	1.89*	2.15*	2.02 (de)
2	PBZ 4 g.a.i./tree + ½ RDF	7.10	6.27	6.68 (cde)	6.52	5.80	6.16 (ef)	1.77	1.95	1.86 (ef)
3	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year)/tree + RDF	7.67	6.52	7.10 (abc)	7.72	7.02	7.37 (cd)	2.25	2.30	2.27 (abc)
4	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year)/tree + ½ RDF	7.42	6.12	6.77 (cdef)	8.10	6.95	7.52 (c)	2.18	2.15	2.16 (cd)
5	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year)/tree + RDF	8.40	6.88	7.64 (a)	9.02	7.98	8.50 (a)	2.39	2.37	2.38 (ab)
6	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year)/tree + ½ RDF	8.12	6.71	7.42 (ab)	8.86	7.48	8.17 (ab)	2.50	2.30	2.40 (a)
7	Control (untreated) + RDF	4.32	3.80	4.06 (g)	4.82	4.42	4.62 (g)	1.52	1.57	1.55 (g)
8	Control (untreated) + ½ RDF	3.92	3.60	3.76 (gh)	4.95	4.07	4.51 (gh)	1.40	1.42	1.41 (gh)
	SEm ± (T) SEm ± (YxT)	0.177 --	0.143 --	0.221 0.161	0.225 --	0.282 --	0.176 0.255	0.084 --	0.079 --	0.060 0.081
	CD at 5 % (T) Cd at 5 % (YxT)	0.537 --	0.435 --	0.739 0.466	0.685 --	0.856 --	0.507 NS	0.255 --	0.240 --	0.173 NS
	CV (%)	4.53	4.29	4.44	5.53	7.87	6.66	6.78	6.78	7.04

* (Mean of fortnightly observations) PBZ : Paclobutrazol RDF:Recommended doze of fertilizer

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)



HRNPBZ : Hopper on non-paclobutrazol trees | HRPBZ : Hopper on paclobutrazol trees + RDF

HHNPBZ : Hopper on non-paclobutrazol trees, | HHPBZ : Hopper on paclobutrazol trees +1/2 RDF

Fig. 10: Abundance of mango hopper on paclobutrazol and non - paclobutrazol treated trees

per tree + RDF (2.27 SM grade per twig) which were statistically similar to it, whereas, the lowest damage of sooty mold (1.41 SM grade per twig) was indicated on control + ½ RDF trees, though it did not differ significantly with control + RDF trees (1.55 SM grade per twig). The interaction of year and treatment was found non-significant thus, confirms the consistency in year wise results (Table 34).

The data presented in Table 34 clearly indicates higher population of hopper and its associated damage in paclobutrazol (PBZ) treatments + RDF followed by same or similar doses of PBZ + half RDF, while control plot + half RDF recorded lowest hopper incidence. Thus, the treatments of PBZ + RDF played vital role in inviting higher incidence of hopper and its associated damage as compared to control plots.

4.6.3 Natural enemies

Amongst natural enemies, predatory spiders and coccinellids were the regular visitors. Highest population of predatory spiders (19.75 per twig) was noticed in PBZ at 4 and 3 g.a. i. (I and II year) per tree + RDF in 2002-2003, and its population was statistically similar to PBZ 4 and 3 g.a. i. (I and II year) per tree + ½ RDF (19.25 per twig). The lowest population (11.25 per twig) was recorded in control + ½ RDF trees, though it did not differ significantly with control + RDF (12.00 per twig). Similarly, in the next year, spider population peaked (18.00 per twig) on PBZ 4 and 3 g.a. i. (I and II year) per tree + RDF followed by PBZ 4 and 3 g.a. i. (I and II year) per tree + ½ RDF (16.50 per twig) which was statistically similar to it. However, it was lowest (8.00 per twig) on control + ½ RDF trees, though it was at par with control + RDF trees) (8.75 per twig) (Table 35).

Table 35: Population of natural enemies in relation to hopper abundance and paclobutrazol doses + fertlization

Sr. No.	Treatment	Predatory spiders /twig			Coccinellids /twig		
		2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled
1	PBZ 4 g.a.i./tree + RDF	15.25*	13.50*	14.37 (de)	8.00*	11.25*	9.62 (e)
2	PBZ 4 g.a.i./tree + ½ RDF	15.00	12.50	13.75 (def)	8.75	10.50	9.62 (ef)
3	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year) /tree + RDF	17.50	14.00	15.75 (c)	10.50	14.50	12.50 (bc)
4	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year) /tree + ½ RDF	16.25	13.50	14.87 (cd)	12.00	12.75	12.37 (cd)
5	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year) /tree + RDF	19.75	18.00	18.87 (a)	14.75	16.25	15.50 (a)
6	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year) /tree + ½ RDF	19.25	16.50	17.87 (ab)	14.25	13.75	14.00 (ab)
7	Control (untreated) + RDF	12.00	8.75	10.37 (g)	5.75	6.25	6.00 (g)
8	Control (untreated) + ½ RDF	11.25	8.00	9.62 (gh)	5.00	5.25	5.12 (gh)
SEm ± (T) SEm ± (YxT)		0.631 --	0.768 --	0.468 0.703	0.795 --	0.618 --	0.566 0.712
CD at 5 % (T) Cd at 5 % (YxT)		1.921 --	2.33 --	1.347 NS	2.413 --	1.876 --	1.627 NS
CV (%)		6.93	10.16	8.44	13.95	9.47	11.65

* (Mean of fortnightly observations)

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

PBZ : Paclobutrazol RDF : Recommended doze of fertilizer

In pooled analysis, spiders similarly peaked (18.87 per twig) in PBZ 4 and 3 g. a. i. (I and II year) per tree + RDF followed by with PBZ 4 and 3 g. a. i. (I and II year) per tree + ½ RDF (17.87 per twig), whereas, it was found lowest (9.62 per twig) in control + ½ RDF trees though, it did not differ significantly with with control + RDF (10.37 per twig) (Table 35). The year and treatment interaction was found non-significant indicating similarity in year wise results.

Similarly, population of coccinellids remained highest (14.75 per twig) in PBZ 4 and 3 g. a. i. (I and II year) per tree + RDF in 2002-2003, followed by the same doze of PBZ but with ½ RDF (14.25 per twig) and was at par with it. However, the lowest (5.00 per twig) was found in control + ½ RDF, though it was at par with control + RDF trees (5.75 per twig). In 2003-2004, trend of coccinellid population was same indicating its peak (16.25 per twig) in PBZ 4 and 3 g. a. i. (I and II year) per tree + RDF followed by PBZ 4 and 2 g. a. i. (I and II year) per tree + RDF (14.50 per twig) and lowest (5.25 per twig) was observed in control + ½ RDF followed by control + RDF (6.25 per twig) (Table 35).

In pooled analysis, highest number of coccinellids (15.50 per twig) was noticed on PBZ 4 and 3 g. a. i. (I and II year) per tree + RDF followed by PBZ 4 and 3 g. a. i. (I and II year) per tree + ½ RDF (14.00 per twig) which was at par with it, whereas the lowest (5.12 per twig) was observed on control + ½ RDF trees, though their population at par with control + RDF) (6.00 per twig) (Table 32). The interaction of year and treatment was non-significant thus, confirms the consistency in year wise results (Table 35).

4.6.4 Comparative hopper abundance on PBZ and non-PBZ trees

Abundance of hopper on PBZ + RDF treated trees varied from 4.10 -13.60, 2.10 - 9.90 and 3.10 – 11.75 per twig in 2002- 2003, 2003-2004 and pooled analysis, respectively as compared to 3.90 – 4.50, 2.10 – 4.80 and 3.00 – 4.65 per twig on non-PBZ trees during the respective years and pooled observations.

On RDF trees, highest population (13.60, 9.90 and 11.75 per twig in 2002, 2003 and pooled analysis, respectively) was noticed during 11-12 standard weeks coinciding with stone size fruit stage of the crop growth. Similar trend was observed on trees which received half RDF though; they were lower in number (Table 36).

On non-PBZ trees + RDF trees, magnitude of hopper population was lower indicating peak status (4.50, 4.20 and 4.35 per twig in 2002-2003, 2003-2004 and pooled analysis, respectively) during 9-12 standard weeks when the crop was passing through pea/marble to stone sized crop stages. The results on trees which had ½ of the recommended doze of fertilizer were nearly the same indicating slight lower hopper population (Table 36)

Thus, it is evident from the data mentioned in Table 36 that magnitude of hopper population was much higher on PBZ treated trees (with RDF or ½ RDF) as compared to those on non-PBZ trees during the same period (standard week) as well as the crop stage.

Correlation

Relationship of crop stage with abundance of hopper was worked out on the basis of correlation coefficient (‘r’ values). Correlation of

Table 36: Comparative abundance of hopper complex

Standard Week and Std. period	Non-PBZ trees							PBZ trees						
	Crop stage	RDF trees			½ RDF trees			Crop stage	RDF trees			½ RDF trees		
		Hopper/twig			Hopper/twig				Hopper/twig			Hopper/twig		
		2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled		2002-2003	2003-2004	Pooled	2002-2003	2003-2004	Pooled
40-41 (1-14 Oct.)	2	3.90	2.10	3.00	3.60	1.80	2.70	1	4.10	2.10	3.10	3.80	2.10	2.95
42-43 (15- 28 Oct)	3	3.90	2.10	3.00	3.60	1.80	2.70	1	4.10	2.10	3.10	3.80	2.10	2.95
44-45 (29 Oct-11 Nov)	3	4.50	2.30	3.40	3.90	1.90	2.90	1	4.30	2.40	3.35	4.20	2.40	3.30
46-47 (12-25 Nov)	3	4.50	2.30	3.40	3.90	1.90	2.90	4	4.30	2.40	3.35	4.20	2.40	3.30
48-49)26 Nov-9 Dec)	4	4.50	2.40	3.45	3.90	2.10	3.00	4	4.40	2.70	3.55	4.30	2.40	3.35
50-52 (10-31 Dec)	4	4.50	2.40	3.45	3.90	2.10	3.00	5	4.40	2.70	3.55	4.30	2.40	3.35
1-2 (1-14 Jan)	5	3.90	3.90	3.90	3.60	3.60	3.60	6	10.60	7.80	9.20	11.40	6.60	9.00
3-4 (15-28 Jan)	5	3.90	3.90	3.90	3.60	3.60	3.60	7	10.60	7.80	9.20	11.40	7.40	9.40
5-6 (29 Jan-11 Feb)	6	4.20	4.20	4.20	3.90	3.70	3.80	7	12.20	7.90	10.05	12.10	7.80	9.95
7-8 (12-25 Feb)	7	4.20	4.20	4.20	3.90	3.70	3.80	7	12.20	8.10	10.15	12.30	7.80	10.05
9-10 (26 Feb-11 Mar)	7	4.50	4.20	4.35	3.90	3.90	3.90	8	13.60	8.80	11.20	12.60	8.10	10.35
11-12 (12-25 Mar)	8	4.50	4.20	4.35	3.90	3.90	3.90	8	13.60	9.90	11.75	12.90	8.80	10.85
13-14 (26 Mar-8 Apr)	8	4.20	4.20	4.20	3.90	4.20	4.05	8	6.60	7.80	7.20	6.30	7.80	7.05
15-16 (9-22 Apr)	8	4.20	4.20	4.20	3.90	4.20	4.05	8	6.90	7.80	7.35	6.30	7.80	7.05
17-18 (23 Apr-6 May)	8	4.50	4.50	4.50	4.20	4.40	4.30	9	7.20	7.90	7.55	6.60	7.80	7.20
19-20 (7-20 May)	9	4.50	4.50	4.50	4.20	4.50	4.35	10	7.20	8.10	7.65	6.90	7.80	7.35
21-22 (21 May-3 June)	10	4.50	4.80	4.65	4.20	4.50	4.35	12	7.80	8.10	7.95	7.50	8.10	7.80
23-26 (4 June-1 Jul)	12	4.50	4.80	4.65	4.20	4.80	4.50	12	8.10	8.40	8.25	8.10	8.40	8.25
Correlation coeff. (‘r’)	**1.000**	**0.394**	**0.910****	**0.955****	**0.741****	**0.932****	**0.924****	**1.0000**	**0.502***	**0.844****	**0.637****	**0.480***	**0.871****	**0.649****

1 : Vegetative 2 : Emergence of new flush 3 : New twig 4 : Bud/bud burst stage

5 : Initiation of flowering 6 : peak flowering 7 : Pea/marble stage 8 : Stone sized stage

9 : Fruiting stage 10: Initiation of ripening 11 : Ripening/harvest 12 : Harvest/Rainy period

crop stage with abundance of hopper on PBZ (‘r’ = 0.502, 0.844 and 0.637 on RDF and 0.480, 0.871 and 0.649 on ½ RDF trees during 2002-2003, 2003-2004 and pooled analysis, respectively) and non – PBZ (‘r’ = 0.910 and 0.955 on RDF in 2003-2004 and pooled analysis and 0.741, 0.932 and 0.924 on ½ RDF trees in 2002-2003, 2003-2004 and pooled analysis, respectively) treated trees were found significant and positive. It means that the hopper abundance was positively correlated with paclobutrazol application as the population on PBZ trees was higher than PBZ trees as compared to non-PBZ trees at every stage of crop growth as well as the standard week. Moreover, with PBZ application, bud burst, initiation of flowering stage and peak flowering stages were advanced by at least 1-2 weeks (Table 36) thus invited relatively higher abundance of hopper on PBZ trees (9.20-11.75 hoppers per twig in pooled analysis) as compared to non-PBZ trees (3.90-4.35 hoppers per twig in pooled analysis) during the same period (1-12 standard weeks).

4.6.5 Date of flowering

It may be concluded that the crop stage advanced from vegetative to flowering to fruit setting stage at a rapid rate in PBZ treated trees than on non-PBZ treated trees ultimately led to the advancement of the arrival and abundance of hopper exhibiting direct positive relationship between crop stage and hopper abundance (Table 34 and 37).

It is evident from the observations on date of flowering that initiation of flowering and full bloom commenced at least one month ahead of those in control (untreated trees) (Table 37). Impact of fertilizer is also evident in the present investigation as recommended doze of fertilizer (0.750, 0.160 and 0.750 Kg NPK per tree) demonstrated earliness in flowering than those in half of the recommended doze of fertilizer so,

Table 37: Comparative date of flowering on non-PBZ and PBZ trees

Sr. No,	Treatment	2002-2003			2003-2004		
		Date of PBZ application	Date of flower initiation	Date of Flower bloom	Date of PBZ application	Date of flower initiation	Date of Flower bloom
1	PBZ 4 g.a.i./tree + RDF	16.8.2002	19.12.2002	16.1.2003	15.8.2003	14.12.2003	11.1.2004
2	PBZ 4 g.a.i./tree + ½ RDF	16.8.2002	27.12.2002	24.1.2003	15.8.2003	19.12.2003	16.1.2004
3	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year) /tree + RDF	16.8.2002	19.12.2002	16.1.2003	15.8.2003	25.12.2003	20.1.2004
4	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year) /tree + ½ RDF	16.8.2002	28.12.2002	24.1.2003	15.8.2003	29.12.2003	23.1.2004
5	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year) /tree + RDF	16.8.2002	19.12.2002	17.1.2003	15.8.2003	22.12.2003	19.1.2004
6	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year) /tree + ½ RDF	16.8.2002	27.12.2002	25.1.2003	15.8.2003	29.12.2003	21.1.2004
7	Control (untreated) + RDF	--	23.1.2003	19.2.2003	--	26.1.2004	23.2.2004
8	Control (untreated) + ½ RDF	--	24.1.2003	19.2.2003	--	26.1.2004	25.2.2004

PBZ: Paclobutrazol RDF: Recommended doze of fertilizer

hopper population on RDF trees (4.10, 2.10 and 3.10 per twig) was higher than that on ½ RDF trees (3.80, 2.10 and 2.95 per twig) during 40-43 standard weeks, the period of initiation of hopper attack, but also relatively higher thus confirms the role of fertilizer in abundance of hopper attack.

It is also evident from data on hopper population mentioned in Table 34 that repeated application of hopper i.e. PBZ at 4, 3 and 2 g.a.i. per tree in I and II year had higher population of mango hopper (7.10-7.64 per twig in pooled analysis) than in treatment of PBZ applied once (6.68-6.80), thus proving the hypothesis that year after year application of PBZ on mango trees not only changes the physiology of mango trees by inducing earliness in flowering and its subsequent stages of crop growth but also sets up higher magnitude of hopper population complex, thus altering the longevity of the pest.

Thus, in the light of ongoing discussion on impact of plant growth regulator (PBZ) on incidence of hopper, it may be concluded that hopper incidence and its associated damage remained higher on trees which received treatment of paclobutrazol (PBZ) + recommended doze of fertilizer (RDF), followed by PBZ + half RDF, whereas, it was significantly lower on control + ½ RDF trees. Paclobutrazol is primarily an antigibberlin based plant growth regulator applied to induce earliness in flowering and fruiting in mango. It is because of its inhibitory action on the biosynthesis in plants, blocks the conversion of ant-kaurene to kaurinoic acid – a precursor of gibberlin (Dalziel and Lawrence, 1984; Graebe, 1987). Thus, it suppresses the emergence of new flush or new twigs immediately after withdrawl of monsonic rains or two to three months prior to the expected period of flowering and thereby strengthens old/mature twigs for initiation of flowering and wherein it prepares a platform for induction of early flowering. Therefore, there is a clear cut difference in crop stage in PBZ and non-PBZ treated trees at every standard week (Table 36).

But, earliness in flowering side by side also advances the arrival of mango hopper, which has been clearly demonstrated in the treatments of paclobutrazol (PBZ) over those of non-paclobutrazol as hoppers were not only higher in number in the former than in the later but they also touched or crossed economic threshold level (five hoppers per twig) much earlier in PBZ trees than non-PBZ trees. It could be due to earliness in induction of flowering as well as full bloom in PBZ over non-PBZ (control) trees wherein they arrival of hopper and their subsequent damages was advanced. It is also an established fact that flowering stage is the preferred stage of hopper multiplication (Anonymous, 1917; Patel, *et al;* 1994; Verghese and Rao, 1987; Srivastava, 1998; Bharat Babu, *et al;* 2001 and Talpur *et al;* 2002). The role of fertilization on abundance of mango hopper has also been illustrated in the investigation as the magnitude of hoppers and its associated damages (Table 34-35) were slightly higher in RDF trees as compared to those on ½ RDF trees.

Though, there are no reports on relationship of earliness in flowering and abundance of hopper, but induction of early flowering and fruiting in mango using 16-20 ml of paclobutrazol as soil treatment, during middle of August in Alphonso mango has been proved by several workers in Maharashtra (Burondkar and Gunjate, 1991and 1993) and Gujarat (Desai and Chundawat, 1994 and Bhatt and Sushil Kumar, 1997), thus confirms the present findings on induction of earliness in flowering.

4.7 Evaluation of newer insecticides against mango hopper

Newer insecticides/molecules have been tested for controlling mango hopper in mango (cv. Alphonso) under field conditions on the basis of following characters during 2002, 2003 and 2004.

4.7.1 Impact on hopper population

From the results presented in Table 38, 40-41, it is evident that hopper population before commencement of spray was statistically similar (non-significant) during 2002, 2004 and pooled analysis which implies statistical similarity in hopper numbers before spray. During 2002, all the insecticide treatments were found statistically superior over control. In different insecticidal treatments, hopper population (per panicle) varied from 0.67-4.33 (after one day), 1.00-5.00 (after seven days), 1.67-8.33 (after ten days), 2.33-11.00 (after fifteen days) and 6.33-12.67 (after twenty one days) in 2002. Lowest hopper population (2.06 per panicle) (irrespective of post spray interval) was observed on trees treated with imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (2.29 hoppers per panicle) which was at par with it, whereas, highest population of hoppers (17.65 per panicle) was recorded on control trees (Table 38). Looking to the period wise significance of these treatments, it is evident from the data presented in Table 38 that imidacloprid 0.005 per cent succeeded in keeping hopper population below economic threshold threshold (ETL) (5 hoppers per panicle) upto 15 days of spraying and on 21st day, the population (6.33 per panicle) could hardly touch the ETL followed by thiamethoxam 0.0084 per cent, whereas, in rest of the treatments, the population touched the ETL either on the 10th or 15th day of spray application.

Table 38: Bio-efficacy of newer insecticides against mango hopper complex during 2002

Sr. No.	Treatment	Hopper population per panicle						
		Before spray	1 DAS	7 DAS	10 DAS	15 DAS	21 DAS	Pooled
1.	Imidacloprid 0.005 %	4.47*(19.67)	1.05*(0.67)	1.22*(1.00)	1.46*(1.67)	1.67*(2.33)	2.61*(6.33)	1.60*(2.06) (a)
2.	Thiamethoxam 0.0084 %	4.44 (19.33)	1.05 (0.67)	1.22(1.00)	1.46(1.67)	2.03(3.67)	2.60(6.33)	1.67(2.29) (ab)
3.	Acetaprimid 0.004 %	4.30(18.00)	1.34 (1.33)	1.77(2.67)	2.12(4.00)	2.61(6.33)	3.07(9.00)	2.18(4.75) (cd)
4.	Fipronil 0.005 %	4.13(16.67)	1.46 (1.67)	1.77(2.67)	2.03(3.67)	2.53(6.00)	3.12(9.33)	2.18(4.75) (cd)
5.	Profenofos 0.1 %	4.33(18.33)	1.46 (1.67)	1.77(2.67)	2.19(4.33)	2.66(6.67)	3.27(10.33)	2.27(4.65) (de)
6.	Diflubenzuron 0.02 %	4.10(16.33)	2.19 (4.33)	2.27(4.67)	2.96(8.33)	3.38(11.00)	3.62(12.67)	2.88(7.79) (ij)
7.	Lambdacyhalothrin 0.003 %	3.91(15.00)	1.76 (2.67)	2.26(4.67)	2.47(5.67)	2.96(8.33)	3.29(10.33)	2.55(6.00) (fgh)
8.	Carbosulfan 0.05 %	3.84(14.33)	2.11 (4.00)	2.33(5.00)	2.61(6.33)	3.02(8.67)	3.29(10.33)	2.67(6.63) (ghi)
9.	Fenubucarb 0.05 %	3.88(14.67)	1.55 (2.00)	1.93(3.33)	2.27(4.67)	2.66(6.67)	3.29(10.33)	2.34(4.98) (def)
10.	Endosulfan 0.07 %	3.97(15.33)	1.55 (2.00)	2.02(3.67)	2.47(5.67)	3.02(8.67)	3.53(12.00)	2.52(5.85) (fg)
11.	Monocrotophos 0.04 %	4.04(16.00)	1.17 (1.00)	1.55(2.00)	1.85(3.00)	2.53(6.00)	3.02(8.67)	2.02(3.58) (c)
12.	Control (Untreated)	4.08(16.33)	4.08 (16.33)	4.13(16.67)	4.28(18.00)	4.36(18.67)	4.43(19.33)	4.26(17.65) (k)
	SEm ± (T)	0.191	0.172	0.130	0.108	0.131	0.104	0.114
	SEm ± (P)	--	--	--	--	--	--	0.022
	SEm ± (T x P)	--	--	--	--	--	--	0.076
	CD at 5 % (T)	NS	0.505	0.382	0.3180	0.384	0.305	0.334
	CD at 5 % (P)	--	--	--	--	--	--	0.061
	CD at 5 % (T x P)	--	--	--	--	--	--	0.214
	CV (%) (T)	8.02	17.20	11.16	7.99	8.13	5.53	18.16

CV (%)(P)	--	--	--				5.43

*√x + 0.5 values Figures in parenthesis indicate original values

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

Similarly in 2003, all the insecticidal treatments recorded significantly lower hoppers than untreated control. Their population varied from 0.67-3.67 (after one day), 2.00-4.67 (after seven days), 2.33-9.67 (after ten days), 3.33-14.67 (after fifteen days) and 5.33-14.67 (after twenty one days) per panicle**.** In pooled population (irrespective of post spraying period), lowest hoppers (2.49 per panicle) were recorded in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (3.30 per panicle) which did not differ significantly with it. On the other hand, highest number of hoppers (27.38 per panicle) was observed on control (untreated) trees. Results on period wise efficacy of insecticides were more or less same as obtained in 2002 indicating effectiveness of imidacloprid 0.005 and thiamethoxam 0.0084 per cent up to 21st day of spray application (Table 39). Effectiveness of different treatments was found significant at different periods indicating effectiveness of imidacloprid 0.005 and thiamethoxam 0.0084 per cent up to the 21st day of spray application i.e. they kept hoppers below ETL (5 hoppers per panicle) whereas, rest of the insecticides were found successful in keeping hopper population below ETL either upto 10th or 15th day of spray (Table 39).

During 2004, all the insecticidal treatments were significantly superior over control wherein the hopper population varied from 0.33-4.33 (after one day), 1.33-4.67 (after seven days), 2.33-9.67 (after ten days), 3.67-12.00 (after fifteen days) and 5.00-14.33 (after twenty one days) per panicle. Lowest population of hoppers (irrespective of post spray period) (2.19 per panicle) was found in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (2.78 per panicle) which was at par with it (Table 40). Insecticide efficacy of various treatments was also found significant at different periods of spray application indicating that imidacloprid 0.005 and thiamethoxam 0.0084 per cent were successful in keeping hoppers below ETL up to 21st day of spray application (5.00 and 5.67 per panicle in respective treatments), whereas, rest of the treatments failed to keep hoppers below ETL beyond 15 days of spraying (Table 40).

Table 39: Bio-efficacy of newer insecticides against mango hopper complex during 2003

Sr. No.	Treatment	Hopper population per panicle						
		Before spray	1 DAS	7 DAS	10 DAS	15 DAS	21 DAS	Pooled
1.	Imidacloprid 0.005 %	5.10*(25.67)	1.05*(0.67)	1.55*(2.00)	1.67*(2.33)	1.95*(3.33)	2.40*(5.33)	1.73*(2.49) (a)
2.	Thiamethoxam 0.0084 %	5.17(26.33)	1.34(1.33)	1.77(3.67)	1.95(3.33)	2.12(4.00)	2.59(6.33)	1.95(3.30) (ab)
3.	Acetaprimid 0.004 %	4.88(23.33)	1.67(2.33)	2.03(3.67)	2.24(4.67)	2.54(6.00)	3.00(8.67)	2.30(4.79) (bcd)
4.	Fipronil 0.005 %	5.09(25.67)	1.77(2.67)	2.03(3.67)	2.26(4.67)	2.67(6.67)	3.18(9.67)	2.38(5.16) (bcde)
5.	Profenofos 0.1 %	5.27(27.33)	1.85(3.00)	2.12(4.00)	2.31(5.00)	2.73(7.00)	3.29(10.33)	2.46(5.55) (cdef)
6.	Diflubenzuron 0.02 %	5.43(29.00)	2.03(3.67)	2.26(4.67)	3.18(9.67)	3.86(14.67)	3.88(14.67)	3.04(8.74) (hijk)
7.	Lambdacyhalothrin 0.003 %	5.39(28.67)	1.95(3.33)	2.12(4.00)	2.73(7.00)	3.12(9.33)	3.67(13.00)	2.72(6.90) (defhi)
8.	Carbosulfan 0.05 %	5.63(31.33)	2.03(3.67)	2.19(4.33)	3.07(9.00)	3.28(10.33)	3.74(13.67)	2.86(7.68) (fghij)
9.	Fenubucarb 0.05 %	5.81(33.33)	1.82(3.00)	2.12(4.00)	2.46(5.67)	2.91(8.00)	3.43(11.33)	2.55(6.00) (cdefg)
10.	Endosulfan 0.07 %	5.39(28.67)	1.85(3.00)	2.12(4.00)	2.60(6.33)	3.02(8.67)	3.46(12.00)	2.61(6.31) (cdefgh)
11.	Monocrotophos 0.04 %	5.63(31.33)	1.55(2.00)	1.95(3.33)	2.11(4.00)	2.40(5.33)	2.89(8.00)	2.18(4.25) (bc)

12.	Control (Untreated)	5.30(27.67)	5.33(28.00)	5.42(29.00)	5.39(28.67)	5.33(28.00)	4.41(23.67)	5.28(27.38) (l)
	SEm ± (T)	0.170	0.160	0.093	0.169	0.143	0.206	0.076
	SEm ± (P)	--	--	--	--	--	--	0.045
	SEm ± (T x P)	--	--	--	--	--	--	0.155
	CD at 5 % (T)	0.499	0.469	0.274	0.496	0.419	0.605	0.225
	CD at 5 % (P)	--	--	--	--	--	--	0.126
	CD at 5 % (T x P)	--	--	--	--	--	--	0.438
	CV (%) (T)	5.51	13.70	7.00	10.98	8.26	10.59	11.11
	CV (%)(P)	--	--	--				10.09

*√x + 0.5 values Figures in parenthesis indicate original values

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

Table 40: Bio-efficacy of newer insecticides against mango hopper complex during 2004

Sr. No.	Treatment	Hopper population per panicle						
		Before spray	1 DAS	7 DAS	10 DAS	15 DAS	21 DAS	Pooled
1.	Imidacloprid 0.005 %	3.38*(11.00)	0.87*(0.33)	1.26*(1.33)	1.67*(2.33)	2.03*(3.67)	2.33*(5.00)	1.64*(2.19)
2.	Thiamethoxam 0.0084 %	3.67 (13.00)	1.05(0.67)	1.55(2.00)	1.85(3.00)	2.14(4.33)	2.44(5.67)	1.81((2.78)
3.	Acetaprimid 0.004 %	3.38(11.00)	1.46(1.67)	1.77(3.33)	2.03(4.00)	2.53(6.00)	2.90(8.00)	2.14(4.08)
4.	Fipronil 0.005 %	3.23(10.00)	1.55(2.00)	1.95(3.33)	2.11(4.00)	2.61(6.67)	3.02(8.67)	2.25(4.56)
5.	Profenofos 0.1 %	3.18((9.67)	1.67(2.33)	2.03(3.67)	2.26(4.67)	2.83(7.67)	3.13(9.67)	2.39(5.21)
6.	Diflubenzuron 0.02 %	3.23(10.00)	2.18(4.33)	2.24(4.67)	3.17(9.67)	3.50(12.00)	3.84(14.33)	2.99(8.44)
7.	Lambdacyhalothrin 0.003 %	3.43(11.33)	1.95(3.33)	2.25(4.67)	2.60(6.33)	3.23(10.00)	3.57(12.33)	2.72(6.90)
8.	Carbosulfan 0.05 %	3.28(10.33)	1.95(3.33)	2.20(4.67)	2.90(8.00)	3.19(11.00)	3.67(13.33)	2.78(7.23)
9.	Fenubucarb 0.05 %	3.43(11.33)	1.87(3.00)	2.03(4.33)	2.22(4.67)	3.07(9.00)	3.42(11.33)	2.52(5.85)
10.	Endosulfan 0.07 %	3.13 (9.33)	1.87(3.00)	2.04(4.67)	2.33(5.33)	3.11(9.67)	3.41(11.67)	2.55(6.00)
11.	Monocrotophos 0.04 %	3.48(11.67)	1.34(1.33)	1.77(2.67)	2.03(3.67)	2.38(5.33)	2.70(7.00)	2.04(3.66)
12.	Control (Untreated)	3.37(11.00)	3.53(12.00)	3.44(12.33)	3.59(12.67)	3.67(13.00)	3.89(14.67)	3.62(12.60)
	SEm ± (T)	0.113	0.116	0.325	0.259	0.349	0.281	0.109
	SEm ± (P)	---	--	--	--	--	--	0.086
	SEm ± (T x P)	---	--	--	--	--	--	0.300
	CD at 5 % (T)	NS	0.341	0.953	0.760	NS	0.825	0.322
	CD at 5 % (P)	---	--	--	--	--	--	0.243
	CD at 5 % (T x P)	---	--	--	--	--	--	NS
	CV (%) (T)	5.88	11.34	27.47	18.69	21.15	15.24	17.31
	CV (%)(P)	---	--					21.17

*√x + 0.5 values Figures in parenthesis indicate original values

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

In pooled analysis (irrespective of period of spray) all the test insecticides proved their significant superiority over control wherein imidacloprid 0.005 per cent was proved most effective and statistically superior over rest of the treatments recording lowest hopper population (irrespective of post spray period) of 2.06, 2.49, 2.19 and 2.22 hoppers per panicle in 2002, 2003, 2004 and mean, respectively, followed by thiamethoxam 0.0084 per cent (2.29, 3.30, 2.78 and 2.78 hoppers per panicle in respective years and mean) which was statistically similar to it, whereas, highest population of hopper in insecticide treatment was recorded in diflubenzuron 0.02 per cent (7.79, 8.74, 8.44 and 8.32 in all the three years of investigation and mean, respectively), though it was at par with carbosulfan 0.05 per cent (6.63, 7.68, 7.23 and 7.17 per panicle). The insecticide efficacy of different treatments at different periods after spraying was also significant suggesting that treatments indicating different effectiveness at different periods. The year wise results have already indicated efficacy (population below ETL) of imidacloprid 0.005 and thiamethoxam 0.0084 per cent up to 21^{st} day of spray, whereas insecticides *viz*; monocrotophos 0.04, fenubucarb 0.05, profenofos 0.01, fipronil 0.005 and acetaprimid 0.004 per cent kept hoppers below ETL upto the 10^{th} day of spray, while diflubenzuron 0.02 per cent, lambdacyhalothrin 0.003 per cent, carbosulfan 0.05 per cent and endosulfan 0.07 per cent were found successful (population below ETL) only upto 7^{th} day of spray application (Table 38-41). The overall order of effectiveness of various treatments based on hopper population was imidacloprid (2.22) > thiamethoxam (2.78) > monocrotophos (3.83) > acetaprimid (4.38) > fipronil (4.65) > profenofos (5.12) > fenubucarb (5.60) > endosulfan (6.05) > lambdacyhalothrin (6.65) > carbosulfan (7.17) > diflubenzuron (8.32) > control (18.68) (Table 41).

Table 41: Bio-efficacy of newer insecticides against mango hopper complex during 2002-2004

Sr. No.	Treatment	Hopper population per panicle (Pooled observations)					Rank
		Before spray	2002	2003	2004	Overall pooled	
1.	Imidacloprid 0.005 %	4.32* (18.16)	1.60*(2.06)	1.73*(2.49)	1.64*(2.19)	1.65*(2.22)(a)	**1**
2.	Thiamethoxam 0.0084 %	4.43(19.12)	1.67(2.29)	1.95(3.30)	1.81((2.78)	1.81(2.78) (ab)	**2**
3.	Acetaprimid 0.004 %	4.19(17.06)	2.18(4.75)	2.30(4.79)	2.14(4.08)	2.21(4.38) (cd)	**4**
4.	Fipronil 0.005 %	4.15(16.72)	2.18(4.75)	2.38(5.16)	2.25(4.56)	2.27(4.65) (cde)	**5**
5.	Profenofos 0.1 %	4.26(17.65)	2.27(4.65)	2.46(5.55)	2.39(5.21)	2.37(5.12) (cdef)	**6**
6.	Diflubenzuron 0.02 %	4.25(17.62)	2.88(7.79)	3.04(8.74)	2.99(8.44)	2.97(8.32) (jk)	**11**
7.	Lambdacyhalothrin 0.003 %	4.25(17.58)	2.55(6.00)	2.72(6.90)	2.72(6.90)	2.66(6.65) (ghi)	**9**
8.	Carbosulfan 0.05 %	4.25(17.62	2.67(6.63)	2.86(7.68)	2.78(7.23)	2.77((7.17) (ghij)	**10**
9.	Fenubucarb 0.05 %	4.37(18.60)	2.34(4.98)	2.55(6.00)	2.52(5.85)	2.47(5.60) (efg)	**7**
10.	Endosulfan 0.07 %	4.16(16.81)	2.52(5.85)	2.61(6.31)	2.55(6.00)	2.56(6.05) (efgh)	**8**
11.	Monocrotophos 0.04 %	4.38(18.68)	2.02(3.58)	2.18(4.25)	2.04(3.66)	2.08(3.83) (bc)	**3**
12.	Control (Untreated)	4.25(17.59)	4.26(17.65)	5.28(27.38)	3.62(12.60)	4.38(18.68) (l)	**12**
	SEm ± (T)	0.139	0.114	0.076	0.109	0.132	
	SEm ± (YxT)	0.161	--	--	--	0.101	
	SEm ± (P)	---	0.022	0.045	0.086	0.033	
	SEm ± (YxP)	---	--	--	--	0.057	
	SEm ± (TP)	---	0.076	0.155	0.300	0.107	
	SEm ± (YTP)	---	--	--	--	0.200	
	CD at 5 % ± (T)	NS	0.334	0.225	0.322	0.389	
	CD at 5 % (YxT)	0.457	--	--	--	0.287	
	CD at 5 % (P)	---	0.061	0.126	0.243	0.092	
	CD at 5 % (YxP)	---	--	--	--	NS	
	CD at 5 % (TP)	---	0.214	0.438	NS	0.297	
	CD at 5 % (YTP)	---	--	--	--	NS	
	CV (%) (T)	6.55	18.16	11.11	17.31	15.61	
	CV (%)(P)	---	5.43	10.09	21.17	0.376	

*$\sqrt{x + 0.5}$ values   Figures in parenthesis indicate original values

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

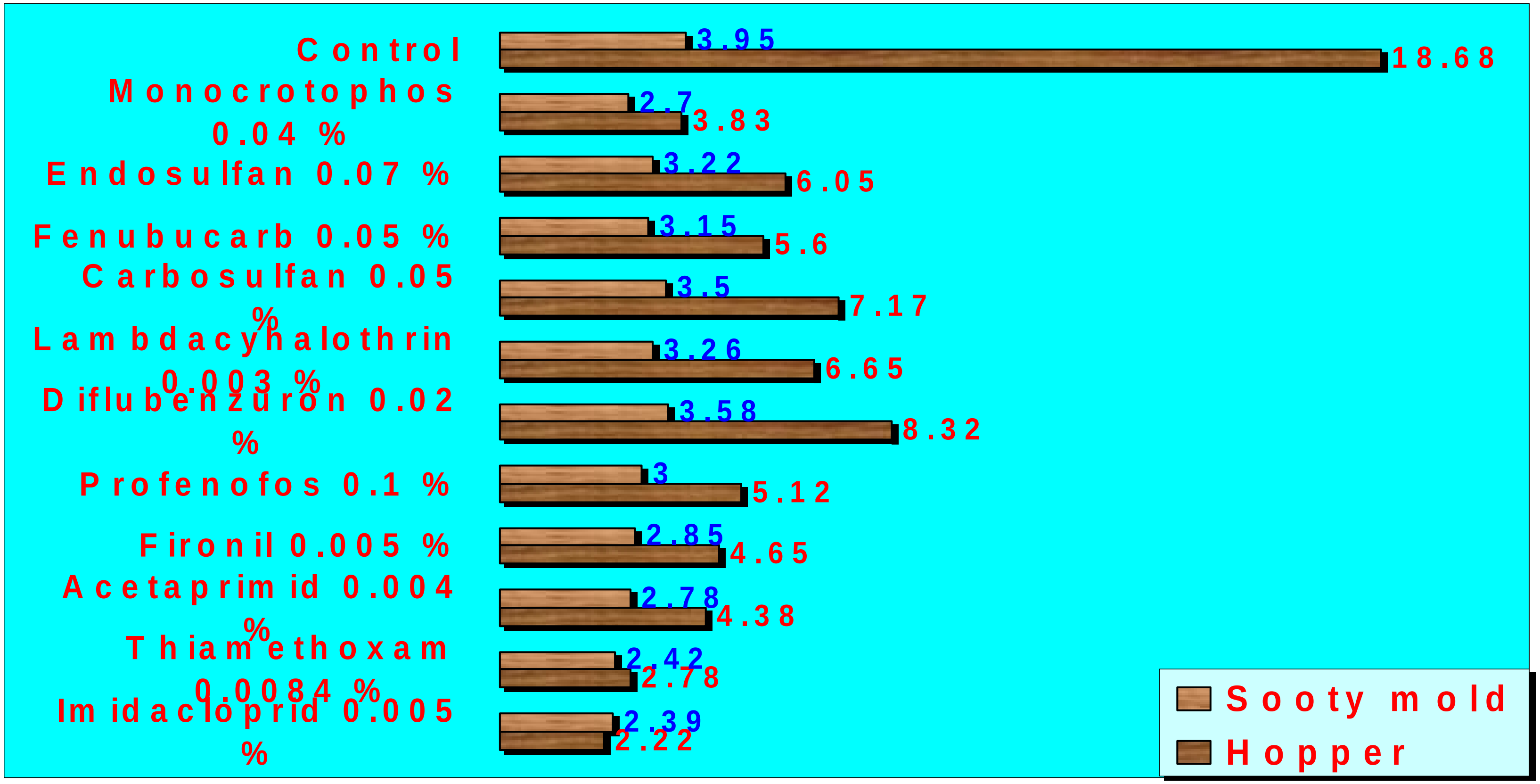


Fig. 11: Impact of newer insecticides on mango hopper population

4.7.2 Impact on sooty mold

Similar to hopper population, development of sooty mold damage also varied significantly in various insecticide treatments, though it did not differ significantly before commencement of insecticide application indicating similarity of sooty mold occurrence before spray application in all the treatments.

The results of three years (irrespective of post spray interval) are pooled and summarized in Table 42. During 2002, all the test insecticides proved their significant superiority over control (untreated) in different treatments. Imidacloprid 0.005 per cent recorded lowest sooty mold damage of 1.60 SM grade, followed by thiamethoxam 0.0084 per cent (1.75 SM grade), whereas, highest damage in any insecticide treatment in terms of sooty mold grade (3.00) was found in diflubenzuron 0.02 percent. Insecticidal efficacy of different treatments varied significantly at different periods which implies that different insecticides had different effectiveness at different periods indicating insecticides like imidacloprid and thiamethoxam 0.0084 per cent had higher significant impact up to 21st day of spray application, while rest of the insecticides could succeed up to 15th day of spray application (Table 42).

During 2003, lowest sooty mold grade (2.60) was noticed in thiamethoxam 0.0084 per cent, followed by imidacloprid 0.005 per cent (3.11 SM grade), whereas highest sooty mold (apart from control) (3.87

Table 42: Bio-efficacy of newer insecticides on hopper associated sooty mold damage during 2002-2004

Sr. No.	Treatment	Sooty mold grade per panicle (Pooled observations)					Rank
		Before spray	2002	2003	2004	Overall pooled	
1.	Imidacloprid 0.005 %	1.93* (3.22)	1.45*(1.60)	1.80*(3.11)	1.86*(2.96)	1.70* (2.39) (a)	**1**
2.	Thiamethoxam 0.0084 %	1.90 (3.11)	1.50 (1.75)	1.76 (2.60)	1.88 (3.03)	1.71 (2.42) (ab)	**2**
3.	Acetaprimid 0.004 %	1.97 (3.38)	1.60 (2.06)	1.92 (3.19)	1.92 (3.19)	1.81 (2.78) (cd)	**4**
4.	Fipronil 0.005 %	1.89 (3.07)	1.63 (2.16)	1.91 (3.15)	1.95 (3.30)	1.83 (2.85) (cde)	**5**
5.	Profenofos 0.1 %	1.95 (3.30)	1.69 (2.36)	1.92 (3.19)	2.01 (3.54)	1.87 (3.00) (cdef)	**6**
6.	Diflubenzuron 0.02 %	1.89 (3.07)	1.87 (3.00)	2.07 (3.78)	2.13 (4.04)	2.02 (3.58) (hijk)	**11**
7.	Lambdacyhalothrin 0.003 %	1.86 (2.96)	1.77 (2.63)	2.00 (3.50)	2.06 (3.74)	1.94 (3.26) (fghi)	**9**
8.	Carbosulfan 0.05 %	1.96 (3.34)	1.81 (2.78)	2.09 (3.87)	2.10 (3.91)	2.00 (3.50) (ghij)	**10**
9.	Fenubucarb 0.05 %	1.94 (3.26)	1.72 (2.46)	1.96 (3.34)	2.04 (3.66)	1.91 (3.15) (efg)	**7**
10.	Endosulfan 0.07 %	1.97 (3.38)	1.71 (2.42)	2.01 (3.54)	2.06 (3.74)	1.93 (3.22) (fgh)	**8**
11.	Monocrotophos 0.04 %	1.98 (3.42)	1.59 (2.03)	1.89 (3.07)	1.88 (3.03)	1.79 (2.70) (abc)	**3**
12.	Control (Untreated)	1.99 (3.46)	2.03 (3.62)	2.14 (4.08)	2.16 (4.17)	2.11 (3.95) (kl)	**12**
	SEm ± (T)	0.042	0.018	0.030	0.024	0.024	
	SEm ± (YxT)	0.0725	--	--	--	0.024	
	SEm ± (P)	--	0.007	0.013	0.012	0.035	
	SEm ± (YxP)	--	--	--	--	0.011	
	SEm ± (TP)	--	0.027	0.047	0.044	0.031	
	SEm ± (YTP)	--	--	--	--	0.040	
	CD at 5 % ± (T)	NS	0.053	0.089	0.070	0.070	
	CD at 5 % (YxT)	NS	--	--	--	0.070	
	CD at 5 % (P)	--	0.021	0.038	0.036	NS	
	CD at 5 % (YxP)	--	--	--	--	0.030	
	CD at 5 % (TP)	--	0.075	0.133	0.125	0.088	
	CD at 5 % (YTP)	--	--	--	--	0.114	
	CV (%) (T)	6.47	4.15	6.03	4.65	5.08	
	CV (%)(P)	--	2.75	4.18	3.86	3.73	

*√x + 0.5 values Figures in parenthesis indicate original values

SM grade) was found in carbosulfan 0.05 per cent follwed by diflubenzuron 0.02 per cent (3.78 SM grade) which was at par with it. Effectiveness of different insecticides also varied significantly at different periods of spray application (Table 42).

During the third year of investigation (2004), sooty mold damage remained lowest (2.96 SM grade) in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (3.03 SM grade) and monocrotophos 0.04 per cent (3.03 SM grade) which were at par with it. On the other hand, highest damage (4.04 SM grade) of sooty mold (other than control trees) was recorded in diflubenzuron 0.02 per cent. Insecticide efficacy of various treatments also varied significantly at different periods after spray application (Table 42).

In overall pooled analysis, lowest sooty mold (2.39 SM grade) was found in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (2.42 SM grade) and monocrotophos 0.04 per cent (2.70 SM grade), whereas, highest damage of sooty mold (3.95 SM grade) was reported in control trees which was statistically similar to diflubenzuron 0.02 per cent (3.58 SM grade). Thus, the order of effectiveness of various treatments based on sooty mold grade per twig was imidacloprid (2.39) > thiamethoxam (2.42) > monocrotophos (2.70) > acetaprimid (2.78) > fipronil (2.85) > profenofos (3.00) > fenubucarb (3.15) > endosulfan (3.22) > lambdacyhalothrin (3.26) > carbosulfan (3.50) > diflubenzuron (3.58) > control (3.95) (Table 42).

4.7.3 Impact of newer insecticides on beneficial fauna

Predaory spiders

Three years pooled results irrespective of post spray observations are summarized in Table 43. Population of predatory spiders was statistically similar before start of spray application indicating similarity in population. However after spray application; population of predatory spiders varied significantly in different treatments being highest during 2002 in controls (untreated) (8.50 per panicle). The next in the order was endosulfan 0.07 per cent (6.79 per panicle). On the other hand lowest population of predatory spiders (1.06 per panicle) was observed in lambdacyhalothrin 0.003 per cent (Table 43).

During 2003, there was no significant difference in various treatments with respect to significance of treatments and periods taken together however, in terms of significance of treatments and periods taken separately however, the population varied significantly in different treatments with respect to significance of treatments alone indicating highest number of predatory spiders (6.16 per panicle) in control (untreated) followed by endosulfan 0.07 per cent (4.61 per panicle), whereas, it was lowest (0.85 per panicle) in lambdacyhalothrin 0.003 per cent (Table 43).

In the year 2004, population of predatory spiders was found statistically similar with respect to significance of treatment and periods taken together. However, from treatment efficacy and periods point of view, it differed significantly in different treatment, being highest (9.93 per panicle) in control trees and next in the order was endosulfan 0.07.per cent (6.47 per panicle), whereas, it was lowest (1.19 per panicle) in lambdacyhalothrin 0.003 per cent (Table 43).

In pooled analysis, though population of predatory spiders was not significant with respect to interaction of treatment and period, however in terms of treatment wise comparision, it was found significant being highest (8.14 per panicle) in control trees. Next in order of

Table 43: Effect of newer insecticides on population of predatory spiders during 2002-2004

Sr. No.	Treatment	Predatory spiders per panicle (Pooled observations)					
		Before spray	**2002**	**2003**	**2004**	**Overall pooled**	**Rank**
1.	Imidacloprid 0.005 %	2.18*(4.25)	2.33*(4.93)	2.12*(3.99)	2.41*5.31)	2.29*(4.74)	**3**
2.	Thiamethoxam 0.0084 %	2.28 (4.70)	2.21 (4.38)	2.03 (3.62)	2.32 (4.88)	2.19 (4.30)	**4**
3.	Acetaprimid 0.004 %	2.13 (4.04)	2.05 (3.70)	1.79 (3.20)	1.95 (3.30)	1.93 (3.22)	**7**
4.	Fipronil 0.005 %	2.37 (5.12)	2.04 (3.66)	1.86 (2.96)	1.99 (3.46)	1.96 (3.34)	**6**
5.	Profenofos 0.1 %	2.32 (4.88)	1.82 (2.81)	1.63 (2.16)	1.64 (2.19)	1.70 (2.39)	**9**
6.	Diflubenzuron 0.02 %	2.43 (5.40)	2.13 (4.04)	1.95 (3.30)	2.24 (4.52)	2.11 (3.95)	**5**
7.	Lambdacyhalothrin 0.003 %	2.43 (5.40)	1.25 (1.06)	1.16 (0.85)	1.30 (1.19)	1.24 (1.04)	**12**
8.	Carbosulfan 0.05 %	2.52 (5.85)	1.72 (2.46)	1.55 (1.90)	1.61 (2.09)	1.63 (2.16)	**11**
9.	Fenubucarb 0.05 %	2.52 (5.85)	1.52 (1.81)	1.41 (1.49)	1.43 (1.54)	1.45 (1.60)	**10**
10.	Endosulfan 0.07 %	2.42 (5.36)	2.70 (6.79)	2.26 (4.61)	2.64 (6.47)	2.53 (5.90)	**2**
11.	Monocrotophos 0.04 %	2.41 (5.31)	1.96 (3.34)	1.74 (2.53)	1.87 (3.00)	1.86 (2.96)	**8**
12.	Control (Untreated)	2.54 (5.95)	3.00 (8.50)	2.58 (6.16)	3.23 (9.93)	2.94 (8.14)	**1**

SEm ± (T)	0.077	0.073	0.070	0.128	0.055
SEm ± (YxT)	0.148	--	--	--	0.094
SEm ± (P)	--	0.026	0.053	0.077	0.060
SEm ± (YxP)	--	--	--	--	0.056
SEm ± (TP)	--	0.093	0.184	0.268	0.104
SEm ± (YTP)	--	--	--	--	0.195
CD at 5 % ± (T)	NS	0.214	0.205	0.377	0.155
CD at 5 % (YxT)	NS	--	--	--	NS
CD at 5 % (P)	--	0.075	0.149	0.217	0.197
CD at 5 % (YxP)	--	--	--	--	0.158
CD at 5 % (TP)	--	0.261	NS	NS	NS
CD at 5 % (YTP)	--	--	--	--	NS
CV (%) (T)	10.80	13.73	14.68	24.23	18.41
CV (%)(P)	--	7.80	17.33	22.58	17.02

*√x + 0.5 values Figures in parenthesis indicate original values

effectiveness (in terms of higher population) was endosulfan 0.07 per cent which showed population of 5.90 per panicle, however lowest spiders (1.04 per panicle) were observed in lambdacyhalothrin 0.003 per cent. The population of predatory spiders however, did not differ significantly at different periods after spray application. The interaction of year, treatment and period was found non-significant indicating consistency in results over the period of investigation i.e. 2002, 2003 and 2004. The order of relative susceptibility of various treatments towards predatory spiders was control (8.14) > endosulfan (5.90) > imidacloprid (4.74) > thiamethoxam (4.30) > diflubenzuron (3.95) > fipronil (3.34) > acetaprimid (3.22) > monocrotophos (2.96) > profenofos (2.39) > carbosulfan (2.16) > fenubucarb (1.60) > lambdacyhalothrin (1.04) (Table 43).

Coccinellids

The pooled results of three years (irrespective of post observation interval) are pooled and summarized in Table 44. Population of coccinellids was statistically similar (non-significant) before spray application indicating similarity in coccinellids population on all the mango trees. However, the population differed significantly after spray application being highest (9.23 per panicle) in control (untreated) trees followed by diflubenzuron 0.02 per cent (6.74 per panicle) in 2002, however, lowest population of coccinellids (3.30 per panicle) was noticed in lambdacyhalothrin 0.003 per cent. The order of effectiveness in terms of coccinellids population was also found significant at different periods after spray.

During the subsequent year, population of coccinellids did not vary significantly in terms of interaction of treatment and period, however their population varied significantly in different treatments in terms of

Table 44: Effect of newer insecticides on coccinellids population during 2002-2004

Sr. No.	Treatment	Coccinellids per panicle (Pooled observations)					
		Before spray	2002	2003	2004	Overall pooled	Rank
1.	Imidacloprid 0.005 %	2.63*(6.42)	2.43*(5.40)	2.52*(5.85)	2.24*(4.52)	2.40*(5.26)	**3**
2.	Thiamethoxam 0.0084 %	2.65 (6.52)	2.49 (5.70)	2.09 (3.87)	2.44 (5.45)	2.34 (4.98)	**4**
3.	Acetaprimid 0.004 %	2.80 (7.34)	2.67 (6.63)	1.80 (2.74)	1.83 (2.85)	2.10 (3.91)	**7**
4.	Fipronil 0.005 %	2.76 (7.12)	2.67 (6.63)	1.96 (3.34)	1.95 (3.30)	2.19 (4.30)	**6**
5.	Profenofos 0.1 %	2.72 (6.90)	2.39 (5.21)	1.63 (2.16)	1.68 (2.32)	1.90 (3.11)	**9**
6.	Diflubenzuron 0.02 %	2.81 (7.40)	2.69 (6.74)	2.02 (3.58)	2.08 (3.83)	2.26 (4.61)	**5**
7.	Lambdacyhalothrin 0.003 %	2.71 (6.84)	1.95 (3.30)	1.05 (0.60)	0.98 (0.46)	1.33 (1.27)	**12**
8.	Carbosulfan 0.05 %	2.68 (6.68)	2.21 (4.38)	1.45 (1.60)	1.43 (1.54)	1.70 (2.39)	**10**
9.	Fenubucarb 0.05 %	2.71 (6.84)	2.31 (4.84)	1.32 (1.24)	1.33 (1.27)	1.65 (2.22)	**11**
10.	Endosulfan 0.07 %	2.70 (6.79)	2.63 (6.42)	2.73 (6.95)	2.62 (6.36)	2.66 (6.58)	**2**
11.	Monocrotophos 0.04 %	2.82 (7.45)	2.59 (6.21)	1.76 (2.60)	1.79 (2.70)	2.05 (3.70)	**8**
12.	Control (Untreated)	2.80 (7.34)	3.12 (9.23)	2.93 (8.08)	3.15 (9.42)	3.07 (8.92)	**1**
	SEm ± (T)	0.089	0.180	0.108	0.110	0.132	
	SEm ± (YxT)	0.167	--	--	--	0.137	
	SEm ± (P)	--	0.014	0.053	0.057	0.026	
	SEm ± (YxP)	--	--	--	--	0.046	
	SEm ± (TP)	--	0.049	0.184	0.200	0.087	
	SEm ± (YTP)	--	--	--	--	0.159	
	CD at 5 % ± (T)	NS	0.528	0.316	0.324	0.389	
	CD at 5 % (YxT)	NS	--	--	--	0.402	
	CD at 5 % (P)	--	0.040	0.149	0.162	0.073	
	CD at 5 % (YxP)	--	--	--	--	NS	
	CD at 5 % (TP)	--	0.138	NS	NS	NS	

CD at 5 % (YTP)	--	--	--	--	NS
CV (%) (T)	10.60	27.72	21.53	21.78	24.78
CV (%)(P)	--	3.39	16.44	17.65	12.92

*√x + 0.5 values   Figures in parenthesis indicate original values

significance of treatments only indicating peak population (8.08 per panicle) in control (untreated) followed by endosulfan 0.07 per cent (6.95 per panicle), which was at par with it. The lowest population of coccinellids (0.60 per panicle) was however noticed in lambdacyhalothrin 0.003 per cent (at par with fenubucarb 0.05 per cent). The population of coccinellids in differed treatments differed at different periods after spray depending upon relative toxicity of these insecticides (Table 44).

During the third year of investigation, interaction of treatment and period was found non-significant, though in terms of impact of insecticides on coccinellids, population in different treatments varied significantly showing highest population (9.42 per panicle) in control (untreated). The next in sequence was endosulfan 0.07 per cent (6.36 per panicle), whereas, minimum number of coccinellids (0.46 per panicle) were recorded in lambdacyhalothrin 0.003 per cent. The population of coccinellids in treatments differed significantly at various periods after spray due to varying residual toxicity of these insecticides (Table 44).

In overall pooled results, interaction of treatment and period was found non-significant, however in terms of significance with respect to treatment efficacy, population of coccinellids was found significant indicating its peak (8.92

per panicle) in control (untreated) trees followed by endosulfan 0.07 per cent (6.58 per panicle) which was again at par with imidacloprid 0.005 per cent (5.26 per panicle) and thiamethoxam 0.0084 per cent (4.98 per panicle), whereas, the lowest number of coccinellids (1.27 per panicle) were noticed in lambdacyhalothrin 0.003 per cent followed by fenubucarb 0.05 per cent (2.22 per panicle) and carbosulfan 0.05 per cent (2.39 per panicle). The population of coccinellids in different treatments varied significantly at different periods after spray which could be due to varying residual toxicity of the test insecticides. The interaction of year and period as well as year, treatment and period was found non-significant indicating similarity in year wise results (Table 44). The order of effectiveness of different treatments was control (8.92) > endosulfan (6.58) > imidacloprid (5.26) > thiamethoxam (4.98) > diflubenzuron (4.61) > fipronil (4.30) > acetaprimid (3.91) > monocotophos (3.70) > profenofos (3.11) > carbosulfan (2.39) > fenubucarb (2.22) > lambdacyhalothrin (1.27) (Table 44).

Thus, it is evident from the data mentioned in Table 43-44 that population of natural enemies viz; predatory spiders and coccinellids differed significantly in different treatments as well as at different periods after spray application. The difference in population of these beneficial fauna could be due to varying levels of residual toxicity of these insecticides. It was found highest in untreated control followed by endosulfan which is said to be safer to natural enemies followed by imidacloprid and thiamethoxam, whereas, their population was found minimum in lambdacyhalothrin, the synthetic pyrethroid, thus confirming its toxicity to these natural enemies. The population of these natural enemies also varied due to fluctuation of hopper population in different treatments and at different periods after spray, indicating the synchronization of natural enemies with the pest i.e. mango hopper.

So, in the light of foregoing discussion, it may be concluded that higher population of natural enemies was found in untreated control as well as in endosulfan and least in synthetic pyrethroid lambdacyhalothrin.

4.7.4 Impact of mango hopper control on fruit setting and retention

Fruit setting

Three years pooled data presented in Table 45 indicated that different fruit setting as affected by different treatments were significant at pea, marble and harvest stages of the crop. All the insecticide treatments were found significantly superior over control.

Pea stage

The results of 2002 related to fruit setting (per hundred panicles per tree) at pea stage varied from 191.66-603.33 in different treatments indicating highest setting of 603.33 fruits per 100 panicles per tree in imidacloprid 0.005

per cent followed by thiamethoxam 0.0084 per cent (551.00 fruits per 100 panicles per tree), whereas, lowest fruits (apart from control) (237.66) were set in diflubenzuron 0.02 per cent. However all the test insecticides were found statistically superior over control.

Similarly in 2003, all the treatments were found significant over control showing highest fruit setting (495.00 fruits per 100 panicles per tree) in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (465.67), however lowest setting (other than control) of 178.00 fruits per 100 panicles per tree was recorded in diflubenzuron 0.02 per cent.

In the year 2004, highest number of fruits (464.67 per 100 panicles per tree) was set in imidacloprid 0.005 per cent, at pea stage of the crop followed by thiamethoxam 0.0084 per cent (425.33), whereas, the lowest setting of 133.33 fruits per hundred panicles per tree was recorded in diflubenzuron 0.02 percent, though all the test insecticides were found statistically superior over control (Table 45).

In pooled analysis, the highest setting of 518.43 fruits per hundred panicles per tree was recorded in imidacloprid 0.005 per cent followed by thiamethoxam 0.084 per cent (477.80) and monocrotrophos 0.04 per cent (447.25), whereas, the lowest fruit setting (179.86) (other than control) on hundred panicles per tree was recorded in diflubenzuron 0.02 per cent, though all the test insecticides were found statistically superior over control. The interaction of year and treatment was found non-significant indicating more or less same results in different years (2002, 2003 and 2004) of investigation (Table 45).

Marble stage

Looking to the fruit setting results at marble stage of the crop mentioned in Table 66, it shows that in 2002, all the insecticides proved their significant superiority over control being highest (346.66 fruits per 100 panicles per tree) in imidacloprid 0.005 per cent, while next in line of effectiveness was thiamethoxam 0.0084 per cent (272.00), whereas, the least effective insecticide was diflubenzuron 0.02 per cent (118.66) followed by carbosulfan 0.05 per cent (137.00) which did not differ significantly with it.

Similarly in the subsequent year, all the test insecticides were found significantly superior over control indicating highest fruit setting (327.00 fruits per 100 panicles per tree) in imidacloprid 0.005 per cent, while least effective insecticide was diflubenzuron 0.02 per cent indicating lowest fruit setting of 88.00 fruits per hundred panicles per tree (Table 45).

During third year of investigation (2004), all the insecticides were found significantly superior over control indicating highest fruit setting (251.00 fruits per 100 panicles per tree) in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (234.00), whereas, least was noticed in diflubenzuron 0.02 per cent (91.33).

In pooled analysis, all the test insecticides were found significantly superior over control indicating highest fruit setting (311.73 fruits per 100 panicles per tree) in imidacloprid 0.005 per cent, while next in line was thiamethoxam 0.0084 per cent (246.93) which did not differ significantly with monocrotophos 0.04 per cent (227.81) and acetaprimid 0.004 per cent (217.95), however, least effective insecticide (98.50) was diflubenzuron 0.02 per cent (Table 45).

Harvest stage

Fruit setting at harvest stages of the crop also varied significantly in different insecticide treatments and they were significantly superior over control.

During 2002, highest number of fruits (281.33 per hundred panicles per tree) were set in imidacloprid 0.005 per cent, while next in line was thiamethoxam 0.0084 per cent (181.00), however lowest fruit setting of 63.33 fruits per 100 panicles per tree was observed in diflubenzuron 0.02 per cent followed by control (64.33), carbosulfan 0.05 per cent (68.33), endosulfan 0.07 per cent (76.66) and lambdacyhalothrin 0.003 per cent (84.66) which did not differ significantly with it (Table 45).

During 2003, all the insecticide treatments were found significantly superior over control indicating highest fruit setting of 191.33 fruits per hundred panicles per tree in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (168.00) which was not statistically different from it, whereas, lowest fruit setting of 44.33 fruits per 100 panicles per tree was observed in control trees followed by diflubenzuron

Table 45: Impact of newer insecticides on fruit setting in mango

Sr. No.	Treatment	No. of fruits set/ 100 panicles at											
		Pea stage				Marble stage				Harvest stage			
		2002	2003	2004	Pooled	2002	2003	2004	Pooled	2002	2003	2004	Pooled
1.	Imidacloprid 0.005 %	24.55* (603.33)	22.25* (495.00)	21.54* (464.67)	22.78*(a) (518.43)	19.10* (346.66)	18.07* (327.00)	15.83* (251.00)	17.67*(a) (311.73)	16.76* (281.33)	13.83* (191.33)	13.00* (168.66)	14.53*(a) (210.62)
2.	Thiamethox-am 0.0084 %	23.43 (551.00)	21.58 (465.67)	20.61 (425.33)	21.87(b) (477.80)	16.46 (272.00)	15.46 (239.00)	15.26 (234.00)	15.73(b) (246.93)	13.44 (181.00)	12.96 (168.00)	12.20 (149.33)	12.87(b) (165.14)
3.	Acetaprimid 0.004 %	22.65 (513.33)	20.14 (405.67)	19.39 (375.67)	20.72(cd) (428.82)	15.47 (239.66)	14.82 (219.67)	14.05 (197.33)	14.78(bcd) (217.95)	11.63 (136.33)	11.79 (138.67)	11.34 (128.66)	11.59(bcd) (133.83)
4.	Fipronil 0.005 %	21.24 (451.00)	19.85 (394.00)	18.46 (340.67)	19.85(e) (393.52)	14.44 (208.33)	14.34 (205.33)	13.59 (184.33)	14.12(de) (198.87)	11.75 (138.66)	11.63 (135.33)	10.74 (115.33)	11.37(bcde) (128.78)
5.	Profenofos 0.1 %	20.19 (407.33)	19.60 (384.00)	18.06 (326.00)	19.28(ef) (371.22)	13.53 (182.66)	13.68 (187.00)	12.81 (164.00)	13.34(fgh) (177.46)	10.09 (101.66)	11.23 (126.00)	10.08 (101.33)	10.47(cdef) (109.12)
6.	Diflubenzuron 0.02 %	15.40 (237.66)	13.34 (178.00)	11.55 (133.33)	13.43(k) (179.86)	10.89 (118.66)	9.39 (88.00)	9.56 (91.33)	9.95(k) (98.50)	7.98 (63.33)	7.49 (56.33)	7.74 (59.66)	7.74(jk) (59.41)
7.	Lambdacyhaloth rin0.003 %	17.48 (305.33)	16.44 (270.33)	15.47 (240.00)	16.46(i) (270.43)	12.27 (150.33)	12.48 (155.67)	12.64 (159.67)	12.46(fghi) (154.75)	9.22 (84.66)	8.35 (69.67)	11.41 (130.66)	9.66(fgh) (92.82)
8.	Carbosulfan 0.05 %	16.30 (265.66)	14.96 (223.63)	14.47 (209.00)	15.24(j) (231.76)	11.72 (137.00)	12.18 (148.33)	11.27 (126.67)	11.72(ij) (136.86)	8.29 (68.33)	8.06 (64.67)	9.14 (83.66)	8.50(ghij) (71.75)

9.	Fenubucarb 0.05 %	19.02 (362.00)	18.10 (327.60)	17.27 (298.33)	18.13(g) (328.20)	13.08 (171.00)	13.33 (177.33)	13.05 (170.00)	13.15(defg) (172.42)	9.37 (87.33)	9.61 (92.00)	10.44 (108.66)	9.80(fg) (95.54)
10.	Endosulfan 0.07 %	18.17 (330.00)	18.02 (324.67)	16.98 (288.00)	17.72(gh) (313.50)	12.47 (155.33)	12.94 (167.33)	12.83 (164.33)	12.75(fgh) (162.06)	8.77 (76.66)	8.84 (78.00)	10.41 (108.00)	9.34(fghi) (86.74)
11.	Monocrotop-hos 0.04 %	23.16 (536.66)	20.59 (424.00)	19.73 (189.00)	21.16(bc) (447.25)	15.70 (246.33)	15.20 (231.00)	14.45 (208.67)	15.11(bc) (227.81)	11.79 (138.66)	11.92 (142.00)	11.21 (125.66)	11.64(bc) (134.99)
12.	Control (Untreated)	13.85 (191.66)	11.37 (129.67)	11.34 (128.33)	12.19(l) (148.10)	9.41 (88.33)	7.89 (63.00)	8.24 (68.33)	8.51(l) (71.92)	7.38 (64.33)	6.63 (44.33)	6.73 (45.33)	6.91(kl) (47.25)
SEm ± (T) SEm ± (YXT)		0.470 --	0.373 --	0.4087 --	0.254 0.419	0.353 --	0.433 --	0.416 --	0.332 0.402	0.436 --	0.421 --	0.413 --	0.524 0.423
CD at 5 % (T) CD at % % (YxT)		1.379 --	1.096 --	1.197 --	0.716 NS	1.036 --	1.272 --	1.22 --	0.978 1.137	1.279 --	1.235 --	1.213 --	1.539 1.197
CV (%)		4.15	3.59	4.14	3.98	4.46	5.63	5.63	5.25	7.16	7.15	6.90	7.08

*√x + 0.5 values Figures in parenthesis indicate original values Figures followed by same letters do not differ significantly as per DMRT

0.02 per cent indicating fruit setting of 56.33 per hundred panicles per tree and did not differ significantly with it (Table 45).

During 2004, all the test insecticides were found significantly superior over control indicating highest fruit setting (168.66 fruits per 100 panicles per tree) in imidacloprid 0.005 per cent, whereas, lowest fruit setting of 45.33 was observed in control trees , though it did not differ significantly with diflubenzuron 0.02 per cent (59.66) (Table 45).

In pooled analysis, all the insecticides were again found superior over control recording highest fruit setting of 210.62 fruits per 100 panicles per tree in imidacloprid 0.005 per cent, next in line were thiamethoxam 0.0084 per cent (165.14), monocrotophos 0.04 per cent (134.99), acetaprimid 0.004 per cent (133.83) and fipronil 0.005 per cent (128.78), whereas, lowest fruit setting of 47.25 fruits per 100 panicles per tree was indicated in control trees followed by diflubenzuron 0.02 per cent (59.41) which was at par with it (Table 45).

Thus, it may be concluded from the results indicated in Table 45 that highest fruit setting was indicated in imidacloprid 0.005 per cent at all the stages of fruit growth i.e. pea, marble and harvest followed by thiamethoxam 0.0084 per cent, whereas, lowest fruit setting was observed in diflubenzuron 0.02 per cent, confirms its inability to control mango hopper thereby led to its inability to reduce mango hopper associated subsequent damage leading either to fruit dropping or less retention. In fact, diflubenzuron 0.02 per cent was found at par with control at harvest stage of the crop growth, whereas, insecticides *viz*; carbosulfan 0.05 per cent, endosulfan 0.07 per cent, lambdacyhalothrin 0.003 per cent and fenubucarb 0.05 per cent were not as effective as imidacloprid 0.005 per cent, thiamethoxam 0.0084 percent, monocrotophos 0.04 per cent, acetaprimid 0.004 per cent and fipronil 0.005 per cent in terms of fruit setting at pea, marble and harvest stages of crop growth.

Fruit retention

Number of fruits retained at marble (over pea) and harvest (over marble) stages of the crop has been assessed in this investigation so as to study the impact of newer insecticides on mango hopper control and is expressed as percentage of fruit retention.

Fruit retention at marble over pea stage remained highest in the treatment of imidacloprid 0.005 per cent (60.66 per cent) in 2002. However, lowest retention was noticed in profenofos 0.1 per cent (44.85 per cent) followed by monocrotophos 0.04 per cent (45.88 per cent), control (46.08 per cent), acetaprimid 0.004 per cent (46.58 per cent), endosulfan 0.07 per cent (47.02 per cent) and fenubucarb 0.05 per cent (47.26 per cent) (Table 46). During the subsequent year, fruit retention in all the treatments was statistically similar, however, it was highest in imidacloprid 0.005 per cent (66.41 per cent) and lowest (47.97 per cent) in control (Table 46). In the third year of investigation, diflubenzuron 0.02 per cent showed highest fruit retention (68.39 per cent) followed by lambdacyhalothrin 0.003 per cent

(66.88 per cent), whereas, lowest (50.21 per cent) was noticed in profenofos 0.1 per cent followed by acetaprimid 0.004 per cent (52.52 per cent) and control (52.65 per cent) which were at par with it (Table 46).

Pooled data indicated highest (45.63 per cent) fruit retention (marble over pea stage) in imidacloprid 0.005 per cent, though it did not differ significantly with carbosulfan 0.02 per cent (45.23 per cent), lambdacyhalothrin 0.003 per cent (44.77 per cent) and diflubenzuron 0.02 per cent (44.20 per cent). On the other hand, lowest fruit retention was noticed in profenofos 0.1 per cent (41.44 per cent), control (41.73 per cent), fipronil 0.005 per cent (42.36 per cent), acetaprimid 0.004 per cent (42.48 per cent), monocrotophos 0.04 per cent (42.53 per cent), thiamethoxam 0.0084 per cent (42.55 per cent), endosulfan 0.07 per cent (42.76 per cent), fenubucarb 0.05 per cent (43.05 per cent) and diflubenzuron 0.02 per cent (44.20 per cent) Interaction of year and treatment was found significant indicating consistency of year wise results (Table 46).

Similarly, fruit retention at harvest over marble stage in 2002 was highest (77.30 per cent) in imidacloprid 0.005 per cent followed by thiamethoxam 0.0084 per cent (66.88 per cent) which was at par with, whereas, lowest retention (49.30 per cent) was found in endosulfan 0.07 per cent, which had statistically similar fruit retention with all the treatments except imidacloprid 0.005 per cent and thiamethoxam 0.0084 per cent (Table 46). In 2003, highest fruit retention (71.06 per cent) was noticed in thiamethoxam 0.0084 per cent followed by control (70.40 per cent), profenofos

0.1 per cent (67.60 per cent), fipronil 0.005 per cent (65.73 per cent), acetaprimid 0.004 per cent (63.58 per cent), diflubenzuron 0.02 per cent (63.39 per cent) and monocrotophos

Table 46: Impact of newer insecticides on fruit retention in mango

Sr. No.	Treatment	Fruit retention (%) on 100 panicles/tree at								Rank (at marble over pea stage)
		Marble over pea stage				Harvest over marble stage				
		2002	2003	2004	Pooled	2002	2003	2004	Pooled	
1.	Imidacloprid 0.005 %	51.16* (60.66)	54.79* (66.41)	47.44* (54.27)	51.13* (a) (45.63)	61.86* (77.30)	49.91* (58.57)	55.31* (67.58)	55.69* (48.16)	**1**
2.	Thiamethoxam 0.0084 %	44.55 (49.25)	45.72 (51.30)	47.69 (54.72)	45.99 (defg) (42.55)	54.86 (66.88)	57.90 (71.06)	53.22 (64.11)	55.33 (48.04)	**7**
3.	Acetaprimid 0.004 %	43.02 (46.58)	47.63 (54.57)	46.43 (52.52)	45.69 (defghi) (42.48)	49.61 (57.68)	52.92 (63.58)	53.81 (65.15)	52.11 (46.20)	**9**
4.	Fipronil 0.005 %	42.78 (46.16)	46.27)52.26)	47.36 (54.16)	45.47 (defghij) (42.36)	46.13 (51.89)	54.19 (65.73)	52.26 (62.50)	50.86 (45.46)	**10**
5.	Profenofos 0.1 %	42.02 (44.85)	44.28 (48.79)	45.09 (50.21)	43.80 (efghijkl) (41.44)	48.18 (55.55)	55.41 (67.60)	52.00 (62.10)	51.86 (46.03)	**12**
6.	Diflubenzuron 0.02 %	44.88 (49.84)	45.19 (50.36)	55.80 (68.39)	48.63 (abcd) (44.20)	47.27 (53.99)	52.82 (63.39)	53.89 (65.31)	51.33 (45.75)	**4**
7.	Lambdacyhalothrin 0.003 %	44.55 (49.26)	49.50 (57.81)	54.85 (66.88)	49.63 (abc) (44.77)	48.59 (56.30)	41.91 (44.68)	66.25 (82.54)	52.25 (46.26)	**3**
8.	Carbosulfan 0.05 %	45.92 (51.65)	54.41 (66.14)	51.07 (40.55)	50.47 (ab) (45.23)	44.93 (49.93)	41.78 (44.53)	54.25 (65.73)	46.99 (43.22)	**2**
9.	Fenubucarb 0.05 %	43.41 (47.26)	47.40 (54.23)	48.99 (56.99)	46.60 (cde) (43.05)	45.66 (51.19)	46.05 (51.87)	53.13 (64.01)	48.28 (43.97)	**5**
10.	Endosulfan 0.07 %	43.27 (47.02)	46.07 (51.88)	49.07 (57.11)	46.13 (def) (42.76)	44.57 (49.30)	42.93 (46.43)	54.13 (65.68)	47.21 (43.39)	**6**
11.	Monocrotophos 0.04 %	42.61 (45.88)	47.64 (54.61)	47.03 (53.58)	45.76 (defgh) (42.53)	48.76 (56.55)	51.62 (61.49)	50.79 (60.07)	50.39 (45.17)	**8**
12.	Control (Untreated)	42.73 (46.08)	43.79 (47.97)	46.52 (52.65)	44.34 (efghijk) (41.73)	51.60 (61.34)	57.01 (70.40)	54.93 (66.90)	54.51 (47.58)	**11**
	SEm ± (T) SEm ± (YXT)	0.733 --	2.57 --	1.544 --	1.151 1.785	2.823 --	2.527 --	2.517 --	2.830 2.626	

CD at 5 % (T) CD at % % (YxT)	2.150 --	NS --	1.531 --	3.242 NS	8.281 --	7.414 --	7.384 --	NS 7.422	
CV (%)	2.87	9.35	5.47	6.58	9.91	8.69	8.00	8.85	

* ARCSINE values

Figures in parenthesis indicate original values

Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

0.04 per cent (61.49 per cent) which were statistically similar to it, whereas lowest (44.53 per cent) fruit retention was noticed in carbosulfan 0.05 per cent (44.53 per cent) followed by lambdacyhalothrin 0.003 per cent (44.68 per cent), endosulfan 0.07 per cent (46.43 per cent) and fenubucarb 0.05 per cent (51.87 per cent) (Table 46). In the third year of investigation, highest fruit retention (82.54 per cent) was observed in lambdacyhalothrin 0.003 per cent, whereas, lowest (60.07 per cent) was recorded in monocrotophos 0.04 per cent, though it did not differ significantly with all the treatments except lambdacyhalothrin 0.003 per cent (Table 46).

In pooled analysis, all the treatments showed statistically similar fruit retention, however highest (48.16 per cent) and lowest (43.22 per cent) fruit retentions at harvest over marble stage was observed in imidacloprid 0.005 per cent and carbosulfan 0.05 per cent, respectively (Table 46).

Thus, it is evident from the data indicated in Table 46 that there was great variation in year wise results of fruit retention at marble (over pea) as well as harvest (over marble) stages of crop growth, yet it is confirmed that imidacloprid 0.005 per cent indicated highest fruit retention at both the crop stages as compared to other treatments. Posible variation in fruit retention in different treatments could be due to variation in fruit dropping, which was again observed highest in imidacloprid 0.005 per cent and lowest in diflubenzuron 0.003 per cent at marble over pea stage, thus confirms linkage of efficacy of treatment with fruit retention.

The order of effectiveness on the basis of per cent fruit retention at marble (over pea) stage was imidacloprid (45.63 per cent) >

carbosulfan (45.23 per cent) > lambdacyhalothrin (44.77 per cent) > diflubenzuron (44.20) > fenubucarb (43.05 per cent) > endosulfan (42.76 per cent) > thiamethoxam (42.55 per cent) > monocrotophos (42.53 per cent) > acetaprimid (42.48 per cent) > fipronil (42.36 per cent) > control (41.73 per cent) > profenofos (41.44 per cent), whereas fruit retention at harvest (over marble) stage was statistically similar (Table 46).

4.7.5 Total number of sprays

Total number of sprays required in each of the insecticidal treatments have been worked out from Table 1-3 in which insecticidal

Table 47: Number of sprays of various insecticides

Sr. No.	Treatment	Number of sprays				
		2002	2003	2004	Av.	Rank
1.	Imidacloprid 0.005 %	3*	3	3	3	**1**
2.	Thiamethoxam 0.0084 %	3	3	3	3	**1**
3.	Acetaprimid 0.004 %	4**	4	4	4	**2**
4.	Fipronil 0.005 %	4	4	4	4	**2**
5.	Profenofos 0.1 %	4	4	4	4	**2**
6.	Diflubenzuron 0.02 %	6***	6	6	6	**3**
7.	Lambdacyhalothrin 0.003 %	6	6	6	6	**3**
8.	Carbosulfan 0.05 %	6	6	6	6	**3**
9.	Fenubucarb 0.05 %	4	4	4	4	**2**
10.	Endosulfan 0.07 %	6	6	6	6	**3**
11.	Monocrotophos 0.04 %	4	4	4	4	**2**
12.	Control (Untreated)	--	--	--	**--**	**--**

*	Three sprays at 21 days interval

**	Four sprays at 15 days interval

***	Six sprays at 10 days interval

treatments were given on need basis application to keep the hopper population below adhoc threshold level i.e. five hoppers per inflorescence have been shown. The same is presented in Table 47. It is evident from the data that there is difference in number of sprays in different treatments. The treatments of imidacloprid 0.005 per cent and thiamethoxam 0.0084 per cent were required thrice (2002, 2003, 2004 and mean of three years) to keep the hopper population below ETL during the course of investigation as compared to four sprays (2002, 2003, 2004 and mean of three years) needed in the treatments of monocrotophos 0.04 per cent, acetaprimid 0.004 per cent, fipronil 0.005 per cent, profenofos 0.1 per cent and fenubucarb 0.05 per cent. Similarly, insecticides having short persistence viz; endosulfan 0.07 per cent, lambdacyhalothrin 0.003 per cent, carbosulfan 0.05 per cent and diflubenzuron 0.02 per cent were sprayed six times (2002, 2003, 2004 and mean of three years) to keep hopper population below ETL.

4.7.6 Number of insecticide sprays required during growth period of fruit

Total number of insecticidal sprays required from initiation of flowering to pea nut, from pea nut to marble and from marble to harvest stages in different insecticide treatments varied differently being lowest **(one spray during initiation of flowering to pea nut)** (2002, 2003, 2004 and mean of three years) in imidacloprid 0.005 per cent and thiamethoxam 0.0084 per cent treatments, whereas remaining insecticide treatments were sprayed twice to keep hopper population below ETL (Table 48).

Similarly, imidacloprid 0.005 per cent, monocrotophos 0.04 per cent , acetaprimid 0.004 per cent, fipronil 0.005 per cent, profenofos 0.01 per cent and fenubucarb 0.05 per cent were required once for spray

Table 48: Number of sprays required between different growth

Sr. No.	Treatment	Number of sprays required from												Total sprays /year
		Initiation of flowering to pea stage				Pea to marble stage				Marble to harvest stage				
		2002	2003	2004	Av.	2002	2003	2004	Av.	2002	2003	2004	Av.	
1.	Imidacloprid 0.005 %	1	1	1	**1**	1	1	1	**1**	1	1	1	**1**	**3**
2.	Thiamethoxam 0.0084 %	1	1	1	**1**	2	2	2	**2**	0	0	0	**0**	**3**
3.	Acetaprimid 0.004 %	2	2	2	**2**	1	1	1	**1**	1	1	1	**1**	**4**
4.	Fipronil 0.005 %	2	2	2	**2**	1	1	1	**1**	1	1	1	**1**	**4**
5.	Profenofos 0.1 %	2	2	2	**2**	1	1	1	**1**	1	1	1	**1**	**4**
6.	Diflubenzuron 0.02 %	2	2	2	**2**	3	3	3	**3**	1	1	1	**1**	**6**
7.	Lambdacyhalothrin 0.003 %	2	2	2	**2**	3	3	3	**3**	1	1	1	**1**	**6**
8.	Carbosulfan 0.05 %	2	2	2	**2**	3	3	3	**3**	1	1	1	**1**	**6**
9.	Fenubucarb 0.05 %	2	2	2	**2**	1	1	1	**1**	1	1	1	**1**	**4**
10.	Endosulfan 0.07 %	2	2	2	**2**	3	3	3	**3**	1	1	1	**1**	**6**
11.	Monocrotophos 0.04 %	2	2	2	**2**	1	1	1	**1**	1	1	1	**1**	**4**
12.	Control (Untreated)	--	--	--	**--**	--	--	--	**--**	--	--	--	**--**	**--**

application to keep hopper population below ETL **during pea nut to marble stage**, followed by two sprays of thiamethoxam 0.0084 per cent. Maximum numbers of sprays (three) were required in case of endosulfan 0.07 per cent, carbosulfan 0.05 per cent, lambdacyhalothrin 0.003 per cent and diflubenzuron 0.02 per cent to keep the population below ETL (2002, 2003, 2004 and mean of three years) (Table 48). Thiamethoxam 0.0084 per cent was not required for any spray from marble to harvest stage of the crop (2002, 2003, 2004 and mean of three years); the remaining insecticidal treatments were sprayed once during the same period (Table 48).

Overall, imidacloprid 0.005 per cent and thiamethoxam 0.0084 per cent were required for three sprays every year (initiation of flowering to pea nut, pea nut to marble and marble to harvest stages of the crop) followed by four sprays every year in case of monocrotophos 0.04 per cent, acetaprimid 0.004 per cent, fipronil 0.005 per cent, profenofos 0.1 per cent and fenubucarb 0.05 per cent i.e. total four sprays. Maximum number of sprays (six every year) was required in case of endosulfan 0.07 per cent, lambdacyhalothrin 0.003 per cent, carbosulfan 0.05 per cent and diflubenzuron 0.02 per cent (Table 48).

4.7.7 Fruit yield

The three years pooled data on production (fruit bearing and yield per tree) presented in Table 49 revealed that differences in production by different treatments were significantly superior over control. Tree bearing was recorded as number of fruits obtained from each experimental tree. It was highest in the treatment of imidacloprid 0.005 per cent in 2002 (297.33 fruits per tree). Next in line was thiamethoxam 0.0084 per cent (203.33 fruits per tree), whereas, lowest tree bearing of 73.00 fruits per tree was observed in control followed by diflubenzuron 0.02 per cent (82.00 fruits per tree), endosulfan 0.07 per cent (99.33 fruits per tree) and lambdacyhalothrin 0.003 per cent (105.66 fruits per tree) which were statistically different from it. Similarly, in 2003, imidacloprid 0.005 per cent recorded highest fruit bearing (227.66 fruits per tree) followed by thiamethoxam 0.0084 per cent (206.33 fruits per tree), whereas lowest (66.33 fruits per tree) was observed in control though, it did not differ significantly with diflubenzuron 0.02 per cent (67.66 fruits per tree), carbosulfan 0.05 per cent (82.66 fruits per tree) and lambdacyhalothrin 0.003 per cent (88.33 fruits per tree). In the third year of investigation, imidacloprid 0.005 per cent with 195.00 fruits per tree stood as the best treatment followed by thiamethoxam 0.0084 per cent (178.66) and monocrotophos 0.04 per cent (171.00), however, least number (68.00) of fruits per tree were indicated in control, though there was no significant difference with diflubenzuron 0.02 per cent (89.00 fruits per tree) (Table 49).

In pooled analysis, imidacloprid (0.005 per cent) with 240.00 fruits per tree was the best treatment and was statistically superior over rest of the treatments. Next best was thiamethoxam 0.0084 per cent (196.11 fruits per tree) followed by monocrotophos 0.04 per cent (174.44), acetaprimid 0.004 per cent (164.00) and fipronil 0.005 per cent (160.88) which were statistically similar to it, however control trees indicated lowest bearing of 69.11 fruits per tree followed by diflubenzuron 0.02 per cent (79.55 fruits per tree) and carbosulfan 0.05 per cent (92.66 fruits per tree) (Table 49).

Similarly with regards to yield, highest yield of 74.33 (2002), 56.91 (2003), 48.75 (2004) and 60.00 kg per tree (pooled) was obtained

Table 49: Mango production in various treatments

Sr. No.	Treatment	Mango production per tree							
		No. of fruits				Yield (Kg)			
		2002	2003	2004	Pooled	2002	2003	2004	Pooled
1.	Imidacloprid 0.005 %	297.33	227.66	195.00	240.00 (a)	74.33	56.91	48.75	60.00 (a)
2.	Thiamethoxam 0.0084 %	203.33	206.33	178.66	196.11 (b)	50.75	51.83	44.33	48.97 (b)
3.	Acetaprimid 0.004 %	157.66	170.66	163.66	164.00 (bcd)	39.00	42.58	41.00	40.86 (bcd)
4.	Fipronil 0.005 %	161.33	159.66	161.66	160.88 (bcde)	40.16	39.75	40.50	40.13 (bcde)
5.	Profenofos 0.1 %	123.66	154.66	159.00	145.77 (cdef)	31.00	38.66	38.01	35.89 (cdef)
6.	Diflubenzuron 0.02 %	82.00	67.66	89.00	79.55 (hijk)	20.33	16.91	26.56	21.27 (hijk)
7.	Lambdacyhalothrin 0.003 %	105.66	88.33	156.33	116.77 (fghi)	26.33	22.00	40.46	29.60 (efgh)
8.	Carbosulfan 0.05 %	89.33	82.66	106.00	92.66 (ghij)	22.58	20.66	28.00	23.75 (ghij)
9.	Fenubucarb 0.05 %	118.33	122.33	158.66	133.11 (defg)	29.33	30.50	39.66	33.16 (defg)
10.	Endosulfan 0.07 %	99.33	99.66	158.66	119.22 (fgh)	24.58	24.30	39.66	29.51 (efghi)

11.	Monocrotophos 0.04 %	164.66	187.66	171.00	174.44 (bc)	41.00	49.56	43.00	44.52 (bc)
12.	Control (Untreated)	73.00	66.33	68.00	69.11 (jkl)	18.33	19.46	20.46	19.42 (hijkl)
	SEm ± (T) SEm ± (YXT)	12.605 --	8.305 --	8.207 --	13.842 9.920	3.133 --	2.187 --	1.883 --	3.636 2.459
	CD at 5 % (T) CD at % % (YxT)	36.971 --	24.361 --	24.074 --	40.602 28.030	9.190 --	6.416 --	5.525 --	10.663 7.215
	CV (%)	15.64	10.57	9.66	12.19	15.59	11.01	8.69	11.97

*√x + 0.5 values Figures followed by the same letters do not differ significantly as per Duncan's multiple range test (DMRT)

from imidacloprid 0.005 per cent treated trees. The next treatment in order of effectiveness (pooled yield) was thiamethoxam 0.0084 per cent (48.97 kg per tree), followed by monocrotophos 0.04 per cent (44.52 kg per tree), acetaprimid 0.004 per cent (40.86 kg per tree) and fipronil 0.005 per cent (40.13 kg per tree). However, lowest yield in an insecticide treatment was recorded in diflubenzuron 0.02 per cent (21.27 kg per tree), which was at par with lambdacyhalothrin 0.003 per cent (29.60 kg per tree), endosulfan 0.07 per cent (29.51 kg per tree) and control (19.42 kg per tree). The order of effectiveness on the basis of yield was imidacloprid (60.00 kg per tree) > thiamethoxam (48.97 kg per tree) > monocrotophos (44.52 kg per tree) > acetaprimid 0.004 per cent (40.86 kg per tree) > fipronil (40.13 kg per tree) > profenofos (35.89 kg per tree) > fenubucarb (33.16 kg per tree) > lambdacyhalothrin (29.60 kg per tree) > endosulfan (29.51 kg per tree) > carbosulfan (23.75 kg per tree) > diflubenzuron (21.27 kg per tree) > control (19.42 kg per tree) (Table 49).

4.7.8 Economics of various insecticides

It is evident from the data on economics of different insecticide treatments (Table 50) that treatment of imidacloprid 0.005 per cent resulted in the highest estimated yield (6000 kg per ha.), gross realization (Rs 90000.00 per ha.), net realization (Rs 83520.00 per ha.), realization over control (Rs 54390.00 kg per tree) and ICBR (1 : 8.39 per ha.), followed by thiamethoxam 0.0084 per cent (ICBR : 1: 7.63) and monocrotophos 0.04 per cent (ICBR 1 : 6.59), whereas, fipronil 0.005 per cent was the least economical treatment (ICBR 1 : 0.16). Treatments of endosulfan (ICBR 1 : 0.32) , carbosulfan 0.05 percent (ICBR 1 : 0.70), lambdacyhalothrin 0.005 per cent (ICBR 1 : 0.77), diflubenzuron 0.02 per cent (ICBR 1 : 0.92) and profenofos 0.1 per cent (ICBR 1 : 0.93) were also uneconomical as they gave negative economics.

Table 50: Economics of different insecticidal treatments tested against mango hopper on mango (cv. Alphonso)

Sr. No.	Treatment	Total no. of sprays requ-ired	Cost of insecticides (Rs/ha.)	Labour Cost (Rs/ha.)	Total cost (Rs/ha.)	Fruit yield (Kg/ha)	Gross Realization /Rank (Rs/ha.)	Net realization/ Rank (Rs/ha.)	Realization over control /Rank (Rs/ha.)	ICBR /Rank
1.	Imidacloprid 0.005 %	3	5880.00	600.00	6480.00	6000.00	90000.00 **1**	83520.00 **1**	54390.00 **1**	1:8.39 **1**
2.	Thiamethoxam 0.0084 %	3	4536.00	600.00	5136.00	4897.00	73455.00 **2**	68319.00 **2**	39189.00 **2**	1:7.63 **2**
3.	Acetaprimid 0.004 %	4	8000.00	800.00	8800.00	4086.00	61290.00 **4**	52490.00 **4**	23360.00 **4**	1:2.65 **4**
4.	Fipronil 0.005 %	4	26000.00	800.00	26800.00	4013.00	60195.00 **5**	33395.00 **8**	4265.00 **8**	1:0.16 **11** (-)
5.	Profenofos 0.1 %	4	12000.00	800.00	12800.00	3589.00	53835.00 **6**	41035.00 **6**	11905.00 **6**	1:0.93 **6**

										(-)
6.	Diflubenzuron 0.02 %	6	34080.00	1200.00	35280.00	2127.00	31905.00 **11**	3375.00 (-) **12**	32505.00 (-) **11**	1:0.92 **7** (-)
7.	Lamdacyhalothrin 0.005 %	6	7200.00	1200.00	8400.00	2960.00	44000.00 **9**	35600.00 **7**	6470.00 **7**	1:0.77 **8** (-)
8.	Carbosulfan 0.05 %	6	21000.00	1200.00	22200.00	2375.00	35625.00 **10**	13625.00 **11**	15505.00 (-) **10**	1:0.70 **9** (-)
9.	Fenubucarb 0.05 %	4	7000.00	800.00	7800.00	3316.00	49740.00 **7**	41940.00 **5**	12810.00 **5**	1:1.64 **5**
10.	Endosulfan 0.07 %	6	10500.00	1200.00	11700.00	2951.00	44265.00 **8**	32925.00 **9**	3795.00 **9**	1:0.32 **10** (-)
11.	Monocrotophos 0.04 %	4	4160.00	800.00	4960.00	4452.00	66780.00 **3**	61820.00 **3**	32690.00 **3**	1:6.59 **3**
12.	Control (Untreated)	3*	---	--	--	1942.00	29130.00 **12**	29130.00 **10**	--	--

Quantity of spray fluid used : 25 lit/tree or 2500 litres/ha.

Price of marketable fruits (Alphonso-mango) : Rs 15.00/Kg (Rs 300/20 Kg)

Labour cost : Rs 50/day

No. of labours employed per spray : 4

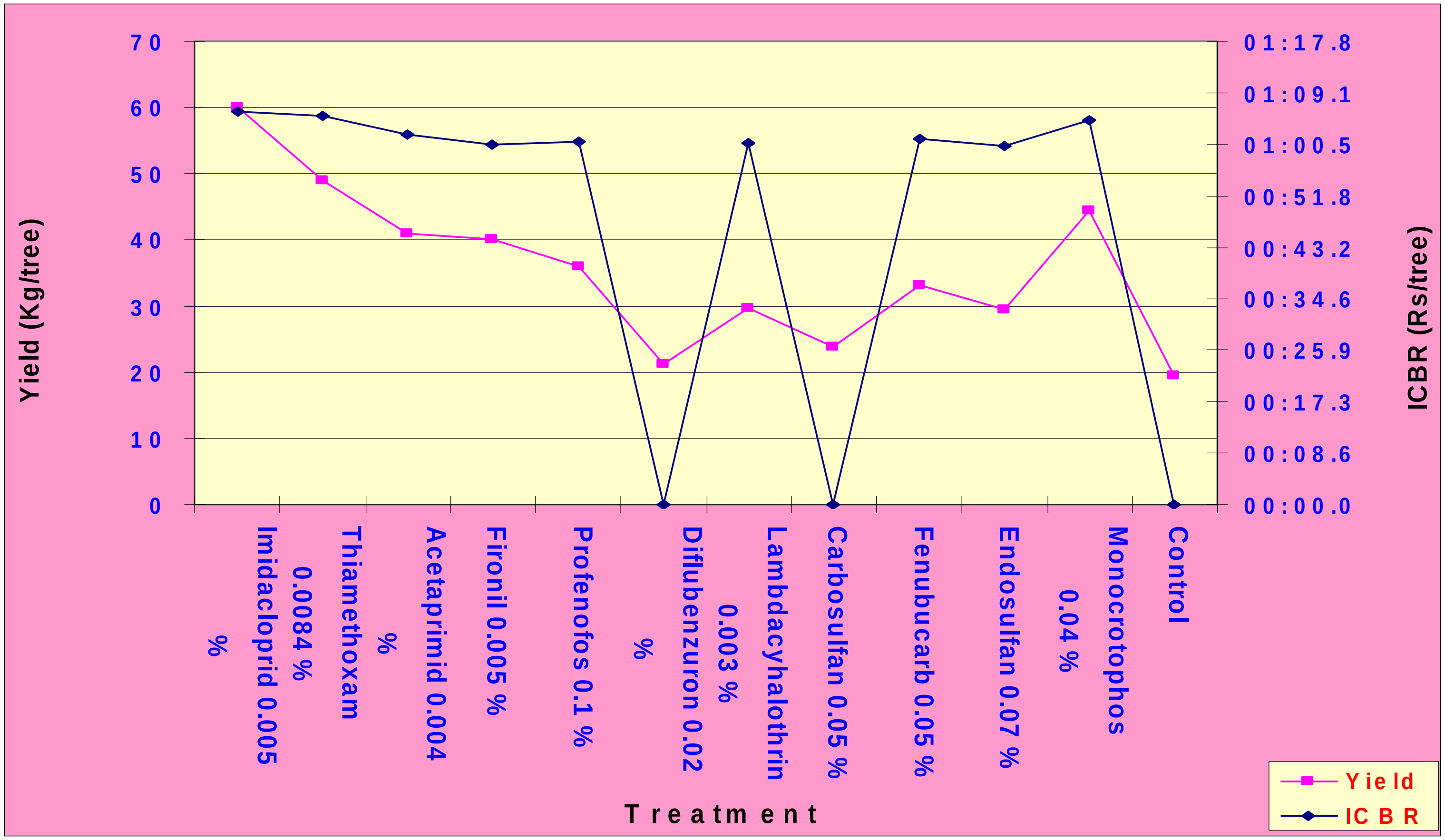


Fig. 12: Mango production and economics in various treatments

4.7.9 Rank of treatments

Evaluation of different insecticides for mango hopper control has been done on the basis of different characters selected for the investigation. Highest rank index (1.25) and rank 1 has been bagged by the treatment of imidacloprid 0.005 per cent which stood as the most effective treatment (rank 1) on the basis of all the characters except toxicity to natural enemies. As far as toxicity to natural enemies is concerned, it was found safest to both the groups of natural enemies next to control (untreated) and endosulfan 0.07 per cent.

The next best treatment was thiamethoxam 0.0084 per cent (av. rank index 2.25 and av. rank 2), followed by monocrotophos 0.04 per cent (av. rank index 3.63 and av. rank 3). Least effective treatment was diflubenzuron 0.02 per cent (av. rank index 11.00 and av. rank 11). The order of effectiveness on the basis of rank was imidacloprid 0.005 per cent (1) > thiamethoxam 0.0084 per cent (2) > monocrotophos 0.04 per cent (3) > acetaprimid 0.004 per cent (4) > fipronil 0.005 per cent (5) > profenofos 0.1 per cent (6) > fenubucarb 0.05 per cent (7) > endosulfan 0.07 per cent (8) > lamdacyhalothrin 0.003 per cent (9) > control (untreated) (10) = carbosulfan 0.05 per cent (10) > diflubenzuron 0.02 per cent (11) (Table 51).

These studies thus revealed that considering the overall performance of test insecticides, imidacloprid 0.005 per cent was the most effective insecticide for the suppression of mango hopper in mango (cv. 'Alphonso') in south Gujarat. The treatment of imidacloprid 0.005 per cent

Table 51: Ranking of various insecticide treatments based on efficacy, yield and economics

Sr. No.	Treatment	Ranking on the basis of									Average rank index	Overall rank
		Efficacy of insecticides on the basis of			No. of sprays	Yield	Gross realiz-ation	Net realiz-ation	Realization over control	ICBR		
		Hopper population	Sooty mold	Toxicity to natural enemies								
1.	Imidacloprid 0.005 %	1	1	3	1	1	1	1	1	1	1.22	**1**
2.	Thiamethoxam 0.0084 %	2	2	4	1	2	2	2	2	2	2.11	**2**
3.	Acetaprimid 0.004 %	4	4	7	2	4	4	4	4	4	4.11	**4**
4.	Fipronil 0.005 %	5	5	6	2	5	5	8	8	11	6.11	**6**
5.	Profenofos 0.1 %	6	6	9	2	6	6	6	6	6	5.89	**5**
6.	Diflubenzuron 0.02 %	11	11	5	3	11	11	12	11	7	9.11	**9**
7.	Lamdacyhalothrin 0.005 %	9	9	12	3	8	9	7	7	8	8.00	**8**
8.	Carbosulfan 0.05 %	10	10	11	3	10	10	11	10	9	9.33	**10**
9.	Fenubucarb 0.05 %	7	7	10	2	7	7	5	5	5	6.11	**6**

10.	Endosulfan 0.07 %	8	8	2	3	9	8	9	9	10	7.33	**7**
11.	Monocrotophos 0.04 %	3	3	8	2	3	3	3	3	3	3.44	**3**
12.	Control (Untreated)	12	12	1	--	12	12	10	--	--	9.83	**11**

not only recorded lowest, hopper population (2.22 per panicle), sooty mold damage (2.39 SM grade), but also resulted in the highest fruit setting at pea (346.66 per hundred panicles per tree), marble (311.73 fruits per hundred panicles per tree) and harvest (210.62 fruits per hundred panicles per tree) of crop thus proving their significant superiority over rest of the treatments in mango hopper control by providing highest, tree bearing (240.00 fruits per tree) and yield (60.00 kg per tree or 6000 kg per ha.). Looking to the economics, it assisted in providing highest, gross realization (Rs 90000.00 per ha.), net realization (Rs 80907.00 per ha.), economic realization over control (Rs 54990.00 Kg per ha.) and ICBR (1: 6.05), besides being comparatively safer to natural enemies as it recoded lowest population of predatory spiders (4.74 per panicle) and coccinellids (5.26 per panicle) next to control (untreated) and endosulfan 0.07 per cent. In terms of overall effectiveness against mango hopper, imidacloprid 0.005 per cent was closely followed by thiamethoxam 0.0084 per cent (ICBR 1: 5.13), monocrotophos 0.04 per cent (ICBR 1:4.40) and acetaprimid 0.004 per cent (ICBR 1: 2.10), whereas, treatments of diflubenzuron 0.02 per cent (ICBR 1:0.84 (-)) and carbosulfan 0.05 per cent (ICBR 1:0.53 (-)) were totally ineffective in reducing the hopper population. Fipronil 0.005 per cent though proved almost as effective (yield 4013 kg per ha.) as thiamethoxam (yield 4897 kg per ha.), monocrotophos (4452 kg per ha.) and acetaprimid (4086 kg per ha.) against mango hopper, but proved comparatively less economical because of its higher cost of spraying (Rs 29413 per ha) as compared to those of monocrotophos (Rs 7573 per ha.), thiamethoxam (Rs 7749 kg per ha.), and acetaprimid (Rs 11413 per ha.). As far as effectiveness of profenofos 0.1 per cent, fenubucarb 0.05 per cent, lambdacyhalothrin 0.003 per cent and endosulfan 0.07 per cent against mango hopper is concerned, they were initially (after one and seven days of spraying) found very effective in reducing the hopper population, but their period of effectiveness was short lived and required more number of applications than imidacloprid 0.005 per cent and thiamethoxam 0.0084 per cent, thus proved uneconomical. The latter kept the hopper population below economic threshold level (5 hoppers per twig or inflorescence) up to twenty one days of spraying. This has been confirmed by a study based on total number of sprays and number of sprays required from initiation of flowering to pea nut, pea nut to marble and marble to harvest stages of the crop growth (Table 47-48). According to Dattataraya (1998), Godase (1998), Godase and Bhole (2002), imidacloprid has been proved very effective against mango hopper up to 21 days of spraying, whereas, Verghese (2000) in Karnataka and Kudagamage (2001) in Sri Lanka found it comparable to monocrotophos. Similarly, Indumathi and Savithri (2003) proved that imidacloprid resulted in the highest reduction of mango hopper in Andhra Pradesh. Murugan and Ramchandran (2001) and Patel *et al*. (2003) reported that two applications of thiamethoxam (beginning of flowering anmd full bloom) checked the hopper (*Idioscopus niveosparsus* and *Amritodus atkinsoni*) infestation in mango.

On the other hand, monocrotophos 0.04 per cent has already been proved and recommended for controlling hopper population (*Amritodus atkinsoni* and *Idioscopus clypealis*) in Gujarat (Shah *et al*; 1979; Anonymous 2000 and Sushil Kumar and Bhatt, 2002), Uttar Pradesh (Tandon and Lal, 1979; Abbas *et al;* 1987; Srivastava and Verghese, 1989) and Karnataka (Verhese, 2000 Kumar *et al;* 1999 and Patel *et al;*2001) indicated the superiority of acetaprimid against jassids in comparison to conventional insecticides.

These reports indicate more or less the same findings as reported in the present experimental trial, thus confirms the investigation.

V SUMMARY AND CONCLUSIONS

Investigations were carried out on seasonal cyclicity and population dynamics of mango hopper, reaction of different mango cultivars to mango hopper, impacts of recurrent flowering, high density plantation, NPK fertilization, plant growth regulator on abundance of mango hopper and efficacy of newer insecticides were evaluated against mango hopper at Agriculture Experimental Station, Gujarat Agricultural University (now, Navsari Agricultural University), Paria, during January 2002 - June 2004 under field conditions. The important findings emerged out from these investigations are summarized and concluded below.

5.1 Population studies of mango hopper

To record species wise (indigenous species) abundance of mango hopper in relation to weather factors as well as crop stages, a survey was carried out at standard week wise interval on ten mango (cv. 'Alphonso') trees from January 2002 - December 2003. Spatial distribution (intra tree) of mango hopper was also assessed on the basis of various statistical parameters during the same period**.**

5.1.1 Abundance of various species of mango hopper in relation to weather parameters

5.1.1.1 Abundance of hopper population

Peak incidence of mango hopper, ***Amritodus atkinsoni*** on tree trunk (3.34, 3.24 and 3.29 hoppers per sq. ft. tree trunk area in 2002, 2003 and mean values, respectively) was recorded during 43th standard week (SW), whereas on tree twig it was found highest during 31-32 (0.29 per twig), 42 (0.56 per twig) and 42 (0.41 per twig) standard weeks in 2002, 2003 and mean of two years.

Similarly, peak population count of ***Idioscopus clypealis*** on tree trunk (1.46, 0.60 and 0.94 hoppers per sq. ft. tree trunk area in 2002, 2003 and mean of two years, respectively) was noticed during 5th standard week, and on tree twig population remained highest on 15 (4.14 per twig), 16 (1.69 per twig) and 16 (2.84 per twig) standard weeks in respective years and mean values, respectively.

Likewise, peak population of ***I. niveosparsus*** was 0.21 (2nd SW in 2002), 0.16 (6th SW in 2003) and 0.14 (2nd SW in mean values) hoppers per sq. ft. on tree trunk area and on tree twig it peaked on 15 (2.91 per twig), 16 (0.61 per twig) and 16 (1.75 per twig) standard weeks in 2002, 2003 and mean, respectively.

Amrasca splendens though low in density throughout the crop season, however, peaked on 43 (0.13 hoppers per sq. ft.), 45 (0.13 hoppers per sq. ft.) and 35-37 (0.10 hoppers per sq. ft.) standard weeks on tree trunk in 2002, 2003 and mean values, respectively, whereas its peak population (0.29, 0.39 and 0.26 per panicle) on tree twig was noticed during 11-12 (2002), 16 (2003) and 16 (mean) standard weeks, respectively.

Overall trunk population of mango hopper (irrespective of species composition) peaked on 43 (3.56 hoppers per sq. tree trunk area), 43 (3.36 hoppers per sq. tree trunk area) and 43 (3.46 hoppers per sq. tree trunk area) standard weeks in 2002, 2003 and mean of two years, respectively, whereas on tree twigs peak was noticed on 15 (7.26 per twig or panicle), 16 (2.80 per twig/panicle) and 16 (4.93 per twig/panicle) standard weeks in respective years and mean of two years, respectively.

The activity of total hopper population (irrespective of species as well as tree location i.e. trunk or twig) remained higher during 1-20 and 32-49 standard weeks in 2002 (2.07-8.12 hoppers per tree) (peak of 8.12 hoppers per tree on 15 SW), 14-17 and 36-47 standard weeks (2.03-3.84 hoppers per tree) (peak of 3.84 hoppers per tree on 43 SW) in 2003 and 7, 9-20 and 34-48 standard weeks (2.01-5.49 hoppers per tree) (peak of 5.49 hoppers per tree on 15 SW) in pooled analysis, whereas, lower activity (< 2 hoppers per tree) of the pest was noticed during 21-31 and 50-52 standard weeks in 2002, 1-13, 18-35 and 48-52 standard weeks in 2003 and 1-6, 7, 21-33 and 49-52 standard weeks in pooled analysis indicating lowest populations of the pest on 26 (0.16 hoppers per tree), 24 (0.24 hoppers per tree) and 24 (0.23 hoppers per tree) standard weeks in 2002, 2003 and pooled analysis, respectively.

5.1.1.2 Correlation

Overall population of mango hopper (irrespective of species or tree location) showed significant positive correlation with maximum temperature and sun shine but significant negative with evening relative humidity, average relative humidity and rainy days in 2002, whereas in the subsequent year, the population indicated significant positive correlation with sun shine but negative with rainfall. In pooled analysis, overall population build-up showed significant and highly positive correlation with maximum temperature and sun shine but significant negative correlation with morning relative humidity, evening relative humidity, average relative humidity, rainfall and rainy days. The multiple correlation coefficient (R) was significant in 2002 (R = 0.5337), 2003 (R = 0.4286) as well as in pooled analysis (R = 0.5416). The regression analysis also explained 20.71, 15.04 and 18.09 per cent variations in the overall population build-up of mango hopper due to weather factors in 2002, 2003 and pooled observations, respectively.

So, it may be concluded that hopper population was directly influenced by maximum temperature and sun shine, whereas, relative humidity (morning, evening and average), rainfall and rainy days had negative bearing on its abundance.

5.1.1.3 Interspecific correlation of mango hopper complex

Interspecefic correlation on tree trunk showed that *A. atkinsoni* had significant positive correlation with *A. splendens* (during 2002 and mean of two years) but exhibited significant negative correlation with those of *I. clypealis* and *I. niveosparsus*. Similarly, *I. clypealis* population showed significant positive correlation with *I. niveosparsus* but significant negative with *A splendens* population whereas, population build-up of *I. niveosparsus* had significant positive relationship with *A splendens* population. So, it may be concluded that population of *A. atkinsoni* increased with an increase of *A splendens* population on tree trunk and vice-versa, while it decreased with an increase of *I. clypealis* and *I. niveosparsus* populations on tree trunk and vice-versa.

Inter specific correlation of mango hopper complex on twig indicated that twig population of *A. atkinsoni* had significant negative correlation with those of *I. clypealis*, *I. niveosparsus* and *A. splendens* (during 2002 and pooled analysis). Similarly, *I. clypealis* population on twig showed significant positive correlation with *I. niveosparsus* and *A. splendens* populations, whereas, population of *I. niveosparsus* was positively correlated with that of *A. splendens*. Thus, it is evident that population of *I. clypealis* increased with an increase in *I. niveosparsus* and *A. splendens* and decreased with an increase in population of *A. atkinsoni* and vice-versa on tree twig.

Inter specific correlation between mango hopper on tree trunk and twig indicated highly significant positive correlation between trunk and twig populations of *A. atkinsoni*, whereas, the same species on tree trunk had significant negative correlation with twig population of *I.* clypealis, *I. niveosparsus* and A*. splendens*. Similarly, trunk population of *I. clypealis* was found to increase with an increase in population of the same species, *I. niveosparsus* and *A. splendens* on twig, however, it was found to decrease with an increase of twig populations of *A. atkinsoni*. Likewise, population build-up of *I. niveosparsus* on tree trunk showed significant positive correlation with *A. splendens* on twig. Similarly, trunk population of *A. splendens* was found positively correlated with twig populations of *A. atkinsoni*, whereas, it exhibited significant negative correlations with twig populations of. *I. clypealis*, *I. niveosparsus* and *A. splendens*. So, it is evident that higher population of *A. atkinsoni* on tree trunk always corresponded with higher population of the same species on tree twig, thereby confirming the positive correlation, whereas, it exhibited negative trend with populations of *I. clypealis, I. niveosparsus* and *A. splendens* on tree twig. Similarly, trunk population of *I. clypealis* was found to increase with increase in the populations of *I. niveosparsus* and

A. splendens on tree twig thereby confirmed positive correlation. Likewise, trunk population of *I. niveosparsus* was found to increase with increase in the twig population of *A. splendens* proving the positive relationship between the two populations. Lastly, trunk population of *A. splendens* increased with increase in twig population of *A. atkinsoni* and decreased with increase in the twig populations of *I. clypealis*, *I. niveosparsus* and *A. splendens* confirming the positive and negative correlations between respective populations.

Looking to the overall trend of species wise differentiation of tree trunk and twig populations, it is evident that *A. atkinsoni* was the predominant species on tree trunk as it always dominated in terms of higher population over rest of the species and was found higher in proportion either during the rainy period (August - September) or immediately after the withdrwal of monsonic rains confirming its affinity towards higher relative humidity, rainfall and rainy days, whereas, its population was found in low intensity both on tree trunk and twig during dry season i.e. flowering (January-March) and post flowering (April-June), the period of bright sun shine. During the rainy season (July-September), populations of *I. clypealis* and *I. niveosparsus* was very low. However, as flowering season initiated and panicle emergence commenced i.e. 1-4 standard weeks (1 January- 28 January) population of *A. atkinsoni* decreased gradually or sometimes abruptly and was replaced by populations of *I. clypealis* and *I. niveosparsus* both on tree and twig not only confirmed their affinity towards flowering and newly set fruits but also towards bright sun shine thereby confirming the positive relationship. Population of *A. splendens* was very low both on tree trunk as well as twig throughout both the years and in pooled analysis.

Thus, it may be concluded that displacement of *A. atkinsoni* (predominant tree trunk population) on tree trunk took place mainly by *I. clypealis* and to a lesser extent by *I. niveosparsus*, on tree twig with initiation of flowering, whereas displacement of *I. clypealis* (predominant tree twig population) and *I. niveosparsus* on tree twig took place mainly by *A. atkinsoni* on tree trunk at harvest or with the commencement of rainy season.

5.1.2 Abundance of hopper associated damage

Abundance of hopper associated damage was evaluated on the basis of hopper egg laying and sooty mold damages. Higher egg laying damage (10.85, 8.90 and 8.99 per cent in respective years) was observed during 14-18 standard weeks. Similarly, sooty mold damage which restricts photosynthetic activity of the crop was highest (3.10, 2.10 and 2.25 SM grade) during 6-18 standard weeks.

Both the parameters of hopper associated damage had significant positive correlation with twig hopper population and significant negative correlation with tree trunk hopper population.

5.1.3 Abundance of natural enemies in relation to mango hopper

Amongst the natural enemies, predatory spiders and coccinellids were the most regular visitors. Predatory spiders peaked (0.64, 0.43 and 0.53 per panicle in 2002, 2003 and mean of two years, respectively) during 12-14 SW, whereas, coccinellids attained peak status (0.51, 0.21 and 0.35) during 14-17 SW.

Similarly, population of predatory spiders and coccinellids were significant and positively correlated with hopper population on tree twig.

5.1.4 Abundance of hopper at various stages of crop growth

Abundance of hopper population was observed comparatively higher during flowering, pea and marble stages of crop growth leading to the peak status (6.46, and 4.31 hoppers per panicle in 2002 and pooled analysis, respectively) at stone sized fruit stage of the crop growth which coincided with 11-18 standard weeks, however, in 2003, peak abundance of hopper (3.07 hoppers per panicle) was noticed at emergence of new flush. In pooled analysis, peak population (4.31 per panicle) was observed at stone sized fruit stage (11-18 standard weeks). After attaining peak status, population declined gradually upto harvest stage of the crop growth and attained another peak immediately after the cessation of rains due to the availability of new leaves and twigs, the preferred ovipositional site of trunk hoppers predominated by *A. atkinsoni*. After attaining second peak at new flush initiation stage, hoppers once again declined gradually (3.33-1.82, 3.07-1.39 and 3.20-1.58 hoppers per panicle) upto the bud burst stage. Thus, it may be concluded that there were two peaks of hopper abundance *viz*; stone formation stage and emergence of new flush.

5.1.5 Spatial distribution of mango hopper

Spatial distribution (intra tree distribution) of mango hopper in different tree sections *viz*; north, south, east and west (both on lower and upper canopy) on mango trees (cv. 'Alphonso) did not differ significantly indicating a range of 1.26 to 1.69, 0.78 to 1.43 and 1.12 to 1.54 per sq. tree trunk area at vegetative and flowering stages of the crop as well as in the entire crop season. Similarly, variance to mean ratio (0.006-0.096, 0.012-0.075 and 0.006-0.027), mean crowding (0.220-0.681, 0.002-0.339 and 0.137-0.361), clumping index (-0.900 to -0.999, -0.598 to -0.977 and -0.973 to -0.998) in vegetative, flowering and entire crop season indicated values which were less than unity, thus confirmed uniformity of hopper distribution in various tree sections.

To study the distribution further, Morista indices in vegetative (9.560 – 9.976), flowering (9.964 – 10.000) stages and throughout the crop season (9.961 – 9.973) indicated more or less similar values, thus confirmed uniform distribution. Possibility of fit (X^2 values) indicated very low values (0.012-0.866, 0.002-0.675 and 0.020-0.239) at vegetative, flowering and entire crop season, respectively) confirming less departure from Poisson distribution. Thus, on the basis of all the statistical parameters it may be concluded that hopper population was found to be uniformly distributed in all the tree sections of mango trees selected in experimental trial.

5.2 Screening of mango cultivars against mango hopper

Fifteen mango cultivars *viz*; Alphonso, Baneshan, Chausa, Dadamio, Dashehari, Jamadar, Kesar, Langra, Makaram, Neelum, Pairi, Rajapuri, Suvarnrekha, Totapuri and Vashibadami (each having two trees) were screened against mango hopper and its associated damages during 2002-2003 and 2003-2004 crop seasons. Lowest hopper population (2.32, 1.00 and 1.61 per twig in 2002-2003, 2003-2004 and mean, respectively) was found in Totapuri, while, it remained highest (6.64, 8.44 and 7.52) in Alphonso. Similarly, lowest hopper egg laying damage (4.53, 1.72 and 2.98 per cent) was observed in Totapuri and highest (13.11, 11.36 and 12.22 per cent per twig) in Alphonso. Likewise, lowest sooty mold (0.82, 0.32 and 0.55 SM grade per twig) was observed in Totapuri and highest (3.15, 3.00 and 3.07 SM grade) in Alphonso.

Amongst the natural enemies, predatory spiders peaked (7.12, 7.37 and 7.25 per twig) in Alphonso and were found lowest in Totapuri (1.99, 1.65 and 1.81 per twig). Similarly, Alphonso and Totapuri had respectively highest (5.21, 5.21 and 5.21 per twig) and lowest (1.65, 0.58 and 1.07 per twig) population of coccinellids. Higher and lower abundance of natural enemies confirmed their synchronization with differential abundance of hopper in these cultivars. Relationship of abundance of hopper and its egg laying damage with morphological characters *viz*; height of mango trees, leaf area, leaf shape, colour of new leaves, length and colour of inflorescence and presence or absence of hairs indicated non- significant values. In terms of production, highest yield (221.50, 312.50, 263.24 kg per tree) was obtained from Totapuri trees, while, lowest was recorded in Chausa (132.50, 178.00 and 154.31 kg per tree). Thus, on the basis of abundance of hopper and its associated damage, Totapuri and Alphonso have been found least and most susceptible entries, respectively and were categorized as resistant and susceptible entries, respectively.

5.3 Influence of recurrent flowering on incidence of mango hopper

Influence of recurrent (repeated) flowering on incidence of mango hopper was assessed both on recurrent (fifty per tree) and non-recurrent (fifty per tree) flowers during 2002- 2003 crop seasons. Recurrent flowers during 14-15 standard weeks (SW) had higher abundance (8.60, 3.25 and 5.45 per panicle in 2002, 2003 and mean, respectively) of mango hopper than on non-recurrent flowers (6.89, 2.91 and 4.41 per panicle) during the same period i.e. 14-15 standard weeks (SW) when the crop was in stone sized fruit stage. Similarly, hopper egg laying and sooty mold damages on recurrent flowers were comparatively higher than on non-recurrent flowers during pea to stone sized fruit stage. Similarly, comparatively higher abundance of predatory spiders and coccinellids was observed on recurrent flowers than those on non-recurrent flowers. Relationship of a particular crop stage with abundance of hopper was found positive but non-significant during both the years of investigation as well as mean of two years, whereas, there was significant negative correlation of crop stage with hopper egg laying ('r' = -0.853) and sooty mold ('r' = -0.809) damages in 2002. This implies that as the crop stage moved from stone to harvest stages of crop growth, hopper egg laying damage and sooty mold grades declined gradually from 10.85 to 0.86 per cent and 3.10-0.30 SM grades, respectively. However, in the subsequent year, crop stage indicated significant positive correlation with hopper egg laying ('r' = 0.594 and 0.686) and sooty mold damages

('r' = 0.541 and 0.599) on both non-recurrent and recurrent flowers, this implies that proportion of both the damages increased as the crop stage moved from marble to stone to harvest stages, whereas, in pooled analysis none of the parameter could establish any significant correlation with crop stage of mango. This variation in respective years could be due to abiotic or any other factor responsible for the transformation of various crop stages which was not taken into consideration.

Hence, on the basis of results it may be concluded that hopper population as well as its associated damage has remained higher on recurrent flowers. This could be due to higher availability of fresh panicles (also fresh cell sap) on recurrent flowers than those on non-recurrent or ageing or old inflorescence which may not be preferred by mango hopper for oviposition and subsequent damage.

5.4 Impact of high density plantation on incidence of mango hopper

Impact of high density plantation (10 x 5 and 10 x 2.5 m.) vis-a-vis normal planting (10 x 10 m.) on abundance of mango hopper and its associated damages was assessed during 2002-2003 and 2003-2004 crop seasons. Highest abundance of hopper population (5.50 per twig) was noticed in 10 x 5 m. spacing in 2002-2003, but in the subsequent year and mean of two years, it remained highest (5.45 and 6.05 hoppers per twig in 2003-2004 and mean, respectively) in 10 x 2.5 m. spacing, whereas it was lowest (4.65 per twig) in 10 x 2.5 m. during 2002-2003, though in the subsequent year and mean values, lowest number of hoppers (3.70 and 2.89 hoppers per twig) was observed in 10 x10 m. spacing. Similarly, hopper egg laying and sooty mold damages were higher in 10 x 2.5 m. spacing and lowest in 10 x 10 m. spacing. Abundance of predatory spiders (5.02, 4.47 and 4.74 per twig) and coccinellids (4.52, 4.34 and 4.43 per twig) was higher in 10 x 2.5 m. spacing and lowest (2.92, 2.60, 2.74 and 2.53, 2.63 2.60 per twig, respectively) in 10 x 10 m. spacing. Thus, it may be stated that closer spacing invite higher abundance of hopper and its associated damages than in normal planting (10 x 10 m.).

5.5 Impact of NPK fertilization on incidence of mango hopper

Role of NPK on abundance of mango hopper and its associated damages was assessed in twenty seven different NPK combinations (including control) (each replicated thrice) on mango (cv. 'Kesar') during 2002-2003 and 2003-2004 crop seasons. Highest population of mango hopper (4.01, 6.26 and 5.08 per twig in respective years and mean) was noticed in $N_2P_2K_2$ (150, 100 and 150 gms of NPK from first year of plantation per tree) and lowest (2.13, 2.31 and 2.22 per twig) in control ($N_0P_0K_0$) trees. Similarly, hopper associated damages *viz*; hopper egg laying and sooty mold were found higher in $N_2P_2K_2$ (4.58, 4.93 and 4.76 per cent) (3.65, sooty mold grade in each year and mean values) and lowest (2.92, 2.77 and 2.84 per cent) (1.75, 1.54 and 1.64 sooty mold grade) in control ($N_0P_0K_0$). Synchronisation of natural enemies viz; predatory spiders and coccinellids was observed along with hopper abundance being highest in $N_2P_2K_2$ (5.49, 4.62, 5.05 and 5.42, 4.74, 5.07 per twig, respectively) and lowest (0, 0.91, 0.40 and 0.16, 0.73, 0.42, respectively) in $N_0P_0K_0$.

Abundance of hopper remained high in these treatments due to higher levels of nitrogen resulting in increased chlrophyll content and higher succullency thereby providing better platform for the attack of the pest.

5.6 Mango hopper as influenced by plant growth regulator and different doses of NPK

To study the relationship between early flowering induced due application of plant growth regulator (paclobutrazol) and early arrival of mango hopper present investigation was carried out with seven different treatments including control (with recommended or half of the recommended doze of fertilizer) on mango (cv. 'Alphonso) trees during 2002-2003 and 2003-2004.

5.6.1 Impact on hopper population

Highest abundance of hopper (8.40, 6.88 and 7.64 per twig in 2002-2003, 2003-2004 and mean, respectively) was recorded in the treatment of paclobutrazol (PBZ) at 4 and 3 gm a.i. per tree (I and II year) + recommended doze of fertilizer (RDF), whereas, it was lowest (3.92, 3.60 and 3.76 per twig) in control + half RDF.

Similarly, amongst hopper associated damages *viz*; hopper egg laying and sooty mold remained highest (9.02, 7.98, 8.50 per cent and 2.50, 2.37, 2.40 SM grade, respectively) in PBZ at 4-3 gm a.i. per tree + RDF, whereas, they were lowest (4.95, 4.07, 4.51 per cent and 1.40, 1.42, 1.41 SM grade, respectively) in control (untreated) + half RDF. Peak population of natural enemies *viz*; predatory spiders and coccinellids (19.75, 18, 18.87 and 14.75, 16.25, 15.50 per twig) was similarly noticed in PBZ (3-4 gm a. i. per tree) (I and II year) which confirmed synchronization of natural enemies with hopper population, while, lowest population 11.25, 8.00, 9.62 (predatory spiders) and 5.00, 5.25, 5.12 (coccinellids) per twig was noticed in control + half RDF.

5.6.2 Correlation

Hopper abundance was higher (4.10-13.60, 2.10-9.90, 3.10-11.75 per twig in 2002-2003, 2003-2004 and mean of two years, respectively) in paclobutrazol treated trees than on non-PBZ trees (3.90-4.50, 2.10-4.80, 3.00-4.65). **Correlations of crop stage** with abundance of hopper was found significant in paclobutrazol and non- paclobutrazol trees indicating that crop stage advanced from vegetative to fruit set to harvest at a much rapid rate on PBZ treated trees than on non- PBZ trees and resulted in higher abundance of hopper on former than later.

5.6.3 Date of flowering

The crop stage advanced from vegetative to flowering to fruit setting stages at least one month earlier in PBZ than on non-PBZ treated trees which ultimately led to the advancement of arrival of mango hopper.

It is also evident from data on hopper population that repeated application of PBZ at 4, 3 and 2 g.a.i. per tree in I and II year had higher population of mango hopper (7.10-7.64 per twig in pooled analysis) than in treatment of PBZ applied once (6.68-6.80), thus proves the hypothesis that year after year application of PBZ on mango trees not only changes the physiology of mango trees by inducing earliness in flowering and its subsequent stages of crop growth but also sets up higher magnitude of hopper population complex, thus altering the longevity of the pest. Thus, it may be concluded that hopper incidence and its associated damage remained higher on trees which received treatment of paclobutrazol (PBZ) + recommended doze of fertilizer (RDF), followed by PBZ + half RDF, whereas, it was significantly lower on control + ½ RDF trees. The economic threshold level (five hoppers per twig) also touched much earlier in PBZ trees than in non-PBZ trees. It could be due to earliness in induction of flowering as well as full bloom in PBZ over non-PBZ (control) trees wherein its application eventually advanced the arrival of ETL of hopper. Thus, it may be concluded that earliness in flowering has advanced arrival of mango hopper. The role of fertilization on abundance of mango hopper has also been illustrated in the investigation as the magnitude of hoppers and its associated damages were higher (4.10, 2.10 and 3.10 per twig) in RDF (0.750, 0.160 and 0.750 Kg per tree) trees as compared to those on ½ RDF trees (3.80, 2.10 and 2.95 per twig) during 40-43 standard weeks.

5.7 Evaluation of newer insecticides against mango hopper

Fourteen insecticides besides a control (untreated) (each replicated thrice) were evaluated against against mango hopper and its associated damage on mango (cv. 'Alphonso') in field conditions during 2002, 2003 and 2004.

5.7.1 Impact on hopper population and its associated damage

Imidacloprid 0.005 per cent was proved most effective and showed significantly lowest hopper population (irrespective of post spray interval) (2.06, 2.49, 2.19 and 2.22 per panicle in 2002, 2003, 2004 and mean, respectively) and sooty mold damage (1.60, 3.11, 2.96 and 2.39 SM grade). Next in the order of effectiveness was thiamethoxam 0.0084 per cent (2.29, 3.30, 2.78, 2.78 hoppers per panicle and 1.75, 2.60, 3.03, 2.42 sooty mold grade), whereas, least effective insecticide was diflubenzuron 0.02 per cent indicating hopper population and sooty mold damage to the tune of 7.79, 8.74, 8.44, 8.32 per panicle and 3.62, 4.08, 4.17, 3.95 SM grade, respectively. The order of effectiveness on the basis of hopper population and sooty mold damage was imidacloprid 0.005 per cent > thiamethoxam 0.0084 per cent > monocrotophos 0.04 per cent > acetaprimid 0.004 per cent > fipronil 0.005 per cent > profenofos 0.1 per cent > fenubucarb 0.05 per cent > endosulfan 0.07 per cent > lambdacyhalothrin 0.003 per cent > carbosulfan 0.05 per cent > diflubenzuron 0.02 per cent > control (untreated).

5.7.2 Impact on beneficial fauna

Amongst the natural enemies, predatory spiders and coccinellids were the most regular visitors. Highest, population of predatory spiders (8.50, 6.16, 9.93 and 8.14 per panicle in 2002, 2003, 2004 and mean, respectively) and coccinellids (9.23, 8.08, 9.42 and 8.92 per panicle) was noticed in control (untreated), followed by endosulfan 0.07 per cent (6.79, 4.61, 6.47, 5.90 and 6.42, 6.95, 6.36, 6.58, respectively) and imidacloprid 0.005 per cent (4.93, 3.99, 5.31, 4.74 and 5.40, 5.85, 4.52, 5.26 per panicle, respectively), whereas, lowest number of predatory spiders (1.06, 0.85, 1.19 and 1.04) and coccinellids (3.30, 0.60, 0.46 and 1.27) were noticed in lambdacyhalothrin 0.003 per cent.

5.7.3 Fruit setting

Highest number of fruits at pea (603.33, 495.00, 464.67 and 518.43 per hundred panicles per tree in 2002, 2003 and 2004, respectively), marble (346.66, 327.00, 251.00, 311.73) and harvest (281.33, 191.33, 168.66 and 210.62) stages of the crop were set in imidacloprid 0.005 per cent, whereas, lowest (237.66, 178.00, 133.33 and 179.86-pea)(118.66, 88.00, 91.33 and 98.50-marble) (63.33, 56.33, 59.66 and 59.44-harvest) were recorded on trees treated by diflubenzuron 0.02 per cent.

5.7.4 Fruit retention

Highest fruit retention at marble (over pea stage) (60.66, 66.41, 54.27 and 45.63 per cent in 2002, 2003, 2004 and mean, respectively) and harvest (over marble stage) (77.30, 58.57, 67.58 and 48.16 per cent) stages of crop was observed in imidacloprid 0.005 per cent, whereas, it was lowest (44.85, 48.79, 50.21, 41.44 and 55.55, 67.60, 62.10, 46.03 per cent) in profenofos 0.1 per cent.

5.7.5 Number of sprays

Efficacy of different insecticides was also proved on the the basis of total number of sprays which indicated lowest (three) applications in imidacloprid 0.004 per cent and thiamethoxam 0.0084 per cent.Number of sprays from initiation of flowering to pea nut to marble to harvest stages were lowest (one during each crop growth stage) in imidacloprid 0.004 per cent and thiamethoxam 0.0084 per cent.

5.7.6 Fruit yield

Highest tree bearing (297.33, 227.66, 195.00 and 240.00 fruits per tree) and fruit yield (74.33, 56.91, 48.75 and 60.00 kg per tree) of mango fruits was recorded on imidacloprid 0.005 per cent treated trees, followed by thiamethoxam 0.0084 per cent (203.33, 206.33, 178.66 and 196.11 fruits per tree) (50.75, 51.83, 44.33 and 48.97 kg per tree), monocrotophos 0.04 per cent (164.66, 187.66, 111.00 and 174.44 fruits per tree) (41.00, 49.56, 43.00 and 44.52 kg per tree) , acetaprimid 0.004 per cent (157.66, 170.66, 163.66 and 164.00 fruits per tree) (39.00, 42.58, 41.00 and 40.86 kg per tree) and fipronil 0.005 per cent (161.33, 159.66, 161.66 and 160.88 fruits per tree) (40.16, 39.75, 40.50 and 40.13 kg per tree), whereas, it was lowest (82.00, 67.66, 89.00 and 79.55 fruits per tree) (20.33, 16.91, 26.56 and 21.27 kg per tree) in duflubenzuron 0.02 per cent treated trees.

The order of effectiveness on the basis of yield was imidacloprid 0.005 per cent > thiamethoxam 0.0084 per cent > monocrotophos 0.04 per cent > acetaprimid 0.004 per cent > fipronil 0.005 per cent > profenofos 0.1 per cent > fenubucarb 0.05 per cent > lambdacyhalothrin 0.003 per cent > endosulfan 0.07 per cent > carbosulfan 0.05 per cent > diflubenzuron 0.02 per cent > control.

5.7.7 Economics

Insecticidal treatment of imidacloprid 0.005 per cent resulted in highest estimated yield (6000.00 kg per ha.), gross realization (Rs 90000.00 per ha.), net realization (Rs 83520.00 per ha.), realization over control (Rs 54390.00 per ha.) and ICBR (1: 8.39), whereas, fipronil 0.005 per cent was the least economical treatment (ICBR 1: 0.16). Treatments of endosulfan (ICBR 1 : 0.32) , carbosulfan 0.05 percent (ICBR 1 : 0.70), lambdacyhalothrin 0.005 per cent (ICBR 1 : 0.77), diflubenzuron 0.02 per cent (ICBR 1 : 0.92) and profenofos 0.1 per cent (ICBR 1 : 0.93) were also highly uneconomical as they gave negative economics. Overall ranking of different treatments on the basis of various characters taken into consideration in the present investigation was imidacloprid 0.005 per cent (1) > thiamethoxam 0.0084 per cent (2) > monocrotophos 0.04 per cent (3) > acetaprimid 0.004 per cent (4) > fipronil 0.005 per cent (5) > profenofos 0.1 per cent (6) > fenubucarb 0.05 per cent (7) > endosulfan 0.07 per cent (8) > lamdacyhalothrin 0.003 per cent (9) > control (untreated) (10) = carbosulfan 0.05 per cent (10) > diflubenzuron 0.02 per cent (11). Thus, considering all the aspects and characters of study, it may be concluded that imidacloprid 0.005 per cent was the most effective treatment and was significantly superior over rest of the treatments. Next in the order of effectiveness was thiamethoxam 0.0084 per cent, monocrotophos 0.04 per cent, acetaprimid 0.004 per cent, whereas, diflubenzuron 0.02 per cent remained least effective insecticidal treatment against mango hopper.

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* Original not seen

APPENDIX - I

Meteorological data recorded at A.E.S. Paria during 2002

Std. Wk	Std. Period	Temp. (°C)			R. H. (%)			Rainfall (mm.)	Rainy days	Sun shine (hr)
		Max	Min	Av	Mor.	Eve.	Av.			
1	1-7 Jan.	31.21	10.31	24.24	86.28	37.42	61.85	0	0	8.70
2	8-14 Jan.	32.51	11.64	22.08	90.00	76.00	83.00	0	0	9.50
3	15-21 Jan.	27.64	9.57	18.61	89.00	42.71	65.86	0	0	8.90
4	22-28 Jan.	26.77	7.07	16.92	89.00	35.71	62.36	0	0	9.30
5	29 Jan.- 4 Feb.	30.24	8.42	19.33	83.42	28.29	55.86	0	0	8.80
6	5-11 Feb.	29.60	9.07	19.34	87.00	34.70	60.85	0	0	9.10
7	12-18 Feb.	33.60	12.92	23.26	82.00	32.00	57.00	0	0	10.10
8	19-25 Feb.	32.98	12.42	22.70	90.00	40.00	65.00	0	0	10.30
9	26 Feb.- 4 Mar.	34.30	11.40	22.85	86.00	33.00	59.50	0	0	10.30
10	5-11 Mar.	33.92	13.14	23.53	85.00	36.42	60.71	0	0	9.90
11	12-18 Mar.	35.31	15.42	25.37	86.14	40.85	63.50	0.71	0.29	10.40

12	19-25 Mar.	35.28	16.50	25.94	83.00	37.85	60.42	0	0	9.90
13	26 Mar- 1 Apr.	33.38	16.42	24.90	85.57	46.71	66.14	0	0	9.80
14	2-8 Apr.	33.71	20.00	26.86	88.42	54.28	71.35	0	0	9.60
15	9-15 Apr.	35.21	17.35	26.28	81.57	40.28	60.93	0	0	10.10
16	16-22 Apr.	35.60	20.05	27.83	84.85	41.14	63.00	0	0	10.30
17	23-29 Apr.	38.14	20.71	29.43	74.85	40.71	57.78	0	0	10.30
18	30 Apr- 6 May	36.71	20.92	28.83	90.85	46.85	68.85	0	0	10.10
19	7-13 May	34.85	24.71	30.78	82.00	58.71	70.36	0	0	10.20
20	14-30 May	33.57	27.14	30.36	79.14	62.14	70.64	0	0	10.40
21	21-27 May	33.64	24.07	28.86	78.85	59.00	68.93	0	0	10.40
22	28 May- 3 June	33.64	25.92	29.78	75.00	58.42	66.71	0	0	9.80
23	4-10 June	34.07	25.24	29.66	80.00	58.00	69.00	0	0	10.00
24	11-17 June	33.74	24.35	29.05	85.00	67.57	76.29	3.43	0.57	9.60
25	18-24 June	31.48	23.78	27.63	94.28	74.14	84.21	26.14	1.00	7.80
26	25 June-1 Jul.	28.52	24.50	26.51	93.14	87.28	90.21	83.71	1.00	4.30
27	2-8 Jul.	30.91	26.00	28.46	83.28	73.71	78.50	0.43	0.43	5.71
28	9-15 Jul.	31.08	25.28	28.18	88.28	73.00	80.64	2.29	0.71	6.07
29	16-22 Jul.	29.84	24.50	27.17	89.57	78.42	84.00	6.14	0.71	3.65
30	23-29 Jul.	29.67	24.64	27.16	90.42	79.28	84.85	11.00	1.00	4.70
31	30 Jul.- 5 Aug.	29.70	24.50	27.10	94.71	82.28	88.50	1.29	0.29	1.84
32	6-12 Aug.	26.52	23.21	24.87	94.71	93.14	93.93	57.29	1.00	0.45
33	13-19 Aug.	28.50	24.00	26.25	91.00	82.85	86.93	3.29	0.71	2.17
34	20-26 Aug.	28.10	23.28	25.69	96.71	82.00	89.36	28.86	1.00	2.51
35	27 Aug.- 2 Sep.	29.17	23.50	26.34	94.42	78.85	86.64	12.60	0.86	4.24
36	3-9 Sep.	28.14	22.78	25.46	95.57	80.85	88.21	10.43	0.57	4.70
37	10-16 sep.	29.67	21.68	25.68	95.57	73.71	84.64	0	0	8.48
38	17-23 Sep.	30.34	22.35	26.35	90.57	72.85	81.71	0.14	0.14	6.67
39	24-30 Sep.	31.50	22.64	27.07	91.40	66.71	79.21	0	0	8.80
40	1-7 Oct.	36.00	21.74	28.87	87.14	51.57	69.36	0	0	9.65
41	8-14 Oct.	36.14	21.35	28.75	86.28	38.28	62.28	0	0	9.24
42	15-21 Oct.	34.00	21.24	27.62	86.71	56.42	71.57	0	0	8.61
43	22-28 Oct.	34.81	16.94	25.88	82.14	42.71	62.43	0	0	9.30
44	29 Oct.- 4 Nov.	35.32	14.64	24.98	77.28	42.71	60.00	0	0	9.30
45	5-11 Nov.	34.57	16.50	25.54	88.28	42.85	65.57	0.14	0.14	8.47
46	12-18 Nov	32.71	16.42	24.57	86.00	42.42	64.21	0	0	9.35
47	19-25 Nov.	33.78	11.92	22.85	85.85	29.00	57.43	0	0	9.28

48	26 Nov.- 2 Dec.	31.92	11.27	21.60	84.42	37.71	61.07	0	0	9.12
49	3-9 Dec.	33.07	13.57	23.32	90.14	42.57	66.36	0	0	8.35
50	10-16 Dec.	33.57	12.21	22.89	84.42	37.57	61.00	0	0	9.10
51	17-23 Dec.	32.65	11.57	22.11	90.71	43.14	66.93	0	0	9.15
52	24 Dec- 31 Dec.	28.93	10.06	19.50	88.00	50.85	69.43	0	0	8.85

APPENDIX – II

Meteorological data recorded at A.E.S. Paria during 2003

Std. Wk	Std. Period	Temp. (º C)			R. H. (%)			Rainfall (mm.)	Rainy days	Sun shine (hr)
		Max	Min	Av	Mor.	Eve.	Av.			
1	1-7 Jan.	29.12	11.17	20.15	84.00	41.71	62.86	0	0	8.12
2	8-14 Jan.	30.50	13.64	22.07	88.14	49.42	68.78	0	0	7.71
3	15-21 Jan.	32.52	10.35	21.44	79.57	32.85	56.21	0	0	9.32
4	22-28 Jan.	31.80	20.97	26.39	86.00	41.00	63.50	0	0	8.85
5	29 Jan.- 4 Feb.	29.31	11.42	20.37	88.40	49.57	68.99	0	0	8.80
6	5-11 Feb.	31.58	11.85	21.72	91.14	45.29	68.22	0	0	9.71
7	12-18 Feb.	32.70	10.78	21.74	89.85	35.28	62.57	0	0	9.82
8	19-25 Feb.	32.21	13.42	22.82	88.28	46.00	67.14	0.14	0.14	9.81
9	26 Feb- 4 Mar.	32.27	13.71	22.99	74.85	37.71	56.28	0	0	9.72
10	5-11 Mar.	34.34	10.07	22.21	79.28	22.28	50.78	0	0	9.97
11	12-18 Mar.	33.85	12.50	23.18	77.57	32.28	54.93	0	0	9.60
12	19-25 Mar.	33.60	14.85	24.23	83.57	43.71	63.64	0	0	9.71
13	26 Mar- 1 Apr.	35.52	17.21	26.37	81.14	36.14	58.64	0	0	9.37
14	2-8 Apr.	34.64	18.14	26.39	83.42	47.00	65.21	0.14	0.14	9.10
15	9-15 Apr.	36.10	18.71	27.41	77.71	36.28	57.00	0	0	10.21
16	16-22 Apr.	31.14	20.07	25.61	85.71	46.00	65.86	0	0	10.78
17	23-29 Apr.	36.47	21.28	28.71	85.42	46.85	66.14	0	0	10.32
18	30 Apr- 6 May	34.31	21.28	27.80	83.28	58.00	70.64	0	0	10.85
19	7-13 May	35.17	21.67	28.42	85.71	55.57	70.64	0	0	10.18
20	14-30 May	33.52	25.81	29.67	89.00	70.57	79.79	0	0	10.52
21	21-27 May	33.78	24.74	29.26	86.14	66.14	76.14	0	0	10.96

22	28 May- 3 June	34.17	25.00	29.59	84.71	67.00	75.86	0	0	10.07
23	4-10 June	34.48	23.21	28.85	86.71	64.71	75.71	0	0	10.77
24	11-17 June	32.88	25.57	29.23	90.00	68.71	79.36	5.71	0.43	5.07
25	18-24 June	29.62	23.57	26.60	94.57	89.42	92.00	37.46	1.00	1.05
26	25 June-1 Jul.	29.27	24.55	26.91	94.00	83.85	88.93	53.87	0.86	3.32
27	2-8 Jul.	30.08	24.35	27.21	92.71	85.57	89.14	56.85	0.85	5.52
28	9-15 Jul.	29.50	24.60	27.05	95.00	85.42	90.21	21.71	1.00	3.54
29	16-22 Jul.	29.21	24.78	26.99	96.14	84.85	90.49	31.42	1.00	2.07
30	23-29 Jul.	28.60	24.50	26.55	94.43	87.00	90.71	48.34	1.00	1.12
31	30 Jul.- 5 Aug.	29.72	24.47	27.09	95.71	84.00	89.85	27.14	0.85	3.14
32	6-12 Aug.	28.52	24.14	26.33	96.42	89.85	93.13	26.92	1.00	3.34
33	13-19 Aug.	29.55	23.85	26.70	94.42	83.00	88.71	7.14	0.85	5.00
34	20-26 Aug.	30.05	24.01	27.03	93.14	80.28	86.71	22.65	1.00	4.00
35	27 Aug.- 2 Sep.	28.51	23.28	25.89	95.42	87.28	91.35	16.12	0.85	2.11
36	3-9 Sep.	28.88	23.35	26.11	95.28	82.71	88.99	3.51	0.71	5.05
37	10-16 sep.	25.92	23.42	24.67	93.28	79.00	86.14	5.22	0.85	6.14
38	17-23 Sep.	29.01	23.37	26.19	95.57	87.42	89.99	30.18	0.42	4.04
39	24-30 Sep.	28.50	23.14	25.82	96.85	83.42	90.13	19.88	1.00	2.77
40	1-7 Oct.	33.14	21.78	27.46	86.57	64.00	75.28	0	0	9.52
41	8-14 Oct.	33.28	21.85	27.56	91.71	56.00	73.85	0	0	9.08
42	15-21 Oct.	34.44	18.07	26.25	90.14	44.00	67.07	0	0	10.22
43	22-28 Oct.	34.00	15.60	24.80	87.14	39.85	63.49	0	0	10.00
44	29 Oct.- 4 Nov.	35.48	19.50	27.49	89.57	39.85	64.71	0	0	9.77
45	5-11 Nov.	34.95	17.67	26.31	90.42	42.42	66.42	0	0	9.62
46	12-18 Nov	33.61	14.67	24.14	91.14	40.14	65.64	0	0	9.71
47	19-25 Nov.	32.78	15.65	24.21	89.57	45.85	67.71	0	0	9.10
48	26 Nov.- 2 Dec.	33.17	16.10	24.63	92.14	47.85	69.99	0	0	9.21
49	3-9 Dec.	32.95	14.85	23.90	89.00	32.42	60.71	0	0	8.94
50	10-16 Dec.	31.71	13.28	22.49	89.85	49.57	69.71	0	0	8.95
51	17-23 Dec.	30.22	9.94	20.08	92.42	43.28	67.85	0	0	9.17
52	24 Dec- 31 Dec.	30.33	9.99	20.16	89.62	39.62	64.62	0	0	9.41

APPENDIX – III

Meteorological data recorded at A.E.S. Paria during 2004

Std. Wk	Std. Period	Temp. (º C)			R. H. (%)			Rainfall (mm.)	Rainy days	Sun shine (hr)
		Max	Min	Av	Mor.	Eve.	Av.			
1	1-7 Jan.	28.44	8.15	18.29	93.28	36.57	64.92	0	0	9.43
2	8-14 Jan.	31.28	10.95	21.15	89.42	38.00	63.71	0	0	9.45
3	15-21 Jan.	31.86	11.00	21.43	91.42	46.71	69.06	0	0	9.31
4	22-28 Jan.	28.21	9.92	19.06	89.28	43.14	66.21	0	0	10.01
5	29 Jan- 4 Feb.	29.36	11.43	20.39	83.00	54.28	68.64	0	0	9.60
6	5-11 Feb.	30.91	7.78	19.34	85.05	37.00	61.02	0	0	10.34
7	12-18 Feb.	32.00	11.28	21.64	90.85	47.43	69.14	0	0	9.83
8	19-25 Feb.	31.95	12.21	22.08	93.28	47.71	70.49	0	0	9.83
9	26 Feb- 4 Mar.	34.21	12.78	23.49	90.62	41.10	65.86	0	0	8.75
10	5-11 Mar.	36.47	12.18	24.32	80.85	30.42	55.63	0	0	8.17
11	12-18 Mar.	37.88	13.92	25.90	88.00	33.00	60.50	0	0	10.01
12	19-25 Mar.	36.60	15.57	26.08	88.57	38.28	63.42	0	0	10.37
13	26 Mar- 1 Apr.	32.98	16.78	24.88	88.28	51.28	69.78	0	0	9.37
14	2-8 Apr.	34.42	19.05	26.73	87.28	48.00	67.64	0	0	9.54
15	9-15 Apr.	34.60	20.60	27.60	86.42	44.42	65.42	0	0	10.38
16	16-22 Apr.	34.95	20.55	27.75	84.71	49.14	66.92	0	0	10.50
17	23-29 Apr.	35.07	22.42	28.74	85.85	58.42	72.13	0	0	10.28
18	30 Apr- 6 May	36.31	21.54	28.92	79.57	43.28	61.42	0	0	10.10
19	7-13 May	36.92	25.42	31.17	83.28	55.71	69.49	4.57	0.57	7.87
20	14-30 May	33.64	25.92	29.78	81.57	63.00	72.28	0	0	9.76
21	21-27 May	33.81	24.24	29.02	79.57	60.14	69.85	0	0	10.40
22	28 May- 3 June	33.50	25.07	29.28	83.85	58.85	71.35	0	0	9.80
23	4-10 June	33.57	24.37	28.97	80.00	61.42	70.71	9.14	0.28	9.02
24	11-17 June	31.57	24.35	27.96	90.71	75.14	82.92	25.04	0.71	5.12
25	18-24 June	29.31	24.78	27.04	89.00	79.71	84.35	4.60	0.28	5.21
26	25 June-1 Jul.	29.78	25.00	27.39	93.28	83.57	88.42	39.02	0.57	3.47

APPENDIX –IV

Meteorological data recorded at A.E.S. Paria during 2002-2003

Std. Wk	Std. Period	Temp. (º C)			R. H. (%)			Rainfall (mm.)	Rainy days	Sun shine (hr)
		Max	Min	Av	Mor.	Eve.	Av.			
1	1-7 Jan.	30.16	10.74	22.19	85.14	39.56	62.35	0	0	8.41
2	8-14 Jan.	31.50	12.64	22.07	89.07	62.71	75.89	0	0	8.60
3	15-21 Jan.	30.08	9.96	20.02	84.28	37.78	61.03	0	0	9.11
4	22-28 Jan.	29.28	14.02	21.65	87.50	38.33	62.93	0	0	9.07
5	29 Jan- 4 Feb	29.77	9.92	19.85	85.91	38.93	62.42	0	0	8.80
6	5-11 Feb.	30.59	10.46	20.53	89.07	39.99	64.39	0	0	9.40
7	12-18 Feb.	33.15	11.85	22.50	85.92	33.64	59.78	0	0	9.96
8	19-25 Feb.	32.62	12.92	22.76	89.14	43.00	66.07	0.37	0.07	10.05
9	26 Feb- 4 Mar.	33.28	12.55	22.92	80.42	35.35	57.89	0	0	10.01
10	5-11 Mar.	34.13	11.60	22.87	82.14	29.35	55.74	0	0	9.93
11	12-18 Mar.	34.78	13.96	24.37	81.85	36.56	59.21	0.35	0.14	10.00

12	19-25 Mar.	34.44	15.67	25.08	83.28	40.78	62.03	0	0	9.80
13	26 Mar- 1 Apr.	34.45	16.81	25.63	83.35	41.42	62.39	0	0	9.58
14	2-8 Apr.	34.17	19.07	26.62	85.92	50.64	68.28	0.07	0.07	9.35
15	9-15 Apr.	35.65	18.03	26.84	79.64	38.28	58.96	0	0	10.15
16	16-22 Apr.	33.37	20.06	26.72	85.28	43.57	64.43	0	0	10.54
17	23-29 Apr.	37.14	20.99	29.07	80.13	43.78	61.96	0	0	10.31
18	30 Apr- 6 May	35.51	21.10	28.31	87.06	52.42	69.74	0	0	10.47
19	7-13 May	35.01	23.19	29.60	83.85	57.14	70.50	0	0	10.19
20	14-30 May	33.54	26.47	30.01	84.07	66.35	75.21	0	0	10.46
21	21-27 May	33.71	24.40	29.06	82.49	62.57	72.53	0	0	10.68
22	28 May- 3 June	33.90	25.46	29.68	79.85	62.71	71.28	0	0	9.93
23	4-10 June	34.27	24.22	29.25	83.35	61.35	72.35	0	0	10.38
24	11-17 June	33.31	24.96	29.14	87.50	68.14	77.82	4.57	0.50	7.33
25	18-24 June	30.55	23.67	27.11	94.42	81.78	88.10	31.80	1.00	4.42
26	25 June-1 Jul.	28.89	24.52	26.71	93.57	85.56	89.57	68.79	0.93	3.81
27	2-8 Jul.	30.49	25.17	27.83	87.99	79.64	83.82	28.64	0.64	5.61
28	9-15 Jul.	30.59	24.94	27.61	91.64	79.21	85.42	12.00	0.85	4.80
29	16-22 Jul.	29.52	24.64	27.08	92.85	81.63	87.24	18.78	0.85	2.86
30	23-29 Jul.	29.13	24.57	26.85	92.42	83.14	87.78	29.67	1.00	2.91
31	30 Jul.- 5 Aug.	29.71	24.48	27.09	95.21	83.14	89.17	12.21	0.57	2.49
32	6-12 Aug.	27.52	23.67	25.60	95.56	91.49	93.53	42.25	1.00	1.89
33	13-19 Aug.	29.02	23.92	26.47	92.71	82.92	87.82	5.21	0.78	3.58
34	20-26 Aug.	29.07	23.64	26.36	94.92	81.14	88.03	25.75	1.00	3.25
35	27 Aug- 2 Sep.	28.34	23.39	26.11	94.92	83.06	88.99	14.36	0.85	3.17
36	3-9 Sep.	28.51	23.06	25.78	95.42	81.78	88.60	6.97	0.64	4.87
37	10-16 sep.	27.79	22.55	25.17	94.42	76.35	85.39	2.61	0.42	7.31
38	17-23 Sep.	29.67	22.86	26.27	93.07	78.63	85.85	15.16	0.28	5.35
39	24-30 Sep.	30.00	22.89	26.44	94.12	75.06	84.67	9.94	0.50	5.78
40	1-7 Oct.	34.57	21.76	28.16	86.85	57.78	72.32	0	0	9.58
41	8-14 Oct.	34.71	21.60	28.15	88.99	47.14	68.06	0	0	9.16
42	15-21 Oct.	34.22	19.65	26.93	88.42	50.21	69.32	0	0	9.41
43	22-28 Oct.	34.40	16.27	25.34	84.64	41.28	62.96	0	0	9.65
44	29 Oct.- 4 Nov.	35.40	17.07	26.23	83.42	41.28	62.35	0	0	9.53
45	5-11 Nov.	34.76	17.08	25.92	89.35	42.63	65.99	0.07	0.07	9.04
46	12-18 Nov	33.16	15.54	24.33	88.57	41.28	64.81	0	0	9.53
47	19-25 Nov.	33.28	13.78	23.53	87.71	37.42	62.57	0	0	9.19

48	26 Nov.- 2 Dec.	32.54	13.68	23.11	88.28	42.78	65.53	0	0	9.16
49	3-9 Dec.	33.01	14.21	23.61	89.57	37.49	63.53	0	0	8.64
50	10-16 Dec.	32.64	12.74	22.69	87.13	43.57	65.35	0	0	9.02
51	17-23 Dec.	31.43	10.75	21.09	91.56	43.21	67.39	0	0	9.16
52	24 Dec- 31 Dec.	29.63	10.02	19.83	88.81	45.23	67.02	0	0	9.13

APPENDIX- V

Impact of recurrent flowering on production of mango

Production parameter	Fruits /50 panicles			'T' values		
	2002	2003	Pooled	2002	2003	Pooled
Pea stage (Fruits /50 panicles)						
Non- recurrent flowers	299.00	597.20	448.10	7.26*	6.41*	11.56**
Recurrent flowers	230.90	493.50	362.20			
Marble stage (Fruits /50 panicles)						
Non- recurrent flowers	152.80	327.00	239.70	9.24*	7.30*	6.30*
Recurrent flowers	102.10	225.80	163.95			
Harvest stage (Fruits /50 panicles)						
Non- recurrent flowers	71.10	187.60	131.15	9.22*	9.77*	10.61**
Recurrent flowers	47.90	104.30	80.55			
Retention at marble over pea stage (%)						
Non- recurrent flowers	51.13	54.70	53.48	4.01*	4.77*	5.14*
Recurrent flowers	44.21	45.90	45.42			
Retention at harvest over marble stage (%)						
Non- recurrent flowers	46.74	57.96	54.86	-0.41	4.10*	1.94
Recurrent flowers	47.30	46.27	49.08	(NS)		(NS)
Fruits/tree						
Non- recurrent flowers	85.30	225.00	155.15	6.25*	11.60**	17.18**
Recurrent flowers	62.80	127.00	95.40			
Yield (Kg/tree)						

Non- recurrent flowers Recurrent flowers	25.560 18.840	67.500 38.100	46.530 28.470	6.22*	11.60**	16.61**

APPENDIX- VI

Impact of high density plantation on fruit setting in mango

Sr. No.	Treatment (based on spacing)	Fruits at pea stage /100 panicles/tree		Fruits at marble stage /100 panicles/tree		Fruits at harvest /tree	
		2002-2003	2003-2004	2002-2003	2003-2004	2002-2003	2003-2004
1	10 x 10 M	307.50	290.80	148.20	140.08	88.10	74.10
2	10 x 5 M.	331.20	495.60	143.20	225.50	91.10	119.10
3	10 x 2.5 M.	255.70	265.40	118.50	136.40	75.00	73.40

APPENDIX – VII

Impact of NPK fertilization on fruit set in mango

Sr. No.	Treatment	Fruits at pea stage		Fruits at marble stage		Fruits at harvest stage	
		Per 100 panicles/tree				Per tree	
		2002-2003	2003-2004	2002-2003	2003-2004	2002-2003	2003-2004
1	$N_0P_0K_0$ (Control)	270.33	518.00	121.67	254.67	65.33	167.00
2	$N_0P_0K_1$	298.33	527.67	142.67	261.33	76.00	156.67
3	$N_0P_oK_2$	297.33	519.00	135.33	260.67	70.33	160.33
4	$N_0P_1K_0$	305.00	540.00	145.33	268.67	77.33	166.00
5	$N_0P_1K_1$	327.67	501.00	157.00	258.67	83.33	145.67
6	$N_0P_1K_2$	309.00	517.33	140.33	239.33	66.33	133.67
7	$N_0P_2K_0$	326.33	502.33	145.00	255.33	71.33	151.67
8	$N_0P_2K_1$	320.00	438.33	147.33	216.33	77.33	120.67
9	$N_0P_2K_2$	332.33	610.67	161.33	289.33	81.33	165.00
10	$N_1P_0K_0$	380.33	611.67	163.00	303.67	87.33	158.67
11	$N_1P_0K_1$	393.67	605.67	179.00	305.00	92.00	162.00
12	$N_1P_0K_2$	374.00	588.33	185.33	305.67	97.67	169.67
13	$N_1P_1K_0$	371.00	597.33	176.33	300.33	111.33	156.67
14	$N_1P_1K_1$	358.67	572.33	174.00	285.00	93.67	157.33
15	$N_1P_1K_2$	372.00	636.33	194.33	313.00	110.00	180.00
16	$N_1P_2K_0$	382.00	645.67	183.00	327.33	101.00	179.00
17	$N_1P_2K_1$	392.00	682.33	181.00	374.67	95.67	197.67

18	$N_1P_2K_2$	405.33	609.00	197.00	358.00	112.00	198.33
19	$N_2P_0K_0$	405.67	626.33	200.33	356.00	116.00	215.67
20	$N_2P_0K_1$	495.67	687.67	241.33	382.67	133.67	193.67
21	$N_2P_0K_2$	485.00	784.67	237.33	421.33	130.00	232.67
22	$N_2P_1K_0$	464.00	847.00	229.33	469.67	128.00	302.67
23	$N_2P_1K_1$	471.00	856.00	236.33	440.67	128.33	278.67
24	$N_2P_1K_2$	497.67	862.33	254.33	453.00	148.33	256.00
25	$N_2P_2K_0$	460.33	716.00	226.00	408.67	136.33	232.00
26	$N_2P_2K_1$	479.33	851.67	251.00	485.67	150.33	311.67
27	$N_2P_2K_2$	509.67	985.67	264.67	599.67	162.00	378.33

Nitrogen : 1. N_0 – 0 Phosphorus : 1. P_0 – 0 Potash : 1. K_0 – 0

(gm/tree) 2. N_1 –75 (gm/tree) 2. P_1 --50 (gm/tree) 2. K_1 -- 75

3. N_2 –150 3. P_2 –100 3. K_2 --150

APPENDIX – VIII

Impact of NPK fertilization on fruit yield in mango

Sr. No.	Treatment	Yield (Kg/ tree) Per tree	
		2002-2003	2003-2004
1	$N_0P_0K_0$ (Control)	19.60	41.92
2	$N_0P_0K_1$	22.80	39.33
3	$N_0P_oK_2$	21.10	40.00
4	$N_0P_1K_0$	23.20	41.33
5	$N_0P_1K_1$	25.00	36.42
6	$N_0P_1K_2$	19.90	33.25
7	$N_0P_2K_0$	21.40	37.92
8	$N_0P_2K_1$	23.20	30.00
9	$N_0P_2K_2$	24.40	41.00
10	$N_1P_0K_0$	26.20	39.50
11	$N_1P_0K_1$	27.60	40.42
12	$N_1P_0K_2$	29.30	42.25
13	$N_1P_1K_0$	33.40	39.08
14	$N_1P_1K_1$	28.10	39.25
15	$N_1P_1K_2$	33.00	44.92
16	$N_1P_2K_0$	30.30	44.58
17	$N_1P_2K_1$	28.70	49.33
18	$N_1P_2K_2$	33.60	49.50
19	$N_2P_0K_0$	34.80	53.92
20	$N_2P_0K_1$	39.93	48.33

21	$N_2P_0K_2$	39.27	58.00
22	$N_2P_1K_0$	38.50	75.58
23	$N_2P_1K_1$	38.43	69.67
24	$N_2P_1K_2$	44.67	64.08
25	$N_2P_2K_0$	40.90	57.92
26	$N_2P_2K_1$	45.00	77.92
27	$N_2P_2K_2$	48.57	94.50

Nitrogen : (gm/tree) 1. N_0 – 0 2. N_1 –75 3. N_2 –150

Phosphorus (gm/tree) :1. P_0 – 0 2. P_1 --50 3. P_2 –100

Potash (gm/tree) :1. K_0 – 0 2. K_1 -- 75 3. K_2 --150

APPENDIX – IX

Influence of paclobutrazol on fruit set in mango hopper

Sr. No.	Treatment	Pea stage		Marble stage		Harvest stage	
		No. of fruits/100 panicles/tree				No. of fruits/tree	
		2002-2003	2003-2004	2002-2003	2003-2004	2002-2003	2003-2004
1	PBZ 4 g.a.i./tree + RDF	377.00	488.33	188.00	234.33	93.67	141.33
2	PBZ 4 g.a.i./tree + ½ RDF	352.33	450.33	182.00	206.33	80.00	128.00
3	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year)/tree + RDF	662.00	695.33	274.67	285.00	134.00	146.33
4	PBZ 4 g.a.i. (I year) & PBZ 2 g.a.i. (II year)/tree + ½ RDF	613.67	623.00	261.75	281.67	123.33	144.67
5	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year)/tree + RDF	697.33	900.33	253.00	492.33	124.00	277.67
6	PBZ 4 g.a.i. (I year) & PBZ 3 g.a.i. (II year)/tree + ½ RDF	660.00	859.00	283.33	423.67	118.67	234.33
7	Control (untreated) + RDF	199.67	192.33	117.00	100.00	45.67	51.67
8	Control (untreated) + ½ RDF	177.33	187.67	98.00	91.00	43.67	46.00

PBZ : Paclobutrazol RDF : Recommended doze of fertilizer

APPENDIX - X

Details of insecticides tested for their bio- efficacy against mango hoppers

Sr. No.	Technical name	Concen-tration (%)	Trade name	Technical (I.U.P.A.C. name)	Formu l-ation	Source
1.	Imidacloprid	0.005	Confidor	1-(6-chloro-3 pyridyl methyl)-N-nitrol-midazolidin-2-ylideneamine	17.8 SL	Bayer (India) Limited, Mumbai - 400036
2.	Thiamethoxam	0.0084 %	Actara	3-(2-chloro-thiazol-5-ylmethyl)-5-methyl-{1,3,5} pxadiazinan-4-ylidene-N-nitroamine	25 WG	Syngenta Crop Protection, Mumbai-400023
3.	Acetamiprid	0.004	Pride	(N1-25); (E)-N1-{(6-chloro-3-pyridyl)methyl}-N2-(cyano N1-methylacetamidine)	20 SP	DE-NOCIL Crop Protection Ltd; Mumbai-400079
4.	Fipronil	0.005	Regent	5-amino-1-{2,6-dichloro-4(trifluoro methyl)phenyl} -4-{(trifluoromethyl) sulfinyl}-1H-pyrazole-3-carbonitrile	5 EC	Rhone Poulenc Agrochemicals (India) Ltd; Mumbai - 400025
5.	Profenofos	0.1	Curacron	O-4-bromo-2-chloro-phenyl-o-ethyl S-propyl phosphorothioate	50 EC	Syngenta Crop Protection, Mumbai-400023
6.	Diflubenzuron	0.02	Dimlin	1-(4-chlorophenyl)-3-(2,6-diflurobenzoyl) urea	25 WP	Northern Minerals Ltd; Gurgaon (Haryana)
7.	Lambda-cyhalothrin	0.005	Karate	∞-cyano-3-phenoxybenzyl 3-(2,chloro-3,3,3, trifluoro propenyl)- 2,2- dimethyl cyclopropane carboxylate, a 1:1 mixture of the (2)-(1R, 3R), S-ester and (2)-(1S, 3S), R-ester	5 EC	Zeneca ICI Agrochemicals Ltd; Chennai - 600057
8.	Carbosulfan	0.05	Marshal	2,3-dihydro-2,2-dimethyl-7-ben-zofuranyl	25 EC	Rallis India Ltd; Mumbai - 400001

				{(dibutylaminothio) methyl carbamate}		
9.	Fenubucarb	0.05	Bipvin	2 sec butyl phenyl-N-methyl carbamate	50 EC	Rhone Poulenc Agrochemicals (India) Ltd; Mumbai - 400025
10.	Endosulfan	0.07	Endocel	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-hexahydro-6,9 methano-2,4,3-benzo(e)-dioxa-thiopin-3-oxide	35 EC	Excel Industries, Mumbai
11.	Monocrotophos	0.04	Nuvacron	Dimethyl (E)-1-methyl-2-methyl carbamoyl vinyl phosphate	36 WSC	Syngenta Crop Protection, Mumbai-4.00023

CERTIFICATE

This is to certify that I have no objection for supplying to any scientist or worker a copy of thesis or any part of it for rendering reference service either in a library or documentation centre.

Place : Navsari

Date : 20th January, 2006

(Sushil Kumar)