

**BIODIVERSITY OF SYRPHID FLIES AND  
THEIR MAJOR ROLE AS POLLINATORS OF  
MANGO (*Mangifera Indica*) AND AS A  
PREDATOR OF APHIDS IN PANTNAGAR  
(UTTARANCHAL)**

*Thesis*

**Submitted to the**

**G.B. Pant University of Agriculture & Technology  
PANTNAGAR – 263 145 (U.S. NAGAR),  
Uttaranchal, INDIA**



**By**

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**IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF**

**Master of Science**

**(Entomology)**

**June, 2005**

# Acknowledgement

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*I wish to express my deep sense of gratitude for Dr. Avdhesh Kumar, presently Associate Professor, Department of Aquaculture, College of Fisheries and Chairman of my advisory committee for his inspiring guidance, compassionate criticism and soothing affection during the course of investigation and propagation of this manuscript. He, not only took pains to help me in my difficulties and treating me all the time affectionately.*

*I would like to express gratitude and fervent thanks to the members of the advisory committee, Dr. Gajendra Singh, Head of the Department of Entomology and Dr. Sri Ram, Professor, Department of Entomology for their keen interest and for their in-valuable suggestions and support extended during the entire course of investigation.*

*Sincere thanks are to Dr. G.C. Sachan, Professor, Department of Entomology for his help in the submission of my synopsis and submission of my thesis. My sincere thanks are also to the Dean, College of Post Graduate Studies, Dean College of Agriculture, Dean Student Welfare and University authorities. I am extremely thankful to the faculty and staff members of the Department of Entomology, who helped me during the course of investigation.*

*My vocabulary fails to express my feelings for the love, affection and blessings and support provided by my parents who have always been the guiding lamp for me, instilling in me importance of learning so that I could build confidence in myself and urging me to strive for the high goals.*

*My sincere thanks are to Shri. Ram Hazoor and Jungi Ji, Laboratory Assistant for their help during this investigation.*

*My special thanks are to my seniors Ajay sir, Medha mam, Nidhi mam, Poonam mam, Anju mam, Garima mam and my batchmates, Mallanagouda, Pradeep, kuldeep, Shweta, Shailendra, Vikas, Harjas, Sunita, Renu, Arvind, Pooja and juniors Rachna,*

*Anju, Anita, Dyaneshwar, Bhiva, Deepchandra, Basant, Nandini, Shikha and other friends like Rachna, Shakti, Deepa, Pinki, Bhupendra, Jagdish and Moonakshi.*

*Heartfelt thanks to my dear friend Shweta who was always with me and helped me out of many problems faced by me and was always of constant help during my years of study in Pantnagar.*

June, 2005  
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## **CERTIFICATE**

This is to certify that the thesis entitled “**BIODIVERSITY OF SYRPHID FLIES AND THEIR MAJOR ROLE AS POLLINATORS OF MANGO (*Mangifera Indica*) AND AS A PREDATOR OF APHIDS IN PANTNAGAR (UTTARANCHAL)**”, submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** with major in **ENTOMOLOGY** of the College of Post-Graduate Studies, G.B. Pant University of Agriculture & Technology, Pantnagar is a record of bona fide research carried out by **Ms. Manju Thakur, Id. No. 30662**, under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation has been acknowledged.

**(Avdhesh Kumar)**  
**Chairman**  
**Advisory Committee**

## **CERTIFICATE**

We, the undersigned, members of the Advisory Committee of **Miss Manju Thakur, Id. No. 30662**, a candidate for the degree of Master of Science in Agriculture with major in **ENTOMOLOGY**, agree that the thesis entitled **“BIODIVERSITY OF SYRPHID FLIES AND THEIR MAJOR ROLE AS POLLINATORS OF MANGO (*Mangifera indica*) AND AS A PREDATOR OF APHIDS IN PANTNAGAR (UTTARANCHAL)”**, may be submitted in partial fulfillment of the requirements for the degree.

**(Avdhesh Kumar)**  
**Chairman**  
**Advisory Committee**

**(G. Singh)**  
**Member**

**(Shri Ram)**  
**Member**

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## Introduction

Syrphid flies or Hoverflies (Diptera: Syrphidae) are one of the most diverse flies of the world, comprising about 200 genera and over 5000 species. Hoverflies adults display a wide range of life style and adaptations (**Gilbert, 1990, 1993 and Gilbert *et al.*, 1994**). According to **Vockeroth and Thompson (1987)**, the Syrphidae (Diptera) comprise three sub-families, 180 genera and about 6000 described species. Adults of many species resemble stinging bees and wasps. Larvae of some species are aphidophagous, which are in the sub-family of syrphinae. Adult of aphidophagous species, which are frequent flower visitors and the morphology of the mouthparts suggests that certain species are predominantly nectarivorous where as others are pollinivorous (**Gilbert, 1981**).

All adult syrphid flies however are melliphagous, i.e. they are dependent upon both nectar and pollen, but when they first hatch from pupae they only take pollen, which is used as the main protein source for maturation of their sex organs (**Gilbert, 1986; Branquart and Hemptine, 2000**). The amount of pollen in the gut was significantly higher in gravid as compared to non-gravid females (**Irvin *et al.*, 1999**). Adults require honeydew or nectar and pollen

to ensure reproduction, whereas larvae usually require aphids to complete development (**Schneider, 1969**). From the comparative study about the alternative food of syrphid fly larvae, the larvae do not accept the psyllid as their food. They accept many kind of aphid species such as *Aphis craccivora* and *Rhopalosiphum pseudobrassicae* as their food and can develop their growth successfully (**Siripan-Tantakom et al., 1993**).

Pollination of flowers require insect like syrphid flies, honey bees, ants and wasps (**Das and Chodhury,1968 and Chaturvedi,1965**). Syrphidae were the most important group of flower visiting beneficial insects comprising (81per cent in 1989 and 95per cent in 1990) and *Sphaerophoria scripta*, *Episyrphus balteatus* and *Metasyrphus corollae* contributed more than three quarters to the group of the aphidophagous syrphids (**Weiss and Stettmer, 1991**). Pollen feeding seems to be extensive in the family Syrphidae (**Grinfeld, 1955; Schneider, 1969 and Pino ,1962**).

**Singh (1982)** observed that the insect pollinators associated with mango were *Syrphus* sp. The mango belongs to the family Anacardiaceae which is a dicotyledonous family consisting of 64 genera. The mango inflorescence is a branched terminal panicles, 4 to 24 inches long with a five hundred to several hundred individual flowers. The number of panicles may range from 200 to 3000 per tree (**Ochae, 1955**).

**(Singh, 1954)** indicated the limitations of anemophilous pollination in this fruit and observed that the development of panicles in the mango was a continuous process which lasted for about the third week of March and flowers start opening long before the panicles reach full growth. He observed that *Syrphus* sp. are one of the principal insect pollinators of mango at Saharanpur (Uttar Pradesh). According to **Maier and Waldbauer (1979)** the syrphid flies fed on flowers when pollen is most plentiful. According to **Chambers and Adams 1986; Chambers et al. (1986)** and **Tenhumberg (1995)** the larvae of many hoverfly species are important natural enemies of aphids.

**Radeva (1983)** studied the fauna of syrphidae preying on *Brevicoryne brassicae* (L) and *Acyrtosiphon pisum* (Harris) on pea and cabbage in Bulgaria. Thus importance of adult syrphid flies as the major insect pollinators of mango, litchi, horticultural, medicinal and agricultural plants and its larvae as an important biological control agent is obvious.

Keeping this in view, a comprehensive study was undertaken to determine the contribution of syrphid fly as an important biological control agent of aphids. These experiments were conducted at Horticultural Research Center, Pattharchatta, Crop Research Center and Department of Entomology of the G.B. Pant

University of Agriculture and Technology with the following objectives:

1. To identify the major syrphid fly species as pollinators of various agricultural, horticultural, medicinal, ornamental, oilseed crops and as the major pollinators of mango.
2. To study the prey preference of syrphid fly larvae as a predator and its biology.
3. Effect of bagging the mango panicles with different number of syrphid flies released in bloom.
4. Studies on the pollinating efficiency of the syrphid fly.
5. Relationship between syrphid fly activity and abiotic factors.

The literature pertaining to the present study was divided under the following heads and sub-heads:

- 2.1. Host range of syrphid flies as pollinator and as predator
- 2.2. Pollen grains and pollination in mango.
- 2.3. Flowering and flower biology.
- 2.4. The insect pollinators of mango and their role in fruit set.

### **2.1. Host range of syrphid flies**

The syrphid flies display a wide host range of flowering plants. Adults require honeydew or nectar and pollen to ensure reproduction, whereas larvae usually require aphids to complete their development (**Schneider, 1969**). All adult syrphid flies are dependent upon both nectar and pollen, but when they first hatch from pupae they only take pollen, which is used as the main protein source for maturation of their sex organs (**Gilbert, 1986, Branquart and Hemptine, 2000**). Adult of aphidophagous species are frequent flower visitors, and the morphology of mouthparts suggests that certain species are predominantly nectarivorous, whereas other are pollinivorous (**Gilbert, 1969**). The aphid-derived complex of sugars, amino acids and water is called honeydew and known to serve as an important oviposition stimulus for syrphids (**Bomboser and Volk, 1966 and Budenberg and Powell, 1992**). The amount of pollen in

the gut was significantly higher in gravid compared to non-gravid females (**Irvin et al.1999**).

### **2.1.1 Host range of adult syrphid flies as pollinators**

Adult melliphagous syrphid flies are frequent flower visitors, and the morphology of the mouthparts suggests that certain species are pollinivorous (**Gilbert, 1981**). According to **Freund and Furgala (1982)** 6 per cent syrphid flies out of all pollinators were observed on sunflower cultivars foraging for nectar or pollen. Regular visits by syrphid flies genera *Melanostoma* and *platycheirus* to the flowers of *Plantago lanceolata* (which is thought to be pollinated by wind) for pollen consumption have often been reported (**Stelleman and Meeuse, 1976**).

**Singh (1988)** observed that major pollinators associated with mango were *Melipona* sp. and *Syrphus* sp. A study was carried out at Jachh in 1992-1993 to determine the relative abundance of insect visitors on litchi and other fruits, out of the 34 insect species recorded on flowers, 15 species were of Diptera. The main pollinators of litchi included the hoverfly, *Episyrphus balteatus* as primary and *Apis florae* as secondary (**Bhatia et al., 1995**).

Syrphid flies were most common insect pollinators visiting flowering plum, peach and almond trees in Himachal Pradesh, India. *Eristalis* sp. was found to be the dominant species and it worked out the longest hours throughout the flowering season of

sarson (*Brassica campestris*) in Himachal Pradesh, India during February-March. Syrphid flies were therefore the most effective pollinators (**Bhalla et al., 1983**). *Eristalis tenax* (Diptera: Syrphidae) was found to be the important pollinator of green house sweet pepper fruits (**Jarlan et al., 1997**).

### **2.1.2. Host range of syrphid fly larvae as predator.**

**George (1957); Hughes (1963); Pimental (1961); Prethebridge and Mellor (1936)** observed that syrphids are the most common and probably the most effective predators of the cabbage aphid.

**Alfiler and Calilung (1978)** studied the life history of *Ischiodon scutellaris* (F.) a syrphid predator of *Melanaphis sachari* (Zhnt.) (*Longiunguis sacchari*) in Philippines both from literature and laboratory experiments in which *M.sacchari* and *Rhopalosiphum maidis* (Fitch) were provided as prey. The egg stage lasted 3-4 days. The larval stage lasted for 5-7 days and included 3 instars. The pupal stage lasted for 4-12 days, but the total development period lasted for 16-17 days. Adult males lived for 7-8 days after emergence and adult females for 11-22 days during which they laid 32-51 eggs each. The number of aphids consumed by each larval instar was about 37 for the 1<sup>st</sup> instar and about 50 for the second, with no significant difference between the relative number of the 2 prey species

taken, but during the third instar the *Ischiodon* larva ate about 71 individuals of *M. sacchari* and about 58 of *R. maidis*.

**Radeva (1983)** studied the fauna of syrphid flies preying on aphids of pea and cabbage in Bulgaria between 1976 and 1980. The main species of syrphid flies preying on cabbage aphids (*Braevicoryne brassicae* (L.) was *Sphaerophoria scripta* (L.) accounted for up to 58 per cent of the total, while on pea (attacked by *Acyrtosiphon pisum* (Harris) the most abundant species was *Episyrphus balteatus* (Deg.) accounting for up to 62 per cent. Aphidophagous syrphid fly larvae are most important predators of cereal aphids in Northern Germany. **(Tenhumberg and Poehling, 1995).**

**Kumar et al. (1997)** reported larvae of *Scaeva latimaculata*, *Ischiodon scutellaris*, *Episyrphus alternans*, *Sphaerophoria indiana*, *Metasyrphus confractor* (*Eupeodes confractor*) and *M. latilunulatus* (*E. latilunulatus*) preying on aphids, including *Lipaphis erysimi*, *Myzus persicae* and *Braevicoryne brassicae* of mustard (*Brassica campestris*) in Punjab, India during 1983-85.

*Episyrphus balteatus* De Geer was found to be the most important predator of aphids of citrus fruits in Tunisia (Belgium) **(Ben.Halema. Kamel et al., 1994).** *Syrphus corollae* (*Eupeodes corollae*) was found to be important natural enemy of soyabean aphids in Jilin, China) **(Gao, 1990).** Syrphid flies *Syrphus*

*(Epistrophe) balteatus* (Deg.), *S.vitripennis* Mg., *S.ribesii*, *S.corollae* F., *Lasiophthicus pyrastris* (L.) and *Sphaerophoria scripta* (L.) were most important predators of *Aphis fabae* Scop and other aphids of sugar beet in France **(Lyon, 1971)**. The abundance of preimaginal stages (eggs, larvae, pupae) of syrphids (Diptera: Syrphidae) were encountered in winter wheat (*Triticum aestivum*) with different levels of aphid infestation. The *Episyrphus balteatus* (Deg.) was predominant species **(Tenhumberg and Poehling, 1989)**.

The occurrence and the composition of species of aphidophagous syrphid flies and their phenology was studied in connection with population dynamics of aphids in maize stands. In the material collected by the trap 26 aphidophagous syrphid species were found, among which *Metasyrphus corollae* (F.), *Sphaerophoria scripta* L. and *Episyrphus balteatus* (Deg.) were dominant **(Visnoyovszky and Raczv, 1989)**. *Metasyrphus corollae* (Fabr.) *Sphaerophoria scripta*, *Episyrphus balteatus* (Deg.) and *Scaeva pyrastris* (L.) were collected from the colonies of cabbage aphid **(Wiech and Jankowska, 1994)**.

Six species of syrphid flies were found in vegetable fields in Shanxi, China among them *Episyrphus balteatus*, *Metasyrphus corollae* (*Eupeodes corollae*) and *Scaeva pyrastris* were most important predators in aphid control **(Yang. Youlan et al., 2002)**.

**Poehling (1988)** reported that the syrphid fly larvae were the most important aphid specific predators in all investigated vegetation periods. Always a good synchronization in time of egg deposition and abundance of larvae with increasing density of cereal aphids could be observed. According to **Adashkevich and Karelin (1995)** syrphid fly larvae are the important predators of aphids and also attack teranychid mites, thrips and eggs of other insects.

**White et al. (1995)** reported that the Brassica in New Zealand are attacked by the cabbage aphid, *Braevicoryne brassicae* (L.) the green peach aphid *Myzus persicae* (Sulzer), the larvae of *Artogeia rapae* (L.), and the diamond back moth *Plutella xylostella* (L.), all these pests are consumed by syrphid fly larvae very well.

**Bisht et al. (2001)** reported that the predators, *C. septempunctata*, *Syrphus* sp., *Machinus indianus* (Ric.), Diptera: Asilidae to be prominent bioagents in minimizing the aphid population on the basis of their appreciable feeding propensity and synchronization of their population with the population of the respective aphid species.

Syrphids were found to be dominant over the other predators in terms of density, species consumption and prey consumption potential as natural enemies on the population of *Lipaphis erysimi* infesting *B. Juncea* var. *rugosa* (**Devi et al., 2002**) Out of twenty five species of syrphids recorded in the locality of Chandigarh, Punjab, India *Eristalis*

*arvorum* was found on *Chrysanthemum* sp., *Paragus* sp. and mustard and *Syrphus corollae* (*Eupeodes corollae*) on wild grasses (**Singh et al., 1990**).

## **2.2 Pollen grains and pollination in mango**

**Popenoe (1917)** reported that 2-10% of the pollens in mango were regularly defective, it happened mainly in early flowering as compared to the late. Shape and size of the pollen grains also have considerable variations. Flowers start opening in the morning and anthesis occur in the forenoon. Mango pollens do not possess the characteristics of the anemophilous plants. On the other hand it is adapted for insect pollination (**Popenoe, 1920**).

Pollen viability has been studied by several workers. It was highest (68.4%) at 3 hours after anthesis and dropped to 9.9% after 6 hours. Maximum pollination was reported from 8 to 10 a.m. (**Sharma and Singh, 1970; Moti, 1973**). Long period of bloom in abnormal cold weather in march or with insecticidal spray at very high concentrations indicated that flowers wait for insect pollinators to a maximum possible period. Reduced activity of pollinators due to low temperature during flowering contributed to the formation of 5.44 per cent parthenocarpic seedless fruits in mango (**Thimmapaiah and Singh, 1983**).

**Khader (1989)** also observed setting of a cluster of abnormal seedless fruitless at the tip of the panicle called “JHUMKA” in

Lucknow area. Most of these fruits contained aborted and shrivelled embryos and dropped in less than two weeks. Failure of pollination due to adverse climatic conditions in February-March was considered a factor responsible for this.

Further it is well evident from the findings of various workers that pollination is quite inadequate in mango and more than 50 per cent of the female flowers are never pollinated in nature. Lack of pollinating insects, limited period of stigmatic receptibility and maturation of stigma before another were some of the factors for the ineffective pollination (**Spencer and Kennard, 1956**). Stigma receptivity in Alphanso ranged from 56.5% on the day of the anthesis to 2.6 per cent on the 3<sup>rd</sup> day. Non-pollinated ovaries continued to grow up to 6 mm in diameter. The percentage of hermaphrodite flowers and fruit set were greater in late than in early flushes. No self-incompatibility was observed but fruit set increased by cross-pollination in Pairi, Totapari, Dudhiya peda, and Vanraj (**Gunjate et al., 1983; Desai et al., 1985**).

## **2.2. (ii) Self versus cross pollination**

**Singh et al., (1962)** observed that self pollinated flowers of Dashehari variety developed fruit only to 'pea' size and open pollinated or cross pollinated flowers produced fruits which ripened normally. Results of self and cross pollination indicated that the fruit set in Langra was nil and 0.18 per cent in Himsagar under

selfing but crossing gave 66.9 to 70.4% fruit set (**Mukherjee and Banerjee, 1976**). Cross-pollination gave increased fruit set and retention in Alfanso, Keshar and Goamankurad although three varieties were not reported to be self incompatible (**Desai et al., 1985**).

Cross-pollination in cv. Kaew resulted more harvested fruits than self pollination. The speed and percentage of pollen germination was higher in those treated with plant growth regulators (**Kasem-Phuangchik, 1994**). **Ram and Sirohi (1994)** revealed self-incompatibility in Langra, fruits were set but failed to grow beyond 35 days. Dashehari was recommended as pollinizer.

**Bhatia et al. (1995)** proved that mango was highly cross-pollinated crop and maximum increase in fruit set was obtained with insect pollinators (Calliphorids). The studies conducted so far clearly prove that most of the mango cultivars set normal fruits, through cross-pollination only with suitable pollenizers.

According to **Degani et al. (1996)** there is an uncertainty whether cross-pollination is necessary in mango for obtaining satisfactory fruit set. They quantitatively proved percentage of cross-pollinated set fruits by using polymorphic enzyme systems, triosephosphate isomerase (TPI) and isocitrate dehydrogenase (IDH). Maya and Tommy Atkins were used each as pollinizers in two different commercial orchards of these varieties. The cross-

pollination rate in 'Maya' was 63% and 34 per cent at distances of 6 m and 108m respectively from Tommy Atkins. In Tommy Atkins block the rate was 79 per cent and 24 per cent at a distance of 6 m and 80m respectively from 'Maya'. The studies indicated that the cross-pollinated fruits survived much more compared to selfed ones.

### **2.3. Flowering and flower biology**

**Singh (1954)** stated that low fruit set in Romani variety was due to the large proportion of staminate to hermaphrodite flowers in a panicle. **Jawanda and Singh (1961)** observed that on set of flowering varied from the end of February to the middle of March. On an average only 0.4 fruits per panicle were retained by the harvest time. The major fruit drop occurred in April.

**Majumdar and Mukherjee (1961)** observed that the percentage of hermaphrodite flowers was more on the North side of the tree and the lowest on the East. In a panicle the upper part produced the most bisexual flowers. **Singh (1962)** stated that 66.74 per cent and 35.99 per cent of hermaphrodite flowers in the varieties of Simmonds and S.B. Chausa, respectively are found.

**Mukherjee and Banerjee (1976)** studied compatibility Langra and Himsagar both were selfed and cross pollinated manually at the optimum time of receptivity at about 10. a.m. during 1974, about 500 flowers were used for each purpose from 32 panicles in 3 different trees of each variety. The selected panicles were bagged

and the flowers emasculated before anthesis early morning. After pollination the remaining flowers and branches of the panicles were clipped off and the panicle bagged again. The success in fruit set was counted from the developing fruits in pea stage and the bags removed. The results indicated that fruit set was nil in Langra and 0.18 per cent in Himsagar under selfing but crossing gave 66.9-70.4 per cent fruit set.

**Bana et al. (1976)** reported that in the Eastern Uttar Pradesh panicle emergence started in mid January and continued till March, the panicles attained their maximal growth rate 2-3 weeks after emergence, and these required 5 weeks to reach maturity. The average percentage of perfect flower per panicle was only 0.5% but in thinned panicle it was 2.7%. Peak anthesis occurred between 2 a.m. to 4 a.m. and dehiscence between 8 a.m. to 12 noon. The stigma was receptive on the day of anthesis, but thereafter its receptivity rapidly declined.

**Santo and Delos (1976)** observed that the 62.6 per cent flowers were hermaphrodite, 31.1 per cent staminate and 6.3 per cent deformed. The flowering period lasted 17 days with 150-200 flowers opening daily. **Kalyanasundaram (1976)** stated that, the panicle emergence started in mid January and continued till early March. Neelam had the highest percentage of perfect flowers (62%) and Mulgoa the least 5 per cent and the duration of flowering period

was 20-24 days. The peak period of dehiscence was between 10 a.m. to 12 noon and stigma receptivity was maximum around 9 a.m.

**Anderson et al. (1982)** observed that large native insect species were shown to pollinate on mango. The pollinators in decreasing order of efficiency were wasps, bees, large ants and large flies. The most efficient pollinators were those that carried large amount of pollen grain on their thorax and used a short proboscis or mouth parts to feed on nectar. Large Diptera and the native bee *Trigona* sp. frequently moved from tree to tree and thus were probably the most effective cross-pollinators of randomly selected hermaphrodite mango flowers thirty six per cent were pollinated.

**Desai et al., (1985)** observed that the percentage of hermaphrodite flowers in all three varieties was greatest on the North side and least on the East side of tree, and increased from early flush to the mid flush to the late flush. The pollen viability was highest in Kesar (93.73per cent) followed by Alphanso (85.44%) and Goamankur (73.75per cent). These three varieties were not self-incompatible but cross-pollination increased fruit set and retention.

## **2.4. Insect pollination**

### **2.4.1 Indispensability of insects as pollinators of mango**

Studies conducted till today did not conclusively answer all the questions pertaining to the pollination ecology of mango. One thing however, is very clear that insects are indispensable

for normal fruit set in most of the commercial cultivars of mango. Covering of mango trees in bloom with fully insect proof nylon screen mesh resulted in zero fruit set. A few parthenocarpic fruit may set in some few cases. Similarly bagging of individual panicles also resulted in zero fruit set **(Singh, 1989, 1996, and Dag and Gazit, 1996)**. **Jiron and Hedstrom (1985)** have also observed in COSTA RICA and Panama that mango with bagged flowers did not set fruit indicating that they did not have the capacity for autogamy.

#### **2.4. 2 Insect pollinators of mango and their role in fruit set**

Effective pollination by insects is necessary for good fruit set and yield in mango. **Dag (1996)** conducted an experiment for three years (1994-1996); the insect pollinators were collected and observed visiting mango bloom in 10 orchards located in all major mango growing areas in Israel. The following species were found to play a significant role in mango pollination in Israel; Diptera: *Lucilia sericata* and *chrysomy albiceps* (blow flies); *Musca domestica* (housefly) and several species of syrphidae family (hoverflies).

**Singh (1989)** observed that the major pollinators associated with mango were *Melipona* sp., *Syrphus* sp. and blue bottle flies; housefly *Musca domestica* was also prevalent. Besides these *Coccinella septempunctata* was another important pollinator. There was no fruit set on completely bagged panicles. Some fruits were set

when bags were opened for 24, 48, 72 hours during the bloom. Similarly fruits were set in insect released bags (**Singh et al., 1997**).

**Jiron and Hedstrom (1985)** observed in COSTA RICA and Panama. They observed that the most common visitors of the flowers of mango were Diptera (Syrphidae, Calliphoridae and Sciaridae) 51.6 per cent of all visitors; Lepidoptera (Nymphalidae and Lycaenidae) 33 per cent, Coleoptera such as Cantharidae 11.6 per cent, and Hymenoptera such as Apidae 13.6 per cent. Some of these insects fed on pollen or nectar, while other preyed on other visitors. Syrphid flies, Calliphorid flies and Tachinid flies had greater amounts of pollen attached to their bodies rather than other visitors.

**Du and Swart (1993)** examined insect foragers for nectar, pollen and bee glue in a 14 ha mango orchard in S. Africa (Lesitele Valley). Low frequencies of foragers indicated limited quantities of available pollen and nectar, honey bees, however, were most frequent. Extra nectaries may help in increasing foragers especially bees.

**Eardley and Mansell (1994)** recorded a total of 816 insect visitors in a flowering mango orchard in South Africa's Lesitele Valley during 1993. The most important insects were small Carpenter bees, (*Baunsapis* sp.) 25 per cent. Honey bees

represented 18 per cent of all insect visitors and blow flies (Calliphoridae) 22 per cent.

**Purnomo et al. (1997)** reported, that the insect pollinators played an important role in increasing fruit set in mango Arumanis cultivar, but the population was relatively low at the time of blooming.

**Dag and Gazit (2001)** observed that effective insect pollination is essential for good fruit set and yield in mango (*Mangifera indica*). The insects blow flies, *Musca domestica* (Housefly) and several species of syrphid fly, of which *Episyrphus balteatus* were the predominant visitors of mango flowers. They concluded that the Dipterans are most important pollinators for mango

A study was conducted by **Singh and Singh (2003)** in 1987-1988 in Nainital, Uttaranchal, India to evaluate the insect visitors of mango. Twenty-four insects were found on mango belonging to the orders of Coleoptera, Diptera, Heteroptera, Hymenoptera and Lepidoptera. The maximum number of insects belonged to the family Syrphidae, Muscidae and Calliphoridae of the order Diptera.

The experimental methods used and procedures followed during the course of investigation are being described below under appropriate heads and subheads:

**Experimental site**

The experiments were conducted in the Horticultural Research Center, Crop Research Center and Department of Entomology of the G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar (Uttaranchal), India during the period (2003-05). Pantnagar is situated at 29°N latitude, and 79.3°N longitude. It has an altitude of 243.84 meters above the mean sea level.

**Climate**

The area under investigation is characterized by humid, sub-tropical climate with maximum temperature from 30-40°C in summers and minimum ranging from 2-10°C in winters. The summers are hot and humid, winters are cold and rainy season receives heavy rainfall (average 1400 mm). Monsoons occur from third week of June to middle of September. June to August are the wettest months (303-529.2 mm rainfall). The frost can be expected from last week of December to the end of January. Occasionally light rains are expected during winters.

Clear skies are observed in the months of January to June. Weekly mean weather parameter prevailing in the course of investigation were recorded from the meteorological observatory of Pantnagar and are presented in Figure 4.1 and 4.2 and Appendix I.

The studies included the following experiments:

1. Detailed survey of the host range of Adult Syrphid flies as pollinators of ornamental plants, vegetable plants, fruit trees, oil seed plants and medicinal plants.
2. Feeding preference and biology of the larval form of syrphid fly.
3. Effect of bagging the mango panicles with different numbers of syrphid flies on fruit setting.
4. Studies on the pollinating efficiency of the syrphid flies.
5. Relationship between syrphid fly activity on fruit setting and quality of the mango fruit.

### **Experiment No. 1:**

This experiment was conducted in the field.

**To study the biodiversity of Adult Syrphid flies,** detailed survey of the host range of adult syrphid flies as pollinators on ornamental plants, vegetable plants, fruit trees, oil seed plants and medicinal plants was conducted under the area of

investigation. The syrphid flies were collected with the help of the hand net from the various flowering host plants. The collected Syrphid flies were pinned, labeled and arranged according to their host plants from where they have been collected, place and time of collection. These collected Syrphid flies were identified by Dr. R. S. Bisht, Professor, Department of Entomology, G.B. P.U.A.& T., Pantnagar.

### **Experiment No. 2:**

This experiment was conducted in the experiment lab of Department of Entomology.

#### **To study the feeding preference of Syrphid larvae over three aphid species and the biology of Syrphid flies**

Different stages of the aphid species viz. *Lipaphis erysimi*, *Braeviorhynchus brassicae* and *Aphis gossypii* were collected from the field and syrphid larvae from the aphid colonies were reared in the laboratory on the respected aphid sp. The experiment was replicated five times per treatment for one of aphid species. Rearing cages were used to investigate the feeding potentiality of *Syrphus* sp. (Diptera: Syrphidae) on the three species of aphids. The experiment was conducted by placing a chimney on a petri dish containing moistened filter paper while its other end was kept covered by a muslin cloth using a rubber band. Fresh leaves were provided as food to the

aphids at every 24 to 48 hrs of interval. Before the start of the experiment the larvae were starved for 24 hrs then for the feeding experiment each syrphid fly larva was fed with the counted number of aphids in each day. The average of daily consumption and total nymphs destroyed by each larva was recorded.

### **Biology of the syrphid fly (*Syrphus corollae*)**

The experiment was conducted at temperature between 22 and 24°C relative humidity of 40% to 80%. During the starting of the experiment five gravid females that had been reared in the laboratory were allowed to oviposit on mustard inflorescence on which aphids were feeding. Adults were fed hazel pollen and a solution of two volumes of water and one volume of honey. The pollen was presented on a filter paper in the bottom of each jar. Two pieces of absorbent cotton, one wetted in honey solution and one wetted with water were also added in each jar. A surplus of pollen was always present in each jar and the absorbent cotton plugs were frequently renewed with fresh honey solution and water. The jars were kept in shelf in a room in which the light was coming regularly. 17 hrs per day of photoperiod was maintained for conducting the experiment. After 24hrs eggs were collected. The gravid females laid eggs that hatched approximately 3 days later. The

larvae were reared on *Braevicoryne brassicae* (mustard aphid). Then the larvae changed into pupae. Each pupa was kept separately in cage and where the adult emerged after 7-9 days.

Data was recorded relating to:

- i. Time of egg laying.
- ii. Number of larval instars.
- iii. Larval period
- iv. Pupal period
- v. Adult longevity

### **Experiment No.3:**

This experiment was conducted on Dashehari mango trees, HRC Pattharchatta.

This experiment was comprised of the following treatments i.e.

- i. Completely closed panicles without flies (T<sub>0</sub>)
- ii. Panicles bagged with 5 syrphid flies (T<sub>1</sub>)
- iii. Panicles bagged with 10 syrphid flies (T<sub>2</sub>)
- iv. Panicles bagged with 15 syrphid flies (T<sub>3</sub>)
- v. Panicles bagged with 20 syrphid flies (T<sub>4</sub>)
- vi. Completely open panicles (T<sub>5</sub>)

Each treatment was replicated four times, for experiment the trees of Dashehari mango aged 30 years old were selected. On each of these trees six panicles were tagged five of these

were bagged in very fine white nylon mesh bags sleeved at both the ends. One panicle was left completely open for experiment first (T<sub>0</sub>) the panicles were kept completely closed throughout from their emergence till fruit setting. Bags were checked for the presence of any undesired insects. For experiment number one (T<sub>1</sub>), number two (T<sub>2</sub>), three (T<sub>3</sub>) four (T<sub>4</sub>) and five (T<sub>5</sub>) the panicles were bagged from their emergence, later during the peak bloom period 5,10,15 and 20 syrphid flies were released into the bags for pollination. The panicles were bagged soon after their emergence to avoid any insect injury or entrance. The activity of released insects was watched regularly. The numbers of fruits were counted in each bag and on open pollinated branches as soon as pollination was over and fruits were set. Observations were recorded after pollination in mango on the following aspects:

**(i) The number of fruits**

The number of fruits at the different stages of growth viz. at pea size, marble size and full size were counted for each bag and open pollinated panicles.

**(ii) Percent fruit set**

The female flowers per panicle were counted for each treatment replication wise. Percentage of fruit set

was calculated on the basis of total number of female flowers.

### **(iii) Fruit drop**

The percentage of fruit drop was calculated on the basis of total number of female flowers.

## **Experiment No. 4:**

This experiment was conducted in mango orchard. HRC, Pattharchatta on the studies of the pollinating efficiency of the syrphid flies in mango under the following parameters:

### **1. Syrphid flies per panicle**

The total number of syrphid flies on one panicle in one minute was counted in each hour during the day from 0700 hr up to 1700 hr. The counting was done on ten panicles and later the average was taken.

### **2. Foraging rate**

The total number of flowers visited by a single syrphid fly per minute was counted for ten flies and later average was taken.

### **3. Foraging time**

The total time spent by a fly on one flower was recorded for ten flies and later on average was taken. All observations were recorded with the help of stopwatch.

#### **4. Meteorological data**

The meteorological data of temperature, light intensity and wind velocity were recorded regularly during the period of study.

#### **Experiment No. 5:**

This experiment was conducted in the experimental laboratory of Department of Horticulture for the study of relationship of the syrphid flies activity on the quality of the mango fruit. In this experiment the ripened fruits matured in the bagged and unbagged panicles with the different numbers of the syrphid fly releases were tested for the following parameters:

##### **1. Total soluble solids (TSS)**

The total soluble solid content of the fruit was recorded using hand refractometer (Erma) at room temperature (by using correction factor) and presented in terms of percentage.

##### **2. Size of the fruit**

The length and diameter of ten fruits of each replication were taken with the help of Vernier Callipers and average was expressed in centimeters (cm).

##### **3. Size of the seed**

The length and diameters of ten seeds of each replication were taken with the help of Vernier Callipers and the average was expressed in centimeters (cm).

#### **4. Fruit weight**

The fruits weight was recorded under the following sub-heads:

- i. Weight of peel (g)
- ii. Weight of pulp (g)
- iii. Weight of seed (g)

All the observations were recorded by weighing ten fruits per replication on a pan balance and the average was expressed in grams.

#### **Statistical analysis**

The data were subjected to statistical analysis as prescribed for randomized block design and interpretation of results were based of 'F' test. The critical difference of results based on 'F' test. The critical difference (CD) at 5% level of significance was calculated for comparing means (Snedecor and Cochran, 1968). All the data were statistically analyzed with the help of computer micro-32 available in the College of C.B.S.H of the G.B.Pant University.

**Treatments:**

T <sub>0</sub>	Completely closed panicles
T <sub>1</sub>	Panicles bagged with 5 syrphid fly releases
T <sub>2</sub>	Panicles bagged with 10 syrphid fly releases
T <sub>3</sub>	Panicles bagged with 15 syrphid fly releases
T <sub>4</sub>	Panicles bagged with 20 syrphid fly releases
T <sub>5</sub>	Completely opened panicles

H <sub>1</sub>	0700-0800 hr.
H <sub>2</sub>	0800-0900 hr.
H <sub>3</sub>	0900-1000 hr.
H <sub>4</sub>	1000-1100 hr.
H <sub>5</sub>	1100-1200 hr.
H <sub>6</sub>	1200-1300 hr.
H <sub>7</sub>	1300-1400 hr.
H <sub>8</sub>	1400-1500 hr.
H <sub>9</sub>	1500-1600 hr.
H <sub>10</sub>	1600-1700 hr.

This chapter deals with the experimental findings obtained during the course of investigations. The data has been analyzed statistically and duly supported through Tables and graphs given at appropriate places. The results have been presented experiment wise.

**I. Survey and identification of the major syrphid flies species as pollinators of various agricultural, horticultural, oilseed crops and as pollinators of mango.**

The insect (Diptera) species of the order, Diptera visiting the mango flowers in the present study are given in Table. 1. Perusal of Table 4.1 indicated that the highest number of insects were recorded from order Diptera.

Syrphid flies in the order: Diptera (Syrphidae) were the most dominating and represented the highest number. It included hoverflies which were best known and are so named for their habit of hovering above flowers like miniature humming birds. Their bodies remain motionless while their wings heat at a break neck pace. These aerial acrobats are also known as syrphid flies. The adult syrphid flies spend a great deal of time visiting flowers and are thus effective pollinators.

**Table.4.1: Insects species of the order: Diptera visiting the mango flowers**

<b>Order</b>	<b>Family</b>	<b>Genera</b>	<b>Species</b>	<b>Frequency of visits</b>
Diptera	Agromyzidae	<i>Melanogromyza</i>	<i>sp.</i>	R
	Anthomyiidae	<i>Delia</i>	<i>platura</i> (Meigen)	R
	Calliphoridae	<i>Chrysomyia</i>	<i>melacephala</i> (Fabricius)	VF
	Calliphoridae	<i>Stomorhina</i>	<i>discolor</i>	VF
	Lonchaeidae	<i>Lonchaea</i>	<i>sp.</i>	R
	Muscidae	<i>Brontaea</i>	<i>tonitru</i> (Wiedemann)	F
	Muscidae	<i>Musca</i>	<i>domestica</i>	VF
	Muscidae	<i>Stomoxys</i>	<i>calcitrans</i>	F
	Otitidae	<i>Phyaiphora</i>	<i>clausa</i>	F
	Sepsidae	<i>Sepsis</i>	<i>sp.</i>	F
	Syrphidae	<i>Melanostoma</i>	<i>orientale</i>	VF
	Syrphidae	<i>Episyrphus</i>	<i>balteatus</i>	VF
	Syrphidae	<i>Eristalis</i>	<i>tenax</i>	VF
	Syrphidae	<i>Ischiodon</i>	<i>scutellaris</i>	VF
	Syrphidae	<i>Eristalinus</i>	<i>sp.</i>	VF
	Syrphidae	<i>Syrphus</i>	<i>corollae</i>	VF
	Syrphidae	<i>Syrphus</i>	<i>isaaci</i>	F

These nectar - feeding flies also have to feed on pollen for maturation of their eggs. Their mouthparts are especially constructed for pulverizing the pollen. Though the proboscis is adapted for sucking the liquids but conditions the labella is strongly reflected permitting the protrusion of peristomal teeth that can be employed as rasping organs. In such situations the food is sucked directly through the oral aperture that allows the particles of larger size as pollen grains to pass, which otherwise cannot gain entry through the pseudotracheae, as stated by **Gilbert (1981)**.

Among the syrphid flies, the individuals seen in largest number were of *Melanostoma orientale* followed by *Episyrphus balteatus*, *Eristalis tenax* and *Syrphus corollae*. The syrphid fly seen in lesser number was *Ischiodon scutellaris*, while the *Episyrphus balteatus* and *Melanostoma orientale* were frequently found on the mango flowers. *Eristalis tenax* was larger in size. Their size ranged from 5-10 mm with black and yellow stripes on the abdomen that gave them a bee like appearance. They were, however true flies with only one pair of wings, and did not sting. While feeding the hover flies frequently stopped to clean the head and proboscis, ingesting the cleaned material.

**Table 4.2: Flowering plants and associated species of hover flies (Diptera: Syrphidae)**

Syrphidae Attracted		Nectar/pollen source			
Genus	Species	Family	Genus	Species	
<b>Angiospermae</b>					
1. <i>Melanostoma</i>	<i>orientale</i>	Leguminaceae	<i>Trifolium</i>	<i>repens</i>	
		Rosaceae	<i>Prunus</i>	<i>sp</i>	
			<i>Pyrus</i>	<i>communis</i>	
		Sapindaceae	<i>Litchi</i>	<i>chinensis</i>	
		Anacardiaceae	<i>Mangifera</i>	<i>indica</i>	
		Asteraceae	<i>Chrysanthemum</i>	<i>sp.</i>	
			<i>Tagetes</i>	<i>patula</i>	
			<i>Zinnia</i>	<i>sp.</i>	
			<i>Calendula</i>	<i>officinalis</i>	
			<i>Tagetes</i>	<i>erecta</i>	
	Solanaceae	<i>Petunia</i>	<i>hybrida</i>		
2. <i>Syrphus</i>	<i>corollae</i>	Rosaceae	<i>Prunus</i>	<i>persica</i>	
			<i>Prunus</i>	<i>armenaica</i>	
		Sapindaceae	<i>Litchi</i>	<i>chinensis</i>	
		Anacardiaceae	<i>Mangifera</i>	<i>indica</i>	
		Asteraceae	<i>Chrysanthemum</i>	<i>sp.</i>	
			<i>Coreopsis</i>	<i>lanceolata</i>	
			<i>Zinnia</i>	<i>sp.</i>	
			<i>Gladiolus</i>	<i>grandiflorus</i>	
			Malvaceae	<i>Althaea</i>	<i>rosea</i>
				<i>Phlox</i>	<i>drumondii</i>

			<i>Tagetes</i>	<i>erecta</i>
			<i>Viola</i>	<i>tricolor</i>
			<i>Dahlia</i>	<i>variabilis</i>
		Scrophularaceae	<i>Antrirrhinum</i>	<i>majus</i>
		Cruciferae	<i>Brassica</i>	<i>junceae</i>
			<i>Brassica</i>	<i>rapa</i> <i>var. yellow</i> <i>sarson</i>
			<i>Brassica</i>	<i>rapa</i> <i>var. toria</i>
			<i>Brassica</i>	<i>rapa</i> <i>var. brown</i> <i>sarson</i>
Episyrrhus	balteatus	Leguminaceae	<i>Trifolium</i>	<i>repens</i>
		Rosaceae	<i>Pyrus</i>	<i>communies</i>
			<i>Prunus</i>	<i>sp.</i>
		Asteraceae	<i>Chrysanthemum</i>	<i>sp.</i>
			<i>Coreopsis</i>	<i>lanceolata</i>
			<i>Zinnia</i>	<i>sp.</i>
			<i>Dianthus</i>	<i>caryophyllus</i>
		Solanaceae	<i>Petunia</i>	<i>hybrida</i>
		Iridaceae	<i>Gladiolus</i>	<i>grandiflorus</i>
		Asteraceae	<i>Gerbera</i>	<i>jamesonii</i>
		Sapindaceae	<i>Litchi</i>	<i>chinensis</i>
		Anacardiaceae	<i>Mangifera</i>	<i>indica</i>
4. Eristalis	tenax	Sapindaceae	<i>Litchi</i>	<i>chinensis</i>
		Anacardiaceae	<i>Mangifera</i>	<i>indica</i>
		Asteraceae	<i>Chrysanthemum</i>	<i>sp.</i>

			<i>Zinnia</i>	<i>sp.</i>
			<i>Tagetes</i>	<i>erecta</i>
			<i>Viola</i>	<i>tricolor</i>
			<i>Calendula</i>	<i>officinalis</i>
			<i>Dahlia</i>	<i>variabilis</i>
			<i>Gerbera</i>	<i>jamesonii</i>
			<i>Coreopsis</i>	<i>lanceolata</i>
5. Eristalinus	sp.	Rosaceae	<i>Pruinus</i>	<i>armenaica</i>
			<i>Prunus</i>	<i>persica</i>
		Sapindaceae	<i>Litchi</i>	<i>chinensis</i>
		Anacardiaceae	<i>Mangifera</i>	<i>indica</i>
		Malvaceae	<i>Althaea</i>	<i>rosea</i>
		Asteraceae	<i>Chrysanthemum</i>	<i>sp.</i>
			<i>Coreopsis</i>	<i>lanceolata</i>
			<i>Calendula</i>	<i>officinalis</i>
			<i>Tagetes</i>	<i>patula</i>
			<i>Zinnia</i>	<i>sp.</i>
			<i>Dahlia</i>	<i>variabilis</i>
Ischiodon	scutellaris	Rosaceae	<i>Rosa</i>	<i>indica</i>
			<i>Prunus</i>	<i>persica</i>
			<i>Pyrus</i>	<i>communis</i>
		Sapindaceae	<i>Litchi</i>	<i>chinensis</i>
		Anacardiaceae	<i>Mangifera</i>	<i>indica</i>
		Cruciferae	<i>Brassica</i>	<i>juncea</i>
			<i>Brassica</i>	<i>campestris</i>
			<i>var. Yellow</i>	
			<i>sasson</i>	



***Syrphus corollae***

**Plate 1:**

***Syrphus corollae* (Adult)**



***Episyrphus balteatus***

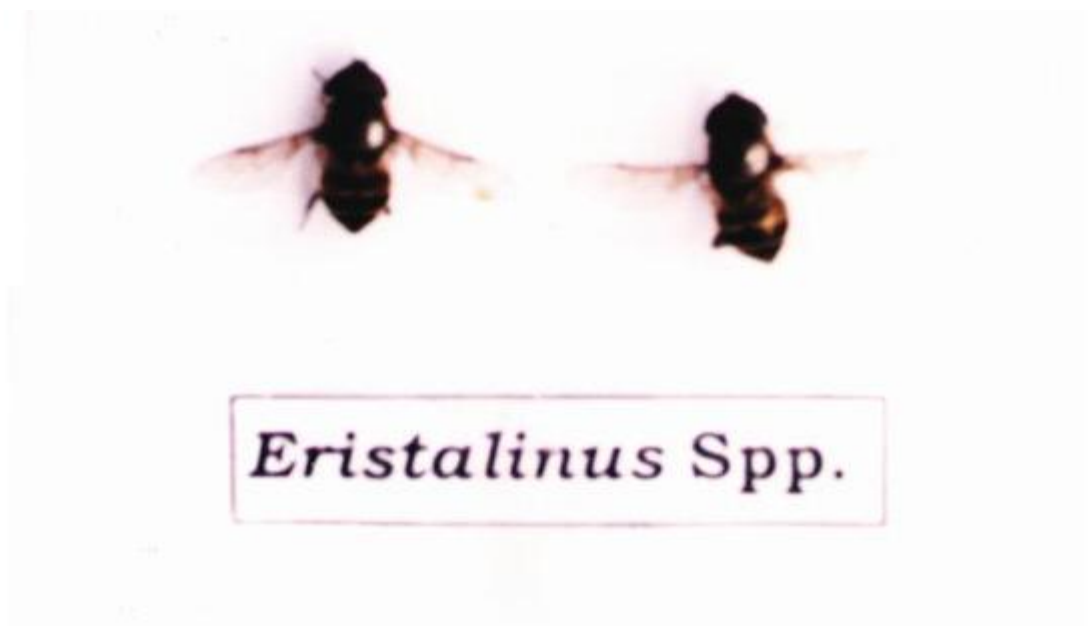
**Plate 2:**

***Episyrphus balteatus* from mango flowers**



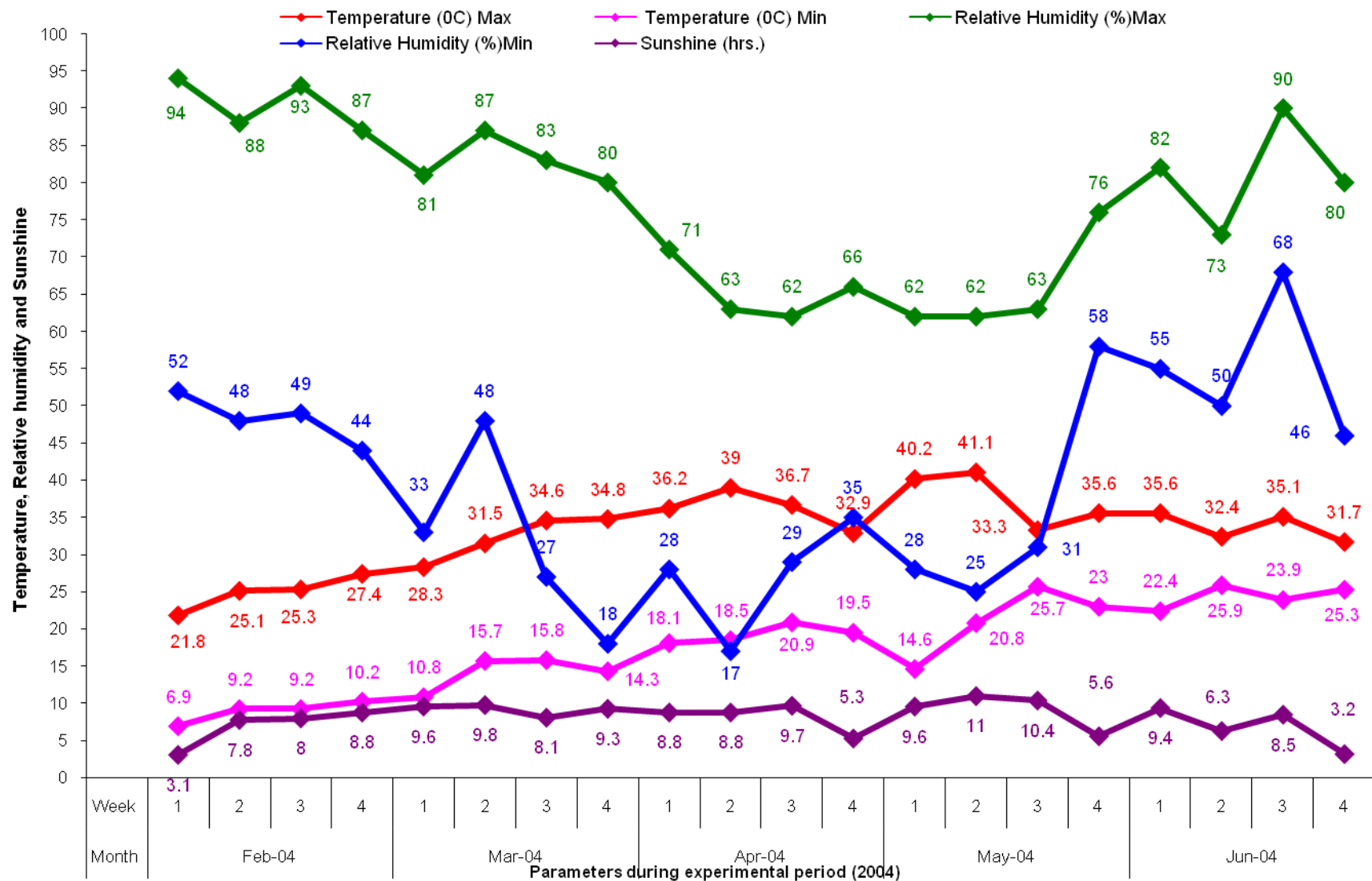
**Plate 3:**

**Syrphid fly (*Melanostoma orientale*) from mango flowers.**

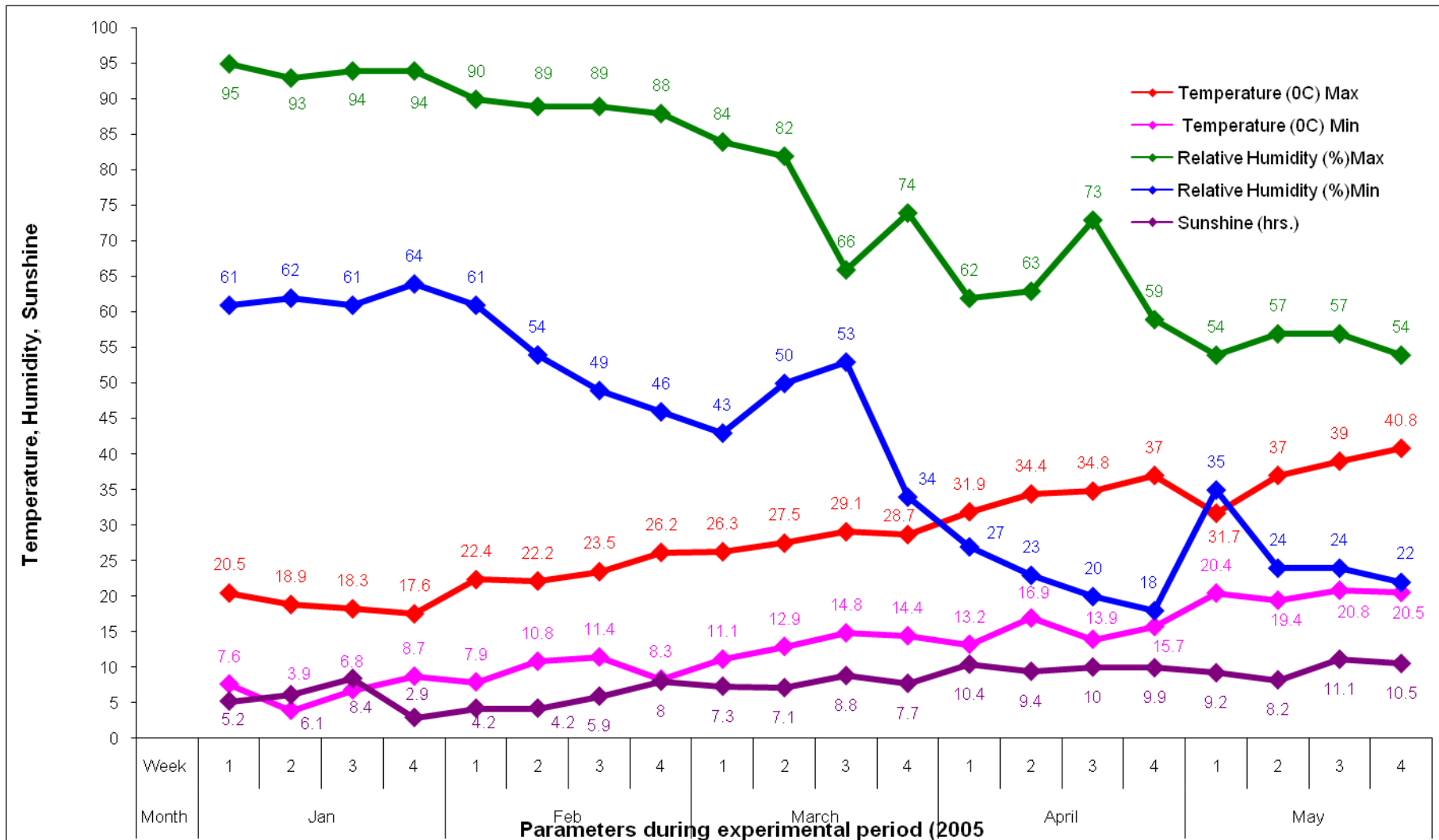


**Plate 4:**

***Eristalinus* sp.**



**Fig. 1: Standard weekly meteorological parameters during experimental period (2004) at Pantnagar**



**Fig. 2: Standard Weekly Meteorological Parameters During Experimental Period (2005) At Pantnagar.**

The morphology of the mouthparts varied with species. While *Episyrphus balteatus* had a short thick proboscis with broad *fleshy* labella, *Eristalis tenax* had a long and slim mouthparts **Heal (1982).**

Table 4.2 shows the major syrphid species visited as pollinators of various agricultural, horticultural, medicinal, ornamental and oil seed crops under the area of investigation and were found to be *Melanostoma orientale*, *Syrphus corollae*, *Episyrphus balteatus*, *Eristalis tenax*, *Ischiodon scutellaris*, *Eristalinus* sp., *Syrphus isaaci*. Syrphid flies were found most common insect pollinators visiting flowering plum, peach and almond trees. They were also found common visitors of *Brassica juncea*, and *Brassica campestris* and other oilseed crops and ornamental plants.

## **II. Feeding preference of the syrphid larvae on the three aphid species viz. *Lipaphis erysimi*, *Braevicoryne brassicae* and *Aphis gossypi*.**

The results obtained in the experiment are given in the Table 4.3 and (fig.3). It was observed that the number of aphids consumed by each larvae increased with the subsequent days of feeding in case of each aphid species. The number of aphids consumed during the first day was minimum 2.4, 2.0, and 1.8 for *L.erysimi*,

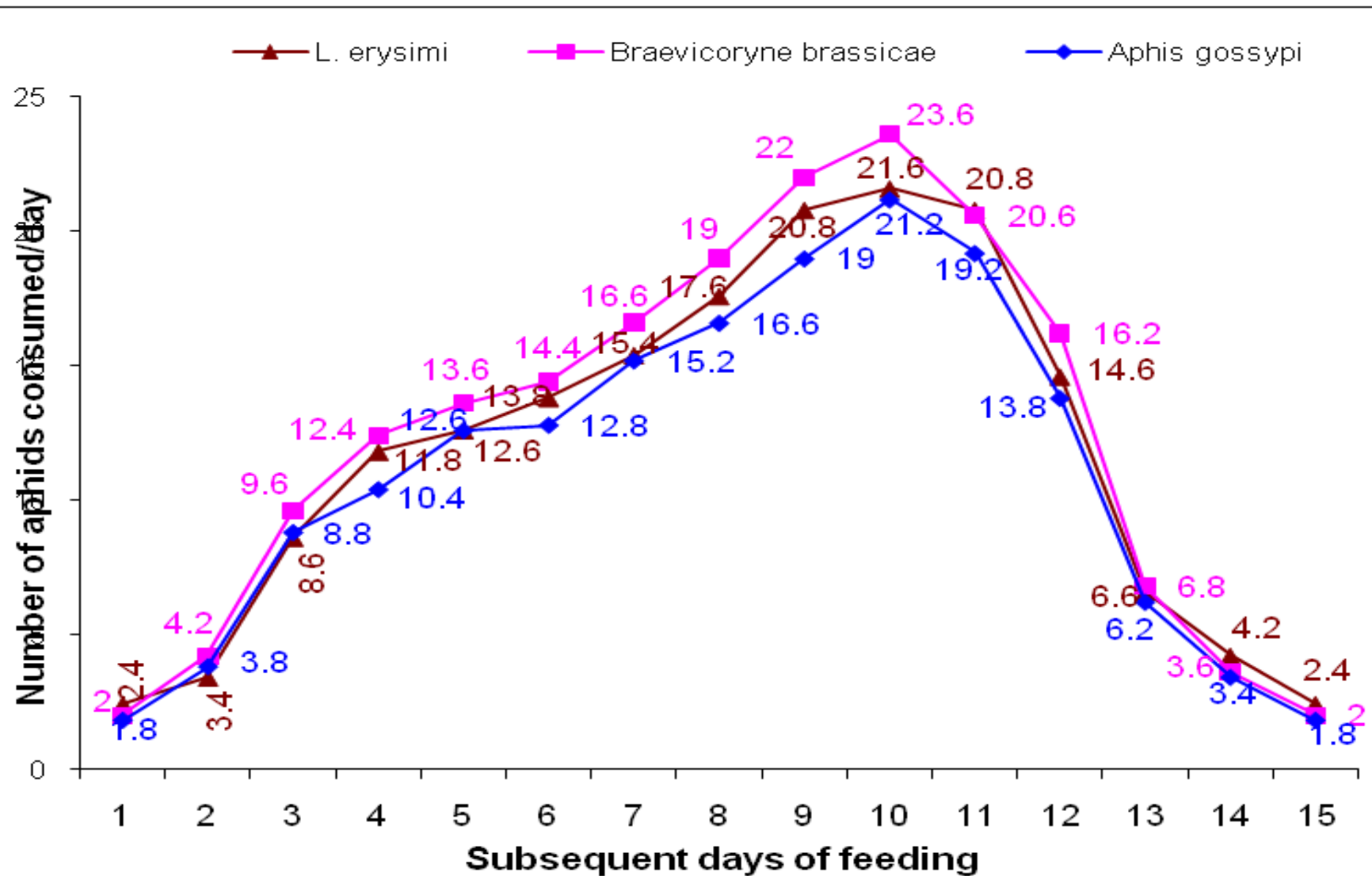
**Table 4.3: Feeding preference of the syrphid larvae on three aphid species. *Lipaphis erysimi*, *Braevicoryne brassicae* and *Aphis gossypi*.**

Treatments	Number of aphids consumed in subsequent days of feeding.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>L. erysimi</i>	2.4	3.4	8.60	11.80	12.60	13.8	15.40	17.60	20.80	21.60	20.80	14.60	6.60	4.20	2.40
<i>Braevicoryne brassicae</i>	2.0	4.2	9.60	12.40	13.60	14.4	16.60	19.00	22.00	23.60	20.60	16.20	6.80	3.60	2.00
<i>Aphis gossypi</i>	1.8	3.8	8.80	10.40	12.60	12.8	15.20	16.60	19.00	21.20	19.20	13.80	6.20	3.40	1.80
<b>SEM±</b>	<b>0.32</b>	<b>0.28</b>	<b>0.29</b>	<b>0.23</b>	<b>0.25</b>	<b>0.29</b>	<b>0.29</b>	<b>0.32</b>	<b>0.54</b>	<b>0.43</b>	<b>0.42</b>	<b>0.38</b>	<b>0.27</b>	<b>0.29</b>	<b>0.32</b>
<b>CD</b>	<b>0.98</b>	<b>0.87</b>	<b>0.91</b>	<b>0.71</b>	<b>0.75</b>	<b>0.87</b>	<b>0.90</b>	<b>1.0</b>	<b>1.67</b>	<b>1.33</b>	<b>1.31</b>	<b>1.17</b>	<b>0.83</b>	<b>0.90</b>	<b>0.97</b>
<b>F test</b>	<b>N S</b>	<b>NS</b>	<b>NS</b>	<b>**</b>	<b>*</b>	<b>**</b>	<b>*</b>	<b>**</b>	<b>*</b>	<b>**</b>	<b>*</b>	<b>**</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>

**NS= Non significant**

**\* Significant at 5% level**

**\*\* Significant at 1% level**



**Fig. 3: Feeding preference of the syrphid larvae on three aphid species. *Lipahis erysimi*, *Braevicoryne brassicae* and *Aphis gossypii***



**Plate 5:** Larva of *Syrphus corollae* feeding on Cabbage aphid.



**Plate 6:** Pupa of Syrphid fly (*Syrphus corollae*).

*Braevicoryne brassicae* and *Aphis gossypi* respectively. The number of aphids consumed during the 10<sup>th</sup> day were maximum 21.60, 23.60, 21.20 for the *L. erysimi*, *B. brassicae* and *Aphis gossypi* respectively. The feeding propensity of the syrphid fly larvae decreased during the 15<sup>th</sup> day of feeding to 2.40, 2.00 and 1.80 respectively. The number of aphids of three different species consumed by syrphid fly larvae were not found to be statistically significant during first day of feeding.

During the second day of feeding the number of nymphs consumed of each aphid species were found to be statistically non-significant. They were found to be 3.4, 4.2, and 3.8 respectively.

During the third subsequent day of feeding the number of aphids consumed of each of three aphid species was found statistically non-significant followed by the 13<sup>th</sup>, 14<sup>th</sup> and 15<sup>th</sup> days in which the number of aphids consumed of each aphid species were also found statistically non significant.

During the fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh and twelfth days of feeding the aphids consumption was found to be statistically significant.

The number of aphids consumed of *L. erysimi* were 11.80, 12.60, 13.8, 15.40, 17.60, 20.80 and 14.60 for fourth, fifth, sixth, seventh, eight, ninth, tenth, eleventh and twelfth day respectively.

For the *B. brassicae* number of aphids consumed were 12.40, 13.60, 14.4, 16.60, 19.00, 22.00, 23.60, 20.60, 16.20 for the fourth day till the twelfth day respectively.

The number of *A. gossypi* consumed were 10.40, 12.60, 12.8, 15.20, 16.60, 19.00, 21.20, 19.20, 13.80 for the fourth, fifth, sixth, seventh, eight, ninth, tenth, eleventh and twelfth day respectively.

### **Biology of the Syrphid Fly (*Syrphus corollae*)**

All the experiments are conducted at temperatures between 22 °C to 24° C, relative humidity of 40% to 80% and the photoperiod of 16 to 17 hour. The experiment was carried out between the middle of February and the end of April.

### **Fecundity, Fertility and Viability**

The mean fecundity of six females, the percentage of their eggs, which were fertile, and the percentage which were viable (proportion of eggs which hatched) are recorded in the Table 4.4. The value quoted for fecundity includes one female which laid no eggs at all. Fertility was based on the five females which laid fertile eggs. Viability was derived from consideration of the proportion of fertile eggs that hatched.

**Table 4.4: Mean fecundity, fertility (proportion of fertile eggs) and viability (proportion of fertile eggs which hatched) of *S. corollae* at 22-24° C, 405- 80% R.H.**

<b>Mean fecundity</b>	<b>Mean % fertility</b>	<b>Mean % viability</b>
58.8 ± 1.36	47.2 ± 1.50	42.2 ± 0.25

**Table 4.5: Time of Development of Immature stature of *S. corollae* at 22-24° C and 40- 80% R.H.**

<b>Length of egg stage (days)</b>	<b>Mean length of larval stage (days)</b>			<b>Mean length of pupal stage (days)</b>
	<b>1st instar</b>	<b>2 instar</b>	<b>3<sup>rd</sup> instar</b>	
	12.40 ± 0.50			
58.8 ± 1.36	3.4 ± 0.16	4.4 ± 0.16	5.4 ± 0.17	8.20 ± 0.25

**Table 4.6: Mortality of Immature Stages in Percentages of the original Number of Eggs of *S. corollae* at 22° -24°C, 40% - 80% R. H.**

<b>Egg</b>		<b>LARVA</b>	<b>PUPA</b>	<b>TOTAL</b>
<b>Infertility</b>	<b>Inviability</b>			
20	13	3	5	41

The mean fecundity of the five females that laid eggs came out to be  $58.8 \pm 1.36$ . The mean % fertility was found to be  $47.2 \pm 1.5$  and the mean % viability was  $42.2 \pm 0.25$

### **Developmental time**

Table 4.5. summarizes the length of egg, larval and pupal stages. Time of embryonic development was relatively constant. All the viable eggs hatched after three days of incubation. The mean lengths of larval and pupal stages were about the same. The mean length of the larval stage was found to be  $12.40 \pm 0.50$ .

The mean length of the 1<sup>st</sup> larval instar was found to be  $12.40 \pm 0.50$ . The mean length of the 2<sup>nd</sup> larval instar was found to be  $3.4 \pm 0.16$ . The mean length of the 3<sup>rd</sup> larval instar was  $4.4 \pm 0.20$  and the pupal stage lasted for  $8.2 \pm 0.25$  days.

### **Mortality**

Table 4.6 shows the percentage mortality in the population in each of the immature stages. Infertility has been considered as mortality. Quoted pupal mortality is that of the F<sub>1</sub> population resulting from the original eggs. Larval mortality was estimated from observed embryonic and pupal mortalities in relation to the total mortality in the immature stages.

Most of the mortality during immaturity occurred in the egg stage. Infertility and inviability accounted for 48.78 % and

53.3% respectively of the total mortality up to the end of the pupal stage.

The infertility and inviability was found to be 20 and 13 respectively during the egg stage. The mortality during the larval stage was 3 and at pupal stage was 5. Therefore the total mortality during the entire life cycle was 41, out of which 20 was due to infertility and 13 was due to inviability.

### **Adult Longevity**

Longevity of males and females of *S. corollae* was the same during the start of adult life, after the first few days of adult life, the proportion of surviving males was slightly higher than that of females, particularly as the time progressed. 50% of the adult males died by the 10<sup>th</sup> day of adult life and 50% of the adult females were dead by the thirteenth day of adult life. The last male died after 15<sup>th</sup> day of adult life and the last female died after the 16<sup>th</sup> day of the experiment.

### **III. Studies on the pollinating efficiency of the syrphid flies in mango.**

The number of syrphid flies per panicle per minute, the number of flowers visited by a single syrphid fly per panicle and time spent on a flower by a single syrphid fly are given in Table- 4.7 and fig. 4, 5 and 6.

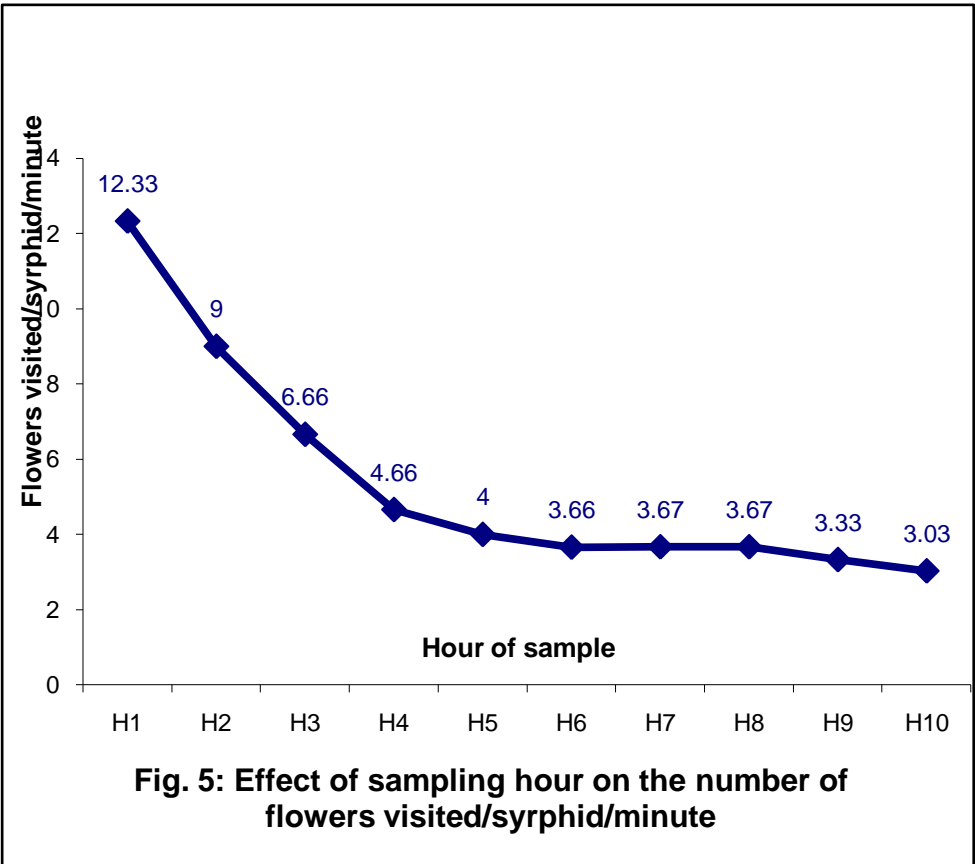
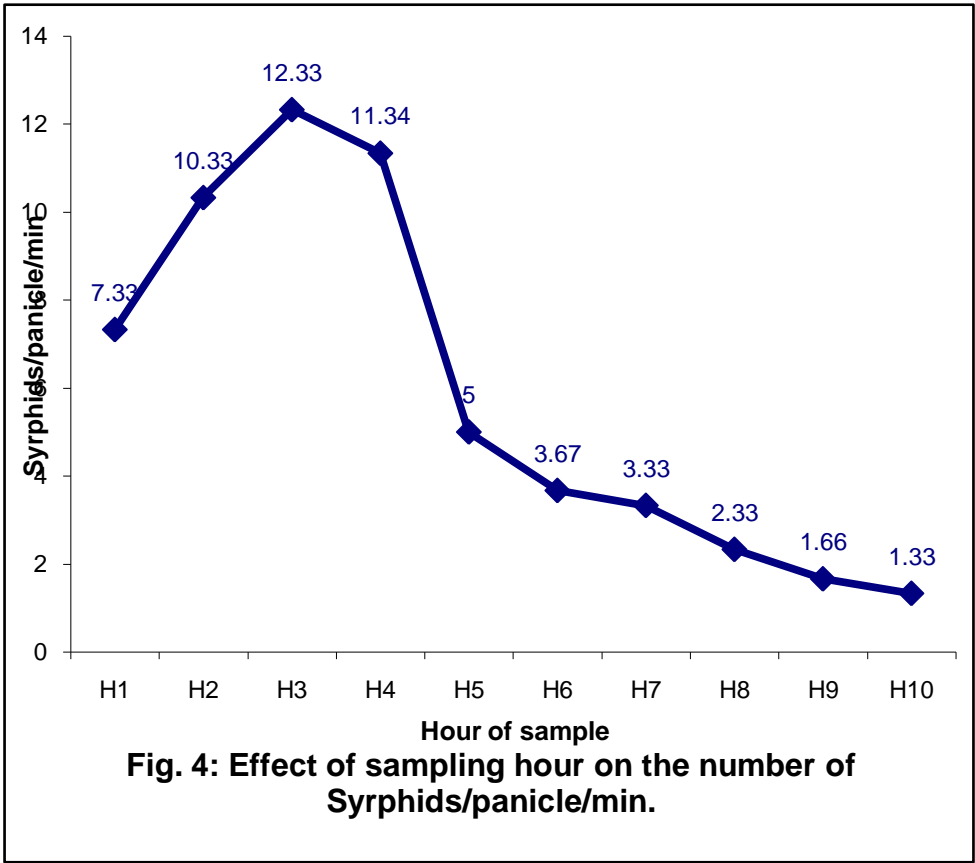
### **The number of syrphid flies per panicle per minute**

The data pertaining to the total number of syrphid flies per panicle per minute as affected by the different hours of sampling, throughout the day has been presented in Table 4.7 and (fig.4). The overall effect of the different hours on the average number of syrphid flies per panicle per minute was found to be significant. The highest number of syrphid flies per panicle was found to be significant. The highest number of syrphid flies per panicle per minute (12.33) was recorded under treatment H<sub>3</sub> (0900-1000h) that was statistically at par with treatment H<sub>2</sub> (10.33) and superior over the rest of the treatments. The treatments H<sub>10</sub> (1.33) recorded lowest number of flies.

**Table 4.7: Effect of treatments on the no. of syrphid flies per panicle per minute, no. of flowers visited per fly per minute and the time spent per flower per syrphid fly.**

<b>Treatments.</b>	<b>No. of syrphid flies per panicle per minute</b>	<b>No. of flower visited per syrphid fly per minute</b>	<b>Time spent per flower per syrphid fly</b>
H <sub>1</sub>	7.33	12.33	8.66
H <sub>2</sub>	10.33	9.0	8.33
H <sub>3</sub>	12.33	6.66	7.66
H <sub>4</sub>	11.34	4.66	7.66
H <sub>5</sub>	5.0	4.0	6.66
H <sub>6</sub>	3.67	3.66	5.33
H <sub>7</sub>	3.33	3.67	4.33
H <sub>8</sub>	2.33	3.67	3.67
H <sub>9</sub>	1.66	3.33	2.67
H <sub>10</sub>	1.33	3.03	2.34
<b>SEM±</b>	<b>0.501</b>	<b>0.52</b>	<b>0.32</b>
<b>C.D. (5%)</b>	<b>1.48</b>	<b>1.54</b>	<b>0.94</b>
<b>F test</b>	<b>**</b>	<b>**</b>	<b>**</b>

**\*\* Significant 1% level**



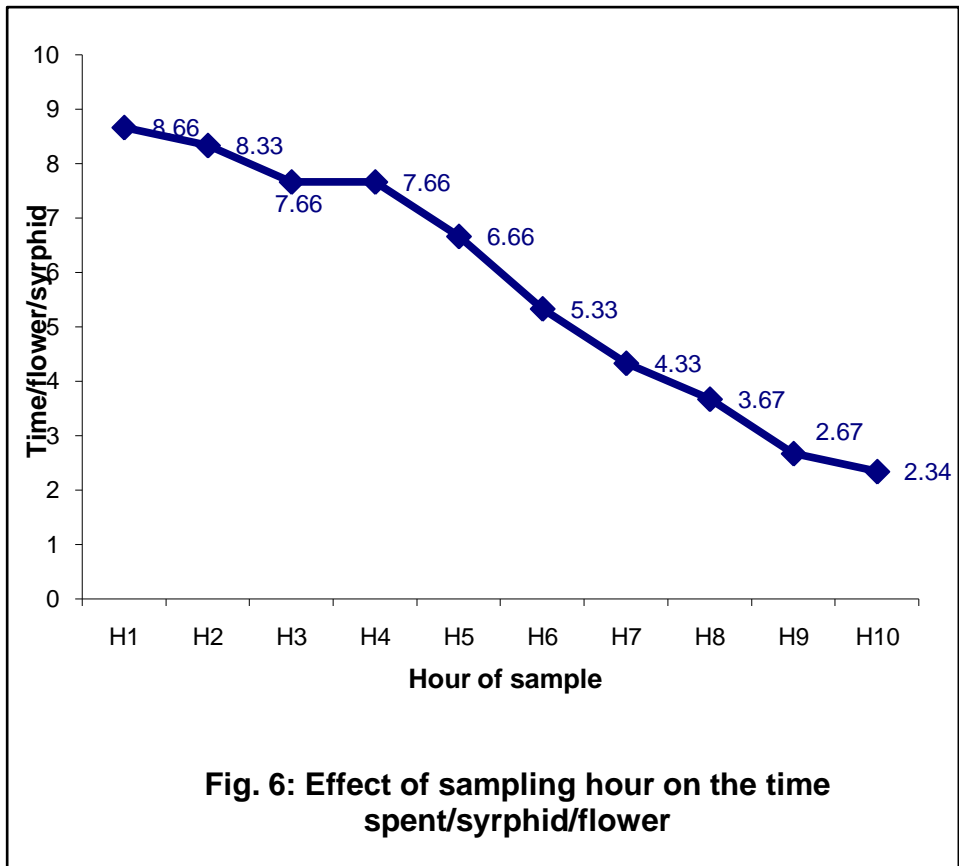
### **The number of flowers visited by a single syrphid fly per minute**

Critical examination of data presented in Table 4.7 and (fig.5) showed that the hour of sample had a significant effect on the number of flowers visited by a single syrphid fly per minute. The maximum number (12.33) was recorded under the treatment H<sub>1</sub> (0700-0800h). This was statistically superior to all other treatments. The minimum number of flowers visited (3.03) was recorded for treatment H<sub>10</sub> (1600-1700h).

### **Time spent (sec.) on a flower by a single syrphid fly**

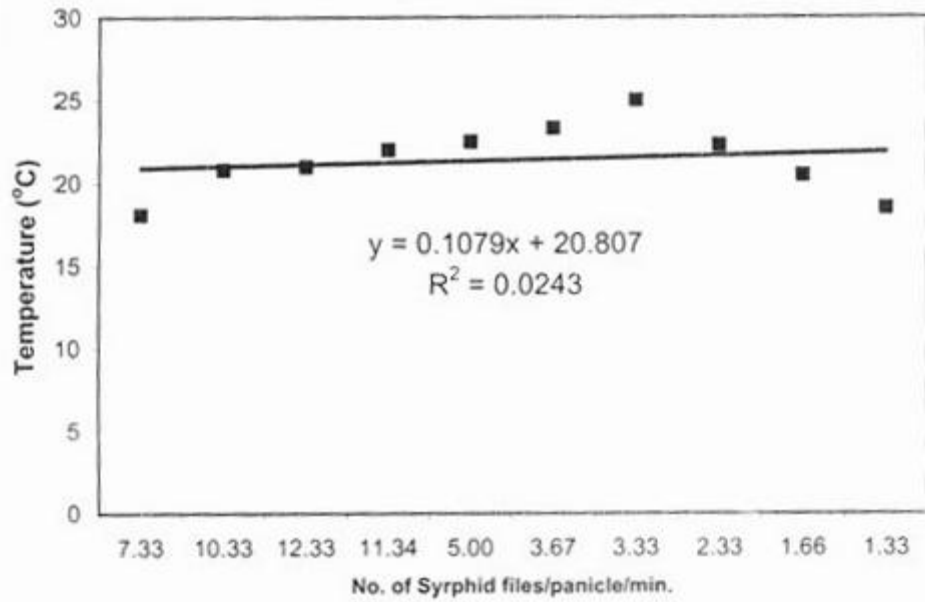
The time spent on one flower by single fly was recorded and has been given in the Table 4.7 and ( fig 6). It revealed that the time spent on a flower by a single syrphid fly varied significantly with hour of sampling. Maximum time (8.66) was recorded for treatment H<sub>1</sub> (0700-0800h) that was statistically at par with treatments H<sub>2</sub> (8.33) and H<sub>3</sub> (7.66) Treatment T<sub>10</sub> (1600-1700) recorded the minimum time spent (2.34).

A critical observation of the data in Table 4.7 and 4.8 revealed that in general, the time spent on one flower by a syrphid fly decreased as the day proceeded. The regression graphs of the number of syrphid flies per panicle per minute with temperature and relative humidity are given in (fig 7 and 8.)

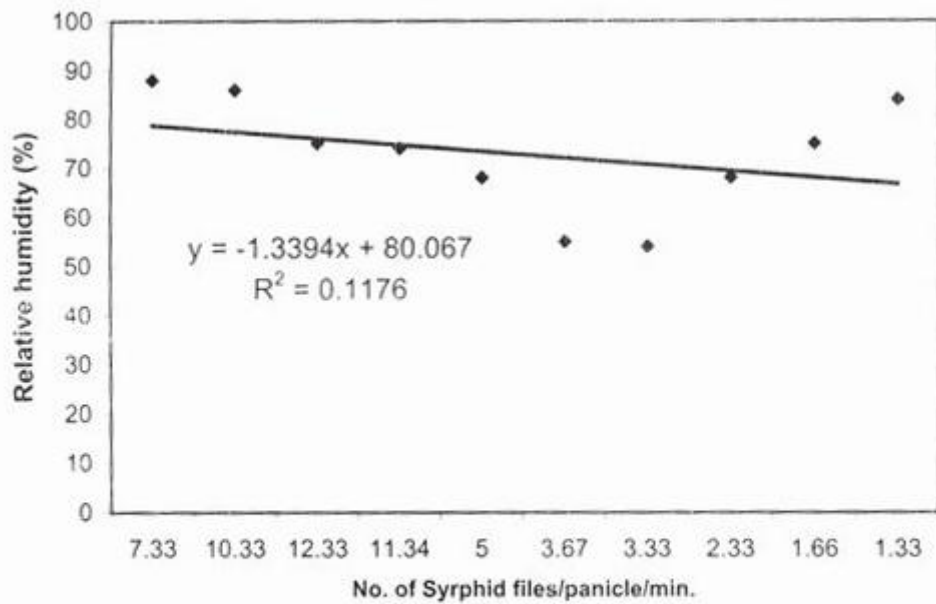


**Table 4.8: Effect of temperature (°C) and relative humidity (%) on the no. of syrphid flies/panicle/minute.**

<b>Treatment</b>	<b>No. of Syrphid flies/panicle/min.</b>	<b>Temperature (°C)</b>	<b>Relative humidity (%)</b>
H <sub>1</sub>	7.33	18.1	88
H <sub>2</sub>	10.33	20.8	86
H <sub>3</sub>	12.33	21.0	75
H <sub>4</sub>	11.34	22.0	74
H <sub>5</sub>	5.0	22.5	68
H <sub>6</sub>	3.67	23.3	55
H <sub>7</sub>	3.33	25	54
H <sub>8</sub>	2.33	22.3	68
H <sub>9</sub>	1.66	20.5	75
H <sub>10</sub>	1.33	18.5	84



**Fig.7: Effect of temperature (°C) on the no. of syrphid files/panicle/minute**



**Fig.8: Effect of relative humidity (%) on the no. of syrphid files/panicle/minute**

## **Effect of bagging the mango panicles with different number of syrphid flies released in the bloom**

### **Pea size fruit set:**

The results obtained in present study are given in Table 4.9 and 4.10 and (fig.9). It was observed that in completely closed panicles the pea size fruits were zero. When 5 syrphid flies ( $T_1$ ) were released (1.75) pea size fruits were set per panicle, that were significantly less as compared to other treatments. When 10 syrphid flies were released ( $T_2$ ), (2.4) pea size fruits were set on Dashehari panicles. This was significantly inferior to the treatments viz. panicles in which (25)  $T_2$ , (20)  $T_4$  syrphid flies were released and completely open panicles.

Treatment ( $T_3$ ) of panicles in which 15 syrphid flies were released was significantly poor to treatment of panicles ( $T_4$ ) in which 20 syrphid flies were released. The treatment ( $T_5$ ) that was kept completely open was significantly superior to all treatments.

### **Marble sized fruit set**

No fruit was set in completely closed panicles to (0.00). The panicles bagged with 5 syrphid flies from Dashehari to Dashehari cultivar, panicles bagged with 10,15, and 20 syrphid flies respectively have significantly more fruit set than all other treatments, but were significantly different with all treatments and also with each other



**Plate 7:**

**Peak bloom in mango cv. Dashehari**



**Plate 8:**

**Bagged mango panicle**



**Plate 9:**

**Nylon screen bags put on mango panicles**



**Plate 10:**

**Fruit set in mango**

**Table 4.9: Effect of Bagging the Mango Panicles With different number of Syrphid Flies on Fruit Setting.**

<b>Treatment</b>	<b>No. of pea size fruits</b>	<b>No. of marble size fruits</b>	<b>No. of full size fruits</b>
T <sub>0</sub>	0.00	0.00	0.00
T <sub>1</sub>	1.75	0.25	0.00
T <sub>2</sub>	2.50	1.00	0.50
T <sub>3</sub>	3.75	2.00	1.00
T <sub>4</sub>	6.50	2.50	2.25
T <sub>5</sub>	9.75	5.00	3.50

**SEM**                      **0.25**                      **0.40**                      **0.32**

**CD (5%)**                      **0.75**                      **1.21**                      **0.95**

**F test**                      **\*\***                      **\*\***                      **\*\***

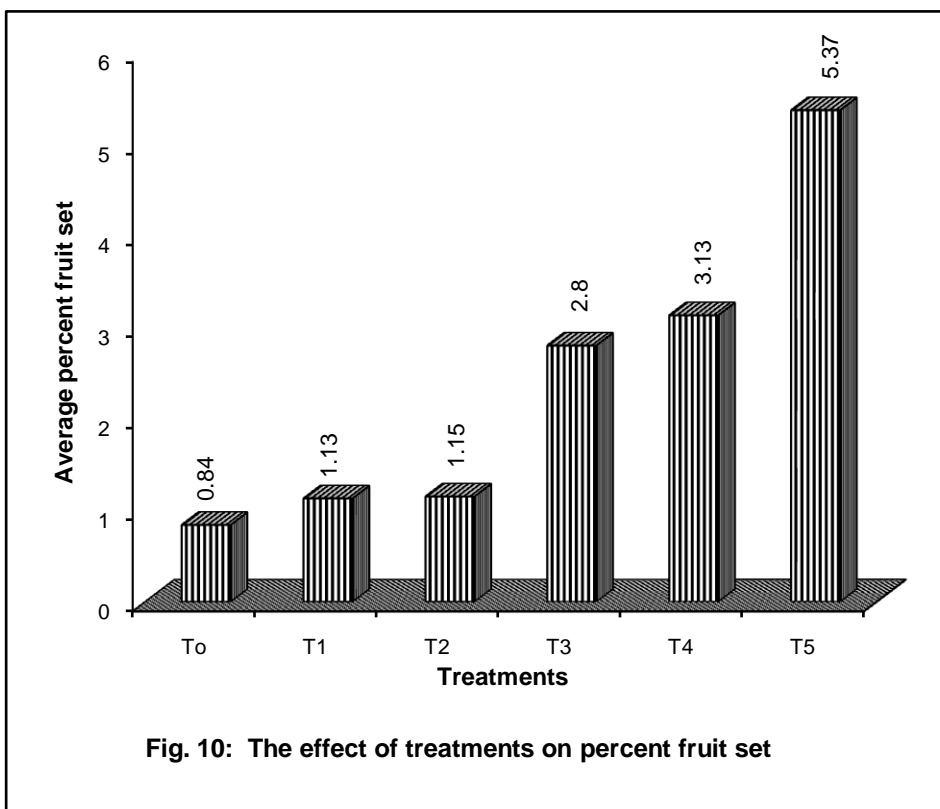
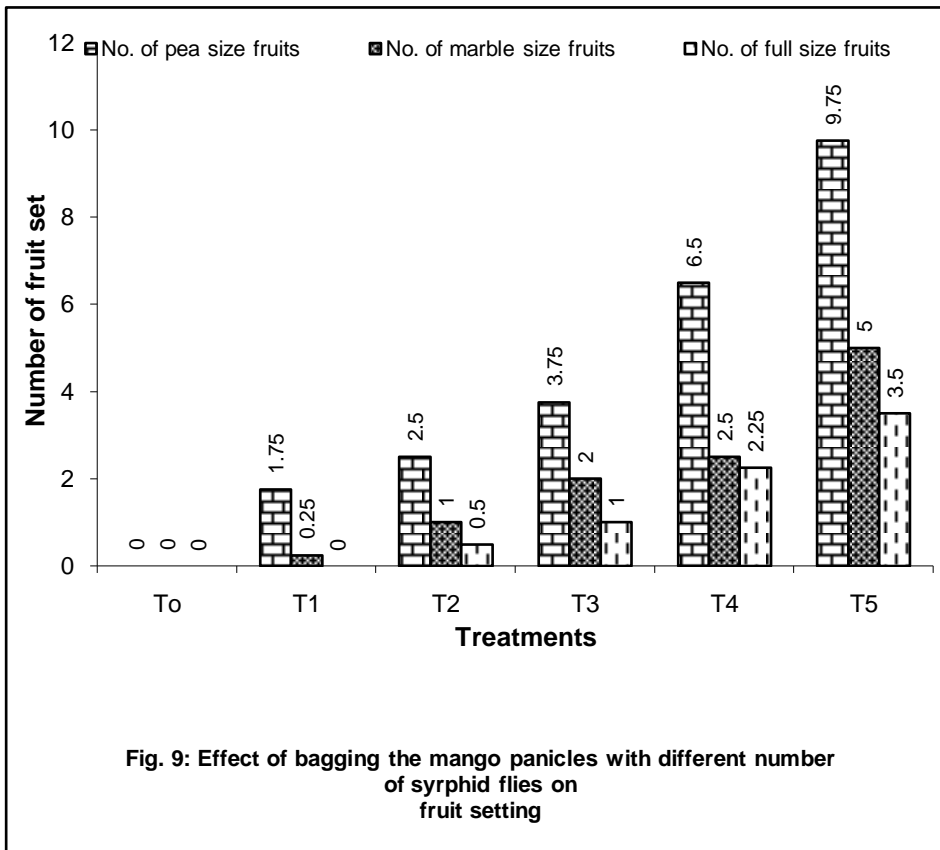
**\*\* Significant at 1% level.**

**Table 4.10: Correlation Studies Among Fruit Setting.**

	<b>Pea size fruits</b>	<b>Marble size fruits</b>	<b>Full size fruits</b>
Pea size fruits	1	0.984**	0.94**
Marble size fruits		1	0.96**
Full size fruits			1

**\*\* Significant at 1% level**

**\*Significant at 5% level**



### **Full size fruit set**

Maximum full size fruits were found on the panicles in which there was no bagging or the completely open panicles. It had significant difference with all the treatments. The fruit set in the panicles bagged with 5 syrphid flies released (T<sub>1</sub>) was (0.0) the panicles in which 10 syrphid flies released were T<sub>2</sub> (0.50), T<sub>3</sub> (1.50), T<sub>4</sub> (1.25) respectively. The maximum number of full size fruits were set in completely open panicles T<sub>5</sub> (2.25) and were found significantly different with all the treatments but at par with each other. The correlation studies of fruit setting in different sized fruits (pea, marble, and full size fruits) are presented in Table 4.10 Pea size fruits were significantly correlated to marble size fruits and marble to full size fruits.

### **Percent female flowers per panicle**

It is pertinent from the data presented in Table 4.11 that the number of female flowers per panicle did not show any significant variation with the bagging of panicles. The percent female flowers ranged from 5.93 % to 7.33 % under the six treatments.

### **Fruit set (%)**

It is evident from the data presented in Table 4.11 and (fig 10) that the bagging of panicles had a significant effect on fruit set percentage. The maximum fruit set (5.37%) was recorded under the treatment T<sub>5</sub> where the panicles were left unbagged for open pollination. Here the number of syrphid flies per panicle was maximum. This was followed by treatment T<sub>4</sub> (3.13%) where 20 syrphid flies were released into the bag. The minimum fruit set was found under treatment T<sub>0</sub> (0.84%).

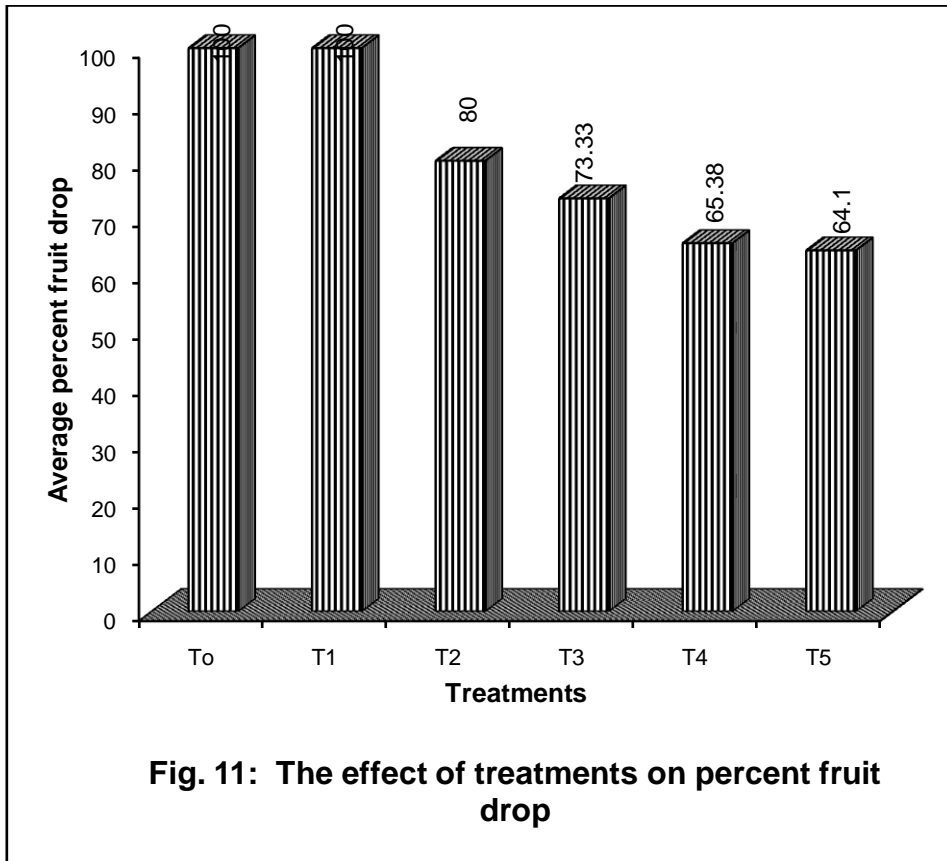
As observed from Table 4.11 the fruit set percentage increased with the increases in the number of pollinators. The treatment T<sub>5</sub> was statistically superior over other treatments.

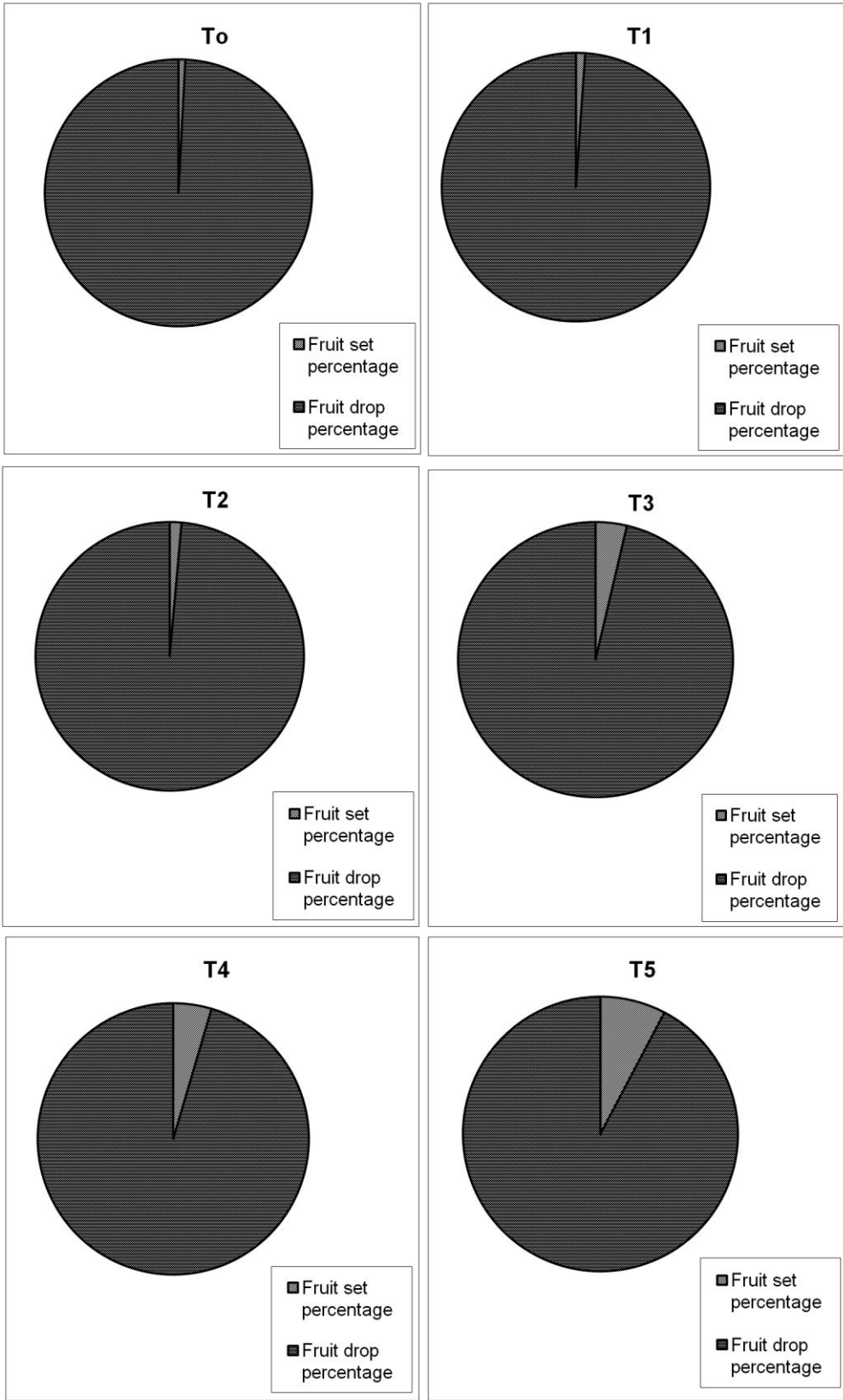
### **Fruit drop (%)**

Observations towards the fruit drop percentage as shown in Table 4.11 and (fig.11and12) revealed that bagging of panicles before their emergence had significant effect on the fruit drop percentage maximum fruit drop (100%) was observed under treatment T<sub>0</sub> (when no syrphid flies were introduced into the bags). This was statistically superior to all the other treatments. The minimum fruit drop was observed under treatment T<sub>5</sub> (64.10%).

**Table 4.11: Effect of treatments on the fruit set percentage and the fruit drop percentage.**

<b>Treatments</b>	<b>Fruit set percentage</b>	<b>Fruit drop percentage</b>	<b>Percent female flowers</b>
T <sub>0</sub>	0.84	100	6.30
T <sub>1</sub>	1.13	100	6.33
T <sub>2</sub>	1.15	80	5.93
T <sub>3</sub>	2.80	73.33	6.53
T <sub>4</sub>	3.13	65.38	7.33
T <sub>5</sub>	5.37	64.10	6.33
<b>SEM ±</b>	<b>0.04</b>	<b>0.009</b>	<b>0.35</b>
<b>CD at%</b>	<b>0.12</b>	<b>0.03</b>	<b>1.19</b>
<b>Test</b>	<b>**</b>	<b>**</b>	<b>NS</b>





**Fig. 12: The effect of treatment on the percent fruit dropped and percent fruit matured**

#### **IV. Relationship between the activity of the syrphid flies and the quality of the mango fruit**

The experimental results pertaining to the present study are given under following heads.

##### **Total soluble solid (TSS) %**

The data for the total soluble solids (TSS) as affected by the different treatments has been presented in Table 4.12 (fig 13). The overall effect of the various treatments on the TSS of the fruits was found to be significant.

The highest TSS content (11.60) was found under treatment T<sub>5</sub> that was statistically at par with treatment T<sub>4</sub> (11.39) and T<sub>3</sub> (11.29) and was superior to over all the other treatments. The minimum TSS was observed under the treatment T<sub>0</sub> (0.00).

##### **Size of the fruit (cm.)**

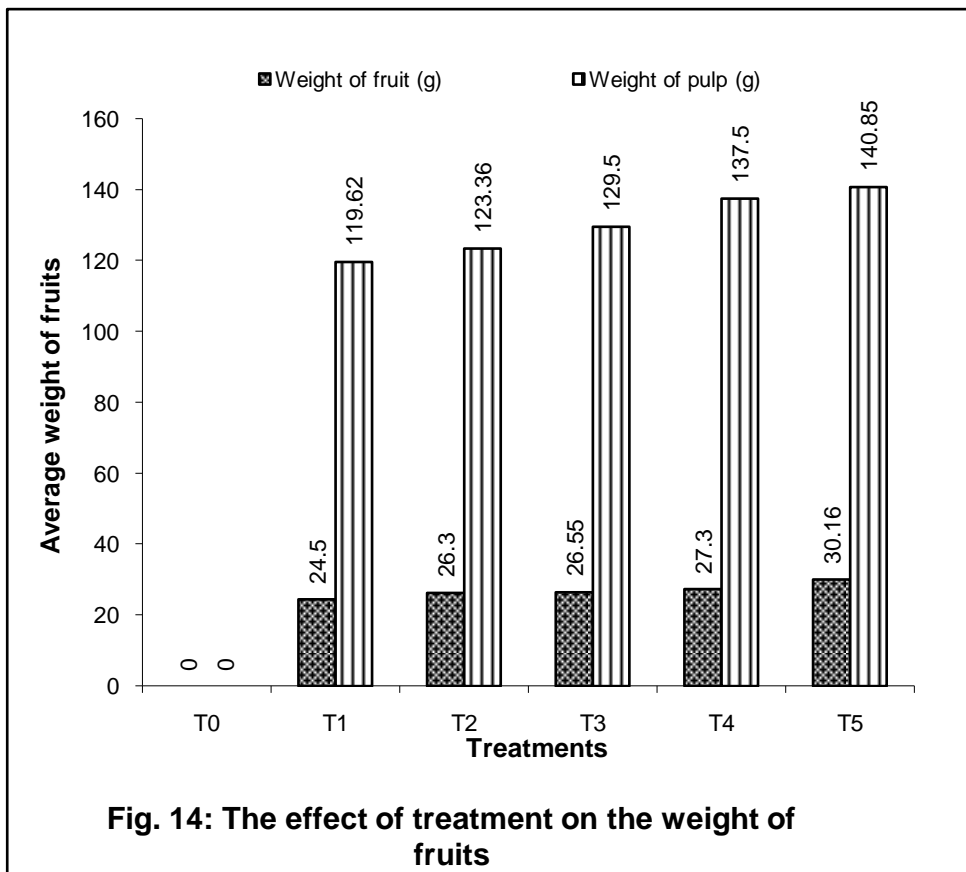
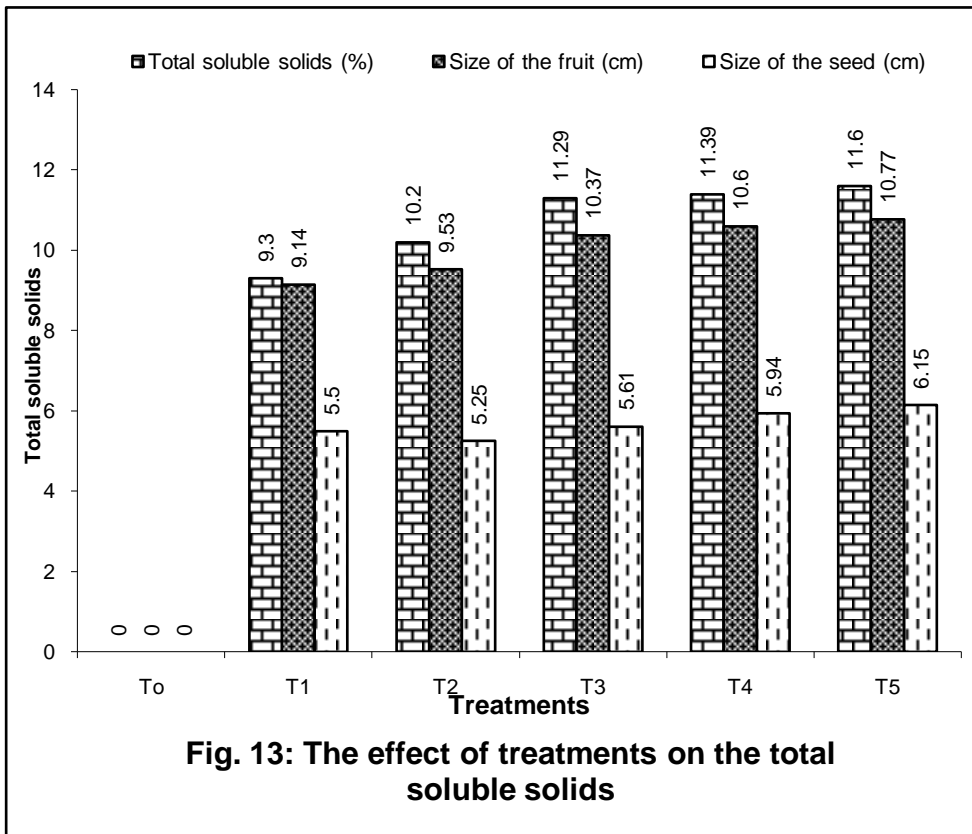
Perusal of data as represented in the Table 4.12. showed that the size of the fruit was significantly affected by the bagging treatments. It was observed that there was a continuous increase in the size of the fruit as the number of syrphid flies in the bags were increased.

It was observed that the maximum fruit size (10.77) was observed when the panicles were left unbagged for open pollination

**Table 4.12. Effect of Treatments on the Total soluble solids, Size of the fruit and Size of the seed.**

<b>Treatment</b>	<b>Total soluble solids (%)</b>	<b>Size of the fruit (cm)</b>	<b>Size of the seed (cm)</b>
T <sub>0</sub>	0.00	0.00	0.00
T <sub>1</sub>	9.30	9.14	6.15
T <sub>2</sub>	10.20	9.53	5.94
T <sub>3</sub>	11.29	10.37	5.61
T <sub>4</sub>	11.39	10.60	5.50
T <sub>5</sub>	11.60	10.77	5.25
<b>SEM</b>	<b>0.04</b>	<b>0.08</b>	<b>0.11</b>
<b>CD</b>	<b>0.14</b>	<b>0.25</b>	<b>0.32</b>
<b>F test</b>	<b>**</b>	<b>**</b>	<b>**</b>

**\*\* Significant at 1% level**



in treatments T<sub>5</sub>. This was statistically at par with treatments T<sub>2</sub> (9.53), T<sub>3</sub> (10.37) and T<sub>4</sub> (10.60) the minimum fruit size was attained for the control T<sub>0</sub> which was (0.00).

### **Size of the seed (cm.)**

It was evident from the data presented in Table 4.12. that there was a significant effect of bagging panicles on the size of the seed.

As seen, the maximum seed size (6.15) was observed under the treatment T<sub>2</sub> when 5 syrphid flies were released into the bag. This was followed by the treatment T<sub>3</sub> (5.94) and T<sub>4</sub> (5.61). The treatment T<sub>5</sub> was statistically at par with treatment T<sub>2</sub>. The minimum seed size was observed for the control T<sub>0</sub> (0.00).

### **Fruit weight**

Data presented in Table 4.13 and (fig .14). revealed that the fruit weight, in general increased with the number of syrphid flies released as pollinator. The significant difference between the different treatments for the fruits is presented in Table 4.13.

There was continuous increase in fruit weight with the treatments. The maximum fruit weight (190.05) was recorded under the treatment T<sub>5</sub> that was followed by T<sub>4</sub> (178.03) and T<sub>3</sub> (185.21).

**Table 4.13: Effect of Treatments on the Weight of the Fruit and Weight of the Pulp.**

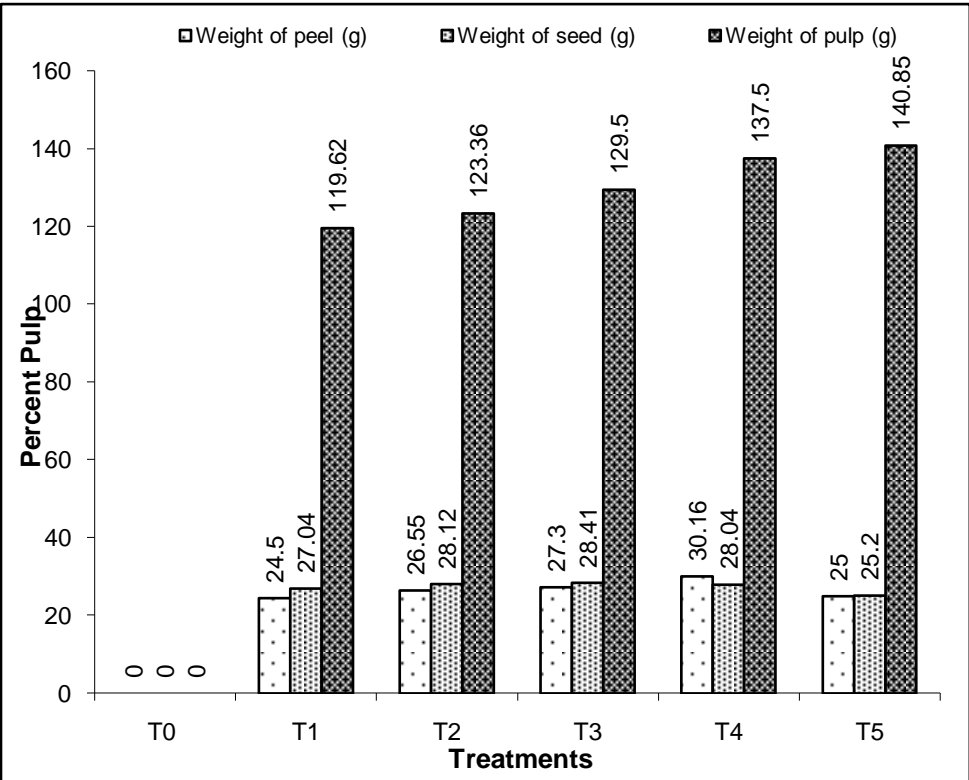
<b>Treatments</b>	<b>Weight of fruit (g)</b>	<b>Weight of pulp (g)</b>
T <sub>0</sub>	0.00	0.00
T <sub>1</sub>	144.12	119.62
T <sub>2</sub>	178.03	123.36
T <sub>3</sub>	185.21	129.5
T <sub>4</sub>	195.70	137.5
T <sub>5</sub>	198.05	140.85
<b>SEM ±</b>	<b>0.80</b>	<b>0.68</b>
<b>CD (at 5%)</b>	<b>2.41</b>	<b>2.05</b>
<b>F test</b>	<b>**</b>	<b>**</b>

**\*\* Significant at 1% level.**

**Table 4.14: Effect of the Treatments on the Weight of the Peel, Weight of Seed and Weight of the Pulp.**

<b>Treatments</b>	<b>Weight of peel (g)</b>	<b>Weight of seed (g)</b>	<b>Weight of pulp (g)</b>
T <sub>0</sub>	0.00	0.00	0.00
T <sub>1</sub>	24.5	27.04	119.62
T <sub>2</sub>	26.55	28.12	123.36
T <sub>3</sub>	27.30	28.41	129.50
T <sub>4</sub>	30.16	28.04	137.50
T <sub>5</sub>	25.0	25.2	140.85
<b>SEM ±</b>	<b>0.79</b>	<b>1.04</b>	<b>0.68</b>
<b>C.D. (at 5%)</b>	<b>2.41</b>	<b>3.14</b>	<b>2.05</b>
<b>F test</b>	<b>**</b>	<b>**</b>	<b>**</b>

**\*\* Significant at 1% level**



**Fig. 15: The effect of treatment on the percent pulp**

The treatment T<sub>5</sub> was significantly superior to other treatments. The minimum fruit weight was recorded for the treatment T<sub>0</sub> (0.00).

**Weight of the pulp (g)**

Critical examination of data presented in the Table 4.14 (fig 15). pointed that the pulp weight was significantly higher (140.85) under treatment T<sub>5</sub> which was significantly superior to all the other treatments. The minimum pulp weight (0.00) has been observed for T<sub>0</sub> (0.00)

In this chapter, an attempt has been made to discuss the results obtained during the course of investigation in order to fulfill the mandate of the objectives of the present study. An examination of the observations and data recorded therein revealed several points of utility, which are discussed below.

Importance of syrphid flies as effective pollinators of various horticultural, agricultural, ornamental, oil seed crops and medicinal crops and as important predators of various species of aphids or as effective biological control agents.

It is evident from the Table 4.1 that the mango inflorescence is visited by a number of insects during the period of flowering. The highest number of insects were from the order Diptera and the major pollinators of mango inflorescence was found out to be from the family Syrphidae. The results are in conformity with the results of **Singh (1988)** who have reported 5 species of syrphid flies from the order Syrphidae in the mango flora.

The syrphid flies or hover flies are expert hoverers, able to remain, absolutely stationary in mid air. These are also known as flower flies due to the adult's affinity for flower nectar. Since the

hover flies are attracted to flowers, they are ranked as effective pollinators. These results are in conformity to the findings of **Muller (1983)** who noted that the different species of syrphid flies took pollen, nectar or both from a large variety of flowers. Also stated by **Drabble and Drabble (1917); Hamm (1934); Maier and Waldbauer (1979)** pollen feeding is important for the ripening of eggs. As noted by **Schneider (1948)** through breeding experiments on *Episyrphus balteatus* (Degeer).

The hoverfly *Episyrphus balteatus* that was present in the largest number, had a short thick proboscis with a broad fleshy labella, modified for pollen feeding, while *Eristalis tenax* had long and slim mouth parts, more suited for nectar feeding. Also reported by **Gilbert (1981)**.

The *Melanostoma orientale* was also found to be the very frequent visitor of mango flora.

Closer examination of the syrphid flies showed the presence of numerous small setae on head and thorax. The antennae were typically three segmented aristate and covered with minute pubescence. These findings are in complete agreement with earlier findings of Nayar **(1964)** who stated that on the head, the scale are present on the posterior concave

surface along its dorsal-lateral, margins behind the compound eye. In the antenna the scape is ventro- apically fringed with a transverse row of setae. The pedicel in its ventro-dorsal surface is covered with a large number of extremely stout bristles.

The setae on the head and thorax and the pubescence in the antennae are responsible for effective transport of pollen of the mango flowers. As the syrphid flies visit these flowers for feeding on nectar and pollen, some of the pollen grains adhere to their body. When these pollen loaded flies visit the female flower, fertilization is completed. **Holloway (1976)** stated that the syrphid flies obtain their pollen by exploiting its adherence to specialized body hairs. The pollen is then removed and ingested during cleaning or flight.

The syrphid flies are the efficient pollinators of various horticultural, oil seed crops, ornamental plants and medicinal plants. This is in accordance with the observations of **Gilbert (1981)** that the syrphid flies are frequent flower visitors and the morphology of the mouth parts suggests that certain species are predominantly nectarivorous where as others are pollinivorous.

The results of the Table 4.2 were in accordance with the findings of **Bhalla et al. (1983)** who reported syrphid flies as the

most common insect pollinators visiting flowering plum, peach and almond trees and found *Eristalis* to be the dominant species which worked out the longest hours throughout the flowering season of sarson (*Brassica campestris*) in Himachal Pradesh, India. Therefore the Syrphid flies were reported to be the most effective pollinators.

**Feeding preference of the syrphids fly larvae on the three aphid species. *Lipaphis erysimi*, *Braevicoryne brassicae* and *Aphis gossypi***

It is evident from the Table 4.3 obtained for the experiment conducted on the feeding preference of syrphid larvae as a predator on the three aphid species viz. *Lipaphis erysimi*, *Aphis gossypi* and *Braevicoryne brassicae* stated that the predatory efficiency of the syrphid fly larval remains almost the same during the first, second and third day of feeding on the three aphids. There was no significant difference in the aphid consumption till the third days. This was because of the early stage of development of the syrphid larval. The syrphid larvae consumed about 2.4 nymphs of *Lipaphis erysimi* 2.0 nymphs of *Aphis gossypi* during the first day. The variety of the syrphid fly larvae increased during the subsequent days of feeding. The number of nymph consumed of *Bravioryne brassicae* were comparatively higher than two other aphids viz. *L.*

*erysimi* and *Aphis gossypi*. From the fourth day onwards till the twelfth day of the larval period the difference of aphid consumption was statistically significant for the three aphids taken into consideration. The number of nymphs consumed of the *B. brassicae* were comparatively higher than of the other two species of aphids taken. Moreover the number of nymphs consumed of the other two aphid species. *L. erysimi* and *A. gossypi* were more or less same. The syrphid larvae consumed maximum of (23.60) nymphs of *B. brassicae* during its 10<sup>th</sup> day of feeding

During the 13<sup>th</sup>, 14<sup>th</sup> and 15<sup>th</sup> day of feeding the aphid consumption by the syrphid larvae was again statistically non significant. That may be due to the pupation of larvae into pupae therefore the voracity of the syrphid fly larvae decreased as the larvae approached the stage of pupae formation. These results were in conformity with the observations of **Bisht et al., (2001)** who reported that the larva of *Syrphus* sp. feeding on *L. erysimi* consumed a maximum No. of nymphs 20 to 29 per day and the feeding rate is directly proportional to the larvae growth as the consumption of aphids is increased gradually till 7<sup>th</sup> to 8<sup>th</sup> day in *Syrphus* larvae.

The average predation potential of individual larva of *Syrphus* sp. varies from 3.0 to 23.0 nymphs per day, which were in conformity with our experimental results. It consumed 115 to 157 nymphs during its entire larval period of 10 to 12 days at temperature ranging from 10 to 21<sup>o</sup> C.

The results obtained in the present study was also in accordance with the studies of **Hagvar (1974)** who reported that the 4½-6 day old larvae always captured the first prey more rapidly than larvae after the same periods of starvation. Larvae up to 4 days old were still small and therefore relatively in efficient foragers because they moved more slowly and were not as strong as older larvae. After 8 days, larvae were approaching pupation and becoming sluggish and this were also less efficient foragers

#### **Biology of the syrphid fly (*Syrphus corollae*)**

The mean fecundity of the five females was found to be 58.8 ± 1.36. Fertility of eggs was less constant, on a day-to-day basis, than viability of eggs. Although one female have not laid fertile eggs, others laid eggs of which have a high percentage of fertile eggs. These results were in conformity with **Barlow (1961)** who reported that such phenomenon might have resulted because fertility is

dependent to some extent on sensory stimulation of the ovipositing female. Time of embryonic development was relatively constant all viable eggs hatched after three days of incubation. The length of the larval and the pupal stage was the same; development of females was slightly longer than that of males in these stages. Larval mortality was estimated from observed embryonic and pupae mortalities in relation to total mortality in the immature stages. Most of the mortality occurred in the egg stage. Infertility and inviability accounted for 48.78 % and 53.3% respectively of the total mortality. The adult longevity was more in the case of females than for the males. These results are in conformity with **Barlow (1961)**.

It is evident from the Table 4.8 that the hour of sampling had a significant effect on the number of syrphid flies per panicle per minute. The highest number of flies were recorded between 0900-1000 h and the lowest number between 1600-1700h. When the temperature was low (18.5°C) on the 28 February, abundance did not peak till 1000 h while on hotter days when temperature reached 23.3°C activity of the syrphid flies commenced in the morning and was almost absent in the afternoon. The syrphids flies were the first visitors each day and

therefore fed on the flowers when pollen was most plentiful. The flowers of mango opened chiefly before noon when the syrphid feeding activity was the greatest. This was in accordance with the findings of **Rana et al., (1976)** that the peak anthesis occurred 2 to 4 a.m. and dehiscence between 8 a.m. to 12.00 noon. The stigma was receptive on the day of anthesis and thereafter the receptivity of the stigma rapidly declines. The pollination by the insect pollinators therefore is more efficient during the early morning hours, which is again in accordance with the peak activity of the syrphid flies during the morning hours of the day.

Moreover, these results are also in accordance with the findings of **Maier and Waldbauer (1979)** who studied the diurnal activity of patterns of flower flies in an Illinois sand area. They showed that the syrphid flies population was more abundant in mid morning than later. Abundance peaked from 0800 to 0900h and dropped drastically by 1100h and remained low thereafter. There was no rebound in activity between 1600-1700h when conditions approximated those at 1000 to 1100h. it was said that adult syrphids flies change their habitat preference in the course of the day. In the morning they congregate on the flowers where pollen and mates were

abundant. Around mid day as the pollen availability decreases and hygrothermal stress increases they go to the surrounding needs where hygrothermal conditions are more favourable. However the syrphids do not exhibit another burst of activity at flowers near the end of the day. This is surely due to the absence of pollen and may be perhaps due to the absence of nectar.

The number of flowers visited per minute per syrphid fly was high in the morning and gradually decreased towards the end of the day the maximum being 12.33 at 0700-0800h. Thereafter, there was a slow decline in the number of flowers visited. In the forenoon the hover flies made shorter, quicker and erratic flights. They were observed on leaves or suspended in mid air towards the direction of the sun during the early morning hours.

These results also support the experimental findings of **Heinrich and Pantle (1975)** who stated that the *Syrphus* adults elevate their thoracic temperature more than 10°C above ambient, by basking and shivering and therefore are able to fly at low temperature.

According to **Kiku (1965)** high temperatures either acting in concert with humidity or alone, limits the activity of syrphid

flies. They leave the flowers and seek shade when air temperatures become high at midday. This adaptive behaviour allows the flies to avoid excessive heating and water loss.

**Maier and Waldbauer (1979)** reported that the total number of flowers visited per minute per syrphid fly was high in the morning and less toward mid day with a slight increase around sunset. This was due to the decrease in the pollen and nectar content. In the forenoon when the pollen and nectar content was high the syrphid flies moved from one flower to another taking their food. As the pollen content decreased during the passage of the day the activity of the syrphid flies also decreased. They avoided the direct sunlight during the hot afternoons.

The time taken per flower per syrphid fly was maximum (8.66) at (H<sub>1</sub>) 0700h-0800h when the pollen content of the flowers was reported to be the highest. As the day proceeded the pollen content of the flower decreased therefore the time spent on flower also showed a decline (2.33) at 1600-1700h. This was in agreement with the results of **Maier and Waldbauer (1979)** who reported that the syrphid fly adults demonstrated a marked change in behaviour between 0900-1000h, the time when the pollen was abundant. They devoted less time to flying,

made shorter moves to cover a number of flowers and spent more time on feeding.

A glance of data depicted in Table 4.11 revealed that bagging of the mango panicles in the nylon screen bags from their emergence had no significant effect on the total number of female flowers per panicle.

The variations in the fruit set quality and quantity for the different treatments were not influenced by the total number of female flowers per panicle. These remained almost equal for all the treatments.

The data presented in Table 4.11. .showed a significant effect of bagging the panicles on the fruit set percentage and fruit drop percentage. The maximum fruit set 5.37 was observed under treatment T<sub>5</sub> where the panicles were left unbagged for open pollination, followed by the treatment T<sub>4</sub> (3.19) where 20 syrphid flies were released into the bag. The minimum fruit set 0.84 was observed for treatment T<sub>0</sub> when the panicles were left completely bagged without any syrphid flies release.

These results were in support with the experimental findings of **(Singh et al. 1997)** who reported that there was no fruit set on completely bagged panicles but when the bagged

panicles opened for 24, 48, and 72h the fruit set was 1.2, 1.2, and 1.6 fruits/panicle, respectively.

Maximum 2.4 fruits/panicle were obtained when 10 syrphid flies (*Melanostoma orientale*) were released from cultivar Langra to Dashehari, followed by 0.4 fruits per panicle set with 5 blue flies.

Moreover the results were also in accordance to the experimental findings of **Baidyala and Garg (1990)** who reported that fruit set in open inflorescence assessable to insects was two to three times greater than in bagged inflorescence.

According to **Toit (1994)** fruit set averaged six per inflorescence in open pollinated panicles compared with two fruits per inflorescence in bagged panicles in litchi inflorescence. The results varied with different cultivars.

These experimental findings proved that the insect pollination was essential for the setting of fruits in mango. As the number of syrphid fly releases increased fruit set percentage, which was maximum when the panicles were left open for pollination and the number of syrphid flies per panicle was the maximum.

A glance at the fruit drop percentage revealed that the maximum value was attained in case of completely closed panicles where fruit drop was 100%. Thus the 1-2 fruits that were set dropped by the time the fruits reached to maturity. However minimum fruit drop 64.10% was observed in the case of the open pollinated panicles (T<sub>5</sub>). Thus the pollination in mango through insects not only affected the percentage of fruit set but also determined the number of fruits that reach to maturity. In self-pollinated panicles the fruits were too weak to mature and therefore dropped off in early stage. The treatment T<sub>5</sub> was better than the other treatments because fruit drop was minimum. the low fruit set may be due to the fact that the mango requires a pollinizer and when they are selfed most of the fruits will drop off and there was a low fruit set.

The results were also in accordance with the experimental findings of **Singh et al. (1962)** who observed that the selfed flowers of Dashehari variety developed fruits only to “pea” stage and open pollinated or cross-pollinated flowers produced fruit, which ripened normally.

According to **Sharma and Singh (1970)** the initial fruit set under self-pollination was negligible (0.0-1.68%) but in

cross-pollination, it was 6.4-23.4%. the majority of dropped fruits attained half of the full size.

Results pertinent to quality parameters of the fruits were superior in enhancing TSS, wt of the fruit, size of the fruit and the weight of the edible portion. Maximum TSS was obtained in the fruits that were set through open pollination, which had a non-significant difference with the TSS content of the fruits that were set through pollination by 15 syrphid flies. There was a non-significant difference between the TSS of fruits set through pollination by 5 and 10 syrphid flies through pollination by 5 and 10 syrphid flies respectively. Since no fruits matured in the completely bagged panicles, the TSS content was 0.00.

The size of the fruits was maximum for the fruits set through open pollination. This had significant difference with the size of the fruit set by 10, 15 and 20 syrphids respectively. Since none of the fruits could reach the maturity level in the control their size was taken to be 0.00.

The size of the seed (6.15) was maximum for the fruits when 20 syrphids were released into the bag. The seed size when 5 syrphid flies were released had a significant difference with the seed size when the bags were left for open pollination so in treatment T<sub>5</sub> the seed size does not correspond with the

size of the fruits. This showed that the size of the edible pulp was maximum for fruits set under open pollinated conditions.

The fruit weight showed a gradual increase as the number of syrphid flies per panicle increased. The maximum value was attained for fruits set under the natural undisturbed conditions, when the number of syrphid flies per panicle was the highest. Since no fruit could mature in self-pollinated. (Without syrphid flies releases) the fruit weight was taken to be (0.00). The weight of the pulp was maximum for the fruits set under the open pollinated conditions. This result was in conformity with the fruit weight. Therefore there was decrease in the pulp weight as the number of pollinators per panicle reduced. These results were similar to the experimental findings of **Baidyala and Garg (1990)** who reported that the fruit size and weight was greater in inflorescence under the open pollinated conditions than in bagged inflorescences.

The present investigation entitled “Biodiversity of syrphid flies and their major role as pollinators of mango (*Mangifera indica*) and as a predator of aphids in Pantnagar (Uttaranchal)” was undertaken to estimate the detailed survey and identification of the different species of syrphid flies. These experiments were conducted at Horticultural Research Center, Pattharchatta, Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar during the year 2003-2005 to assess the role of syrphid flies as major pollinators in the fruit setting of mango (*Mangifera indica*) with mature trees of cv. Dashehari and as the predators of three important species of aphids viz. *Lipaphis erysimi*, *Braevicoryne brassicae* and *Aphis gossypi*. The biology of the syrphid fly (*Syrphus corollae*) was studied and the studies were conducted on the effect of bagging the mango panicles for various time periods with the different number of syrphid flies, studies on the pollinating efficiency of syrphid flies on mango and relationship between their activity and fruit setting of mango.

The salient findings of the present investigation are summarized below:

1. Out of the total number of insect species visiting the mango flowers, the highest number of insects was found to be of the order Diptera and syrphid flies in the order, Diptera

2. (Syrphidae) were the most dominating and represented the highest number. These included *Episyrphus balteatus*, *Melanostoma orientale*, *Eristalis tenax*, *Ischiodon scutellaris*, *Eristalinus* sp., *Syrphus corollae* and *Syrphus isaaci*.
3. It was observed that the number of aphids consumed by each larva increased with the subsequent days of feeding in case of each aphid species viz. *Lipaphis erysimi*, *Braevicoryne brassicae* and *Aphis gossypii*.
4. The numbers of aphids consumed during the first, second and third subsequent day of feeding was found to be statistically non-significant or the consumption by the syrphid larvae during the early stages of development were almost the same.
5. During the later stages of the feeding the aphid consumption by the syrphid larvae was again statistically non-significant, as the larvae approached the stage of pupal formation.
6. The mean fecundity of five females was found to be  $58.8 \pm 1.36$ . The mean length of the larval stage was found to be  $12.40 \pm 0.50$ .
7. The total number of syrphid flies per panicle per minute was highest (12.33) between 0800 and 1000hr. the population of the syrphid flies varied both with temperature, humidity as well as the pollen content in the flowers. As the day proceeded and the temperature increased, the pollen content

8. and nectar was supposed to decrease, the population of the syrphids also decreased.
9. The total number of flowers visited per minute per syrphid fly was maximum for 0700 and 0800h. Thereafter there was a steady decrease in the value. This was because of the increase in the pollen and nectar content in the forenoon. Also the syrphid flies avoided direct contact with sunlight during the afternoon and preferred to stay in the shade.
10. The total time spent per flower per syrphid fly was highest in the morning hours from 0700-0800h, as the flowers are rich in pollen and nectar content the syrphid flies devoted very less time in flying and more time on feeding.
11. The fruit set percentage was highest (5.37) in panicles that were left unbagged for open pollination. This was followed by panicles, which were pollinated by 20 syrphid flies (3.13). The minimum was in case of completely bagged panicles (0.84), which served as the control.
12. The fruit drop percentage was highest in the control (100%) where none of the fruits reached to maturity. The lowest fruit drop was in panicles that were open pollinated.
13. Total soluble solids were found maximum (11.60) in fruit set in the panicles left unbagged for open pollination. This was followed by fruits that were set through pollination by 15 syrphid flies (11.39).

14. Size of the fruit was found to be maximum (10.77) in those panicles that were left for open pollination.
15. The weight of the fruit was highest (30.16) in those panicles that were left unbagged. Here the number of syrphid flies visiting per panicle was the highest.
16. The size of the seed was maximum (6.15) for fruits set through pollination by 10 syrphid flies followed by the ones pollinated by 15 syrphid flies (5.94).
17. The maximum pulp weight ((140.85) was obtained in the fruits set in completely open panicles. This value showed a continuous decline as the number of syrphid flies per panicle decreased.

Therefore it is concluded that the Syrphid flies have greatest potentialities for use in controlling of aphid pests of crops in Pantnagar.

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**Table 1: Standard weekly meteorological parameters during experimental period (2004) at Pantnagar.**

Month	Week No	Temp		Relative humidity%		Sunshine (hrs)
		Max °C	Min °C	Max	Min	
Feb 2004	1	21.8	6.9	94	52	3.1
	2	25.1	9.2	88	48	7.8
	3	25.3	9.2	93	49	8.0
	4	27.4	10.2	87	44	8.8
March 2004	1	28.3	10.8	81	33	9.6
	2	31.5	15.7	87	48	9.8
	3	34.6	15.8	83	27	8.1
	4	34.8	14.3	80	18	9.3
April 2004	1	36.2	18.1	71	28	8.8
	2	39.0	18.5	63	17	8.8
	3	36.7	20.9	62	29	9.7
	4	32.9	19.5	66	35	5.3
May 2004	1	40.2	14.6	62	28	9.6
	2	41.1	20.8	62	25	11.0
	3	33.3	25.7	63	31	10.4
	4	35.6	23.0	76	58	5.6
June 2004	1	35.6	22.4	82	55	9.4
	2	32.4	25.9	73	50	6.3
	3	35.1	23.9	90	68	8.5
	4	31.7	25.3	80	46	3.2

**Table 2: Standard Weekly Meteorological Parameters during Experimental Period (2005) at Pantnagar.**

Month	Week No	Temp		Relative humidity (RH) %		Sunshine (hrs)
		Max °C	Min °C	Max	Min	
Jan 2005	1	20.5	7.6	95	61	5.2
	2	218.9	3.9	93	62	6.1
	3	18.3	6.8	94	61	8.4
	4	17.6	8.7	94	64	2.9
Feb 2005	1	22.4	7.9	90	61	4.2
	2	22.2	10.8	89	54	4.2
	3	23.5	11.4	89	49	5.9
	4	26.2	8.3	88	46	8.0
March 2005	1	26.3	11.1	84	43	7.3
	2	27.5	12.9	82	50	7.1
	3	29.1	14.8	66	53	8.8
	4	28.7	14.4	74	34	7.7
April 2005	1	31.9	13.2	62	27	10.4
	2	34.4	16.9	63	23	9.4
	3	34.8	13.9	73	20	10.0
	4	37.0	15.7	59	18	9.9
May 2005	1	31.7	20.4	54	35	9.2
	2	37	19.4	57	24	8.2
	3	39.0	20.8	57	24	11.1
	4	40.8	20.5	54	22	10.5

## VITA

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## ABSTRACT

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**Major:** Entomology

**Thesis title:** “Biodiversity of syrphid flies and their major role as pollinators of mango (*Mangifera indica*) and as a predator of aphids in Pantnagar (Uttaranchal)”

The syrphid flies (Diptera:syrphidae) are one of the most diverse flies of the world, comprising about 200 genera and over 5000 species. Hoverflies adults display wide range of lifestyle and adaptations. Adult of aphidophagous species are frequent flower visitors, certain species are predominantly nectarivorous, whereas others are pollinivorous. Adult require honeydew or nectar and pollen to ensure reproduction, whereas larvae require aphids to complete development. *Syrphus sp.* has been observed as the major insect pollinators associated with mango, pollination of flowers require insects. The mango belongs to the family Anacardiaceae which is a dicotyledonous family consisting of 64 genera. cross pollination occurs in mango flowers therefore a pollinizer is required. The effective insect pollination is essential for good fruit set and yield in mango (*Mangifera indica*) Present investigation was therefore, initiated to assess the role of syrphid flies as major insect pollinators in fruit set of mango. For this purpose 30 years old mature mango trees c.v. Dashehari were selected and 20 panicles were bagged. 3 panicles in one bag 0, 5, 10, 15, and 20 syrphid flies were released into each bag respectively at the time of peak bloom. At the time peak bloom different insects were collected with the help of hand net and identified. The activity of syrphid flies was also observed. The number of syrphid flies per panicle, the number of flowers visited per minute and the time spent per flower were checked. Further the role syrphid flies in fruit setting quantity was assessed by counting the number of fruit set and fruits matured in all the six treatments.

The quality parameters were determined by testing for the TSS content, fruit size, fruit weight, amount edible pulp. The quantity parameters were determined by testing the number of fruits at different sizes viz. pea size, marble size and full size fruits. The highest number of insects visiting the mango flora belonged to the family syrphidae. Six species *Syrphus corollae*, *Episyrphus balteatus*, *Melanostoma orientale*, *Eristalis sp.*, *Ischiodon scutellaris*, *Syrphus isaaci* were found frequently in Pantnagar and were found as the efficient pollinators of various agricultural, horticultural, ornamental, oil seed crops. The highest number of flies were observed between 0900-1000 h, they spent more time per flower and visited maximum number of flowers early in the morning between 0700-0800h. In fruits, that were set under open pollinated conditions where syrphid flies population was maximum, high results were obtained with TSS, fruit size and fruit weight while low results with seed size and peel.

Thus, it can be concluded that syrphid flies has greatest potentialities for use in controlling of aphid pests of crops in Pantnagar.

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