

Project ID: 315

## Competitive Research Grant

# Sub-Project Completion Report

On

## Arthropod Pest Infesting Ornamental Plants in Bangladesh: Strategies for Management

Project Duration

May 2016 to September 2018

Department of Entomology  
Bangabandhu Sheikh Mujibur Rahman Agricultural University  
Gazipur 1706

Submitted to

Project Implementation Unit-BARC, NATP-2  
Bangladesh Agricultural Research Council  
Farmgate, Dhaka-1215



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#### ***Acknowledgement***

The execution of CRG sub-project has successfully been completed by Department of Entomology Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706 using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thank the World Bank for arranging the grand fund and supervising the CRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. Preparing the project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are due to the Director PIU-BARC, NATP 2 and his team who have given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation as well as increasing production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

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## Acronyms

ai	Active Ingredient
BSMRAU	Bangabandhu Sheikh Mujibur Rahman Agricultural University
EC	Emulsifiable Concentrate
IPM	Integrated Pest Management
L	Liter
ml	Milliliter
N	Number of observation
SC	Soluble Concentrate
SG	Soluble Granule
SP	Soluble Powder
WG	Wettable Granule

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## Executive Summary

The study was conducted to survey and identify the arthropod pests infesting the ornamental plants viz., rose, China rose, gladiolus, thuja, chrysanthemum, tuberose, marigold, dahlia, cosmos and ixora at five locations in Bangladesh namely Gazipur, Jashore, Narsingdi, Cox's Bazar and Satkhira during November 2017 to May 2018. In total 51 insect and 4 mite species were identified of which 23% infested rose followed by China rose (21%) and the lowest (3%) was observed on ixora. The abundance of major and minor pests occupied 16% and 84%, respectively. The arthropod pests were found under 10 taxonomic orders and the order Hemiptera showed the highest abundance (31%) followed by Lepidoptera (26%) and Coleoptera (16%). A total of 12 insect species and one mite species infested rose of which thrips, aphid, mealybug, bagworm, budworm and mite were found as the major pests. China rose was infested by 12 arthropod species and all were identified as the minor pests. In total 5 arthropod species were found as the pest of gladiolus of which thrips was identified as the major pest. A total of 4 insect species were identified as pest of thuja of which bagworm was found as major pest. Chrysanthemum was infested by 5 insect species and all were found as minor pests. In total 6 arthropod species were identified as the pest of tuberose of which aphid was identified as the major pest. Marigold was infested by 4 insect species of which aphid was found as major pest. Dahlia was attacked by 4 insect species and mealybug was found as the major pest. Cosmos and ixora were infested by 2 insect species which were found as the minor pest. Weather parameters exerted significant effect on the population dynamics of the major pest species. Rose thrips, aphid, mite and budworm had the highest abundance in the month of February, December, March and January, respectively. Marigold aphid and gladiolus thrips showed the highest abundance in January. Dahlia mealybug, tuberose aphid and thuja bagworm showed the highest abundance in the month of February. Tundra 20 SP, actara 240SC, abom 1.8 EC and proclaim 5 SG significantly reduced the abundance of rose thrips, aphid, mite and budworm, respectively. Actara 25WG, talstar 2.5EC, liquor 1.8 EC, fenitox 50EC and Roxin 40EC significantly reduced the abundance of marigold aphid, thuja bagworm, dahlia mealybug, gladiolus thrips and tuberose aphid, respectively. The tested pesticides could be used as a tool of integrated management of the ornamental plants in Bangladesh.

# CRG Sub-Project Completion Report (PCR)

## A. Sub-project Description

1. **Title of the CRG sub-project: Arthropod Pests Infesting Ornamental Plants in Bangladesh: Strategies for Management**

2. **Implementing organization: Department of Entomology Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706**

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

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4. **Sub-project budget (Tk):**

4.1 Total: 1500000/=

4.2 Revised (if any): Not applicable

5. **Duration of the sub-project: From May 2017 to September 2018**

5.1 Start date (based on LoA signed): 09 May 2017

5.2 End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

Bangladesh has demand for cut flowers, worth \$ 8.0 million of which \$ 5.0 million is locally produced. About 5,000 resilient farmers are growing flower and foliage in the country and 80,000-90,000 people are directly or indirectly involved in floriculture business (Chowdhury, 2010). Insect and mite infestation is one of the important obstacles of ornamental crop production. There is a report that sixty five insect species cause damage to different ornamental plants in Himachal Pradesh, India (Pal

and Sarkar, 2009), but such information is scarce in Bangladesh. Pest species abundance and infestation differ from place to place with the variation in the agro-climatic conditions of the locality. Information on pest complex in a specific agro-ecosystem is very much essential in developing pest management strategies, which would be economically feasible and sound. Therefore, pest survey and identification were conducted to know their scenario on ornamental plants in Bangladesh, their population dynamics with weather parameters, to develop their management strategies, and to create awareness among the commercial flower growers through intensive training programs.

**7. Sub-project goal:**

Identification, categorization, loss assessment and management of arthropod pests of ornamental plants in different areas.

**8. Sub-project objective (s):**

- Survey and identification of insect and mite species cause damage to ornamental plants in Bangladesh.
- Establishment of relationship between weather factors and pest population dynamics.
- Development of management tactics.
- Training for commercial flower growers.

**9. Implementing location (s):**

- Gazipur
- Narsingdi
- Jessore
- Satkhira
- Cox's Bazar

**10. Methodology in brief:**

**Project area:** Under this project, the ornamental plant production farmers were selected Jhikargacha Uapzila of Jashore, Raipura Uapzila of Narsingdi, Chokoria Uapzila of Cox's Bazar and Sadar Uapzila of Satkhira. Experiment was also conducted in Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur. Three farmers in each location of Jashore, Narshindi and Satkhira were brought under this project for cultivation and data collection on arthropod pest infested ornamental plants. One day long training program for 10 farmers in each location was arranged along with the agricultural extension and BARI personnel.

**Study materials:** Ornamental plants like Rose, China rose, Gladiolus, Thuja, Chrysanthemum, Tuberose Marigold, Dahlia, Cosmos, Ixora were cultivated in the experimental sites.

**Pest collection and identification:** The cultivated ornamental crops in the study locations were surveyed at fortnightly intervals to observe the pest incidence. A pocket lens (10X), microscope, insect collecting nets, yellow sticky trap, Malaise trap, glass vials and polythene bags were used for collection, observation, identification and preservation of pests. The collected pests were brought from the experiment field to the Entomology Laboratory of Bangabandhu Sheikh Mujibur Rahman

Agricultural University for counting total abundance. Some pests were identified on the spot and the unknown species were killed by storing in a freezer in the laboratory. Then these were mounted on paper card points and dried. Information explored from the field survey and identification were compiled and presented for taxonomic profiling (common name, scientific name, family and order) of the pests.

**Pest characterization:** Based on the mode of occurrence and frequency, the pests were categorized as major and minor. Pests those have caused 10% or above infestation were termed as major pests.

**Observation of thrips abundance:** The sampling schedule was lengthened to fortnightly intervals and adapted to consist of leaves from three positions on a shoot. The thrips were dislodged and dropped onto the tray where they were counted. Counting was done both for nymphs and adults with the help of magnifying lens.

**Observation of aphid incidence:** The aphids were brushed off by using camel hair brush from the apical 5 cm of rose plants on a white paper sheet and counted to calculate aphid severity. Percentage of incidence of aphid was computed by using the formula:

$$\text{Incidence} = \frac{n}{N} \times 100$$

Where, n = Number of twigs infested, and N = Total number of twigs examined.

**Observation of mean abundance of aphid:** In each infected plant, 10 leaves, 10 stems (10 cm), 10 flower buds and 10 rose flowers were randomly collected. The aphid populations were counted under stereo microscope as (a) on the upper and bottom surfaces of leaves, (b) on new stems, (c) on rose flower buds, and (d) on rose flowers.

**Observation of mite abundance:** Mite infested leaves were collected and brought to the laboratory using polythene bag and the number of mite per leaf was counted using stereo microscope.

**Collection of weather data:** Temperature, relative humidity and rainfall data are collected from the weather station of BSMRAU.

**Data analysis:** Data were analyzed by Chi statistics, analysis of variance (ANOVA) and correlation coefficients were calculated for pest abundance with meteorological parameters. All the analyses were done using IBM SPSS 21.1 software. The mean values were separated by Tukey's posthoc statistic.



Plate 1. Labors and an MS student are working in the field.



Plate 2. Labors are carrying seedlings.



Plate 3. MS student is working in the field.



Plate 4. Labor is watering in the field.



Plate 5. Principal Investigator and farmers are visiting the experimental field.



Plate 6. Co-PI is monitoring the pest of rose.



Plate 7. Dahlia field.



Plate 8. Cosmos field.



Plate 9. Thuja field.



Plate 10. Marigold field



Plate 11. Thrips infested rose leaf and flower.



Plate 12. Rose aphid.



Plate 13. Red spider mite infested rose leaf.



Plate 14. Bagworm infested thuja plant.

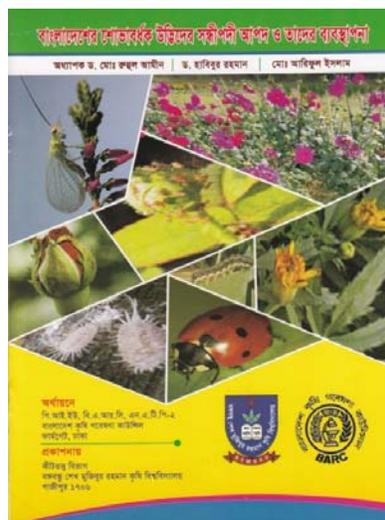


Plate 15. Front cover of the published Booklet.



Plate 16. PI is handing over booklet to the Vice-Chancellor of BSMRAU.



Plate 17. PI is handing over booklet to the Director of PIU-BARC, NATP-2.



Plate 18. PI is distributing booklet among the ornamental plant producing farmers.

## 11. Results and discussion:

In total 51 insect and 4 mite species were identified as the pests of the studied ornamental plants namely rose, dahlia, marigold, gladiolus, tuberose, chrysanthemum, thuja, cosmos, China rose and ixora. Most infested parts of plant were twigs and flowers. Thrips, aphid, mealybug, bagworm, budworm and mite were found as the major pests. Pal and Sarkar, (2009) reported that 65 insect species caused damage to different ornamental plants in Himachal Pradesh, India.

**Table 1. Taxonomic profile and status of the pests of rose**

Pests	Taxonomic profile	Status
Thrips	<i>Rhipiphorothrips cruentatus</i> (Thysanoptera: Thripidae)	Major
Aphid	<i>Macrosiphum rosae</i> (Hemiptera: Aphididae)	Major
Rose scale	<i>Lindingaspis rossi</i> (Hemiptera: Coccidae)	Minor
Leaf hopper	<i>Edwardsiana rosae</i> (Hemiptera: Cicadellidae)	Minor
Chaffer beetle	<i>Oxycetonia versicolor</i> (Coleoptera: Cetoniidae)	Minor
Spotted cucumber beetle	<i>Diabrotica duodecimpunctata</i> (Coleoptera: Chrysomelidae)	Minor
Rose weevil	<i>Merhynchites bicolor</i> (Coleoptera: Curculionidae)	Minor
Budworm	<i>Helicoverpa virescens</i> (Lepidoptera: Noctuidae)	Major
Hairy caterpillar	<i>Orgyia posticus</i> (Lepidoptera: Lymantriidae)	Minor
Castor semilooper	<i>Achaea janata</i> (Lepidoptera: Noctuidae)	Minor
Leaf folder	<i>Acleris extensana</i> (Lepidoptera: Tortricidae)	Minor
Rose midge	<i>Dasineura rhodophaga</i> (Diptera: Cecidomyiidae)	Minor
Red spider mite	<i>Tetranychus cinnabarinus</i> (Acari: Tetranychidae)	Major

A total of 13 arthropod pest species were identified as pest of rose of which 12 species were found insect and one species was found as mite (Table 1). Among the pests, four species namely rose thrips, rose aphid, rose spider mite, rose budworm were identified as major and others were found as minor pest. Flint and Karlik (2008) observed 11 arthropod species as pest of rose in California.

**Table 2. Taxonomic profile and status of the pests of China rose**

Pests	Taxonomic profile	Status
Red spider mite	<i>Tetranychus tumidus</i> (Acari: Tetranychidae)	Major
Thrips	<i>Thrips hawaiiensis</i> (Thysanoptera: Thripidae)	Minor
Aphid	<i>Aphis gossypii</i> (Hemiptera: Aphididae)	Minor
White fly	<i>Aleurodicus dugesii</i> (Hemiptera: Aleurodidae)	Minor
Dusky cotton bug	<i>Oxycarenus laetus</i> (Hemiptera: Lygaeidae)	Minor
Hollyhock tinged bug	<i>Urentius euonymus</i> (Hemiptera: Tingidae)	Minor
Lace wing bug	<i>Cadmilos retarius</i> (Hemiptera: Tingidae)	Minor
Banded blister beetle	<i>Mylabris phalerata</i> (Coleoptera: Meloidae)	Minor
Castor hairy caterpillar	<i>Euproctis lunata</i> (Lepidoptera: Lymantriidae)	Minor
Ak butter fly	<i>Danaus chrysippus</i> (Lepidoptera: Nymphalidae)	Minor
Lily moth	<i>Polytela gloriosae</i> (Lepidoptera: Noctuidae)	Minor
Gerbera leaf miner	<i>Liriomyza trifolii</i> (Diptera: Agromyzidae)	Minor

Table 2 showed that a total of 12 arthropod species were identified as pest of China rose of which 11 species were found as insect and one species was found as mite. All the arthropods were identified as minor pest.

**Table 3. Taxonomic profile and status of the pests of gladiolus**

Pests	Taxonomic profile	Status
Thrips	<i>Teniothrips simplex</i> (Thysanoptera: Thripidae)	Minor
Mealy bug	<i>Ferrisia virgata</i> (Hemiptera: Pseudococcidae)	Minor
Cutworms	<i>Agrotis segetum</i> (Lepidoptera: Noctuidae)	Minor
Leaf eating caterpillar	<i>Spodoptera litura</i> (Lepidoptera: Noctuidae)	Minor
Bulb mite	<i>Rhizoglyphus sp.</i> (Acari: Tetranychidae)	Minor

Table 3 showed that a total of 5 arthropod species were identified as the pest of gladiolus of which 4 species were found as insect and one species was found as mite. Among the pests, one species namely gladiolus thrips was identified as major and others were minor pests. Pal and Sarkar (2009) studied the insect pest of gladiolus in India and reported that the gram pod borer (*Helicoverpa armigera*) was the most important insect inflicted serious damage. They also reported that the green semiloop ( *Plusia orichalcea* ) caused damage to gladiolus by feeding on the leaves.

**Table 4. Taxonomic profile and status of the pests of thuja**

Pests	Taxonomic profile	Status
Bag worm	<i>Thyridopteryx ephemeraeformis</i> (Lepidoptera: Psychidae)	Major
Shield backed bug	<i>Scuteler anobelis</i> (Hemiptera: Scutelleridae)	Minor
Cedar bark weevil	<i>Phloeosinus sp.</i> (Coleoptera: Curculionidae)	Minor
Bark weevil	<i>Otiorhynchus rugosostriatus</i> (Coleoptera: Curculionidae)	Minor

Table 4 showed that a total of 4 insect species were identified as the pest of thuja of which one namely thuja bagworm was found as major pest. Pal and Sarkar (2009) identified bagworm as a pest of ornamental plants in India.

**Table 5. Taxonomic profile and status of the pests of chrysanthemum**

Pests	Taxonomic profile	Status
Termite	<i>Microtermes obesi</i> (Isoptera: Termitidae)	Minor
Thrips	<i>Frankiniella sp.</i> (Thysanoptera: Thripidae)	Minor
Aphid	<i>Macrosiphoniella sanborni</i> (Hemiptera: Aphididae)	Minor
Bud borer	<i>Helicoverpa armigera</i> (Lepidoptera: Noctuidae)	Minor
Hairy caterpillar	<i>Spilosoma oblique</i> (Lepidoptera: Erebidae)	Minor

A total of 5 insect species were identified as pest of chrysanthemum and all were minor pest (Table 5). Sohi and Singh (1996) reported that *Helicoverpa armigera* and *Tetranychus urticae* were economically important pests of chrysanthemum in India.

**Table 6. Taxonomic profile and status of the pests of tuberose**

Pests	Taxonomic profile	Status
Grasshopper	<i>Atractomorpha crerulata</i> (Orthoptera: Tettigoniidae)	Minor
Aphid	<i>Aphis craccivora</i> (Hemiptera: Aphididae)	Major
Weevil	<i>Mylocherus sp.</i> (Coleoptera: Cucurlionidae)	Minor
Bud borer	<i>Helicoverpa armigera</i> (Lepidoptera: Noctuidae)	Minor
Hairy caterpillar	<i>Spilosoma oblique</i> (Lepidoptera: Erebidae)	Minor
Red spider mite	<i>Tetranychus urticae</i> (Acari: Tetranychidae)	Minor

Table 6 showed that a total of 6 arthropod species were identified as pest of tuberose of which 5 species were found as insect and one species was found as mite. Among the pests, one species namely tuberose aphid was identified as major and others were minor pest.

**Table 7. Taxonomic profile and status of the pests of marigold**

Pests	Taxonomic profile	Status
Ear wig	<i>Forficula oricularia</i> (Dermaptera: Forficulidae)	Minor
Aphid	<i>Neotoxoptera oliveri</i> (Hemiptera: Aphididae)	Major
White fly	<i>Trialeurodes vaporariorum</i> (Hemiptera: Aleurodidae)	Minor
Leaf miner	<i>Liriomyza frifolii</i> (Diptera: Agromyzidae)	Minor

A total of 4 insect species were identified as pest of marigold of which one namely marigold aphid was found as major and others were minor pest (Table 7). Ganai *et al.* (2017) reported that nine insect species and one mite species attacked marigold in the Jammu of India.

**Table 8. Taxonomic profile and status of the pests of dahlia**

Pests	Taxonomic profile	Status
True bug	<i>Acanthocephala thomasi</i> (Hemiptera: Coreidae)	Minor
Mealy bug	<i>Plannococcus citri</i> (Hemiptera: Pseudococcidae)	Major
Leaf beetle	<i>Labidomera clivicollis</i> (Coleoptera: Chrysomelidae)	Minor
Weevil	<i>Otiorhynchus sulcatus</i> (Coleoptera: Cucurlionidae)	Minor

A total of 4 insect species were identified as pest of dahlia of which mealy bug was found as major and others were minor pest (Table 8).

**Table 9. Taxonomic profile and status of the pests of cosmos**

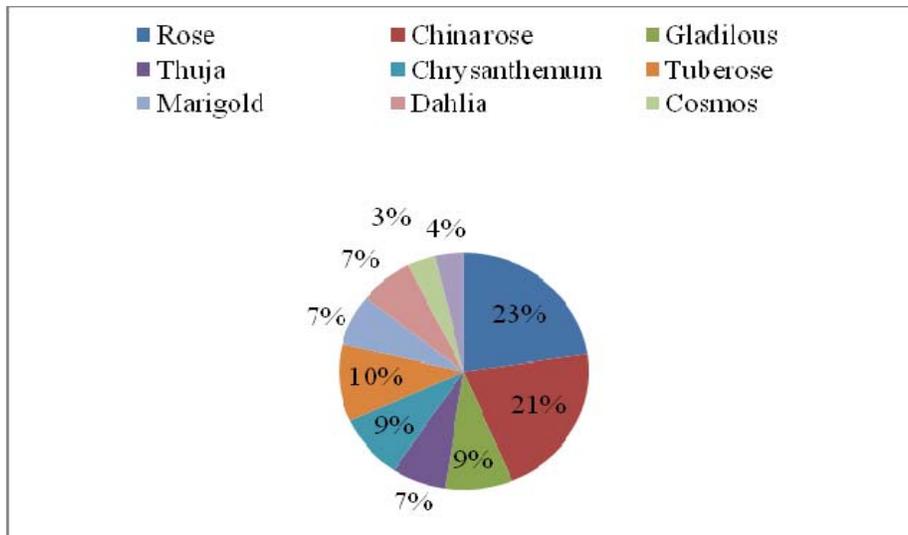
Pests	Taxonomic profile	Status
Thrips	<i>Microcephalothrips abdominalis</i> (Thysanoptera: Thripidae)	Minor
Aphid	<i>Aphis spiraeicola</i> (Hemiptera: Aphididae)	Minor

Table 9 showed that a total of 2 insect species were identified as pest of cosmos and all were found as minor pest. Table 10 showed that a total of 2 insect species were identified as pest of ixora and all were found as minor pest.

**Table 10. Taxonomic profile and status of the pests of ixora**

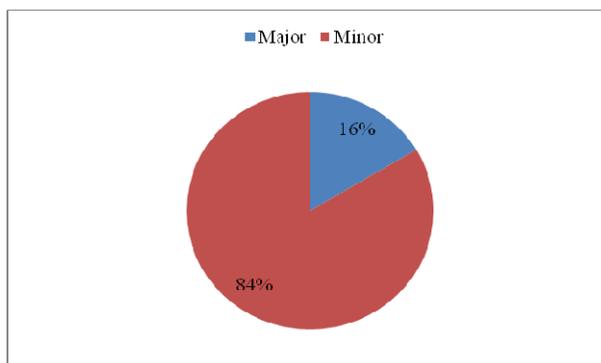
Pests	Taxonomic profile	Status
Scale insect	<i>Coccus viridis</i> (Hemiptera: Coccidae)	Minor
Aphid	<i>Aphis gossypii</i> (Hemiptera: Aphididae)	Minor

Among the identified 51 insect and 4 mite species which infesting the studied ornamental plants, 23% of them attacked rose followed by China rose (21%) and lowest level (3%) infested ixora (Figure 1).



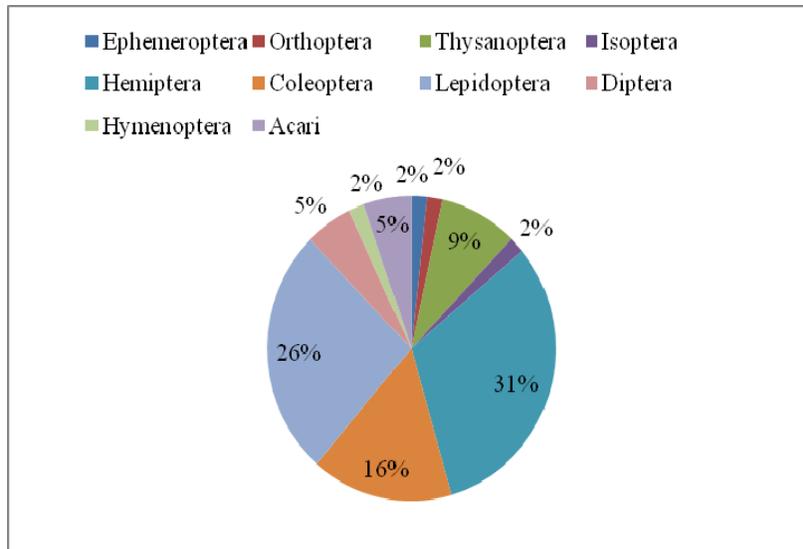
**Figure 1. Arthropod species (%) belonged to different ornamental plants found in the study location.**

Figure 2 showed that 16% arthropods were found as major and 84% were found as minor pests.

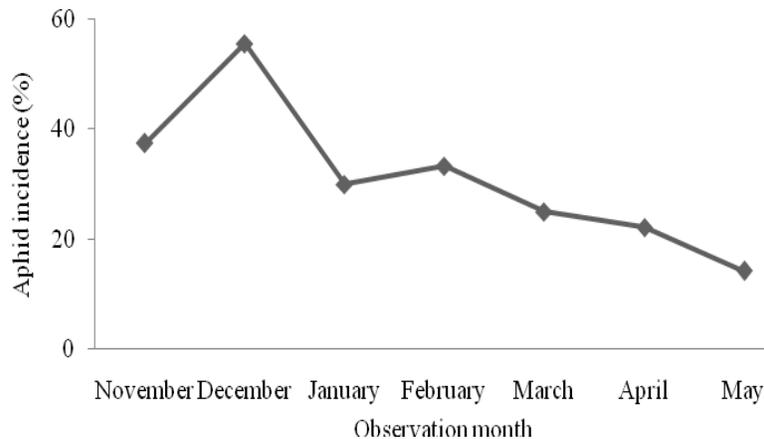


**Figure 2. Major and minor arthropod pest species (%) belonged to different ornamental plants found in the study location.**

Figure 3 showed that arthropods belonged to 10 taxonomic orders infested ornamental plants in the study locations. Among the orders Hemiptera showed the highest abundance (31%) followed by Lepidoptera (26%), Coleoptera (16%). Pal and Sarkar (2009) revealed that the Hemipteran insects were most abundant on ornamental plants in India.



**Figure 3. Arthropods (%) belonged to different taxonomic orders found on the ornamental plants in the study location.**

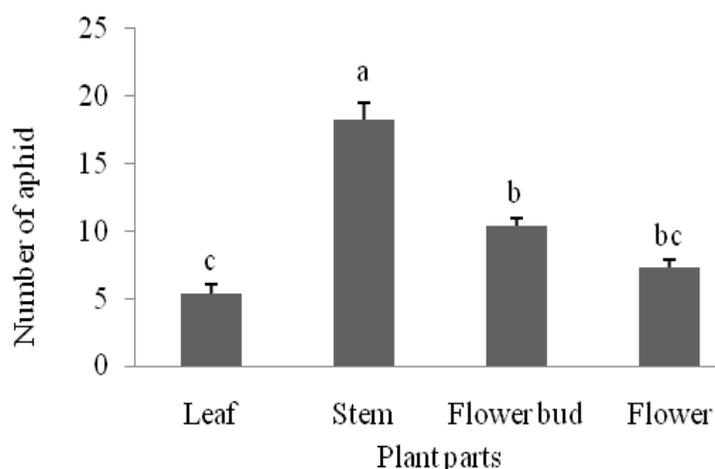


**Figure 4. Incidence of aphid on rose at Gazipur during November 2017 to May 2018.**

The incidence of aphid on rose plant was found from November to end of May (Figure 4). Monthly incidence of aphid during November 2017 to May 2018 showed significant difference ( $\chi^2 = 34.8$ ,  $df = 6$ ,  $p < 0.001$ ). The incidence of aphid was highest in the month of December and then decreased

gradually. Jaskiewicz (1995) reported that high temperature (30°C), heavy rain fall and strong winds resulted lower abundance of aphid on rose.

Figure 5 showed the mean abundance of aphid on different parts of rose plant and the results differed significantly ( $F_{3, 36} = 45.7, p < 0.001$ ). The mean abundance of aphid on different plant parts varied from  $5.4 \pm 0.7$  to  $18.2 \pm 1.2$  and the highest and lowest abundance were found on stem and leaf, respectively. Hole *et al.* (2007) observed the occurrence of aphid in cluster on tender shoots, buds and flowers and caused considerable yield loss and quality of flowers.



**Figure 5. Abundance of aphid (mean ± SE) on different plant parts of rose. Bars with common letter(s) are not significantly different by Tukey’s posthoc statistic at  $p \leq 0.05$ .**

Table 11 showed that the monthly mean temperature, relative humidity and rainfall during the study varied from  $17.5 \pm 3.0$  to  $29.8 \pm 1.8$  °C,  $47.5 \pm 0.5$  to  $81.0 \pm 3.0$  % and  $0.0 \pm 0.0$  to  $6.5 \pm 2.5$  mm, respectively.

**Table 11. Monthly distribution of weather factors during November 2017 to May 2018 at Gazipur. Data expressed as mean ± SE. Number of observation in each month was two.**

Month	Weather parameters		
	Temperature (°C)	Relative humidity (%)	Rainfall (mm)
November	25.0±1.5	62.0±1.0	0.0±0.0
December	23.3±1.3	61.0±1.0	0.0±0.0
January	17.5±3.0	47.5±0.5	0.0±0.0
February	24.5±1.0	53.0±1.0	0.0±0.0
March	28.5±0.5	74.5±2.0	1.5±0.2
April	27.3±0.8	77.5±3.5	3.5±2.5
May	29.8±1.8	81.0±3.0	6.5±2.5

Rose thrips, aphid, mite and budworm differed in their monthly abundance (thrips:  $F_{6,7} = 47.0$ ,  $p < 0.001$ ; aphid:  $F_{6,7} = 6.5$ ,  $p < 0.05$ ; mite:  $F_{6,7} = 112.0$ ,  $p < 0.0001$ ; budworm:  $F_{6,7} = 27.33$ ,  $p < 0.001$ ) and their abundance varied from  $0.0 \pm 0.0$  to  $2.4 \pm 0.2$ ,  $4.0 \pm 0.0$  to  $8.0 \pm 0.4$ ,  $0.0 \pm 0.0$  to  $8.4 \pm 0.2$  and  $0.0 \pm 0.0$  to  $1.1 \pm 0.1$  leaf<sup>-1</sup>, respectively (Table 12). Rose thrips showed the highest abundance in the month of February when temperature and relative humidity were  $24.5 \pm 1.0$  °C and  $53.0 \pm 1.0\%$ , respectively, and there was no rainfall. Rose aphid appeared to the highest abundance in the month of December when temperature and relative humidity were  $23.3 \pm 1.3$  °C and  $61.0 \pm 1.0\%$ , respectively, and there was no rainfall. Rose mite attained to their highest abundance in the month of March when temperature, relative humidity and rainfall were  $28.5 \pm 0.5$  °C,  $74.5 \pm 2.0\%$  and  $1.5 \pm 0.2$  mm, respectively. Rose budworm attained to their highest abundance in the month of January when temperature, relative humidity and rainfall were  $17.5 \pm 3.0$  °C,  $47.5 \pm 0.5\%$  respectively and there was no rainfall.

Dixon (1987) reported that the population build up of aphid was greatly influenced by the environmental factors such as temperature, relative humidity and rainfall and these abiotic factors are important environmental variables that affect the rate of aphid development, reproduction, mortality and survival. Narayan (2010) reported that the incidence of rose thrips prevailed throughout the flowering period and attained peak in high humidity. Meena *et al.* (2013) observed that the mite population declined at the start of the rainy season and remained at extremely low levels in the winter. Parajulee *et al.* (2004) observed that budworm population was attained peak in high temperature.

The marigold aphid and gladiolus thrips differed in their monthly abundance (aphid:  $F_{6,7} = 17.4$ ,  $p < 0.01$ ; thrips:  $F_{6,7} = 105.8$ ,  $p < 0.001$ ) and their abundance varied from  $0.0 \pm 0.0$  to  $2.0 \pm 0.2$ , and  $0.0 \pm 0.0$  to  $6.8 \pm 0.4$  leaf<sup>-1</sup>, respectively (Table 12). Marigold aphid and gladiolus thrips depicted higher abundance in January when temperature and relative humidity were  $17.5 \pm 3.0$  °C and  $47.5 \pm 0.5\%$ , respectively, and there was no rainfall.

Dahlia mealybug showed the highest abundance in the month of February when temperature and relative humidity were  $24.5 \pm 1.0$  °C and  $53.0 \pm 1.0\%$ , respectively, and there was no rainfall (Table 12). Tuberose aphid showed statistically higher abundance in the month of February when temperature and relative humidity was  $24.5 \pm 1.0$  °C,  $53.0 \pm 1.0\%$  and there was no rainfall (Table 12). Thuja bagworm showed the highest abundance in the month of February when temperature and relative humidity were  $28.5 \pm 0.5$  °C and  $74.5 \pm 2.0\%$  and rainfall  $1.5 \pm 0.2$ , respectively (Table 12).

Saiyad (2015) reported that the population of gladiolus thrips decreased with increasing temperature and relative humidity. Griffiths and Thompson (1957) reported that mealybugs are most common during the spring and early summer. Dhaliwal *et al.* (2007) stated the incidence, growth and multiplication of aphid are largely influenced by meteorological parameters like temperature, relative humidity, rainfall, wind speed and cloudiness. Rhinds and Sadof (2008) observed that the pupation and emergence of adult bagworm occurred in late summer and early fall. McDonald *et al.* (2003) reported that more abundant aphids were collected from mid-September through mid-May than from mid-May through mid-September.

**Table 12. Abundance of the major arthropod pests on cultivated ornamental plants during November 2017 to May 2018 at Gazipur**

Month	Arthropod pests								
	Rose thrips	Rose aphid	Rose budworm	Rose mite	Dahlia mealybug	Marigold aphid	Gladiolus thrips	Thuja bagworm	Tuberose aphid
November	0.0±0.0c	6.8±0.8ab	0.0±0.0c	0.0±0.0d	0.0±0.0c	1.6±0.4a	0.9±0.1b	0.0±0.0b	0.6±0.2c
December	0.0±0.0c	8.0±0.4a	0.7±0.1ab	1.2±0.4d	0.5±0.1c	1.8±0.2a	6.2±0.6a	0.2±0.0b	1.2±0.2bc
January	1.2±0.2b	6.0±0.0ab	1.1±0.1a	3.6±0.6c	1.9±0.1b	2.0±0.2a	6.8±0.4a	0.4±0.2b	1.8±0.0ab
February	2.4±0.2a	6.0±1.0ab	0.6±0.1b	4.3±0.1bc	3.4±0.2a	1.7±0.1a	5.4±0.2a	0.7±0.1ab	2.2±0.2a
March	1.4±0.2b	5.0±0.0ab	0.5±0.1b	8.4±0.2a	1.7±0.1b	1.0±0.2ab	0.3±0.3b	1.3±0.1a	1.1±0.1bc
April	0.3±0.1c	4.5±0.5b	0.6±0.1b	5.6±0.2b	1.4±0.2ab	0.0±0.0b	0.0±0.0b	0.6±0.2ab	0.9±0.1c
May	0.0±0.0c	4.0±0.0b	0.3±0.1bc	0.0±0.0d	0.8±0.2bc	0.0±0.0b	0.0±0.0b	0.3±0.1b	0.6±0.2c

Number of observation in each month for a pest is two. Data expressed as mean± SE. Means within a column followed by same letter(s) are not significantly different by Tukey posthoc statistic at  $p \leq 0.05$ .

**Table 13. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of rose aphid during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	% Role of individual factor	F statistic	P
$Y = 10.480 - 0.1881X_1$	0.306	30.6	30.6	$F_{1,12} = 5.3$	$P < 0.05$
$Y = 10.607 - 0.063 X_1 - 0.050X_2$	0.356	35.6	5.0	$F_{2,11} = 3.04$	$P = 0.09$
$Y = 8.753 - 0.079X_1 - 0.011X_2 - 0.0197X_3$	0.410	41.0	5.4	$F_{3,10} = 2.4$	$P = 0.14$

$Y$ =aphid population /leaf,  $X_1$  = temperature ( $^{\circ}C$ ),  $X_2$  = relative humidity (%),  $X_3$  = rainfall (mm).

Table 13 showed that temperature individually exerted 30.6 % population abundance of aphid and its effect was significant. The temperature with combination of relative humidity revealed 35.6% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 5.0% abundance. The individual effect of rainfall was 5.4%. The combination effect of temperature, relative humidity and rainfall depicted 41.0% abundance and the result was statistically insignificant. Weather parameters namely maximum and minimum temperature and relative humidity showed positive correlation with aphid population (Ali, 2013).

Table 14 showed that temperature individually exerted 3.7 % population abundance of thrips and its effect was insignificant. The temperature with combination of relative humidity revealed 37.1% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 33.4% abundance. The individual effect of rainfall was 4.7%. The multiple linear regression analysis showed that the weather parameters together contributed 38.1% abundance of thrips and equations were insignificant. Temperature, relative humidity, rainfall and wind velocity

were negatively correlated and sunshine hours were positively correlated with seasonal incidence of thrips (Narayan, 2010).

**Table 14. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of rose thrips during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	% Role of individual factor	F statistic	
$Y = 1.790 - 0.041x_1$	0.037	3.7	3.7	$F_{1,12} = 0.46$	$P = 0.51$
$Y = 1.997 + 0.162 X_1 - 0.082X_2$	0.371	37.1	33.4	$F_{2,11} = 3.23$	$P = 0.08$
$Y = 2.506 + 0.167X_1 - 0.092X_2 + 0.054X_3$	0.381	38.1	4.7	$F_{3,10} = 2.1$	$P = 0.17$

$Y$ =thrips population /leaf,  $X_1$  = temperature ( $^{\circ}C$ ),  $X_2$  = relative humidity (%),  $X_3$  = rainfall (mm).

Table 15 showed that temperature individually exerted 1.4 % population abundance of mites and its effect was significant. The temperature with combination of relative humidity revealed 1.4% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 0.0% abundance. The individual effect of rainfall was 7.5%. The combination effect of temperature, relative humidity and rainfall depicted 8.9% abundance and the result was statistically insignificant. Maximum and minimum temperatures had a significant positive correlation and rainfall and relative humidity had non-significant negative correlations with mite incidence (Meena *et al.* 2013).

**Table 15. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of rose mite during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	% Role of individual factor	F statistic	
$Y = 1.214 + 0.083x_1$	0.014	1.4	1.4	$F_{1,12} = 0.17$	$P = 0.69$
$Y = 1.226 + 0.095 X_1 - 0.005X_2$	0.014	1.4	0.0	$F_{2,11} = 0.08$	$P = 0.93$
$Y = -3.331 + 0.056X_1 + 0.092X_2 - 0.483X_3$	0.089	8.9	7.5	$F_{3,10} = 0.33$	$P = 0.81$

$Y$ =mite population /leaf,  $X_1$  = temperature ( $^{\circ}C$ ),  $X_2$  = relative humidity (%),  $X_3$  = rainfall (mm).

Table 16 showed that temperature individually exerted 7.5% population abundance of rose budworm and its effect was insignificant. The temperature with combination of relative humidity revealed 7.8% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 0.3% abundance. The individual effect of rainfall was 2.5%. The combination effect of temperature, relative humidity and rainfall depicted 10.3% abundance and the result was

statistically insignificant. Parajulee *et al.* (2004) observed a significant positive relationship between moth abundance and average weekly temperatures, whereas a significant negative relationship was observed between budworm moth abundance and average weekly wind velocity.

**Table 16. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of rose budworm during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	% Role of individual factor	F statistic	P
$Y = -0.147 + 0.032x_1$	0.075	7.5	7.5	$F_{1,12} = 0.966$	$P = 0.345$
$Y = -0.177 + 0.047x_1 - 0.005x_2$	0.078	7.8	0.3	$F_{2,11} = 0.462$	$P = 0.64$
$Y = -0.625 + 0.037x_1 + 0.007x_2 - 0.057x_3$	0.103	10.3	2.5	$F_{3,10} = 0.382$	$P = 0.77$

$Y$  = budworm population /leaf,  $x_1$  = temperature ( $^{\circ}C$ ),  $x_2$  = relative humidity (%),  $x_3$  = rainfall (mm).

**Table 17. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of gladiolus thrips during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	% Role of individual factor	F statistic	P
$Y = 16.797 - 0.557x_1$	0.601	60.1	60.1	$F_{1,12} = 18.1$	$P < 0.01$
$Y = 17.267 - 0.094x_1 - 0.186x_2$	0.755	75.5	15.4	$F_{2,11} = 16.9$	$P < 0.001$
$Y = 20.042 - 0.071x_1 - 0.245x_2 + 0.294x_3$	0.782	78.2	2.7	$F_{3,10} = 11.9$	$P < 0.01$

$Y$  = thrips population /leaf,  $x_1$  = temperature ( $^{\circ}C$ ),  $x_2$  = relative humidity (%),  $x_3$  = rainfall (mm).

Table 17 showed that temperature individually exerted 60.1% population abundance of thrips and its effect was significant. The temperature with combination of relative humidity revealed 75.5% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 15.4% abundance. The combination effect of temperature, relative humidity and rainfall depicted 78.2% abundance and the result was statistically insignificant. The individual effect of rainfall was 2.7%. The multiple linear regression analysis showed that the weather parameters together contributed 78.2% abundance of thrips and equations were insignificant. Among various weather parameters, maximum temperature, minimum temperature and average temperature showed highly significant negative effect on the abundance of gladiolus thrips (Saiyad, 2015).

Table 18 showed that temperature individually exerted 6.7 % population abundance of thuja bagworm and its effect was insignificant. The temperature with combination of relative humidity revealed 6.8% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 0.1% abundance. The combination effect of temperature, relative humidity and rainfall depicted 11.2% abundance and the result was statistically insignificant. The individual

effect of rainfall was 4.4%. The multiple linear regression analysis showed that all the weather parameters together contributed 11.2% abundance of thuja bagworm and equations were insignificant.

**Table 18. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of thuja bagworm during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	%Role of individual factor	F statistic	
$Y = 0.027x_1 - 0.189$	0.067	6.7	6.7	$F_{1,12} = 0.863$	$P = 0.37$
$Y = -0.190 - 0.022 X_1 + 0.002X_2$	0.068	6.8	0.1	$F_{2,11} = 0.404$	$P = 0.68$
$Y = -0.720 + 0.017X_1 + 0.014X_2 - 0.065X_3$	0.112	11.2	4.4	$F_{3,10} = 0.422$	$P = 0.74$

$Y$ =bagworm population /leaf,  $X_1$  = temperature ( $^{\circ}C$ ),  $X_2$  = relative humidity (%),  $X_3$  = rainfall (mm).

Table 19 showed that temperature individually exerted 3.8 % population abundance of dahlia mealy bug and its effect was insignificant. The temperature with combination of relative humidity revealed 14.4% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 10.6% abundance. The combination effect of temperature, relative humidity and rainfall depicted 18.6 % abundance and the result was statistically insignificant. The individual effect of rainfall was 4.2%. The multiple linear regression analysis showed that the weather parameters together contributed 18.6% abundance of dahlia mealy bug and equations were insignificant. Griffiths and Thompson (1957) reported that the population of mealybug declined with the advent of the rainy season and warm weather.

**Table 19. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of dahlia mealybug during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	%Role of individual factor	F statistic	
$Y = 2.696 - 0.052x_1$	0.038	3.8	3.8	$F_{1,12} = 0.472$	$P = 0.51$
$Y = 2.712 + 0.077 X_1 - 0.050X_2$	0.144	14.4	10.6	$F_{2,11} = 0.925$	$P = 0.43$
$Y = 4.019 + 0.089X_1 - 0.079X_2 + 0.160X_3$	0.186	18.6	4.2	$F_{3,10} = 0.761$	$P = 0.54$

$Y$ = mealybug population /leaf,  $X_1$  = temperature ( $^{\circ}C$ ),  $X_2$  = relative humidity (%),  $X_3$  = rainfall (mm).

**Table 20. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of marigold aphid during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	% Role of individual factor	F statistic	
$Y = 5.022 - 0.154x_1$	0.602	60.2	60.2	$F_{1,12} = 18.2$	$P < 0.01$
$Y = 5.169 - 0.009 X_1 - 0.058X_2$	0.799	79.9	19.7	$F_{2,11} = 21.9$	$P < 0.001$
$Y = 4.581 - 0.014X_1 - 0.046X_2 - 0.062X_3$	0.815	81.5	1.6	$F_{3,10} = 14.7$	$P < 0.01$

$Y =$  aphid population /leaf,  $X_1 =$  temperature ( $^{\circ}C$ ),  $X_2 =$  relative humidity (%),  $X_3 =$  rainfall (mm).

Table 20 showed that temperature individually exerted 60.2 % population abundance of aphid and its effect was significant. The temperature with combination of relative humidity revealed 79.9% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 19.7% abundance. The combination effect of temperature, relative humidity and rainfall depicted 81.5% abundance and the result was statistically insignificant. The individual effect of rainfall was 1.6%. The multiple linear regression analysis showed that all the weather parameters together contributed 81.5% abundance of aphid and equations were insignificant.

**Table 21. Multiple regression models along with coefficients of determination ( $R^2$ ) regarding the impact of weather parameters on the seasonal abundance of tuberose aphid during November 2017 to March 2018**

Regression equation	$R^2$	100 $R^2$	%Role of individual factor	F statistic	
$Y = 3.234 - 0.081x_1$	0.294	29.4	29.4	$F_{1,12} = 5.00$	$P = 0.045$
$Y = 3.249 + 0.032 X_1 - 0.044X_2$	0.555	55.5	26.1	$F_{2,11} = 6.86$	$P = 0.01$
$Y = 3.604 + 0.035X_1 - 0.051X_2 + 0.044X_3$	0.565	56.5	1.0	$F_{3,10} = 4.33$	$P = 0.03$

$Y =$  aphid population /leaf,  $X_1 =$  temperature ( $^{\circ}C$ ),  $X_2 =$  relative humidity (%),  $X_3 =$  rainfall (mm).

Table 21 showed that temperature individually exerted 29.4 % population abundance of tuberose aphid and its effect was insignificant. The temperature with combination of relative humidity revealed 55.5% abundance, which was statistically insignificant. The individual effect of relative humidity demonstrated 26.1% abundance. The combination effect of temperature, relative humidity and rainfall depicted 56.5% abundance and the result was statistically insignificant. The individual effect of rainfall was 1.0%. The multiple linear regression analysis showed that all the weather parameters together contributed 56.5% abundance of tuberose aphid and equations were insignificant. Ahmad and Kumar (2018) reported that tuberose aphid population increased gradually and attained its peak level during 3rd week of December.

**Table 22. Effect of insecticide (Actara 240SC) on the abundance of rose aphid at different days after treatment**

Days after treatment	Abundance of aphid (number/shoot) at different treatment doses				
	Control	1 ml/L	1.25 ml/L (Farmers' practice)	1.5 ml/L (Recommended)	1.75 ml/L
1 day	7.1±0.4a	3.7±0.2b	2.6±0.1bc	2.1±0.3cd	1.4±0.2d
3 days	8.1±0.4a	3.3±0.2b	2.4±0.1bc	1.9±0.1cd	1.2±0.1d
7 days	8.5±0.5a	2.9±0.2b	2.0±0.1bc	1.7±0.1bc	1.0±0.1c

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by Tukey posthoc statistic.

The abundance of rose aphid at 1, 3 and 7 days after treatment with different doses of actara 240SC varied from 1.4±0.2 to 7.1±0.4, 1.2±0.1 to 8.1±0.4 and 1.0±0.1 to 8.5±0.5, respectively and all the treatments revealed significantly lower abundance compared to control (Table 22; 1day:  $F_{4,10} = 87.9$ ,  $p < 0.001$ ; 3 days:  $F_{4,10} = 143.5$ ,  $p < 0.001$ ; 7days:  $F_{4,10} = 122.1$ ,  $p < 0.001$ ). Malathion reduced the population of *Aphis durantii* on duranta hedge from 96.7 to 99.8% and reduced the population of *Aphis nerii* on oleander shrubs from 95.7 to 100% (Salem *et. al.*, 2009).

**Table 23. Effect of insecticide (Tundra 20 SP) on the abundance of rose thrips at different days after treatment**

Days after treatment	Abundance of thrips (number/shoot) at different treatment doses				
	Control	0.25g/L	0.50 g/L (Farmers' practice)	0.75 g/L (Recommended)	1.0 g/L
1 day	4.8±0.1a	3.4±0.1b	2.7±0.2b	1.8±0.2c	1.1±0.1c
3 days	4.5±0.3a	2.9±0.2b	2.3±0.1b	1.6±0.2c	0.9±0.1c
7 days	4.9±0.2a	2.6±0.1b	2.0±0.1c	1.3±0.1d	0.7±0.1e

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by Tukey's posthoc statistic.

Table 23 presented the effect of different doses of tundra 20 SP on the abundance of thrips at different days after treatment. Results showed that the treatment had significant effect on the abundance of thrips at 1, 3 and 7 days after treatment (1day:  $F_{4,10} = 67.2$ ,  $p < 0.001$ ; 3 days:  $F_{4,10} = 44.6$ ,  $p < 0.001$ ; 7days:  $F_{4,10} = 164.1$ ,  $p < 0.001$ ). The abundance of thrips at 1, 3 and 7 days after treatment varied from 1.1±0.1 to 4.8±0.1, 0.9±0.1 to 4.5±0.3 and 0.7±0.1 to 4.9±0.2, respectively. All the treatments revealed significantly lower abundance compared to control. The most efficient controlling of tobacco thrips was found with Actara 25 VG having an efficiency of 97%, followed by Fastac 10 EC having an efficiency of 86% (Zepa *et al.* 2011).

**Table 24. Effect of acaricide (Abom 1.8 EC) on the abundance of rose spider mite at different days after treatment**

Days after treatment	Abundance of spider mite (number/shoot) at different treatment doses				
	Control	1 ml/L	1.25 ml/L (Farmers' practice)	1.5 ml/L (Recommended)	1.75 ml/L
1 day	11.2±0.2a	2.6±0.1b	2.6±0.1b	2.4±0.1b	2.1±0.1b
3days	13.5±0.2a	2.1±0.1b	1.9±0.1bc	1.9±0.1bc	1.7±0.1c
7 days	18.5±0.2a	1.9±0.1b	1.7±0.1b	1.6±0.1b	1.3±0.1b

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by Tukey posthoc statistic.

The effect of different doses of Abom 1.8 EC on the abundance of rose mite at different days after treatment showed significant difference (Table 24: 1day:  $F_{4,10} = 787.9$ ,  $p < 0.001$ ; 3 days:  $F_{4,10} = 2771.0$ ,  $p < 0.001$ ; 7days:  $F_{4,10} = 3364.4$ ,  $p < 0.001$ ). The abundance of mite at 1, 3 and 7 days after treatment varied from 2.1±0.1 to 11.2±0.2, 1.7±0.1 to 13.5±0.2 and 1.3±0.1 to 18.5±0.2, respectively. All the treatments revealed significantly lower abundance compared to control. Chlorphenamide, Tetradifon, Aldicarb and Chlorphenamide plus Formetanate resulted good control of rose mite (French and Ludlam, 1972).

Table 25 presented the effect of different doses of Proclaim 5 SG on the abundance of rose budworm at different days after treatment. Results showed that the treatment had significant at 1days but had insignificant effect on the abundance of budworm at 3 and 7 days after treatment (1day:  $F_{4,10} = 9.4$ ,  $p < 0.005$ ; 3 days:  $F_{4,10} = 7.5$ ,  $p=0.05$ ; 7days:  $F_{4,10} = 7.2$ ,  $p=0.05$ ). The abundance of aphid at 1, 3 and 7 days after treatment varied from 0.2±0.1 to 1.0±0.0, 0.4±0.1 to 1.2±0.1 and 0.1±0.1 to 0.8±0.1, respectively. All the treatments revealed significantly lower abundance compared to control. Layton (2008) reported that foliar sprays of Spinosad exerted the best treatment for budworm.

**Table 25. Effect of insecticide (Proclaim 5 SG) on the abundance of rose budworm at different days after treatment**

Days after treatment	Abundance of budworm (number/shoot) at different treatment doses				
	Control	0.5 g/L	0.75g/L (Farmers' practice)	1.0 g/L(Recommended)	1.25 g/L
1 day	1.0±0.0a	0.8±0.1ab	0.4±0.1bc	0.6±0.1ac	0.2±0.1c
3days	1.2±0.1a	0.8±0.1ac	1±0.1b	0.6±0.1bc	0.4±0.1c
7 days	0.8±0.1a	0.6±0.1ab	0.4±0.1ac	0.3±0.1bc	0.1±0.1c

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by Tukey posthoc statistic.

The effect of different doses of liquor 1.8 EC on the abundance of gladiolus thrips at different days after treatment showed significant difference (Table 26: 1day:  $F_{4,10} = 74.9$ ,  $p < 0.001$ ; 3 days:  $F_{4,10} = 90.7$ ,  $p < 0.001$ ; 7days:  $F_{4,10} = 137.2$ ,  $p < 0.001$ ). The abundance of thrips at 1, 3 and 7 days after treatment varied from  $2.1 \pm 0.1$  to  $6.3 \pm 0.3$ ,  $1.9 \pm 0.3$  to  $8.3 \pm 0.5$  and  $1.6 \pm 0.2$  to  $9.4 \pm 0.5$ , respectively. All the treatments revealed significantly lower abundance compared to control. Saiyad (2015) reported that Fipronil 5 SC showed the best performance in reducing thrips followed by the Acetamiprid 20 SP.

**Table 26. Effect of insecticide (Liquor 1.8 EC) on the abundance of gladiolus thrips at different days after treatment**

Days after treatment	Abundance of thrips (number/shoot) at different treatment doses				
	Control	1.75 ml/L	2 ml/L (Farmers' practice)	2.5ml/L(Recommended)	2.75 ml/L
1 day	$6.3 \pm 0.3a$	$4.7 \pm 0.2b$	$4.1 \pm 0.2b$	$2.6 \pm 0.1c$	$2.1 \pm 0.2d$
3days	$8.3 \pm 0.5a$	$4.2 \pm 0.1b$	$3.8 \pm 0.1b$	$2.3 \pm 0.1c$	$1.9 \pm 0.2c$
7 days	$9.4 \pm 0.5a$	$3.8 \pm 0.1b$	$3.6 \pm 0.1b$	$2.1 \pm 0.1c$	$1.6 \pm 0.2c$

Data expressed as mean $\pm$ SE. Means within a row followed by same letter(s) are not significantly different by Tukey posthoc statistic.

Table 27 presented the effect of different doses of Talstar 2.5EC on the abundance of thuja bagworm at different days after treatment. Results showed that the treatment had significant effect on the abundance of bagworm at 1, 3 and 7 days after treatment (1day:  $F_{4,10} = 3.6$ ,  $p=0.05$ ; 3 days:  $F_{4,10} = 1.6$ ,  $p=0.20$ ; 7days:  $F_{4,10} = 0.4$ ,  $p=0.80$ ). The abundance of bagworm at 1, 3 and 7 days after treatment varied from  $0.3 \pm 0.2$  to  $1.2 \pm 0.1$ ,  $0.7 \pm 0.2$  to  $1.2 \pm 0.1$  and  $0.5 \pm 0.2$  to  $0.8 \pm 0.1$ , respectively. All the treatments revealed significantly lower abundance compared to control. Application of Acephate 15.6EC, Acetamiprid 30SG, Deltamethrin 4.75EC, Indoxacarb 2.4SC, and Malathion 57 EC showed good control of bagworm (Sadof, 2017).

Table 28 presented the effect of different doses of Fenitox 50EC on the abundance of mealy bug at different days after treatment. Results showed that the treatment had significant effect at 1 day but significant effect on the abundance of mealy bug at 3 and 7 days after treatment (1day:  $F_{4,10} = 5.4$ ,  $p=0.01$ ; 3 days:  $F_{4,10} = 15.8$ ,  $p < 0.001$ ; 7days:  $F_{4,10} = 49.6$ ,  $p < 0.001$ ). The abundance of mealy bug at 1, 3 and 7 days after treatment varied from  $2.2 \pm 0.1$  to  $3.2 \pm 0.3$ ,  $1.7 \pm 0.0$  to  $3.4 \pm 0.3$  and  $1.4 \pm 0.0$  to  $3.4 \pm 0.2$ , respectively. All the treatments revealed significantly lower abundance compared to control. Spraying of less hazardous insecticides, such as Acephate, 75 SP 1gm/l, Malathion 50 EC 2ml/l, Buprofezin 25 SC 1ml/l water exerted successful control of mealy bug (Ahmad, 2011).

**Table 27. Effect of insecticide (Talstar 2.5EC) on the abundance of thuja bagworm at different days after treatment**

Days after treatment	Abundance of bugworm (number/twigs) at different treatment doses				
	Control	1.25 ml/L	1.5ml/L (Farmers' practice)	2.0ml/L(Recommended)	2.5 ml/L
1 day	1.2±0.1a	0.6±0.1ab	0.9±0.2ab	0.7±0.2ab	0.3±0.2c
3days	1.2±0.1a	1.0±0.1a	0.8±0.1a	0.7±0.2a	0.7±0.2a
7 days	0.8±0.1a	0.6±0.1a	0.5±0.2a	0.6±0.3a	0.5±0.2a

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by Tukey posthoc statistic.

**Table 28. Effect of insecticide (Fenitox 50EC) on the abundance of dahlia mealybug at different days after treatment**

Days after treatment	Abundance of mealybug (number/shoot) at different treatment doses				
	Control	1.5 ml/L	1.75 ml/L (Farmers' practice)	2 ml/L(Recommended)	2.5 ml/L
1 day	3.2±0.3a	2.7±0.1ab	2.6±0.1ab	2.4±0.1b	2.2±0.1b
3days	3.4±0.3a	2.2±0.1b	1.9±0.1b	1.9±0.1b	1.7±0.0b
7 days	3.4±0.2a	1.9±0.1b	1.7±0.1b	1.6±0.1b	1.4±0.0b

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by Tukey posthoc statistic.

Table 29 presented the effect of different doses of Actara 25WG on the abundance of marigold aphid at different days after treatment. Results showed that the treatment had significant effect on the abundance of aphid at 1, 3 and 7 days after treatment (1day:  $F_{4,10} = 165.5$ ,  $p < 0.001$ ; 3 days:  $F_{4,10} = 141.8$ ,  $p < 0.001$ ; 7days:  $F_{4,10} = 522.7$ ,  $p < 0.001$ ). The abundance of aphid at 1, 3 and 7 days after treatment varied from 1.5±0.2 to 6.6±0.1, 1.2±0.1 to 7.0±0.3 and 1.0±0.1 to 7.6±0.1, respectively. All the treatments revealed significantly lower abundance compared to control. Spraying of Monocrotophos 0.05%, Phosphamidon 0.02%, or Dimethoate 0.03% at 10-15 days interval helped to check the population of aphid (Halstead, 2000).

**Table 29. Effect of insecticide (Actara 25WG) on the abundance of marigold aphid at different days after treatment**

Days after treatment	Abundance of aphids (number/shoot) at different treatment doses				
	Control	0.10 g/L	0.20 g/L (Farmers' practice)	0.25 g/L(Recommended)	.30 g/L
1 day	6.6±0.1a	3.5±0.2b	2.6±0.1c	2.1±0.2cd	1.5±0.2d
3days	7.0±0.3a	3.1±0.2b	2.4±0.1bc	2.0±0.2cd	1.2±0.1d
7 days	7.6±0.1a	2.7±0.1b	2.1±0.1c	1.7±0.1c	1.0±0.1d

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by tukey posthoc statistic.

**Table 30. Effect of insecticide (Roxin 40EC) on the abundance of tuberose aphid at different days after treatment**

Days after treatment	Abundance of aphid (number/shoot) at different treatment doses					
	Control	0.5 ml/L	0.75 ml/L (Farmers' practice)	1.0ml/L(Recommended)	1.25 ml/L	
1 day	2.1±0.2a	1.9±0.1ab	1.4±0.3ab	1.1±0.3ab		0.7±0.3c
3 days	2.1±0.3a	1.7±0.4a	1.7±0.1a	1.3±0.3a		1.2±0.4a
7 days	1.7±0.4a	0.9±0.1a	1.3±0.4a	1.7±0.4a		0.9±0.2a

Data expressed as mean±SE. Means within a row followed by same letter(s) are not significantly different by tukey's posthoc statistic.

Table 30 presented the effect of different doses of Roxin 40EC on the abundance of tuberose aphid at different days after treatment. Results showed that the treatment had significant effect on the abundance of budworm at 1, 3 and 7 days after treatment (1day:  $F_{4,10} = 5.2$ ,  $p=0.01$ ; 3 days:  $F_{4,10} = 1.5$ ,  $p=0.30$ ; 7days:  $F_{4,10} = 1.8$ ,  $p=0.20$ ). The abundance of aphid at 1, 3 and 7 days after treatment varied from  $0.7\pm0.3$  to  $2.1\pm0.2$ ,  $1.2\pm0.4$  to  $2.1\pm0.3$  and  $0.9\pm0.2$  to  $1.7\pm0.4$ , respectively. All the treatments revealed significantly lower abundance compared to control. Foliar application of phosphamidon, dimethoate, thiometon and pirimicarb are effective against the pest (Jackai and Daoust, 1986).

## 12. Research highlight/findings (Bullet point – max 10 nos.):

- In total 51 insects and 4 species of mites were identified as the pests of the studied ornamental plants namely rose, dahlia, marigold, gladiolus, tuberose, chrysanthemum, thuja, cosmos, china rose, ixora.
- The study revealed that thrips, aphid, mite and budworm were found as major pests of rose and they exerted highest abundance in the month of February, December, March and January, respectively.
- The major pests of marigold and gladiolus were aphid and thrips, respectively and they showed the peak abundance in the month of January.
- The major pests of dahlia, tuberose and thuja were mealy bug, aphid and bagworm, respectively and they showed the peak abundance in the month of February.
- The weather parameters together contributed 41.0, 38.1, 8.9 and 48.9% on the abundance of rose aphid, thrips, mite and budworm, respectively.
- Abundance of gladiolus thrips, thuja bagworm, dahlia mealy bug, marigold aphid and tuberose aphid was affected by the weather parameters by 78.2, 11.2, 18.6, 81.5 and 56.5%, respectively.
- Tundra 20 SP, Actara 240SC, Abom 1.8 EC, Proclaim 5 SG significantly reduced the population of rose thrips, aphid, mite and budworm, respectively.

- The abundance of marigold aphid, thuja bagworm, dahlia mealy bug, gladiolus thrips and tuberose aphid was significantly reduced by Actara 25WG, Talstar 2.5EC, Liquor 1.8 EC, Fenitox 50EC and Roxin 40EC, respectively.

## B. Implementation Position

### 1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Visitor Chair (10)	40000/=	100%	100%	
	Laboratory Shelf (01)	15000/=	100%	100%	
(b) Lab & field equipment	Laptop (01)	60000/=	100%	100%	
	Laser printer (01)	20000/=	100%	100%	
	Scanner (01)	10000/=	100%	100%	
	Digital Camera (01)	25000/=	100%	100%	
	Aerial net (10)	4000/=	100%	100%	
	Insect preservation box (10)	75000/=	100%	100%	
	Air Cooler (1)	30000/=	100%	100%	
	Refrigerator (1)				
(c) Other capital items					

### 2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Repair, renovation and maintenance of laboratory desk and equipments.	20000/=	100%	-	-	

### 3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	34	01	35	1day	
(b) Workshop	-	-	-	-	-

### C. Financial and physical progress

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Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/unspent	Physical progresses (%)	Reasons for deviation
A. Contractual staff salary	396950.0	388500.2	391013.0	-2512.84	100%	GoB fund not provided fully
B. Field research/lab expenses and supplies	505050.0	585449.8	516263.0	69186.76	100%	GoB fund not provided fully
C. Operating expenses	133000.0	109570.8	110321.0	-750.24	100%	GoB fund not provided fully
D. Vehicle hire and fuel, oil & maintenance	18000.0	9162.28	7269.0	1893.278	100%	
E. Training/workshop/seminar etc.	50000.0	25500.32	24800.0	700.32	100%	
F. Publications and printing	75000.0	28000.0	23800.0	4200.0	100%	
G. Miscellaneous	18000.0	13700.28	13214.0	4200.0	100%	
H. Capital expenses	304000.0	258401.3	291133.0	-32731.7	100%	
Total	150000.0	1418285.0	1377813.0	40442.0	100%	

### D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
Survey and identification of insect and mite species cause damage to ornamental plants in Bangladesh	Survey was conducted at five locations namely Gazipur, Narsingdi, Jessore, Cox's Bazar and Satkhira in Bangladesh	Fifty five arthropod species were identified as the pests of ornamental plants. Among them 51 species were insect and 4 species were mite. Of the arthropods 8 insect species and one mite species were found as major pests.	Management practices are recommended against the major pest species.
Establishment of relationship between weather factors and pest population dynamics	Weather data regarding temperature, relative humidity and rainfall were collected from the weather station of BSMRAU and data on the abundance of arthropod species were collected from the experimental field of BSMRAU.	Seasonal peak abundances of the major pests as well as the individual and combined effect of different weather parameters were found out.	Management practices are recommended on the basis of the trend of abundance of the major pests and weather factors.
Development of management tactics	Pesticides were applied at different doses against the major pest species.	Applied pesticides significantly reduced the population of major	Management practices are recommended

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
		pest species.	with those pesticides against the major pest species.
Training for commercial flower growers.	Training programs were conducted at Narsingdi, Jessore, Cox's Bazar and Satkhira in Bangladesh.	Farmers acquired knowledge on the cultivation and pest management strategies of the ornamental plants.	Farmers can cultivate the ornamental plants and manage the pest species efficiently and effectively.

**E. Materials Development/Publication made under the Sub-project:**

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Booklet	-----	01	evsjv†`‡ki †kvfvea©K Dw™ç‡`i mÜxc`x Avc` I Zv‡`i e`e`vcbv
Journal publication	04	----	-----
Information development	----	-----	-----
Other publications, if any	-----	04	1. Incidence of the major insect pests of rose and their insecticidal management 2. Population dynamics and insecticidal management of marigold aphid 3. Seasonal abundance and insecticidal management of gladiolus thrips 4. Seasonal incidence and management of rose mite 21 <sup>st</sup> National Conference & AGM 2018 Zoological Society of Bangladesh

**F. Technology/Knowledge generation/Policy Support (as applied):**

- i. Generation of technology (Commodity & Non-commodity)  
Not applicable
- ii. Generation of new knowledge that help in developing more technology in future  
Generation of an MS thesis entitled 'Arthropod pests infesting ornamental plants in Bangladesh: Strategies for management'.
- iii. Technology transferred that help increased agricultural productivity and farmers' income

Not applicable

iv. Policy Support

Not applicable

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

Not applicable

ii) Field Monitoring (time& No. of visit, Team visit and output):

Not applicable

H. Lesson Learned/Challenges (if any)

i) Thirty five farmers got lesson on pest management practices of ornamental plants.

ii) One student is going to be awarded M S degree.

iii) Strengthen teaching and research knowledge through exercises on survey and identification of arthropods.

I. Challenges (if any)

Motivation of farmers in training program and encouraging them to IPM practices.

Signature of the Principal Investigator

Date .....

Seal

Counter signature of the Head of the organization/authorized representative

Date .....

Seal