INSECT PEST RISK ANALYSIS OF CUCURBITS IN BANGLADESH

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CERTIFICATE

*This is to certify that thesis entitled **"INSECT PEST RISK ANALYSIS OF CUCURBITS IN BANGLADESH"** submitted to the **Faculty of Agriculture,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY,** embodies the result of a piece of bona fide research work carried out by **MD. TOUHEDUL ISLAM, Registration no. 12-04899** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2020
Place: Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED

PARENTS

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ABSTRACT

The study was conducted in the 6 upazila of 3 selected cucurbit vegetable growing districts of Bangladesh during the period from January, 2018 to May, 2018 to find out the current status and damage intensity of insect pests of cucurbit and their management options. The data were collected through interview of 300 farmers using a predesigned questionnaire considering 50 farmers from each upazila and 18 field level officers of DAE considering one UAO, one AEO and one SAAO of DAE. The field study that was conducted among 300 farmers. Maximum land of cucurbit cultivable land was used for bitter gourd cultivation by the farmers, followed by snake gourd, water melon, bottle gourd, pointed gourd, cucumber, sweet gourd, wax gourd, sponge gourd, ridge gourd, squash and melon. Maximum farmers' collected their cucurbit seed/seedlings from seed businessman and maximum farmers reported that bitter gourd was more susceptible than other cucurbit vegetables. Maximum farmer reported that fruit fly was the major insect for bitter gourd, snake gourd, sponge gourd, cucumber and bottle gourd. Farmers also reported that thrips was also the major insect for wax gourd, sweet gourd, ridge gourd, water melon, squash and pointed gourd. Farmer reported that mealy bug was the major insect for sponge gourd. Maximum farmers' opined that fruit fly was the major insect pest for cucurbit vegetables, and other major insect pests were Whitefly, red mite, jassid, epilachna beetle, thrips and red pumpkin beetle. Insect pests attack leaf, stem, flower, root and fruit of cucurbit crops. Maximum farmers opined that they used pheromone trap against insect pests of cucurbit, followed by used food bait, spraying insecticides, application insecticide along with irrigation and application insecticide before irrigation.

ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BMD	Bangladesh Meteorological Department
CV	Coefficient of variation
^{o}C	Degree Celsius
d.f.	Degrees of freedom
DAS	Days after sowing
et al.	And others
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
G	Gram
Ha	Hectare
IPM	Integrated Pest Management
J.	Journal
Kg	Kilogram
LSD	Least Significant Difference
Mg	Milligram
MP	Muriate of Potash
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources Development Institute
TSP	Triple Super Phosphate

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CHAPTER I

INTRODUCTION

Bangladesh has a long history of growing some cucurbits which include water melon, muskmelon as dessert crops, cucumber as salad and bitter gourd, snake gourd, bottle gourd, ash gourd, sponge gourd, ribbed gourd as vegetables. Bottle gourd is primarily a winter vegetable but now days it is available also in summer. Pumpkins are grown round the year. They are grown in homestead for family consumption as well as in larger plots for commercial purpose. The total area of cucurbit crops in 2017-18 was around 77,608 hectares and the total production was about 5,31,076 metric tons (BBS 2019). Cucurbits occupy 66 percent of the land under vegetable production in Bangladesh and contribute 11 percent of total vegetable production in the country (IPM CRSP 2004). Area covered by bitter gourd was 10720 hectare with a total production of 57908 tons (BBS 2019). In Bangladesh, the production of snake gourd is 37342 tons over 7493 ha (BBS 2019). The major vegetables grown in the summer are cucurbits and they play a prime role to the supplement this shortage during the lag period (Rashid 1993). Some of them can be grown throughout the year because of their photo insensitiveness. The climate of Bangladesh is favorable for growing most of the vegetable crops specially cucurbits.

Cucurbit production is severely affected by a number of insect pests such as red pumpkin beetle, cucurbit fruit fly, epilachna beetle etc (Kamal *et al.* 2013). Among them, cucurbits fruit fly, *Bactrocera cucurbitae* is the major pest responsible for considerable damage of cucurbits (Alam 1969). The genus *Bactrocera* is considered a serious threat of horticultural crops because of the wide host range of its species and the invasive power of some species within the genus (Clarke *et al.* 2005). It is important to prevent or minimize pest problems before serious outbreaks occur, to detect pest problems early, and to select appropriate controls. Traditionally farmers combat this noxious pest using chemical insecticides. But most of the cases, it is not possible to control it due to the larvae live in the internal portion of fruits. Even though, farmers use toxic chemicals without considering economic injury level (EIL) of the pest. Thus, toxic chemicals kill natural enemies, regular occurrence of upset and resurgence, residues of pesticides on edible fruits of cucurbits. But the bio-pesticides are completely safe for environment, health and nature. The studies on resistant and or tolerant varieties as well as resistant/tolerant cucurbitaceous vegetables against cucurbit fruit fly are also less. Host- performance in herbivorous insects has been demonstrated in numerous studies, however host preference may vary and change in it might have been the critical requirement to initiate the host shifting. Host-specific insects are estimated to represent 25-40% of all species (Bush and Butlin 2004). Integrated Pest Management (IPM) is one method to achieve sustainable agricultural production with less damage to the environment (Kogan and Bajwa 1999). While IPM has many definitions, it often includes a diverse mix of approaches to manage pests and keep them below economically damaging levels, using control options that range from cultural to chemical components. In practice, IPM ranges from chemically-based systems that involve the targeted and judicious use of synthetic pesticides, to biologically-intensive approaches that manage pests primarily or fully through nonchemical means (Pedigo and Rice 2008). In recent years, IPM has been seen as an effective method for managing pestiferous fruit flies in an attempt to make fruit production more sustainable (Vargas *et al.* 2008).

Pest management in tropical and sub-tropical cucurbit vegetable crops has been particularly problematical for many years. The complex of insect pests, the quality issues regarding the level of control required problems with insecticide resistance and the health risks to operators and consumers associated with excessive insecticide use all contribute to the intractability of the problem. Implementation of Integrated Pest Management (IPM) systems in vegetable crops is also difficult as it usually involves more complex decision-making processes when compared with calendar treatment with insecticides. Considering this present condition, this study has been taken to know about the farmers' opinion about the cucurbit insect pests in their field and their management practices.

Overall objectives of the research

1. To evaluate the host preference of cucurbitaceous vegetables against different insect pests of cucurbit;
2. To evaluate the major insect pest(s) of cucurbit vegetables;
3. To find out the level of insect pests infestation on cucurbitaceous vegetables;
4. To evaluate the efficacy of management practices practiced by the farmers' against cucurbit vegetable insect pests.

CHAPTER II

REVIEW OF LITERATURE

Cucurbit vegetables are well spread in Bangladesh and cultivated widely. So, this review is cited for the insect pest of cucurbit vegetables along with the nature of damage and management practices for them. Details are given bellow under the following sub-headings:

2.1. List of insect pest of cucurbit vegetables in Bangladesh

A total number of 21 arthropod pests of cucurbits of which 20 insect pests and 1 mite pest were reported in Bangladesh. The incidences of insect pests of cucurbits recorded in Bangladesh were cucurbit fruit fly (*Bactrocera cucurbitae*), oriental fruit fly (*Bactrocera dorsalis*), guava fruit fly (*Bactrocera zonata*), mango fruit fly (*Bactrocera tau*), lesser fruit fly (*Dacus ciliates*), vegetable leaf miner (*Liriomyza sativae*), black cutworm (*Agrotis ipsilon*), cucumber moth (*Diaphania indica*), epilachna beetle (*Epilachna vigintioctopunctata*), epilachna beetle (*E. dodecastigma*), red pumpkin beetle (*Raphidopalpa foveicollis*), cucumber beetle (*Aulacophora indica*), green stink bug (*Nezara viridula*), melon thrips (*Thrips palmi*), cucurbit aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci* Genn.), cotton jassid (*Amrasca bigutula bigutula*), pink mealybug (*Maconellicoccus hirsutus*) and mole cricket (*Gryllotalpa brachyptera*), whereas one mite pest of cucurbit was recorded in Bangladesh named two-spotted spider mite (*Tetranychus urticae*) (Table 1) (PRA 2016).

Among these insect and mite pests of cucurbits, cucurbit fruit fly was more damaging than other arthropod pests. The cucurbit fruit fly was designated as major pest of all cucurbits and caused damage with high infestation intensity. The pest status of all other insect and mite pests was minor significance and caused low level of infestation. Usually Bangladesh's farmers always used chemical insecticides and acaricides through which these pests were suppressed in every season (PRA 2016).

Table 1. Insect and mite pests of cucurbits in Bangladesh, their status (PRA 2016)

Common name	**Scientific name**	**Family**	**Order**	**Pest status**
Cucurbit fruit fly	*Bectocera cucurbitae*	Tephritidae	Diptera	Major
Oriental fruit fly	*Bectocera dorsalis*	Tephritidae	Diptera	Minor
Guava fruit fly	*Bectocera zonata*	Tephritidae	Diptera	Minor
Mango fruit fly	*Bectocera tau*	Tephritidae	Diptera	Minor
Lesser fruit fly	*Dacus ciliates*	Tephritidae	Diptera	Minor
Vegetable leaf miner	*Liriomyza sativae*	Agromyzidae	Diptera	Minor
Black cutworm	*Agrotis ipsilon*	Noctuidae	Lepidoptera	Minor
Cucumber moth	*Diaphania indica*	Crambidae	Lepidoptera	Minor
Epilachna beetle	*Epilachna vigintioctopunctata*	Coccinellidae	Coleoptera	Minor
Epilachna beetle	*Epilachna dodecastigma*	Coccinellidae	Coleoptera	Minor
Red pumpkin beetle	*Raphidopalpa foveicollis*	Chrysomelidae	Coleoptera	Minor
Cucumber beetle	*Aulacophora indica*	Chrysomelidae	Coleoptera	Minor
Green stink bug	*Nezara viridula*	Pentatomidae	Hemiptera	Minor
Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Minor
Cucurbit aphid	*Aphis gossypii*	Aphididae	Homoptera	Minor
Whitefly	*Bemisia tabaci*	Aleurodidae	Homoptera	Minor
Cotton jassid	*Amrasca bigutula bigutula*	Cicadellidae	Hemiptera	Minor
Pink mealybug	*Maconellicoccus hirsutus*	Pseudococcidae	Homoptera	Minor
Mole cricket	*Gryllotalpa brachyptera*	Gryllotalpidae	Orthoptera	Minor
Two-spotted spider mite	*Tetranychus urticae*	Tetranichidae	Acarina	Minor

2.2. Insect pests of cucurbit vegetable

2.2.1. Cucurbit fruit fly

a. Taxonomic position

Cucurbit fruit fly also known as melon fly. The taxonomic position of cucurbit fruit fly is given bellow:

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Diptera
Section: Schizophora
Family: Tephritidae
Genus: *Bactrocera*
Species: *B. cucurbitae* (Coquillett)

Common names

English: Melon fly, Melon fruit fly
Spanish: Moscadel melon
French: Mouche de melon, Mouche du concombre, Mouche des curcurbitacees
Germany: TropischeMelonenfliege
Italy: Moscadelmelone
Japan: Uri-mibae

Synonyms of *Bactrocera cucurbitae*

Chaetodacus cucurbitae
Dacus cucurbitae
Strumeta cucurbitae
Zeugodacus cucurbitae

b. Geographical Distribution

The Asian parts of the range of this species represent its natural (native) range. In Hawaii it is known to be an introduction, having arrived there late in the 19th century (Clausen 1978). Old records for Australia derive from an eradicated outbreak in Darwin, but as no specimens could be traced this may have been based on a misidentification of *Bactrocera chorista* (White 1999).

In Africa, *B. cucurbitae* is found in several countries in East and West Africa, including Benin, Burkina Faso, Cameroon, Gambia, Guinea, Ivory Coast, Mali, Niger, Nigeria, Senegal and Togo in West Africa, and Kenya, Sudan, Tanzania and Uganda in East Africa (Meyer *et al.* 2007).

c. Morphology

Egg: The eggs of *Bactrocer aolae* were described in detail by Margaritis (1985) and those of other species are probably very similar with the micropyle protruding slightly at the anterior end. The chorion is reticulate. White to yellow-white in colour (CABI 2020, White and Elson-Harris 1997).

Larva: Head: Stomal sensory organ small, completely surrounded by 6-7 large preoral lobes, some bearing serrated edges similar to oral ridges; oral ridges with 17-23 rows of moderately long, uniform, bluntly rounded teeth; accessory plates numerous, with serrated edges and interlocking with oral ridges; mouthhooks large, heavily sclerotized, each with a small, but well-defined preapical tooth.

Thoracic and abdominal segments: anterior portion of T1 with an encircling, broad band of spinules which dorsally and laterally form small plates 7-10 rows deep, becoming discontinuous rows ventrally; T2 with smaller, stouter spinules, forming 5-7 discontinuous rows around anterior portion of segment; T3 similar to T2, but reduced to 4-6 rows. Creeping welts obvious, with 9-13 rows of small spinules. A8 with large well rounded intermediate areas, almost linked by a large, slightly curved, pigmented transverse line (mature larvae only). Tubercles and sensilla well defined.

Anterior spiracles: 16-20 tubules.

Posterior spiracles: spiracular slits large, with heavily sclerotized rimae; about 3 times as long as broad. Spiracular hairs long, fine and often branched in apical half; dorsal and ventral bundles of 6-12 spiracular hairs; lateral bundles of 4-6 hairs.

Anal area: lobes large with a lightly sculptured surface, surrounded by 3-7 rows of spinules. Around outer edges spinules small, in discontinuous rows; closer to anal lobes, spinules becoming stouter, and forming small groups below anal opening (CABI 2020, White and Elson-Harris 1994).

Pupa: Barrel-shaped with most larval features unrecognisable, the exception being the anterior and posterior spiracles which are little changed by pupariation. White to yellow-brown in colour. Usually about 60-80% length of larva (CABI 2020, White and Elson-Harris 1994).

Adult: Head: Pedicel+1st flagellomere no longer than ptilinal suture. Face with a dark spot in each antennal furrow; facial spot round to elongate. Frons 2-3 pair frontal setae; 1 pair orbital setae.

Thorax: Predominant colour of scutum red-brown. Postpronotal (humeral) lobe entirely pale (yellow or orange). Notopleuron yellow. Scutum with parallel sided lateral post suturalvittae (yellow/orange stripes) which extend anterior to suture and posteriorly to level of the intra-alar setae. Medial vitta present; not extended anterior to suture. Scutellum yellow, except for narrow basal band. Anepisternal stripe not reaching anterior notopleural seta. Yellow marking on both anatergite and katatergite. Postpronotal lobe (humerus) without a seta. Notopleuron with anterior seta. Scutum with or without anterior supra-alar setae; with prescutellara crostichal setae. Scutellum rarely (5%) with basal as well as apical pair of setae.

Wing: Length 4.2-7.1 mm. With a complete costal band; depth to below R2+3, sometimes reaching R4+5. Costal band expanded into a spot at apex, which extends about half way to M. With an anal streak. Cells bc and c colourless. May have a transverse mark over crossvein r-m. Always with transverse mark over crossveindm-cu. Cells bc and c without extensive covering of microtrichia. Cell br (narrowed part) with extensive covering of microtrichia.

Legs: All femora pale basally, red-brown apically.

Abdomen: Predominant colour orange-brown. Tergites not fused. Abdomen not wasp waisted. Pattern distinct; transverse band across tergite 3; tergite 4 dark laterally; medial longitudinal stripe on T3-5.

Terminalia and secondary sexual characters: male wing without a bulla. Male tergite 3 with a pecten (setal comb) on each side. Male sternite 5 not V-shaped. Surstylus (male) with a long posterior lobe. Wing (male) with a deep indent in posterior margin. Hind tibia (male) with a preapical pad. Aculeus apex pointed (CABI 2020, White and Elson-Harris 1997).

d. Life cycle

The melon fruit fly remains active throughout the year on one or the other host. During the severe winter months, they hide and huddle together under dried leaves of bushes and trees. During the hot and dry season, the flies take shelter under humid and shady places and feed on honeydew of aphids infesting the fruit trees. The lower developmental threshold for melon fruit fly was recorded as 8.1°C (Keck 1951). The lower and upper developmental thresholds for eggs were 11.4 and 36.4°C (Messenger and Flitters 1958). The accumulative day degrees required for egg, larvae, and pre-egg laying adults were recorded as 21.2, 101.7, and 274.9 day degrees, respectively (Keck 1951). This species actively breeds when the temperature falls below 32.2°C and the relative humidity ranges between 60 to 70%. Fukai (1938) reported the survival of adults for a year at room temperature if fed on fruit juices. In general, its life cycle lasts from 21 to 179 days (Narayanan and Batra 1960; Fukai 1938). Development from egg to adult stage takes 13 days at 29°C in Solomon Islands (Hollingsworth *et al.* 1997). High temperature, long period of sunshine and plantation activity influences the *B. cucurbitae* abundance in the North-Eastern Taiwan (Lee *et al.* 1992). Bhatia and Mahto (1969) reported that the life cycle is completed in 36.3, 23.6, 11.2, and 12.5 days at 15, 20, 27.5 and 30°C, respectively. There are 8 to 10 generations in a year (Weems and Heppner 2001, White and Elson-Harris 1994).

Incubation period

Narayanan and Batra (1960) *B. cucurbitae* eggs laid creamy white, oblong, bananas shaped and are about 1.3 mm in length. The posterior extremity was broadly rounded while the anterior end was appeared more pointed. The eggs were fixed vertically or slightly at an angle and touching each other. The eggs are laid singly or in clusters of into flowers or tender fruits.

The eggs hatch within 18 hours in summer and 3–4 days in winter. The egg incubation period on pumpkin, bitter gourd, and squash gourd has been reported to be 4.0 to 4.2 days at 27 ± 1°C (Doharey 1983), 1.1 to 1.8 days on bitter gourd, cucumber and sponge gourd (Gupta and Verma 1995), and 1.0 to 5.1 days on bitter gourd (Hollingsworth *et al.* 1997, Koul and Bhagat 1994).

Hatching percent eggs of fruit fly 87.5 ± 2.5 was observed in 2015 at average maximum and minimum temperature 34.36–25.46°C and average relative humidity 87.5% respectively during experiment in the month of June and July (Sohrab *et al.* 2018).

Lanjar *et al.* (2013) and Manzar and Srivastava (2007) were fairly close this experiment and who reported the respective range of incubation period of eggs of fruit fly were 1.4 ± 0.16 and 2.29 ± 0.18 days respectively.

The eggs were hatch out from eggs in 1-1.5 days feed on the pulp and seeds of fruit, drop to the ground (Sohrab *et al.* 2018).

Larval period

Soon after hatching the young larvae (maggots) bore into the flower buds or into the fruits and start feeding. The full-grown maggots measure 9–10 mm long and 2 mm broad across the thorax and are cream or pale white in colour. The full-grown larvae develop into barrel shaped, light brown or pale colour pupae in 0.5 to 3 inches deep in soil within 7–14 days. The pupae emerge into adults within 5- 8 days in summer and within about 3 weeks in winter.

The larval period lasts for 3 to 21 days (Hollingsworth *et al.* 1997, Narayanan and Batra 1960, Renjhan 1949), depending on temperature and the host. On different cucurbit species, the larval period varies from 3 to 6 days (Gupta and Verma 1995, Koul and Bhagat 1994, Doharey 1983, Chelliah 1970, Chawla 1966).

Fully developed maggot of fruit fly was white in color white grey color patches on body. The apodous maggot was passed through 3 instars. Mean of total maggot period was with a mean

5.18 ± 1.16 days (Sohrab *et al.* 2018).

Mir *et al.* (2014), Lanjar *et al.* (2013), Ullah *et al.* (2008), Manzar and Srivastava (2007) and Shivay *et al.* (2007) were fairly close this experiment and who reported the respective range of Maggots (larvae) period of cucurbit fruit fly were 5.9 ± 0.9, 12.25, 4.5-7.5, 7.00, 4-7, 8.94 ± 0.6, 4.5 ± 1.13 days respectively.

The eggs were hatch out from eggs in 1-1.5 days feed on the pulp and seeds of fruit, drop to the ground. Fully developed maggot of fruit fly was white in color white grey color patches on body. The apodous maggot was passed through 3 instars. Mean of total maggot period was with a mean 5.18 ± 1.16 days.

The creamy white maggot gradually becomes darker as it matures. The length of mature larvae is about 12 mm. The full grown larvae come out of the bores and make a loop holding the last abdominal segment by mouth hook and drop forcedly on the soil by releasing their mouth hook for pupation. This phenomenon takes place usually in the early morning between 6:00 am to 9:00 am. The most of the full grown larvae penetrate the soil rapidly and pupate under the soil surface. The larval period is 4-7 days, varying with temperature, nutritional condition, larval rearing density etc. (Anon. 1987).

The description of different stages of maggots is as follow:

First instar maggot: Freshly emerged first instars maggot was translucent and white in color. First instar maggots were taken the range of time 15-24 hrs and with a mean (0.81 ± 0.19) days for go to second instar maggot (Sohrab *et al.* 2018).

Second instar maggot: The second instar maggots were slightly different from the first instar maggots of fruit flies. There were larger sizes from the first instar maggots of fruit flies. The second instar maggots were translucent, elongate and ellipsoidal in shape and creamy white in color. The second instar maggots were taken average time of 1.5 ± 0.5 days to complete this stage and go to next instar maggot of fruit fly (Sohrab *et al.* 2018).

Third instar maggot: The fully grown third instars were a pointed head with well-developed mandibular hooks and anterior and posterior spiracles. The 3rd instar was a conspicuous dark transverse line extending between intermediate areas of the caudal segment and exhibited a peculiar habit of curving itself and springing into the air to a lateral distance of 15-20 cm by the sudden relaxation of certain muscles. In this way, the 3rd instar was displaced itself 6 to 8 inches (15-20 cm) from the fruit to the site of pupation. The second 3rd instars maggot were taken average time of 3.0 ± 0.5 days to complete this stage (Sohrab *et al.* 2018).

Pupal period

Pre-pupal period and pupal period was 0.75 ± 0.25 and 9.5 ± 0.5 days respectively during experiment in the month of June and July (Sohrab *et al.* 2018).

The full-grown larvae come out of the fruit by making one or two exit holes for pupation in the soil. The larvae pupate in the soil at a depth of 0.5 to 15 cm. The depth up to which the larvae move in the soil for pupation, and survival depend on soil texture and moisture (Pandey and Misra 1999, Jackson *et al.* 1998).

Doharey (1983) observed that the pupal period lasts for 7 days on bitter gourd and 7.2 days on pumpkin and squash gourd at 27 ± 1°C. In general, the pupal period lasts for 6 to 9 days during the rainy season, and 15 days during the winter (Narayanan and Batra 1960). Depending on temperature and the host, the pupal period may vary from 7 to 13 days (Hollingsworth *et al.* 1997). On different hosts, the pupal period varies from 7.7 to 9.4 days on bitter gourd, cucumber, and sponge gourd (Gupta and Verma 1995), and 6.5 to 21.8 days on bottle gourd (Koul and Bhagat 1994).

The duration of pupal stage varied 9 to 10 days with a mean of 9.5 ± 0.5 days, respectively. Mir *et al.* (2014), Lanjar *et al.* (2013), Ullah *et al.* (2008), Manzar and Srivastava (2007) and Shivay *et al.* (2007) were fairly close and differ this experiment result and who reported the respective range of pupal period of cucurbit fruit fly were 7.3 ± 0.23, 7.75, 7.00-711.50, 8.33, 9, 9.94 ± 1.03 and 8.4 ± 0.51 days respectively at different hosts, time, weather conditions and etc.

The pupal stage lasts for 8-12 days at 23-25°C and 9 days at 27°C (Rituraj 2011). At the 23-25oC, the pupal stage lasts for 8-12 days. At 27°C, the mean pupal period for *B. dorsalis* and *Ceratitis capitata* (Wiedcmann) is 10 days and that for *B. cucurbitae* is 9 days (Mitchell *et al.* 1965).

Pupation formation may require as little as one hour and complete within the puparium by less than 48 hours (Christenson and Foote 1960). The larvae spend 4th instar in the puparium formed by the exuviae of the 3rd instar and subsequently become pupae (Mitchell *et al.* 1965).

Adult longevity

The fruit fly adults are free living, reddish brown with lemon yellow in colour, having curved vertical markings and fuscous shading on the outer margin of the wings.

The average longevity of adult fruit flies were neither food nor water immediately, die after range of 1.5 ± 0.5 days after emergence from pupa. When was provided with cucurbit vegetables materials to fruit flies then fruit flies were lived 13.5 ± 1.5 days. The duration of total life cycle was 16.81 ± 2.18 days during 2015 in June and July under room temperature in meerut condition (Sohrab *et al.* 2018).

The adults survive for 27.5, 30.71 and 30.66 days at 27 ± 1°C on pumpkin, squash gourd and bitter gourd, respectively (Doharey 1983). Khan *et al.* (1993) reported that the males and females survived for 65 to 249 days and 27.5 to 133.5 days respectively.

The females survived for 123 days on papaya in the laboratory (24°C, 50% RH and LD 12: 12) (Vargas *et al.* 1992), while at 29°C they survived for 23.1 to 116.8 days (Vargas *et al.* 1997).

The longevity of adults was extended up to 2-3 and 3-4 days by access to water only. When was provided with cucurbit vegetables materials then fruit flies were lived 12-15 days. Mir *et al.* (2014), Lanjar *et al.* (2013), Ullah *et al.* (2008), Manzar and Srivastava (2007) and Shivay *et al.* (2007) were fairly closed and differed this experiment and who reported the respective range of adult longevity of cucurbit fruit fly were 13.09 ± 2.7, 18.4 ± 0.64, 26.00, 37.86 ± 1.40 and 30-52 days respectively at different hosts, time, temperature and weather conditions.

e. Host preference

B. cucurbitae is a very serious pest of cucurbit crops. According to Weems (1964), it has been recorded from over 125 plants, including members of families other than Cucurbitaceae; however, many of those records were based on casual observation of adults resting on plants or caught in traps set in non-host trees. In common with some other species of subgenus Bactrocera (Zeugodacus) it can attack flowers as well as fruit, and additionally, will sometimes attack stem and root tissue. In Hawaii, pumpkin and squash fields have been known to be heavily attacked before fruit had even set, with eggs being laid into unopened male and female flowers, and larvae even developing successfully in the taproots, stems and leaf stalks (Back and Pemberton 1914).

f. Disparsal of fruit fly

The first *B. cucurbitae* specimens from Africa are from the early 1930s, but it is possible that the fly has been established on the continent for much longer. It was restricted to eastern Africa for several decades, but has recently been reported from western Africa and the Seychelles (Meyer *et al.* 2007).

B. cucurbitae was first found in Hawaii in the 1890s (Meyer *et al.* 2007).

In November 1999, *B. cucurbitae* was detected for the first time in the Seychelles. It is believed that the flies came from infested fruits and vegetables from a meal served on a plane, and the waste was not correctly treated at the airport. *B. cucurbitae* established quickly on Mahe Island and then invaded the other islands of the archipelago. An eradication programme was planned for 2004 after delimitation of the infestation (Knight 2003).

g. Damage Assessment

Damage symptoms

Eggs are normally inserted under the skin of the fruits, vegetables, nuts or fleshy parts of plants, stems or flowers where they are protected from sun. The maggots feed inside just after hatching from the eggs (Feron *et al.* 1958).

Females lay their eggs mostly on soft fruit tissue (fruit in formation) and produce necrotic areas (brown dots) over the surface of the fruit and as a result the marketability of the product is reduced. Immature feed inside the fruits (although sometimes they can move to feed in other plant structures such as flowers or the stems), bore into the pulp tissue and make their feeding galleries, as a result fruits rot or becomes distorted. Normally, early instar larvae leave the necrotic areas of the fruit and move to healthy tissue expanding the damage and at the same time introducing various pathogens and hastening fruit decomposition (Dhillon *et al.* 2005a).

Economic loss

Fruit flies can cause 30-100% economic losses annually in various crops such as gourds, melons and summer guavas (DFID 2005).

The majority of these fruit fly species pose a serious economic threat to agriculture due to the direct damage done to commercial horticulture (Yong *et al.* 2010). These losses can approach 100% in cucurbit species due to the melon fly, *B. cucurbitae* (Dhillon *et al.* 2005), on mango (12-60%), papaya (12-60%) and guava (40-90%) (Allwood *et al.* 1999).

Depending on the environmental conditions and susceptibility of the crop species, the extent of losses varies between 30 to 100% (Gupta and Verma 1992; Dhillon *et al.* 2005a, b, c; Shooker *et al.* 2006). The field experiments on assessment of losses caused by cucurbit fruit fly in different cucurbits been reported 28.7-59.2, 24.7-40.0, 27.3-49.3, 19.4-22.1 and 0-26.2% yield losses in pumpkin, bitter gourd, bottle gourd, cucumber, and sponge gourd, respectively, in Nepal (Pradhan 1976). Considering previous facts and reports, it is apparent that >50% of the cucurbits are either partially or totally damaged by fruit flies and are unsuitable for human consumption (Sapkota *et al.* 2010).

Maggots feed inside the fruits, but at times, also feed on flowers, and stems. Generally, the females prefer to lay the eggs in soft tender fruit tissues by piercing them with the ovipositor. A watery fluid oozes from the puncture, which becomes slightly concave with seepage of fluid, and transforms into a brown resinous deposit. Sometimes pseudo-punctures (punctures without eggs) have also been observed on the fruit skin. This reduces the market value of the produce. In Hawaii, pumpkin and squash are heavily damaged even before fruit set. The eggs are laid into unopened flowers, and the larvae successfully develop in the taproots, stems, and leaf stalks (Weems and Heppner 2001). Miyatake (1996) reported <1% damage by pseudo-punctures by the sterile females in cucumber, sponge gourd and bitter gourd. After egg hatching, the maggots bore into the pulp tissue and make the feeding galleries. The fruit subsequently rots or becomes distorted. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition. The vinegar fly, *Drosophilla melanogaster* has also been observed to lay eggs on the fruits infested by melon fly, and acts as a scavenger (Dhillon *et al.* 2005b). The extent of losses vary between 30 to 100%, depending on the cucurbit species and the season. Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89% (Lall and Sinha 1959; Narayanan and Batra 1960; Kushwaha *et al.* 1973; Gupta and Verma 1978; Rabindranath and Pillai (1986). The melon fruit fly has been reported to infest 95% of bitter gourd fruits in Papua (New Guinea), and 90% snake gourd and 60 to 87% pumpkin fruits in Solomon Islands (Hollingsworth *et al.* 1997). Singh *et al.* (2000) reported 31.27% damage on bitter gourd and 28.55% on watermelon in India.

Environmental effect

The melon fruit fly remains active throughout the year on one or the other host. During the severe winter months, they hide and huddle together under dried leaves of bushes and trees. During the hot and dry season, the flies take shelter under humid and shady places and feed on honeydew of aphids infesting the fruit trees. The lower developmental threshold for melon fruit fly was recorded as 8.1°C (Keck 1951). The lower and upper developmental thresholds for eggs were 11.4 and 36.4°C (Messenger and Flitters 1958). The accumulative day degrees required for egg, larvae, and pre-egg laying adults were recorded as 21.2, 101.7, and 274.9 day degrees, respectively (Keck 1951). This species actively breeds when the temperature falls below 32.2°C and the relative humidity ranges between 60 to 70%. Fukai (1938) reported the survival of adults for a year at room temperature if fed on fruit juices. In general, its life cycle lasts from 21 to 179 days (Narayanan and Batra 1960, Fukai 1938). Development from egg to adult stage takes 13 days at 29°C in Solomon Islands (Hollingsworth *et al.* 1997). High temperature, long period of sunshine, and plantation activity influence the *B. cucurbitae* abundance in the North-eastern Taiwan (Lee *et al.* 1992). Bhatia and Mahto (1969) reported that the life cycle is completed in 36.3, 23.6, 11.2, and 12.5 days at 15, 20, 27.5, and 30°C, respectively. There are 8 to 10 generations in a year (Weems and Heppner 2001, White and Elson-Harris 1994).

The egg incubation period on pumpkin, bitter gourd, and squash gourd has been reported to be 4.0 to 4.2 days at 27 ± 1°C (Doharey 1983), 1.1 to 1.8 days on bitter gourd, cucumber and sponge gourd (Gupta and Verma 1995), and 1.0 to 5.1 days on bitter gourd (Hollingsworth *et al.* 1997, Koul and Bhagat 1994). The larval period lasts for 3 to 21 days (Hollingsworth *et al.* 1997, Narayanan and Batra 1960, Renjhan 1949), depending on temperature and the host. On different cucurbit species, the larval period varies from 3 to 6 days (Gupta and Verma 1995, Koul and Bhagat 1994, Doharey 1983, Chelliah 1970, Chawla 1966). Egg viability and larval and pupal survival on cucumber have been reported to be 91.7, 86.3, and 81.4%, respectively; while on pumpkin these were 85.4, 80.9, and 73.0%, respectively, at 27 ± 1°C (Samalo *et al.* 1991).

The full-grown larvae come out of the fruit by making one or two exit holes for pupation in the soil. The larvae pupate in the soil at a depth of 0.5 to 15 cm. The depth up to which the larvae move in the soil for pupation, and survival depend on soil texture and moisture (Pandey and Misra 1999, Jackson *et al.* 1998). Doharey (1983) observed that the pupal period lasts for 7 days on bitter gourd and 7.2 days on pumpkin and squash gourd at 27 ± 1°C. In general, the pupal period lasts for 6 to 9 days during the rainy season, and 15 days during the winter (Narayanan and Batra 1960). Depending on temperature and the host, the pupal period may vary from 7 to 13 days (Hollingsworth *et al.* 1997).

On different hosts, the pupal period varies from 7.7 to 9.4 days on bitter gourd, cucumber, and sponge gourd (Gupta and Verma 1995), and 6.5 to 21.8 days on bottle gourd (Koul and Bhagat 1994, Khan *et al.* 1993).

The males of the *B. cucurbitae* mate with females for 10 or more hours, and sperm transfer increases with the increase in copulation time. Egg hatchability is not influenced by mating duration (Tsubaki and Sokei 1988). Yamagishi and Tsubaki (1990) observed that no sperms were transferred during the first 0.5 h of copulation. Sperm transfer increased to nearly 6400 until 4 h, and thereafter, the number of sperms remained almost unchanged up to 8 h of copulation. The pre-oviposition period of flies fed on cucumbers ranged between 11 to 12 days (Hollingsworth *et al.* 1997, Back and Pemberton 1917). Pre-oviposition and oviposition periods range between 10 to 16.3, and 5 to 15 days, respectively, and the females live longer (21.7 to 32.7 days) than the males (15.0 to 28.5 days) (Koul and Bhagat 1994). The adults survive for 27.5, 30.71 and 30.66 days at 27 ± 1°C on pumpkin, squash gourd and bitter gourd, respectively (Doharey, 1983). Khan *et al.* (1993) reported that the males and females survived for 65 to 249 days and 27.5 to 133.5 days respectively. The pre-mating and oviposition periods lasted for 4 to 7 days and 14 to 17 days, respectively. The females survived for 123 days on papaya in the laboratory (24°C, 50% RH and LD 12:12) (Vargas *et al.* 1992), while at 29°C they survived for 23.1 to 116.8 days (Vargas *et al.* 1997). Mean single generation time is 71.7 days, net reproductive rate 80.8 births per female, and the intrinsic rate of increase is 0.06 times (Vergas *et al.* 1992). Yang *et al.* (1994) reported the net reproductive rate to be 72.9 births per female.

Bactrocera cucurbitae strains were selected for longer developmental period and larger body size on the basis of pre-oviposition period, female age at peak fecundity, numbers of eggs at peak fecundity, total fecundity, longevity of males and females, age at first mating, and number of life time matings (Miyatake 1995). However, longer developmental period was not necessarily associated with greater fecundity and longevity (Miyatake 1996). The peak larval, pre-oviposition, and oviposition periods were observed to be 6.48 versus 6.89, 14.0 versus 20.0, and 32 versus 62 days, respectively after nine and 24 generations of mass rearing and selection under laboratory conditions (Miyatake 1998a, 1997). The egg hatchability and larval-pupal survival were 81.3 versus 89%, and 75.8 versus 77.2% after nine and 24 generations of mass rearing and selection. Miyatake (1998b) reported that males show heritable variation in pre-mating period, while no such effects were observed in the females. The population of *B. cucurbitae* mass reared for a long time has a shorter pre-mating period than the population reared for short-term. A genetic trade-off has been observed between early-fecundity and longevity. The mass reared population has a negative genetic correlation between early-fecundity and longevity indicating antagonistic pleiotropy. The selected strain had lower and early fecundity than the non-selected strain (Miyatake 1997, Kakinohana and Yamagishi 1991, Kamikado *et al.* 1987, Soemori and Nakamori 1981). Therefore, it may be interesting to examine the mating ability of the males of the selected strain, because the effectiveness of the sterile-male release technique depends on the mating ability of the sterile males released into the eco-system. The genetic trade-off between behavioral traits should be taken into account along with life history during mass rearing programs, which might result in significant pre-mating isolation in the melon fly populations (Miyatake and Shimizu 1999, Miyatake1998a).

2.2.2. Red pumpkin beetle

a. Origin and distribution

Hutson (1972) reported that the red pumpkin beetle occurs on various cucurbits in Ceylon. Pawlacos (1940) stated *Raphidopalpa foveicollis* (Lucas) as one of the most important pests of melon in Greece. Manson (1942) reported it to occur in Palestine. Azim (1966) indicated that the red pumpkin beetle, *Aulacophora foveicollis* (Lucas), is widely distributed throughout all zoogeographic regions of the world except the Neo-arctic and Neo-tropical region. Alam (1969) reviewed that the red pumpkin beetle, *A. foveicollis* (Lucas), is widely distributed throughout the Pakistan, India, Afghanistan, Ceylon, Burma, Indo-China, Iraq, Iran, Persia, Palestine, Greece, Turkey, Israel, South Europe, Algeria, Egypt, Cyprus and the Andaman Island. Butani and Jotwani (1984) reported that the RPB is widely distributed all over the South-East Asia as well as the Mediterranean region towards the west and Australia in the east. In India, it is found in almost all the states, though it is more abundant in the northern states (Butani and Jotwani, 1984). According to York (1992), this insect pest is found in the Mediterranean region, Africa and Asia.

b. Host preferences

Khan (2012) studied to find out preferred cucurbit host(s) of the pumpkin beetle and to determine the susceptibility of ten different cucurbits to the pest under field conditions. The results revealed that the most preferred host of the red pumpkin beetle (RPB) was muskmelon, which was followed by khira, cucumber and sweet gourd, and these may be graded as susceptible hosts. Bitter gourd, sponge gourd, ribbed gourd and snake gourd were least or non-preferred hosts of RPB and these may be graded as resistant hosts. Other two crops, the bottle gourd and ash gourd were moderately preferred hosts of the insect and these may be graded as moderately susceptible hosts. According to his result, it indicate that the order of preference of RPB for ten tested cucurbit hosts was muskmelon> sweet gourd> cucumber > khira > ash gourd > bottle gourd > sponge gourd > ribbed gourd > snake gourd > bitter gourd.

Host preference of Red Pumpkin Beetle, *A. foveicollis* was studied by Khan *et al.* (2011) among ten cucurbitaceous crops (viz., sweet gourd, bottle gourd, ash gourd, bitter gourd, sponge gourd, ribbed gourd, snake gourd, cucumber, khira and muskmelon). At 1, 6, 12 and 24 hours after release (HAR), RPB population was found highest on sweet gourd. At 48 HAR the highest peak was found on muskmelon. The population of RPB on those two crops was significantly different only at 6 HAR. The populations of RPB on ash gourd, ribbed gourd, cucumber and khira ranged 1.00-3.33, 0.00-2.00, 0.67-1.67 and 0.00-2.00 per two plants, respectively. Three crops (Sweet gourd, musk melon and ash gourd) may be noted as highly preferred hosts of RPB. Bitter gourd was free from infestation and it was noted as non-preferred host. On khira and cucumber average population of RPB was 1.07-1.53 per two plants. On other cucurbits, population of RPB was less than one accordingly the highest percentage of leaf area damage per plant was observed on musk melon leaves followed by sweet gourd and ash gourd. The lowest percentage of leaf area damage was found on snake gourd followed by sponge gourd and bottle gourd. This insect showed different preference for various host species. Sweet gourd (pumpkin), Cucurbita maxima Duch was the preferred host.

An experiment was conducted on the host preference of *A. foveicollis* Lucas (Coleoptera, Chrysomelidae) on melon Cucumis melo, snake cucumber *C. flexuosus*, cucumber *C. sativus* and bottle gourd *Lagenaria siceraria*. Descending order of host preference was *C. melo*, *C. sativus* and *L. siceraria* for both 1975 and 1978 seasons. Yet, the first three crops did not differ significantly in their preference from each other and, thus, can be regarded collectively as the beetle's first choice.

Roy and Pande (1990) investigated the preference order of 21 cucurbit vegetables and noted that bitter gourd was highly resistant to the beetle, while the sponge gourd and bottle gourd were moderately resistant; muskmelon and cucumber were susceptible to the pest. They also observed that banana squash, muskmelon and bottle gourd were the preferred hosts of the adults, while cucumber, white gourd/ash gourd, chinese okra, snake gourd, watermelon and sponge gourd achieved the second order of preference to the beetle, *A. foveicollis*.

Mehta and Sandhu (1989) studied 10 cucurbitaceous vegetables and noted that bitter gourd was highly resistant to the RPB, while sponge gourd and bottle gourd were resistant. The cucumber, muskmelon and water melon were moderately resistant to the pest.

c. Seasonal abundance

Khan *et al.* (2012) reported that the highest population of RPB was recorded in the month of May. In March, food availability was the lowest because plants were young. In May, plant growth was maximal covering largest canopy. In June, plants were at their senescent stage causing food scarcity. It was also found that the 6 highest incidence of pumpkin beetles was observed at around 9:00 am and 6:00 pm, while the lowest incidence was at 2:00 pm. The highest population of red pumpkin beetle on sweet gourd, cucumber, ribbed gourd and sponge gourd was recorded in the month of May.

d. Economic loss

Cucurbits are attacked by a number of insect pests, including striped cucurbit beetle, 12 spotted cucumber beetles and Red Pumpkin Beetle. The Red Pumpkin Beetle, *A. foveicophora* Lucas is the most serious pest of the cucurbits. It causes 35-75% damage to all cucurbits except Bitter Gourd at seedling stage and the crop needs to be re-sown. They feed underside the cotyledonous leaves by bitting holes into them. Percent damage rating gradually decreases from 70-15% as the leaf canopy increases. Percent losses are obvious from the percent damage, which may reach upto 35-75% at seedling stage.

Khan (2013) studied to determine the biochemical composition of cucurbit leaves and their influence on red pumpkin beetle. Result revealed that the highest quantity of moisture was recorded in young leaf of bottle gourd (86.49%) and mature leaf of khira (87.95%). The lowest moisture content was obtained in young leaf of snake gourd (79.21%) and mature leaf of ribbed gourd (76.43%).

2.2.3. Aphid

a. Scientific classification

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Hemiptera
Family: Aphididae
Genus: *Aphis*
Specis: *A. fabae*

b. Origin and distribution

Aphids are distributed worldwide, but are most common in temperate zones. In contrast to many taxa, aphid species diversity is much lower in the tropics than in the temperate zones (Zyla *et al.* 2017). They can migrate great distances, mainly through passive dispersal by riding on winds. For example, the currant lettuce aphid, *Nasonovia ribisnigri*, is believed to have spread from New Zealand to Tasmania in this way (Pip Courtney 2005). Aphids have also been spread by human transportation of infested plant materials.

Winged aphids may also rise up in the day as high as 600 m where they are transported by strong winds (Berry and Taylor, 1968; Isard *et al.*, 1990). For example, the currant-lettuce aphid, *Nasonovia ribisnigri*, is believed to have spread from New Zealand to Tasmania around 2004 through easterly winds (Hill 2012). Aphids have also been spread by human transportation of infested plant materials, making some species nearly cosmopolitan in their distribution (John *et al.* 2009).

The black bean aphid may have originated in Europe and Asia, but it is now one of the most widely distributed species of aphids. It is found throughout temperate areas of Western Europe, Asia, and North America and in the cooler parts of Africa, the Middle East, and South America (AphID 2012). In the warmer parts of its range, apterous individuals can survive the winter and they may continue to reproduce asexually all year round (HYPP 2013). It is known to be migratory (Johnson, C. G. 1963).

c. Host range

The black bean aphid can feed on a wide variety of host plants. Its primary hosts on which the eggs overwinter are shrubs such as the spindle tree (*Euonymus europaeus*), Viburnum species, or the mock-orange (*Philadelphus* species). Its secondary hosts, on which it spends the summer, include a number of crops including sugar beets, spinach, beans, runner beans, celery, potatoes, sunflowers, carrots, artichokes, tobacco, and tomatoes. It colonize more than 200 different species of cultivated and wild plants. Among the latter, it shows a preference for poppies (*Papaver* species), burdock (*Arctium tomentonum*), fat-hen (*Chenopodium album*), saltbush (*Atriplex rosea*), chamomile (*Matricaria chamomilla*), thistles (*Cirsium arvense*) (Berim 2009), and docks (*Rumex* spp.) (RIR, 2013).

Two conflicting factors are involved in host preferences, the species and the age of the leaf. Offered spindle and beet leaves on growing plants throughout the year, winged aphids moved from one to the other depending on the active growth state of each and the senescence of each host plant. Thus, in late summer and autumn, the beet leaves were old and unattractive to the aphids in comparison with the leaves of the spindle, whereas in spring, the young unfolding leaves of the beet were more attractive than those of the spindle (Kennedy and Booth 1951).

d. Life cycle

The black bean aphid has both sexual and asexual generations in its life cycle. It also alternates hosts at different times of year. The primary host plants are woody shrubs, and eggs are laid on these by winged females in the autumn. The adults then die and the eggs overwinter. The aphids that hatch from these eggs in the spring are wingless females known as stem mothers. These are able to reproduce asexually, giving birth to live offspring, nymphs, through parthenogenesis (Chinery and Michael, 1993). The lifespan of a parthenogenetic female is about 50 days and during this period, each can produce as many as 30 young (Berim 2009). The offspring are also females and able to reproduce without mating, but further generations are usually winged forms. These migrate to their secondary host plants, completely different species that are typically herbaceous plants with soft, young growth (HYPP, 2013; Chinery and Michael, 1993; Berim 2009).

Further parthenogenesis takes place on these new hosts on the undersides of leaves and on the growing tips. All the offspring are female at this time of year and large populations of aphids develop rapidly with both winged and wingless forms produced throughout the summer. Winged individuals develop as a response to overcrowding and they disperse to new host plants and other crops. By midsummer, the number of predators and parasites has built up and aphid populations cease to expand (RIR, 2013). As autumn approaches, the winged forms migrate back to the primary host plants. Here, both males and sexual females are produced parthogenetically, mating takes place, and these females lay eggs in crevices and under lichens to complete the lifecycle. Each female can lay six to ten black eggs which can survive temperatures as low as −32°C (−26°F) (HYPP 2013; Chinery and Michael 1993; Berim 2009). More than 40% of the eggs probably survive the winter, but some are eaten by birds or flower bugs, and others fail to hatch in the spring (Way and Banks 1964).

e. Nature of damage

The black bean aphid is a major pest of sugar beet, bean, and celery crops, with large numbers of aphids cause stunting of the plants. Beans suffer damage to flowers and pods which may not develop properly. Early-sown crops may avoid significant damage if they have already flowered before the number of aphids builds up in the spring (RIR, 2013). Celery can be heavily infested. The plants are stunted by the removal of sap, the stems are distorted, harmful viruses are transmitted, and aphid residues may contaminate the crop (Godfrey and Trumble, 2009). As a result of infestation by this aphid, leaves of sugar beet become swollen, roll, and cease developing. The roots grow poorly and the sugar content is reduced. In some other plants, the leaves do not become distorted, but growth is affected and flowers abort due to the action of the toxic saliva injected by the aphid to improve the flow of sap (HYPP, 2013).

To obtain enough protein, aphids need to suck large volumes of sap. The excess sugary fluid, honeydew, is secreted by the aphids. It adheres to plants, where it promotes growth of sooty molds. These are unsightly, reduce the surface area of the plant available for photosynthesis and may reduce the value of the crop. These aphids are also the vectors of about 30 plant viruses, mostly of the non-persistent variety. The aphids may not be the original source of infection, but are instrumental in spreading the virus through the crop

(RIR, 2013). Various chemical treatments are available to kill the aphids and organic growers can use a solution of soft soap (Godfrey and Trumble, 2009).

2.2.4. Thrips

Thrips is an invasive pest insect in agriculture. This species of thrips belongs to the family Thripidae.

a. Scientific classification

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Thysanoptera
Family: Thripidae
Genus: *Scirtothrips*
Species: *Scirtothrips dorsalis*

Synonim

Anaphothrips andreae Karny 1925
Heliothrips minutissimus Bagnall 1919
Neophysopus fragariae Girault 1927
Scirtothrips padmae Ramakrishna 1942

Other common name

Assam thrips; castor thrips; strawberry thrips; yellow tea thrips.

b. Origin and distribution

This species of thrips is native to the Southwestern United States (Clarke *et al.* 2000) but has spread to other continents, including Europe, Australia (where it was identified in May 1993(Clarke *et al.* 2000)), and South America via transport of infested plant material (Kirk and Terry 2003).

S. dorsalis is a highly polyphagous pest widespread between Pakistan, Japan, the Solomon Islands and Australia, but it is now established in South Africa, Israel, the Caribbean and Florida (USA). It also present in Bangladesh, Brunei, Uganda, China, India, Indonesia, Iran, Malaysia, Myanmar, Phillippines, Sri Lanka, Taiwan, Vietnam, Thailand, Austria, United Kingdom, Jamaica and Venezuela (CABI 2020).

c. Host range

It has been documented to feed on over 500 different species of host plants, including a large number of fruit, vegetable, and ornamental crops.

Thrips is a major pest of chili plants. Thrips are polifag, can attack many kinds of plants, including crops (Johari 2016).

S. dorsalis is recorded from more than 100 plant species in 40 families, although the original wild host plants were probably *Acacia* species. In India this thrips is particularly important on chillies (Ramakrishna Ayyar 1932; Ramakrishna Ayyar and Subbiah 1935; Chakraborti 2004), although in recent years it has become a commercial problem on cultivated roses (Duraimuragan and Jagadish 2004). Amin (1979 & 1980) records *S. dorsalis* as a pest of *Arachis*, and it is also serious on Ricinus, and in southern India it has been reported damaging both cassava and taro (Rajamma *et al.* 2004). In Bangladesh it is recorded from *Mangifera*, and it sometimes causes damage to this crop in northern Australia. In Malaysia, *S. dorsalis* is sometimes a pest on leaves of Hevea and has been found in large numbers on *Mimosa pudica*. In Thailand this species was collected on sacred lotus (*Nelumbo*), although some came from orange, beans and roses (Mound and Palmer 1981). In Taiwan (Chang 1991) it is recorded damaging mango, citrus, sugar apple, tea, peppers and groundnuts; it is also a serious pest of lotus (Wang *et al.* 1999). In Java, long series were collected at Bogor Botanic Gardens on young tender leaves of Brownea, in flowers of *Saraca minor*, and on *Acacia* leaves. In southern China, where it is known as the yellow tea thrips, it causes damage to the shoots of litchi (Li *et al.* 2004). In Japan, *S.*

dorsalis is regarded as a pest of citrus (Tatara and Furuhashi 1992) and tea (Kodomari 1978), as it is in India (Dev 1964). *S. dorsalis* occurs as a pest of grapevines in Japan and India (Miyahara *et al.* 1976), and since 2000 it has become a pest of vines in Venezuela. In Goa *S. dorsalis* has been recorded on cashew (Sundararaju 1984) and also on onion (Thiramurthi *et al.* 1989). On the West Indian islands of St Vincent and St Lucia a wide range of vegetable crops are reported to be damaged, particularly Capsicums but including aubergine, squash, cucumber, cantaloupe, watermelon, pumpkin, bean and tomato (Seal and Ciomperlik 2004).

d. Morphology

The adult male is about 1 mm long; the female is slightly larger, about 1.4 mm in length. Most western flower thrips are female and reproduce by arrhenotokous parthenogenesis; i.e. females can produce males from unfertilized eggs, but females arise only from fertilized eggs (Clarke *et al.* 2000). Males are rare, and are always pale yellow, while females vary in color, often by season, from red to yellow to dark brown (Clarke *et al.* 2000). Each adult is elongated and thin, with two pairs of long wings. The eggs are oval or kidney-shaped, white, and about 0.2 mm long. The nymph is yellowish in color with red eyes.

e. Life cycle

The lifecycle of the western flower thrips varies in length due to temperature, with the adult living from two to five or more weeks, and the nymph stage lasting from five to 20 days. Each female may lay 40 to over 100 eggs in the tissues of the plant, often in the flower, but also in the fruit or foliage.

In India, where the life cycle has been studied particularly, females start ovipositing on Ricinus 3-5 days after emergence, and the total number of eggs laid ranges from 40 to 68. The life cycle is completed in 15-20 days, and the sex ratio is 6:1 females to males. On chillies, a single female lays 2-4 eggs per day for a period of about 32 days. The prepupa lasts for 24 hours and the pupa 3-5 days (CABI 2020).

Egg: Typically oval, whitish to yellowish, narrow anteriorly, incubation period 4-6 days.

Larva: First instar- Larva transparent; body short, legs longer; antennae short, swollen; mouth cone bent and short; and antennae seven-segmented and cylindrical. Sclerotization not distinct, head and thorax, reticulate.

Second instar- Antennae longer, cylindrical, seven-segmented; mouth cone longer; maxillary palpi three-segmented; body setae longer than the first instar; head and thorax reticulate with sclerotization of head.

Prepupa- Yellowish; antennae swollen, short, with distinct segmentation; two pairs of external wing buds on each meso- and meta-thorax.

Pupa: Dark yellow with eyes and ocelli bearing red pigmentation; wing buds are elongate; antennae short and reflected over the head; female pupae with larger pointed abdomen that of male smaller, with blunt abdomen.

Adult: Almost white on emergence, turning yellowish subsequently; abdominal tergites with median dark patch, tergites and sternites with dark antecostal ridge; ocellar setae pair III situated between posterior ocelli; 2 pairs of median post-ocular setae present; pronotum with four pairs of posteromarginal setae, major setae 25-30 μm long; metanotum medially with elongate recticles or striations, arcuate in anterior third, median setae not at anterior margin; forewing first vein with three setae distally, second vein with two setae, posteromarginal cilia straight; tergal microtrichial fields with 3 discal setae, VIII and IX with microtrichia medially; sternites with numerous microtrichia, more than two complete rows medially; male without drepanae on tergite IX (Palmer and Mound, 1983).

f. Seasonal abundance

In the Guntur area of India, *S. dorsalis* appears in two distinct periods: in the nurseries in August-September, when it is not serious, and from the third week of November to March (CABI 2020).

g. Nature of damage

The newly hatched nymph feeds on the plant for two of its instars, then falls off the plant to complete its other two instar stages. The insect damages the plant in several ways. The major damage is caused by the adult ovipositing in the plant tissue. The plant is also injured by feeding, which leaves holes and areas of silvery discoloration when the plant reacts to the insect's saliva. Nymphs feed heavily on new fruit just beginning to develop from the flower. The western flower thrips is also the major vector of tomato spotted wilt virus, a serious plant disease.

Thrips attack on the young leaves and flowers (Kalshoven 1981). Thrips attacks can cause chilli leaf curling to the upward. The attack of thrips on chilli plants starts from a mild attack to heavy. Mild attack begins from attack symptoms on leaves marked with silvery white color. Furthermore, the silvery color changed to be brown. Paroxysm attack occurs when thrips act as vectors of viruses that cause disease in chilli (Ananthakrishnan 1993).

Thrips attack can degrade the quality of agricultural products can reach the half. Thrips attack the buds so that the leaf buds die. Extreme damage can result in yield loss and can be exacerbated by cold weather which further slows plant growth (Williams *et al.* 2011).

2.3. Farmer’s perception on insect pests of cucurbit crops and their management practices

Kabir and Rainis (2012) conducted a study on farmers‟ perception on the adverse effects of pesticides on environment: the case of Bangladesh. The Results showed that an overwhelming majority (86.1 %) of the farmers had low to medium level of perception; while only 13.9% farmers had high perception regarding adverse effects of pesticides on environment.

Adeola (2012) conducted a study on perceptions of environmental effects of pesticides use in vegetable production by farmers in Ogbomoso, Nigeria. The Results showed that majority (85 %) of the farmers had low to medium level of perception; while only 15% farmers had high perception regarding environmental effects of pesticides use in vegetable production. Pal (2009) conducted a study on the perception of organic farmers regarding introduction of ICT in organic farming. The Results showed that more than half (54 percent) of the farmers perceived that organic products are superior to inorganic one.

Sharmin (2005) conducted her study on rural women’s perception of benefits of involvement in Income Generating Activities (IGAs) under a non-government Organization (NGO) and she found that majority (91 percent) of the respondents had medium perception of benefit of involvement in IGAs under a NGO, while 9 percent had high perception of this issue.

Sayeed (2003) conducted a study on perception on farmer’s benefits from using manure towards Integrated Nutrient Management (INM) for sustainable crop production. He found that 56.7 percent of the farmers had less favorable perception of benefit of using manure towards INM for sustainable crop production, while the rest 43.3 percent had favorable perception of this issue.

Chakraborty (2002) conducted a study on Sub Assistant Agriculture Officers' (former BS) perception of changes from mono rice culture to diversified crop cultivation. He reported that the highest proportion (68.0 percent) had high perception and 10.0 percent had low perception of changes.

Majlish (2007) conducted a study regarding perception of participant women on social forestry program of BRAC. The study revealed that the relationship between age and perception of social forestry program was negatively significant. Afique (2006) mentioned that there was no significant relationship between the age of the rural women and their perception of benefits of invovement in agricultural model farm project activities of Sabalam by Unnayan Samity (SUS). Islam (2005) found that age of the farmers had no significant relationship with their perception of causes and remedies of Monga in Kurigram district. Sharmin (2005) stated that age of the rural women had no significant relationship with the perception of benefits of involvement in IGAs under a NGO. Uddin (2004) conducted a study on perception of sustainable agriculture. The findings revealed that age of the respondents had negative significant relationship with their perception of sustainable agriculture. Sayeed (2003) found that age had negative relation with farmers' perception of benefit from using manure towards INM for sustainable crop production by the farmers. Ismail (1979), Chowdhury (2001) and Alom (2001) obtained similar type of findings in their respective studies. Kabir (2002) studied perception of farmers on the effects of integrated area development project towards environmental upgradation. The study revealed that there was no significant relationship between age and perception of environmental upgradation. Similar finding was obtained by Fardous (2002) in his study.

Sharmin (2005) found that personal education of the rural women had significant positive relationship with their perception of benefits of involvement of IGAs under a NGO. Uddin (2004) concluded that the level education of the farmers had a significant positive relationship with their perception of sustainable agriculture.

Sayeed (2003) revealed that the education of the respondents had significant positive relationship with their perception from using manure towards Integrated Nutrient Management (INM) for sustainable crop production. Fardous (2002) found a significant positive relationship between education of the farmers' and their perception of the forestry development activities of Village and Farm Forestry Program (VFFP) towards sustainable forestry development.

Alom (2001) found that education of farmers' had a significant and positive relationship with their perception of Binamoog-5 as a summer crop. Majydyan (1996) and Sarker (1999) and Islam (2001) found similar type of result. But, Kashem and Mikuni (1998) did not find any relationship between education of farmers and their perception about benefit of using Indigenous Technical Knowledge (I TK).

Majlish (2007) found that the relationship between family size of the participant women and perception of social forestry program of BRAC was non-significant and followed a negative trend. Afique (2006) found no significant relationship between family size of the rural women and their perception of benefits of involvement in agricultural model farm project activities of Sabalamby Unnayan Samity (SUS). Islam (2005) found that family size of the farmers had no significant relationship with their perception of both causes and remedies of Monga in Kurigram district. Sharmin (2005) in a study found that family size of the rural women had no significant relationship with their perception of benefits involvement of IGAs under a NGO. Uddin (2004) found that the family size of the farmers had no relationship with their perception of sustainable agriculture. Sayeed (2003) found that family size of farmers had no significant relationship with their perception of benefit from using manure towards Integrated Nutrient Management (INM) for sustainable crop production. Kabir (2002) in his study found that family size of farmers had negative relationship with their perception on the effects of BIADP towards environmental upgradation. Similar finding was also obtained by Alom (2001) in his study.

Adeola (2012) conducted a study on perceptions of environmental effects of pesticides use in vegetable production by farmers in Ogbomoso, Nigeria. The study revealed that household size had a non-significant influence on the farmers' perception.

Pal (2009) conducted a study on the perception of organic farmers regarding introduction of ICT in organic farming. The study revealed that farm size had no significant relationship with farmers' perception. Roy (2009) stated that farm size had negatively significant relationship with farmers' perception. Majlish (2007) revealed from her study that the relationship between farm size of participant women and perception of social forestry program of BRAC was non-significant and followed a positive trend. Afique (2006) stated that there was no significant relationship between family farm size of the rural women and their perception of benefits of involvement in agricultural model farm project activities of Sabalamby Unnayan Samity (SUS). Islam (2005) found that farm size of farmers had no significant relationship with their perception of both causes and remedies of Monga in Kurigram district. Sharmin (2005) found in her study that farm size of the rural women had no significant relationship with their perception of benefits of involvement in IGAs under a NGO. Uddin (2004) found that farm size of the farmers had significant and positive relationship with their perception of sustainable agriculture. Sayeed (2003) observed that farm size of the farmers had a significant positive relationship with their perception of benefit from using manure towards Integrated Nutrient Management (INM) for sustainable crop production.

Fardous (2002) found that there was no significant relationship between farm size of the farmers and their perception of Village and Farm Forestry Program (VFFP) towards sustainable forestry development. Hossain (2001), Hossain (1999) and Majydyan (1996) found similar findings in their respective studies.

Kabir and Rainis (2012) conducted a study on farmers" perception on the adverse effects of pesticides on environment: the case of Bangladesh. They found that training had a significant influence on the farmers' perception. Pal (2009) conducted a study on the perception of organic farmers regarding introduction of ICT in organic farming. The study revealed that training received had a positive significant influence on the farmers' perception. Roy (2009) stated that training received had a positive significant relationship with farmers' perception. Majlish (2007) found from her study that the relationship between training experience of participant women and perception of social forestry program of BRAC was positively significant. Afique (2006) mentioned that there was no significant relationship between training exposure of the rural women and their perception of benefits of involvement in agricultural model farm project activities of Sabalamby Unnayan Samity (SUS). Sharmin (2005) reported from her study that training exposure of the rural women had no significant relationship with their perception of benefits of involvement in Income Generating Activities (IGAs) under a NGO.

Uddin (2004) from his study concluded that farmers’ training exposure had a significant positive relationship with their perception of sustainable agriculture.

Kabir (2002) found that training experience of the farmers had a significant positive relationship with their perception of the effects of BIADP on environmental upgradation.

Fardous (2002) observed that training exposure of the farmers was significantly correlated with the perception of the respondents of VFFP towards sustainable forestry development.

Pal (2009) conducted a study on the perception of organic farmers regarding introduction of ICT in organic farming. The study revealed that organizational participation had no significant relationship with farmers’ perception. Roy (2004) stated that organizational participation had no significant relationship with farmers’ perception. Uddin (2004) studied on fanners’ perception of sustainable agriculture and concluded that organizational participation of the farmers had a significant positive relationship with their perception of sustainable agriculture.

Sayeed (2003) reported that organizational participation of the farmers had no significant effect on their perception of benefit from using manure towards INM for sustainable crop production. Fardous (2002) found that organizational participation of the farmers had significant positive relationship with their perception of VFFP towards sustainable forestry development. Chowdhury (2001) found a significant relationship between organizational participation and the impact of a forestation as perceived by the farmers.

Alom (2001) reported that organizational participation of the farmers had significant positive relationship with their perception of Binamoog-5 as a summer crop.

Kabir and Rainis (2012) conducted a study on Farmers" Perception on the Adverse Effects of Pesticides on Environment: The Case of Bangladesh. They found that experience of farmers had a significant influence on the farmers' perception. Adeola (2012) conducted a study on perceptions of environmental effects of pesticides use in vegetable production by farmers in Ogbomoso, Nigeria. The study revealed that farming knowledge had a significant influence on the farmers' perception. Roy (2009) stated that knowledge on IPM practices had a positive significant relationship with farmers' perception. Majlish (2007) conducted her study regarding perception of participant women on social forestry program of BRAC. She found from her study that the relationship between knowledge on tree plantation and perception of social forestry program of BRAC was positively significant.

Uddin (2004) conducted his study on farmers" perception of sustainable agriculture. He found that knowledge of environment friendly farming had significant and positive relationship with their perception of sustainable agriculture. He further conduct environment friendly farming had higher perception of sustainable agriculture.

Furdous (2002) conducted a study and found that there was a significant positive relationship between knowledge of forestry of farmers and their perception of VFFP towards sustainable forestry development.

Roy (2009) stated that majority (98.75 percent) of the respondent had high problem while only 1.25 percent had medium problem in using IPM.

Uddin (2004) conducted his study on farmers' perception of sustainable agriculture. He found that knowledge of environment friendly faming had significant and positive relationship with their perception of sustainable agriculture. He further concluded that the respondents with higher knowledge of environment friendly farming had higher perception of sustainable agriculture.

CHAPTER III

MATERIALS AND METHODS

3.1.1. Sources of data

The study had been conducted to generate stipulated primary data. To develop the study instruments accurately and comparison with major indicators of the study, the secondary data were carefully scanned and had been collated according to the objectives of the study. For generating the desired primary data, the proposed sample study had been conducted using an appropriate sampling design and a formatted questionnaire.

3.1.2. Study location

The survey had been conducted in four cucurbit vegetable growing districts of Bangladesh. Based on area and production, the three major cucurbit vegetable growing districts such as Dhaka, Manikgonj and Munshiganj had been considered as sampled districts. Under this study, two Upazilas from each districts had been sampled. The name of sampled Upazilas under three sampled districts are as follows:

Plate 1. Field of a sample area

Table 2: List of the sampled districts and sampled upazilas

Sl. No.	District	Upazila
1	Dhaka	Savar
		Keranigonj
2	Munshiganj	Sadar
		Tongibari
3	Manikgonj	Sadar
		Singair

3.1.3. Study period

Field survey for this study had been conducted from February, 2018 to March, 2018. And this study had been conducted from January, 2018 to May, 2018.

3.1.4. Stakeholders

The Upazila Agricultural Officer, Agriculture Extension Officer and Sub-Assistance Agriculture Officer of DAE worker under the sampled upazila of the selected cucurbit vegetable growing districts had been interviewed through pre-designed structured questionnaire. Among the field level officials, the Upazila Agriculture Officer (UAO), Agriculture Extension Officer (AEO) and Sub-Assistant Agriculture Officer (SAAO) had been considered from each of the sampled upazila for face-to-face interview under this survey study.

3.1.5. Sample design

Two types of analysis had been made to gather information about the study and those were-

a. Quantitative analysis: In order to ensure representativeness of the data and information collected, the proposed sampling strategy was delineated below:

The population under the study were constituted to assess the farmers' perception on the extent of incidence and damage caused by various insect pests of cucurbit and their management practices. The survey study had been conducted from 3 districts of Bangladesh namely Dhaka, Manikgonj and Munshiganj, where the cucurbit vegetables are intensively grown. Two upazilas were covered for respondent selection from each of the sampled districts and 50 farmers were chosen for data collection from each upazila. Thus, the sample size of the study considered 300 farmers. Using 95% confidence level with 5% margin of error it was needed to obtain a representative sample size of farmers 300 for this study. For such purpose a sound statistical formula with Finite Population Correction (FPC) recommended by Daniel (1999) had been adopted to determine the appropriate sample size as given below;

$$n = \frac{Z^2 PQ}{e^2}$$

Where,

n = Sample size without finite population correction (FPC),

P = Proportion/Probability of success (If the prevalence is 50%, P=0.5),

Q = 1-P (1-0.5= 0.5, Q=0.5),

Z = Z statistic for a level of confidence, Z=1.96 (The value of the standard variation at 95% Confidence level)

e = Precision or allowable margin of error (If the precision is 2%, then e=0.02) e=0.0575 (Allowable margin of error at 5.75%)

Therefore, using this formula the sample size (n) for respective stakeholders had been calculated as follows:

$n = \{(1.96)^2 \times 0.5 \times 0.5\}/(0.0575)^2 = 3.8416*0.25/0.00330625 = 0.9604/0.00330625 = 290.$

The sample size became 300 by using round figure of 290 for respondents. The respondents/farmers had been selected by using simple random sampling technique.

However, the determined number of respondents had been proportionately allotted to the sampled districts. In order to reach stipulated respondents at sampled districts a census had been done in the chosen respondents before the study. Such census was aimed at identifying targeted population of respondents in the districts.

Table 3: District and upazila-wise distribution of respondents under the field survey study

Sl. No.	District	Upazila	No. of cucurbit growers	No. of FLO of DAE		
				UAO	AEO	SAAO
1	Dhaka	Savar	50	1	1	3
		Keranigonj	50	1	1	3
2	Munshiganj	Sadar	50	1	1	3
		Tongibari	50	1	1	3
3	Manikgonj	Sadar	50	1	1	3
		Singair	50	1	1	3
Total	**03**	**06**	**300**	**06**	**06**	**18**

3.1.6. Variables/Indicators Covered

The following variables had been considered during development of questionnaire for data collection from the respondents.

1. Demographic : Name, Age, Sex etc. information were included so that the data were collected from the respondent cucurbit grower who were selected for face to face interview conducted by the researcher.

2. Social : Education, Profession and Experience etc. information were also needed to collect from the respondent cucurbit grower who were selected for face to face interview conducted by the researcher.

3. Study related indicators:

- **Demographic information:** Some demographic information of selected respondent cucurbit grower from the sample area were collected. This information was collected for getting information as individual as respondent cucurbit grower. Some of these information was represented in this study.

- **Categories of farmers' and land for cucurbit cultivation:** Categories of farmers according their total land for cultivation and amount of lands for cucurbit cultivation data were collected from the cucurbit grower of the sample area.
- **Types of cucurbit cultivation:** Types of cucurbit vegetables, income etc. information were collected from the sample area.
- **Problems of cucurbit production:** To identify the insect pest problems of the production of cucurbit at the sample area and the general management practices against the insect pests of cucurbit, response of the cucurbit grower of sample area was collected via face to face interview. Data were collected by the using of appropriate questioner and then data were codded for analysis.

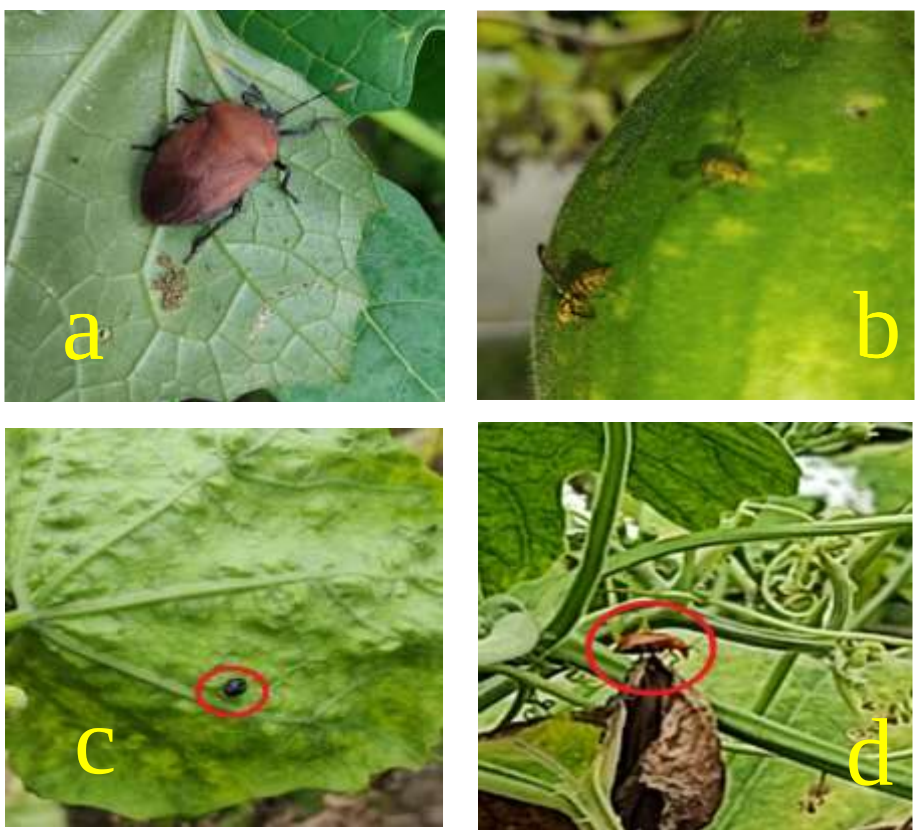

Plate 2. Some insect pests of cucurbit (a. squash beetle, b. fruit fly, c. epilachna beetle, d. red pumpkin beetle)

3.1.7. Development of study tools/questionnaire

In consultation with the Supervisor and Co-supervisor, the questionnaire for cucurbit growers (Appendix I) had been prepared based on the objectives and indicators for the survey study and proposed methodologies. The study questionnaire pre-tested in the study location and thereafter it had been finalized with due care to include appropriate questions for collection of necessary information from different levels and types of respondents to reflect the indicators relevant to the objectives of the study. The final questionnaire had been translated into Bangla also.

3.1.8. Method of data collection

The face-to-face interview of the cucurbit growers under the sampled districts had been collected for the study and those were given below:

- Direct personal interview approach had been adopted for collection of primary data. That method was effectively related to the collection of data directly from the cucurbit growers and people relevant with cucurbit production.

Plate 3. Data collection from a farmer

- The targeted sample cucurbit growers had been selected and finalized in consultation with the UAO and SAAO of the respective upazila selected for sampled districts.

- The data were recorded only after fully being satisfied that he had been able to make the respondents understood the question, and the respondents were offering any of the probable answers in his own perception.
- The investigators had made all efforts to have a friendly and open-minded interaction with the respondent instead of asking questions like a school teacher to his students. All questions had been asked one by one, and data were filled up on the spot.
- The face-to-face interview of targeted number had been conducted with UAO, AEO and SAAO of the respective sampled districts.

As per sample design, the 300 survey respondents had been interviewed for 6 upazilas, where 2 upazila for each of 3 sampled districts.

3.1.9. Data Analysis

The filled up questionnaire had been coded according to the upazilas and district. The filled up questionnaire for cucurbit growers and filed level officials of DAE had been coded separately. Then the entry of data had been performed using SPSS computer package and accordingly analyzed to generate objective wise desired information.

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted in the 6 upazila of 3 selected cucurbit vegetable growing districts of Bangladesh during the period from January 2018 to May 2018 to find out the current status and damage intensity of insect pests of cucurbit and their management options. The data were collected through interview of 300 farmers using a predesigned questionnaire considering 50 farmers from each upazila and 18 field level officers of DAE considering one UAO, one AEO and one SAAO of DAE. The results obtained from the studies have been presented below sequentially in various forms and thus interpreted and discussed as to extract the findings systematically in line with the objective of the study.

4.1. Farmers' demographic information

4.1.1. Farmers' respondent on gender of them

From the field survey it was found that, out of 300 farmers' respondents from 3 cucurbit vegetable growing districts, most (86.41%) of the farmer were male, where only 13.59% farmer were female.

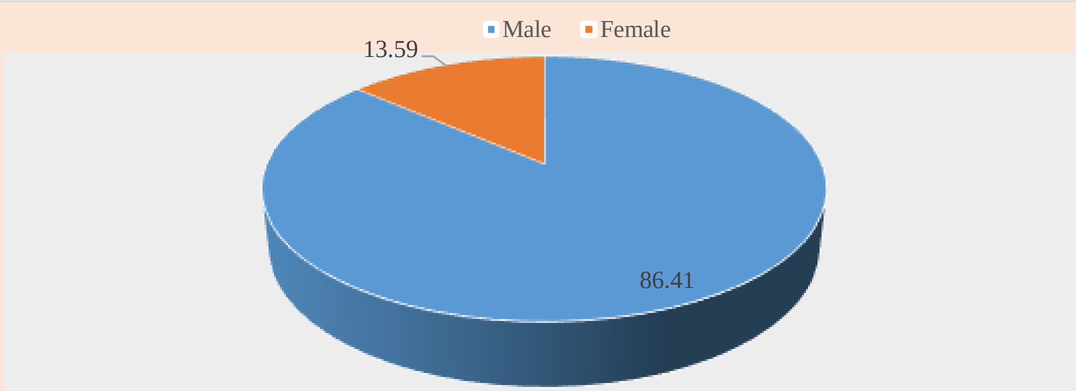

Figure 1: Gender of the farmers' participated in the survey [N=300]

4.1.2. Farmer’s response on age range of the farmers’

Out of 300 respondent farmers’, maximum (33.06%) farmers’ age range was 41-50 years, whereas 26.41% were 51-60 years, 17.12% were above 60 years and 16.37% were 31-40 years. On the other hand, only 1.57% were below 20 years and 5.47% farmers’ age range was 21-30 years.

Table 4. Farmers’ response on age range of the respondent farmers’

Sl. No.	Age range	Number of respondents [N=300]	% response
1	> 20 years	5	1.57
2	21-30 years	16	5.47
3	31-40 years	49	16.37
4	41-50 years	100	33.06
5	51-60 years	79	26.41
6	> 60 years	51	17.12
Total		300	100.0

4.1.3. Farmers’ response on educational qualification of the respondent farmers’

Among the 300 respondent farmers’ who were directly involved with cucurbit vegetable production, maximum (35.33%) farmers’ educational qualification were not more than primary level whereas 29.00% were up to class eight, 16.33% were illiterate and 10.67% were SSC passed. On the other hand, only 1% had masters or higher degree whereas 2% had bachelor degree and 5.67% were HSC passed.

Table 5. Farmers' response on educational qualification of the respondent farmers'

Sl. No.	Education level	Number of respondents [N=300]	% response
1	Illiterate	49	16.33
2	Up to primary	106	35.33
3	Up to Class Eight	87	29
4	SSC	32	10.67
5	HSC	17	5.67
6	Bachelor degree	6	2
7	Masters or higher degree	3	1
Total		300	100.0

4.1.4. Farmers' response on categories of the respondent farmers'

Among 300 respondent farmers' from the survey area, maximum (49.67%) were small farmer who had less than 10 decimal of cultivable land, whereas 38.00% were medium farmers who had 11-33 decimal of cultivable land. On the other hand, only 12.33% were large farmers who had more than 33 decimal of cultivable land (Table 6).

From the table 6 it was revealed that, average 19.44% of cultivable land was used for cucurbit vegetable cultivation by the farmers of the survey area. Where maximum 49.13% and minimum 5.78% cultivable land was used for cucurbit vegetable cultivation in the survey area.

Respondent farmers' who were involved with cucurbit vegetables cultivation from average 7 years, whereas the farmer of the survey area were involved with the cucurbit vegetable cultivation maximum 12 years and minimum 1 year (Table 6).

Table 6. Farmers' response on categories of the farmers participated in the survey

Categories	Number of respondents [N=300]	% response
Small farmers	149	49.67
Medium farmers	114	38.00
Large farmers	37	12.33
Total	300	100
Land used for cucurbit vegetable cultivation		
Minimum	5.78%	
Maximum	46.13%	
Average	19.44%	
Years of cucurbit cultivation by the farmers		
Minimum (years)	1	
Maximum (years)	12	
Average (years)	7	

4.2. Farmers' perception on cucurbit vegetable cultivation

4.2.1. Farmers' response on land under cucurbit vegetables cultivation

From the discussion with the respondent farmers' of survey area it was revealed that, maximum (15.66%) land of cucurbit cultivable land was used for bitter gourd cultivation by the farmers, followed by snake gourd (12.75%), water melon (12.47%), bottle gourd (11.37%), pointed gourd (10.52%), cucumber (9.77%), sweet gourd (7.13%), wax gourd (6.44%), sponge gourd (5.51%), ridge gourd (3.72%) and squash (2.55%). On the other hand, only 2.11% land of cucurbit cultivation was used for melon cultivation by the farmers of the survey area (Figure 2).

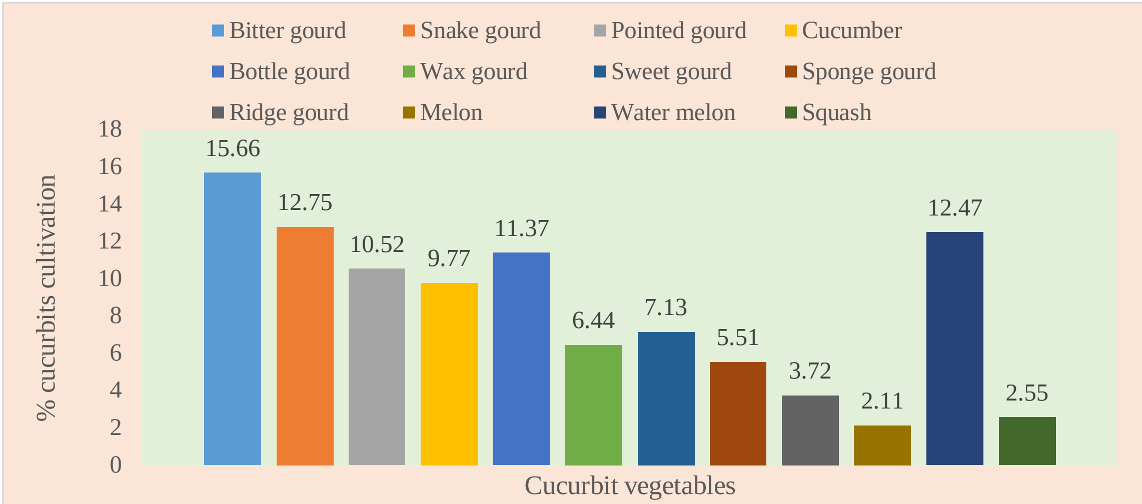

Figure 2. Percent land area used by different cucurbit vegetables by the farmers

4.2.2. Farmers' response on income from cucurbit vegetable production

Out of 300 respondent farmers' under the survey area, maximum income (1,55,885 tk) was earned from bitter gourd per acre, followed by snake gourd (130585 tk/acre), cucumber (125572 tk/acre), pointed gourd (111225 tk/acre), bottle gourd (110255 tk/acre), wax gourd (105458 tk/acre), sweet gourd (98572 tk/acre) and water melon (95255 tk/acre). On the other hand, minimum income (55250 tk/acre) was earned from melon production by the farmers' under the survey area (Table 7).

Table 7. Farmers' response on income per acre from cucurbitous crops

Cucurbits types	Income (Tk/acre)
1. Bitter gourd	155885
2. Snake gourd	130585
3. Pointed gourd	111225
4. Cucumber	125572
5. Bottle gourd	110255
6. Wax gourd	105458
7. Sweet gourd	98572
8. Sponge gourd	75285
9. Ridge gourd	68250
10. Melon	55250
11. Water melon	95255
12. Squash	66578

4.2.3. Farmers' response on sources of purchasing cucurbit seed/seedlings

Out of 300 respondent farmers', maximum (80.76%) of respondent farmers' collected their cucurbit seed/seedlings from seed businessman, followed by NGO's (70.78%), local market (41.84%), seed importer (38.99%), company seed (35.94%), farmers' own (27.09%) and neighbors (25.85%). On the other hand, only 24.47% farmers' collect their seed/seedlings from BADC for cucurbit cultivation.

Table 8. Farmers' response on sources of purchasing cucurbits seedlings usually used

Sources of purchasing cucurbits seedling	Number of respondents [N=300]	Response (%)
1. Farmer's own	81	27.09
2. From neighbors	78	25.85
3. BADC seed	73	24.47
4. Company seed	108	35.94
5. Local market	126	41.84
6. From importer	117	38.99
7. From research institution	90	30.06
8. From NGO's	212	70.78
9. Seed businessman	242	80.76
Multiple answer		

4.3. Farmers' knowledge about the insect pests of cucurbit vegetables

4.3.1. Farmers' response on knowledge about insect pest susceptibility of cucurbits

Among the 300 respondent farmers', maximum (56.54%) farmers reported that bitter gourd was more susceptible than other cucurbit vegetables, followed by sponge gourd (33.88%), snake gourd (33.03%), cucumber (29.15%), ridge gourd (17.93%), water melon (17.03%), sweet gourd (16.99%), melon (11.60%), wax gourd (8.41%) and pointed gourd (6.74%). On the other hand, only 0.46% farmers' reported that squash was less susceptible than the other cucurbits.

Table 9. Farmers' response on susceptibility of cucurbits to different insect pests in Bangladesh

Sl. No.	Cucurbits types	Number of respondents [N=300]	Response (%)
1.	Bitter gourd	170	56.54
2.	Snake gourd	99	33.03
3.	Sponge gourd	102	33.88
4.	Cucumber	87	29.15
5.	Bottle gourd	44	14.65
6.	Wax gourd	25	8.41
7.	Sweet gourd	51	16.99
8.	Ridge gourd	54	17.93
9.	Melon	35	11.60
10.	Pointed gourd	20	6.74
11.	Water melon	51	17.03
12.	Squash	1	0.46
Multiple answer			

4.3.2. Farmers' response on knowledge on insect pest incidence of different cucurbits

Bitter gourd: Out of 300 respondents, maximum (47.76%) farmer reported that fruit fly was the major insect for bitter gourd, followed by thrips (46.44%), mealy bug (29.00%), whitefly (26.54%), red mite (14.44%), epilachna beetle (12.13%) and red pumpkin beetle (10.68%). On the other hand, 0.54% farmers reported that, semi-looper was the minor pest for bitter gourd, followed by cutworm (1.00%), cucumber beetle (2.26%), fruit borer (2.84%), flea beetle (3.21%) and leaf miner (6.25%) (Table 10).

Snake gourd: Out of 300 respondents, maximum (47.91%) farmer reported that fruit fly was the major insect for snake gourd, followed by thrips (44.28%), mealy bug (27.51%), whitefly (26.41%), red mite (13.34%), epilachna beetle (13.43%) and red pumpkin beetle

(9.82%). On the other hand, 0.65% farmers reported that, semi-looper was the minor pest for snake gourd, followed by cutworm (0.96%), cucumber beetle (1.21%), fruit borer (1.57%), flea beetle (2.60%) and leaf miner (6.79%) (Table 10).

Sponge gourd: Out of 300 respondents, maximum (43.78%) farmer reported that fruit fly was the major insect for sponge gourd, followed by thrips (39.09%), mealy bug (25.97%), whitefly (25.16%), red mite (16.16%), epilachna beetle (16.60%) and red pumpkin beetle (14.29%). On the other hand, 0.78% farmers reported that, semi looper was the minor pest for sponge gourd, followed by cutworm (1.12%), cucumber beetle (1.51%), fruit borer (1.29%), flea beetle (1.35%) and leaf miner (4.18%) (Table 10).

Cucumber: Out of 300 respondents, maximum (40.03%) farmer reported that fruit fly was the major insect for cucumber, followed by thrips (38.35%), mealy bug (32.54%), whitefly (28.21%), red mite (30.99%), epilachna beetle (20.32%) and red pumpkin beetle (16.00%). On the other hand, 0.32% farmers reported that, semi looper was the minor pest for cucumber, followed by cutworm (0.49%), cucumber beetle (0.97%), fruit borer (0.62%), flea beetle (1.00%) and leaf miner (3.07%) (Table 10).

Bottle gourd: Out of 300 respondents, maximum (45.97%) farmer reported that bottle gourd was the major insect for bottle gourd, followed by thrips (38.99%), mealy bug (41.37%), whitefly (30.78%), red mite (25.41%), epilachna beetle (22.59%) and red pumpkin beetle (14.53%). On the other hand, 0.43% farmers reported that, semi looper was the minor pest for bottle gourd, followed by cutworm (0.62%), cucumber beetle (0.56%), fruit borer (0.75%), flea beetle (0.68%) and leaf miner (1.63%) (Table 10).

Wax gourd: Out of 300 respondents, maximum (38.49%) farmer reported that thrips was the major insect for wax gourd, followed by fruit fly (33.59%), mealy bug (31.00%), whitefly (28.91%), red mite (25.43%), epilachna beetle (20.18%) and red pumpkin beetle (11.88%). On the other hand, 0.40% farmers reported that, semi looper was the minor pest for wax gourd, followed by cutworm (0.46%), cucumber beetle (0.65%), fruit borer (1.00%), flea beetle (0.47%) and leaf miner (1.63%) (Table 10).

Sweet gourd: Out of 300 respondents, maximum (37.07%) farmer reported that thrips was the major insect for sweet gourd, followed by fruit fly (32.24%), mealy bug (24.32%), whitefly (20.78%), red mite (22.37%), epilachna beetle (16.06%) and red pumpkin beetle (13.43%). On the other hand, 0.19% farmers reported that, semi looper was the minor pest for sweet gourd, followed by cutworm (0.25%), cucumber beetle (0.49%), fruit borer (0.85%), flea beetle (1.29%) and leaf miner (3.43%) (Table 10).

Melon: Out of 300 respondents, maximum (47.62%) farmer reported that mealy bug was the major insect for melon, followed by fruit fly (29.57%), thrips (31.16%), whitefly (38.49%), red mite (19.91%), epilachna beetle (13.66%) and red pumpkin beetle (13.10%). On the other hand, 0.43% farmers reported that, semi looper was the minor pest for melon (Table 10).

Ridge gourd: Out of 300 respondents, maximum (29.00%) farmer reported that thrips was the major insect for ridge gourd, followed by fruit fly (24.15%), mealy bug (19.28%), whitefly (20.84%), red mite (19.00%), epilachna beetle (12.19%) and red pumpkin beetle (9.15%). On the other hand, 0.41% farmers reported that, semi looper was the minor pest for ridge gourd (Table 10).

Water melon: Out of 300 respondents, maximum (19.28%) farmer reported that thrips was the major insect for water melon, followed by fruit fly (16.29%), mealy bug (12.04%), whitefly (9.01%), red mite (8.71%), epilachna beetle (6.35%) and red pumpkin beetle (4.93%). On the other hand, 0.26% farmers reported that, semi looper was the minor pest for water melon (Table 10).

Squash: Out of 300 respondents, maximum (28.21%) farmer reported that thrips was the major insect for squash, followed by fruit fly (26.35%), mealy bug (9.09%), whitefly (26.54%), red mite (14.44%), epilachna beetle (12.13%) and red pumpkin beetle (10.68%). On the other hand, 0.18% farmers reported that, semi looper was the minor pest for squash (Table 10).

Pointed gourd: Out of 300 respondents, maximum (13.51%) farmer reported that thrips was the major insect for pointed gourd, followed by fruit fly (12.68%), mealy bug (29.00%), whitefly (26.54%), red mite (14.44%) and epilachna beetle (12.13%). On the other hand, 2.26% farmers reported that, semi looper was the minor pest for pointed gourd, followed by cutworm (Table 10).

Table 10. Farmers' response on insect pest incidence of different cucurbitous crops

Sl. No.	Insect pests	Bitter gourd	Snake gourd	Sponge gourd	Cucu mber	Bottle gourd	Wax gourd	Sweet gourd	Melon	Ridge gourd	Water melon	Squash	Pointed gourd
1	Fruit fly	47.76	47.91	43.78	40.03	45.97	33.59	32.24	29.57	29.00	19.28	28.21	13.51
2	Thrips	46.44	44.28	39.09	38.35	38.99	38.49	37.07	31.16	24.15	16.29	26.35	12.68
3	Mealy bug	29.00	27.51	25.97	32.54	41.37	31.00	24.32	47.62	19.28	12.04	9.09	10.91
4	White fly	26.54	26.41	25.16	28.21	30.78	28.91	20.78	38.49	20.84	9.01	8.54	6.40
5	Red mite	14.44	13.34	16.16	30.99	25.41	25.43	22.37	19.91	19.00	8.71	6.43	7.54
6	Epilachna beetle	12.13	13.43	16.60	20.32	22.59	20.18	16.06	13.66	12.19	6.35	3.21	9.59
7	Red Pumpkin beetle	10.68	9.82	14.29	16.00	14.53	11.88	13.43	13.10	9.15	4.93	2.88	1.75
8	Stink bug	9.15	7.74	9.15	10.53	14.87	10.51	9.09	9.07	9.10	3.22	1.69	1.29
9	Aphid	9.00	7.78	6.07	4.72	6.13	9.01	8.03	8.03	6.35	2.82	2.38	1.41
10	Jassid	7.47	6.07	5.16	5.60	3.74	4.19	4.19	4.96	7.54	1.37	1.22	1.04
11	Leaf miner	6.25	6.79	4.18	3.07	1.63	2.12	3.43	3.06	3.22	0.79	0.63	0.96
12	Cucumber caterpillar	4.40	3.10	1.87	1.57	0.93	1.41	1.57	1.29	1.57	0.50	0.56	0.78
13	Flea beetle	3.21	2.60	1.35	1.00	0.68	0.47	1.29	1.60	1.06	0.41	0.25	0.62
14	Fruit borer	2.84	1.57	1.29	0.62	0.75	1.00	0.85	1.06	1.26	0.28	0.16	0.49
15	Cucumber beetle	2.26	1.21	1.51	0.97	0.56	0.65	0.49	0.68	0.54	0.19	0.10	0.10
16	Cutworm	1.00	0.96	1.12	0.49	0.62	0.46	0.25	0.76	0.28	0.38	0.13	0.19
17	Semi lopper	0.54	0.65	0.78	0.32	0.43	0.40	0.19	0.43	0.41	0.26	0.18	0.26
18	Others	0.26	0.41	0.28	0.43	0.24	0.43	0.24	0.31	0.16	0.34	0.34	0.18

4.3.3. Farmers' response on infestation severity of insect pests on cucurbit

Among 300 respondents, maximum (61.4%) farmers' opined that fruit fly was the major insect pest for cucurbit vegetables. Major insect pests of cucurbits are listed as per the response of the respondent farmers', where include Whitefly, red mite, jassid, epilachna beetle, thrips and red pumpkin beetle (Table 11).

In terms of, severity of infestation of insect pests of cucurbits, maximum (66.1%) respondents informed that fruit fly infestation was highly severe than the other insect pest of cucurbit crops (Table 11).

Again, among 300 respondents, maximum (14.3%) farmers' opined that aphid was the minor insect pest for cucurbit vegetables. Besides this respondent farmers' opined that, mealy bug, stink bug, aphid, leaf miner, cucumber caterpillar, flea beetle, fruit borer, cucumber beetle, cutworm and semi-looper were the minor insect pests for cucurbits (Table 12).

In terms of, severity of infestation of insect pests of cucurbits, maximum (12.4%) respondents informed that fruit borer infestation was highly severe than the other insect pest of cucurbit crops (Table 12).

Table 11. Farmers' response on infestation severity of major insect pests of cucurbits

Sl. No.	Name of Insects pest	Pest status			Severity of infestation		
		Major	Minor	No infestation	High	Medium	Low
1	Fruit fly	61.4	26.7	11.9	66.1	19.8	14.1
2	White fly	64.1	21.4	14.5	63.8	22.4	13.8
3	Red mite	58.2	28.6	13.2	58.9	26.4	14.7
4	Jassid	47.9	39.5	12.6	52.8	31.9	15.3
5	Epilachna beetle	47.6	34.5	17.9	52.1	25.7	22.2
6	Thrips	46.5	27.1	26.4	43.6	35.8	20.6
7	Red Pumpkin beetle	45.8	33.6	20.6	40.2	31.2	28.6

Table 12. Farmers' response on infestation severity of minor insect pests of cucurbits

Sl. No.	Name of Insects pest	Pest status			Severity of infestation		
		Major	Minor	No infestation	High	Medium	Low
1	Mealy bug	8.6	17.5	73.9	10.8	21.4	67.8
2	Stink bug	9.7	13.2	77.1	10.9	12.5	76.6
3	Aphid	14.3	22.7	76	13.2	12.8	74
4	Leaf miner	8.1	19.7	72.2	9.9	17.8	72.3
5	Cucumber caterpillar	7.1	11.8	81.1	8.7	10.1	81.2
6	Flea beetle	6.7	15.4	77.9	8.2	19.8	72
7	Fruit borer	8	14	78	12.4	11.3	67.9
8	Cucumber beetle	10.8	16.8	72.4	13.4	19.7	66.9
9	Cutworm	8.7	16.2	75.1	9.7	14.3	76
10	Semi lopper	4.5	17.9	77.6	3.5	8.7	87.8
11	Others	6.1	17.4	76.5	6.8	12.7	80.5

4.3.4. Farmers' response on knowledge about insect pest infestation

Among 300 respondents, maximum (20.6%) respondent share information about the vulnerable stage of cucurbit fruit fly whereas only 3.5% respondent reported that, cucurbit vegetables were vulnerable for semi-looper in the field at the survey area (Table 13).

Again, among 300 respondents, shared information about the vulnerable plant parts of cucurbit crops for insect pests, where they reported that insect pests could attack leaf, stem, flower, root and fruit of cucurbit crops (Table 14).

Table 13. Farmers' response on vulnerable stages of cucurbits plants to insect pests

Name of Insects pest	Vulnerable stage of cucurbits plants		
	Seedling	Vegetative	Inflorescence
1.Fruit fly	20.6	15.8	63.6
2.Thrips	18.6	21.2	60.2
3.Mealy bug	10.4	11.8	77.8
4.White fly	12.2	15.7	72.1
5.Red mite	10.3	11.9	77.8
6.Epilachna beetle	14.4	16.7	68.9
7.Red Pumpkin beetle	11.8	14.4	73.8
8.Stink bug	10.5	12.9	76.6
9.Aphid	13.2	12.1	74.7
10.Jassid	14.1	11.8	74.1
11.Leaf miner	9.3	11.8	78.9
12.Cucumber caterpillar	8.1	10.7	81.2
13.Flea beetle	8.2	19.8	72
14.Fruit borer	12.4	11.3	67.9
15.Cucumber beetle	13.4	19.7	66.9
16.Cutworm	9.7	14.3	76
17.Semi lopper	3.5	8.7	87.8
18.Others	6.8	12.7	80.5

Table 14. Farmers' response on vulnerable parts of cucurbits plants to insect pests

Name of Insects pest	Vulnerable parts of Cucurbits plants				
	Leaf	**Stem**	**Flower**	**Root**	**Fruit**
1.Fruit fly	37.4	23.3	8.1		31.2
2.Thrips	31.2	36.3	14.1	11.4	
3.Mealy bug	33.2	27.6	29.8	9.4	
4.White fly	40.5	39.6	31.7		
5.Red mite	29.9	41.3	28.8		
6.Epilachna beetle	26.7	36.4	29.1	7.8	
7.Red Pumpkin beetle	28.9	16.4	25.5	5.8	23.4
8.Stink bug	31.5	24.3	19.8	9.8	14.6
9.Aphid	30.1	37.8	28.4	3.7	
10.Jassid	26.3	40.5	30.9	2.3	
11.Leaf miner	38.7	41.5	19.8		
12.Cucumber caterpillar	33.9	38.2	25.1	2.8	
13.Flea beetle	26.5	45.8	22.8	4.9	
14.Fruit borer	36.4		17.5	2.3	43.8
15.Cucumber beetle	38.4	39.5	28.7	3.4	
16.Cutworm	12.8	66.5	26.8	3.9	
17.Semi lopper	41.9	38.6	26	3.5	
18.Others	35.3	31.5	31.2	1.8	

4.4. Farmers' response on management practices against insect pests of cucurbit

Out of 300 respondent farmers, maximum (60.51%) farmers opined that they used pheromone trap against insect pests of cucurbit, followed by used food bait (56.71%), spraying insecticides (53.74%), application insecticide along with irrigation (58.56%) and application insecticide before irrigation (Table 15).

Table 15. Farmers' response on controlling insect pests of cucurbits

Code No.	Control options	Number of respondents [N=300]	% response
1	Spraying of insecticides on the cucurbits tree	161	53.74
2.	Used of Pheromone Trap	182	60.51
3.	Used food bait	170	56.71
4.	Used sticky trap	112	37.37
5.	Application of granular insecticide during seed sowing	61	20.37
6.	Application of granular insecticide before irrigation	148	49.35
7.	Application of insecticide with irrigation	176	58.56
8.	Seed treatment before sowing	104	34.53
9.	By irrigation	96	32.13
10.	Remove of harmful insect especially by hand picking	58	19.24
11.	By perching	89	29.22
12.	IPM management	117	39.03
13.	Application of balanced fertilizer	133	44.37
14.	Others	7	2.46
Multiple answer			

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the 6 upazila of 3 selected cucurbit vegetable growing districts of Bangladesh during the period from January 2018 to May 2018 to find out the current status and damage intensity of insect pests of cucurbit and their management options. The data were collected through interview of 300 farmers using a predesigned questionnaire considering 50 farmers from each upazila and 18 field level officers of DAE considering one UAO, one AEO and one SAAO of DAE. The results obtained from the studies have been presented below sequentially in various forms and thus interpreted and discussed as to extract the findings systematically in line with the objective of the study.

5.1. Summary

The field study that was conducted among 300 farmers, most (86.41%) were male farmers, while only 13.59% farmers were female. Among them maximum (33.06%) farmers' age was ranged from 41 to 50 years. Most of the farmers' 35.33% were under primary level.

Out of 300 respondent farmers' from the survey area, maximum (49.67%) were small farmer who had less than 10 decimal of cultivable land, and only 12.33% were large farmers who had more than 33 decimal of cultivable land.

From the discussion of the respondent farmers' it was revealed that average 19.44% of cultivable land was used for cucurbit vegetable cultivation by the farmers of the survey area.

The respondent farmers' were involved with cucurbit vegetables cultivation from average 7 years, whereas the farmer of the survey area were involved with the cucurbit vegetable cultivation maximum 12 years and minimum 1 year.

From the discussion with the respondent farmers' of survey area it was revealed that, maximum (15.66%) land of cucurbit cultivable land was used for bitter gourd cultivation by the farmers, followed by snake gourd (12.75%), water melon (12.47%), bottle gourd (11.37%), pointed gourd (10.52%), cucumber (9.77%), sweet gourd (7.13%), wax gourd (6.44%), sponge gourd (5.51%), ridge gourd (3.72%) and squash (2.55%). On the other hand, only 2.11% land of cucurbit cultivation was used for melon cultivation by the farmers of the survey area.

Out of 300 respondent farmers' under the survey area, maximum income (1,55,885 tk) was earned from bitter gourd per acre, followed by snake gourd (130585 tk/acre), cucumber (125572 tk/acre), pointed gourd (111225 tk/acre), bottle gourd (110255 tk/acre), wax gourd (105458 tk/acre), sweet gourd (98572 tk/acre) and water melon (95255 tk/acre). On the other hand, minimum income (55250 tk/acre) was earned from melon production by the farmers' under the survey area.

Out of 300 respondent farmers', maximum (80.76%) farmers' collected their cucurbit seed/seedlings from seed businessman.

Among the 300 respondent farmers', maximum (56.54%) farmers reported that bitter gourd was more susceptible than other cucurbit vegetables, and only 0.46% farmers' reported that squash was more susceptible than the others.

Out of 300 respondents, maximum (47.76%) farmer reported that fruit fly was the major insect for bitter gourd, snake gourd (47.91%), sponge gourd (43.78%), cucumber (40.03%) and bottle gourd (45.97%). Maximum (38.49%) farmer reported that thrips was the major insect for wax gourd, sweet gourd (37.07%), ridge gourd (29.00%), water melon (19.28%), squash (28.21%) and pointed gourd (13.51%). Maximum (47.62%) farmer reported that mealy bug was the major insect for sponge gourd.

Maximum (61.4%) farmers' opined that fruit fly was the major insect pest for cucurbit vegetables, and other major insect pests were Whitefly, red mite, jassid, epilachna beetle, thrips and red pumpkin beetle.

Maximum (14.3%) farmers' opined that aphid was the minor insect pest for cucurbit vegetables and other minor insect pests were mealy bug, stink bug, aphid, leaf miner, cucumber caterpillar, flea beetle, fruit borer, cucumber beetle, cutworm and semi-looper.

Severity of infestation, maximum (66.1%) respondents informed that fruit fly infestation was highly severe than the others.

Maximum (20.6%) respondent share information about the vulnerable stage of cucurbit fruit fly whereas only 3.5% respondent reported that, cucurbit vegetables were vulnerable for semi-looper in the field.

Among 300 respondents, shared information about the vulnerable plant parts of cucurbit crops for insect pests, where they reported that insect pests could attack leaf, stem, flower, root and fruit of cucurbit crops.

Maximum (60.51%) farmers opined that they used pheromone trap against insect pests of cucurbit, followed by used food bait (56.71%), spraying insecticides (53.74%), application insecticide along with irrigation (58.56%) and application insecticide before irrigation.

5.2. Conclusion

From this study it can be concluded that, some cucurbit production was profitable for the farmer, in this why they become more interested to cultivate cucurbit vegetables. Though farmers' were aware about different insect pests of cucurbit, among them maximum farmers reported that fruit fly and thrips were major insect pest of cucurbit. Beside this, respondent farmers were practiced pheromone trap for fruit fly in cucurbit vegetable fields and they also use insecticide against different insect pests of cucurbit.

From this above conclusion it can be recommended that:

1. This type of survey needed including more area of Bangladesh,
2. Beside pheromone trap using, more IPM practices needed to select appropriate packages against insect pests of Bangladesh.

CHAPTER VI

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APPENDIXES VII

Appendix 1: Questionnaire for cucurbits farmer

Sher-e-Bangla Agricultural University

Department of Entomology

Sher-e-Bangla Nagor, Dhaka-1207

INSECT PEST DIVERSITY AND RISK ASSESSMENT FOR CUCURBITS IN BANGLADESH

Prepared by:

MD. TOUHEDUL ISLAM

Department of Entomology

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Set-1: Questionnaire for cucurbits farmer

Code:						**Mobile**											

A.0 **Personal Information of Cucurbits Farmer**

A.1 Name: --

A.2 Village ---

A.3 Agri-Block: -----------------------------------

A.4 Upazilla: ---------------------------------------

A.5 Educational qualification: ------------------

A.6 District: ---------------------------------------

A.7 Age: --

A.5 Occupation: [Code: 1= Big farmer, 2= Medium farmer, 3= Small farmer] ☐

A.9 Sex: (Code: 1= Male, 2= Female) ☐

B.1 Name of the variety that you cultivated this year?

Sl. No.	Cultivated cucurbits variety	Land utilization for cucurbits cultivation (Decimal)	Yield (sack/acre)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
			*1 sack = 85 kg

B.2 Name of the Sources of purchasing cucurbits seeds?

	Sources	Type of answer [Code: Yes=1, No=2]	
1.	Own cucurbits seed		
2.	From neighbour		
3.	From BADC		
4.	From seed company		
5.	Local seed grower		
6.	Directly from Importer		
7.	NGOs		
8.	From cucurbits seed dealer		
9.	Other sources(if any)		

B.3 Major problems faced during cucurbits cultivation?

	Major problems	Type of answer [Code: Yes=1, No=2]	
1.	Insect pest attack		
2.	Weed infestation		
3.	Disease infection		
4.	Lack of HYV variety		
5.	Lack of irrigation facilities		
6.	Pest attack in storage		
7.	Lack of marketing facilities		
8.	Lack of farmers training facilities		
9.	High price of pesticides		
10	Low price of produced cucurbits		

B.4 Opinion on susceptibility of cucurbits species to pests

Sl. No.	Cucurbits species	Opinion on susceptibility to pests: [Code: Insect=1, Diseases=2, Weed=3]
1	Poited Gourd	
2	Snake Gourd	
3	Bitter Gourd	
4	Cucumber	
5	Bottle Gourd	
7	Sweet Gourd	
	Loofah Gourd	
9	Ridge Gourd	
10	Muskmelon	
11	Watermelon	

B.5 Insects occurrence in cucurbits field

Sl. No.	Name of Insects pest	Type of answer [Code: Yes=1, No=2]	
1	Fruit fly		
2	Thrips		
3	Mealy bug		
4	White fly		
5	Red mite		
6	Red pumpkin beetle		
7	Sting bug		
8	Leaf miner		
9	Cucumber caterpillar		
10	Cucumber beetle		
11	Friut borer		
12	Others		

B.6 Infestation status of insect pests of cucurbits in field condition

Sl. No.	Name of insect pests	Opinion on Infestation status of pests [Code: Major=1, Minor=2]
1	Fruit fly	
2	Thrips	
3	Mealy bug	
4	White fly	
5	Red mite	
6	Red pumpkin beetle	
7	Sting bug	
8	Leaf miner	
9	Cucumber caterpillar	
10	Cucumber beetle	
11	Fruit borer	

B.7 Vulnerable stages of cucurbits plants to insect pests in field condition

Sl. No.	Name of insect pests	Opinion on vulnerable stages of pests infestation [Code: Seedling=1, Vegetable=2. Tuberization=3]
1	Fruit fly	
2	Thrips	
3	Mealy bug	
4	White fly	
5	Red mite	
6	Red pumpkin beetle	
7	Sting bug	
8	Leaf miner	
9	Cucumber caterpillar	
10	Cucumber beetle	
11	Fruit borer	
12	Others	

B.8 Vulnerable parts of cucurbits plants to insect pests in field condition

Sl. No.	Name of insect pests	Opinion on vulnerable parts of plants to pests infestation [Code: Leaf=1, Stem=2. Tuber=3, Root=4]
1	Fruit fly	
2	Thrips	
3	Mealy bug	
4	White fly	
5	Red mite	
6	Red pumpkin beetle	
7	Sting bug	
8	Leaf miner	
9	Cucumber caterpillar	
10	Cucumber beetle	
11	Fruit borer	
12	Others	

B.9 Infestation severity of cucurbits by insect pests in field condition

Sl. No.	Name of insect pests	Opinion on Infestation severity [Code: High=1, Moderate=2. Low=3]
1	Fruit fly	
2	Thrips	
3	Mealy bug	
4	White fly	
5	Red mite	
6	Red pumpkin beetle	
7	Sting bug	
8	Leaf miner	
9	Cucumber caterpillar	
10	Cucumber beetle	

B.10 Is there any relationship among insect, disease and weed pest infestations in the cucurbits field? [Code: Yes = 1, No=2]

B.13 If yes, what is the relationship among insect, disease and weed incidence in cucurbits field?

13.1 Insect population high when weed incidence is:

1. high, 2. medium, 3. low and 4. don't know

13.2 Disease incidence high when weed incidence is:

1. high, 2. medium, 3. low and 4. don't know

13.3 Disease incidence high when incidence of insect vector is:

1. high, 2. medium, 3. low and 4. don't know

Appendix 2: FGD for agricultural crop farmer

Sher-e-Bangla Agricultural University
Department of Entomology
Sher-e-Bangla Nagor, Dhaka-1207.

HOST DIVERSITY AND RISK ASSESSMENT OF MEALYBUG IN BANGLADESH

Prepared by:
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Department of Entomology
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Set 2: Directions for F.G.D.
Code:
A.0 Location of F.G.D. --.
A.2 Village: ---. A.3 Agri Block: ----------------------------------.
A.4 Upazila: ---. A.5 District: --------------------------------------.

B.1 Name of the variety that you cultivated this year?

B.2 Name of the Sources of purchasing cucurbits seeds?

B.3 Major problems faced during cucurbits cultivation?

B.4 Opinion on susceptibility of cucurbits species to pests

B.5 Insects occurrence in cucurbits field

B.6. Infestation status of insect pests of cucurbits in field condition

B.7. Vulnerable stages of cucurbits plants to insect pests in field condition

B.8. Vulnerable parts of cucurbits plants to insect pests in field condition

B.9. Infestation severity of cucurbits by insect pests in field condition

B.10. Is there any relationship among insect, disease and weed pest infestations in the cucurbits field? [Code: Yes = 1, No=2]

B.11. what is the relationship among insect, disease and weed incidence in cucurbits field?

LIST OF PARTICIPANTS IN FOCUS GROUP DISCUSSION (FGD)

Sl. No.	Name	Village	Occupation	Mobile No.	Signature
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					