EVALUATION OF SOME CHEMICAL AND NON-CHEMICAL OPTIONS AGAINST THE INSECT PESTS OF GLADIOLUS

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CERTIFICATE

This is to certify that the thesis entitled, "**Evaluation Of Some Chemical And Non-Chemical Options Against The Insect Pests Of Gladiolus**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Entomology,** embodies the result of a piece of *bona fide* research work carried out by **Md. Jahir Uddin Majumdar,** Registration number: **14-06183** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2021
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Dedicated
To
The People Beseeching
Justice

ABBREVIATIONS

Agro Ecological Zone	= AEZ
And Others (Co-workers)	= *et al.*
Centimeter	= cm
Coefficient of Variation	= CV
Degree Centigrade	= ^{o}C
Degree of Freedom	= df
Example	= viz.
Fiscal Year	= FY
Genetically Modified	= GM
Least Significant Difference	= LSD
Metric Ton	= mt
Nitrogen	= N
Non- Significant	= NS
Per-Hectare	= ha^{-1}
Percentage	= %
Phosphorus	= P
Potassium	= K
Randomized Complete Block Design	= RCBD
Relative Humidity	= %RH
Standard Week	= SW
Sher-e-Bangla Agricultural University	= SAU
Standard Error	= SE
That is	= i.e
Tons	= t

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EVALUATION OF SOME CHEMICAL AND NON-CHEMICAL OPTIONS AGAINST THE INSECT PESTS OF GLADIOLUS

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ABSTRACT

The experiment was conducted at the apiary of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from January to June 2019 to study the efficacy of some non-chemical methods in comparison to conventional chemical pesticides against insect pests of gladiolus. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were: (1) Neem oil @ 3ml/L water, (2) Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m, (3) Neem seed kernel @ 200 gm/L water, (4) Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m, (5) Ripcord 10 EC @ 2.0 ml/L water, (6) Radial 20 EC @ 3.0 ml/L water and (7) Untreated. The highest number of plants (54.66) obtained in T_1 (Neem oil @ 3ml/L water). The highest number of pest population derived in (T_7) Untreated control and and followed by remained at T_6 (Radial 20 EC @3.0 ml/L water. The lowest pest population derived in T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L) 6 sq. m at early, mid and late stage of gladiolus respectively. The best outcomes has been obtained from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L) and lowest outcome came from untreated control.

CHAPTER I
INTRODUCTION

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INTRODUCTION

Floriculture is an international, multibillion-dollar industry that includes the production of bedding and garden plants, foliage plants, potted flowering plants, cut flowers, cut cultivated greens and floriculture materials. Flower cultivation has been found as a profitable business which assures higher potential to earn money compared to other crops. Gladiolus, *Gladiolus grandiflorus* is one of the most economically important flowers worldwide. The demand of cut flower increases day by day (Sharma and Sharga, 1988).

Gladiolus (*Gladiolus grandiflorus*) is an ornamental bulbous plant native to South Africa, known as Sward lily belongs to monocot family Iridadceae, having approximately one hundred and fifty known species (Negi *et al.*, 1982). It has its natural habitat in the Mediterranean regions and South Africa. In subcontinent, Gladiolus cultivation gets back the nineteenth century, when it was confined to temperate regions (Jhon *et al.*, 1996). Gladiolus is one of the most important bulbous cut flowers in the flower industry. It occupies the fifth position in the international floriculture trade. It has great economic value as a cut flower and for decoration and known as queen amongst the bulbous flower.

However, the production of gladiolus is hindered by various factors. Among these factors, insect pests are major keys. Among the major insect pests of gladiolus, aphids, thrips and cutworms are notable.

Thrips is one of the most serious pests of gladiolus. Yellow coloured nymphs and black adults damage leaves and spikes. Affected leaves and spikes develop silver streaks, turn brown, get deformed and dry if damage is severe. Attack on young

plants reduces flower production. The pest also attacks corms under storage. Infected corms become sticky, shrivel and produce weak plants when planted.

Cutworms attack mainly the newly planted gladiolus plants. Female moth lays eggs near ground on plant parts. Hatched larvae feed during nights on emerging shoots. Grown up larvae, which are clay colored, cut the plants at ground level. Plants are vulnerable to attack up to 3rd leaf stage. They also damage underground corms and developing spikes. (Mahnata and Pagwan, 1994).

Biological control is defined as the action of natural enemies on a population of pests in order to keep it at a population density that does not cause economic damage to crops (Pal and McSpadden Gardener 2006). Natural enemies have been known since the third century BC, when the Chinese used predatory ants for pest control in citrus. However, after 1939, with the synthesis of the chlorinated pesticide dichlorodiphenyltrichloroethane (DDT) and organophosphorus pesticides, research on synthetic chemical pesticides and their use increased greatly, while the opposite occurred with biological control methods (Doutt 1964, Niu *et al.* 2014). Currently, with the emergence of the concept of Integrated Pest Management (IPM), there is a resurgence of research with emphasis on biological control techniques. Such systems seek to harmoniously integrate various forms of control, with emphasis on biological control, in order to gain economic, social, and environmental improvements (Kogan 1998, Ehler 2006, EPA 2016).

Neem has acquired commercial recognition due to its various beneficial properties, which have been extensively investigated over time. Compared to conventional chemicals, which are generally persistent in the environment and highly toxic, botanical pesticides are biodegradable and leave no harmful residues. Most botanical pesticides are non-phytotoxic and are also more selective toward the target pest.

Trichogramma is a genus of minute polyphagous wasps that are endoparasitoids of insect eggs. *Trichogramma* is one of around 80 genera from the family Trichogrammatidae, with over 200 species worldwide. Although several groups of egg parasitoids are commonly employed for biological control throughout the world, *Trichogramma* spp. have been the most extensively studied. More than a thousand papers have been published on *Trichogramma* species, and they are the most used biological control agents in the world. *Trichogramma* spp. have less than 10,000 neurons, approaching the size limit of how small an insect can be, determined by how few neurons they can fit in their central nervous systems, yet exhibiting a complex behavior to sustain their lives.

Keeping all the information ahead, present study was undertaken to accomplish the following objectives-

1. To identify incidence of different insect pests of gladiolus and
2. To evaluate some chemical and non-chemical options insecticides for controlling insect pests of gladiolus.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Gladiolus is one of the most common and important flower in Bangladesh aspects, as well as many other countries around the world. Insect and Pests have an impact on growth and yield of gladiolus flower. Various researchers from around the world have conducted studies on the infestation of insects pest of gladiolus. Many studies on growth and yield of gladiolus have been conducted in many countries around the world. The work done in Bangladesh thus far has been insufficient and conclusive. Nonetheless, some of the most important and informative works and research findings on this topic have been reviewed in this chapter under the following headings:

2.1. Biology of gladiolus

Cultivated gladiolus belongs to Genus *Gladiolus,* Species: *grandiflorus,* Order: Iridales, Family: 'Iridaceae', Sub- family: 'Iriodae' Inflorescence: Spike. In gladiolus, new varieties are evolved through hybridization. Being a flowering plant, the study of floral biology is the prerequisite for undertaking conventional breeding program so that maximum possible number of viable seeds may be produced in the shortest possible time (Mahawer & Misra 1993). Gladiolus genotypes exhibit great variability in respect of days to flower, time of anthesis, anther dehiscence and stigma receptivity. Asynchrony in such flowering characteristics could be an impediment to plant breeders for hybridization. Gladiolus inflorescence is the spike. As such, the individual florets are attached directly to the axis. The outermost three segments make up the calyx and the next whorl of three segments comprises the corolla. The perianth surrounds three stamens and a tricarpeled pistil with a three-forked stigma. The ovary contains between 75 and 150 ovules. Each flower bud is enclosed separately

within its own spathe that consists of two green bracts. The anthers dehisce within 3-4 hours after unfurling of the perianth with most of the pollen falling down on the ground or landing on the lower tepals or lip of the floret. The position of the stigma is above anther and is not receptive until it becomes feathery (Nazir & Dwivedi, 2006).

2.2. Aphid

2.2.1. Distribution

Aphid occurs in tropical and temperate regions throughout the world except northernmost areas. In Bangladesh, it is regularly a pest in the southeast and southwest, but is occasionally damaging everywhere. Because aphid sometimes overwinters in greenhouses, and may be introduced into the field with transplants in the spring, it has potential to be damaging almost anywhere (Stoetzel *et al.* 1996).

2.2.2. Host plants

Aphid has a very wide host range. At least 60 host plants are known in tropical region, and perhaps 700 host plants worldwide. However, the taxonomy of this species is uncertain, so some records may be incorrect. Among cucurbit vegetables, it can be a serious pest on watermelon, cucumber, and cantaloupe, and to a lesser degree squash and pumpkin (Slosser *et al.* 1989). This is the basis for the common name melon aphid. Other vegetable crops sometimes affected are flowers, asparagus, bean, beet, carrot, celery, parsley, parsnip, pea, pepper, radish, tomato, eggplant, and okra. Some other important crops injured regularly are citrus, cotton, and hibiscus. In the south, cotton is an important host, which explains the second common name, cotton aphid.

2.2.3. Biology and life cycle

The life cycle differs greatly between north and south. In the north, female nymphs hatch from eggs in the spring on the primary hosts. They may feed,

mature, and reproduce parthenogenetically (viviparously) on this host all summer, or they may produce winged females that disperse to secondary hosts and form new colonies. The dispersants typically select new growth to feed upon, and may produce both winged (alate) and wingless (apterous) female offspring. Under high density conditions, deterioration of the host plant, or upon arrival of autumn, production of winged forms predominates. During periods stressful to the host plant, small yellow or white forms of the aphid are also produced. Late in the season, winged females apparently seek primary hosts, and eventually both males and egg-laying (oviparous) females are produced. They mate and females deposit yellow eggs: eggs are the only overwintering form under cold conditions. Under warm conditions, a generation can be completed parthenogenetically in about seven days (Romanow *et al.* 1986).

In the south, and at least as far north as Arkansas, sexual forms are not important. Females continue to produce offspring without mating so long as weather allows feeding and growth. Unlike many aphid species, melon aphid is not adversely affected by hot weather. Melon aphid can complete its development and reproduce in as little as a week, so numerous generations are possible under suitable environmental conditions.

Egg: When first deposited, the eggs are yellow, but they soon become shiny black in color. As noted previously, the eggs normally are deposited on catalpa and rose of sharon.

Nymph: The nymphs vary in color from tan to gray or green, and often are marked with dark head, thorax and wing pads, and with the distal portion of the abdomen dark green. The body is dull in color because it is dusted with wax secretions. The nymphal period averages about seven days.

Adult: The wingless (apterous) parthenogenetic females are 1 to 2 mm in length.

The body is quite variable in color: light green mottled with dark green is most common, but also occurring are whitish, yellow, pale green, and dark green forms. The legs are pale with the tips of the tibiae and tarsi black. The cornicles also are black. Small yellow forms apparently are produced in response to crowding or plant stress. Winged (alate) parthenogenetic females measure 1.1 to 1.7 mm in length. The head and thorax are black, and the abdomen yellowish green except for the tip of the abdomen, which is darker. The wing veins are brown. The egg-laying (oviparous) female is dark purplish green; the male is similar. The duration of the adult's reproductive period is about 15 days, and the post-reproductive period five days. These values vary considerably, mostly as a function of temperature. The optimal temperature for reproduction is reported to be about 21 to 27 degrees. Viviparous (gives birth to live young) females produce a total of about 70 to 80 offspring at a rate of 4.3 per day.

2.2.4. Nature of damage

Aphids feed on the underside of leaves, or on growing tip of vines, sucking nutrients from the plant. The foliage may become chlorotic and die prematurely (Perring *et al.*1992). Their feeding also causes a great deal of distortion and leaf curling, hindering photosynthetic capacity of the plant. In addition, they secrete a great deal of honeydew which provides a substrate for growth of sooty mold, so the quality of fruit may be impaired and the photosynthetic capacity of foliage further hindered.

Melon aphid effectively transmits potyviruses, although it is only one of dozens of species implicated in the spread of plant viruses in cucurbits. Cucumber mosaic virus, watermelon mosaic virus 2, and zucchini yellow mosaic virus are transmitted despite applications of insecticide and oil sprays, probably because the viruses can be transmitted within 15 seconds (Marco 1986).

2.3. Thrips

2.3.1. Distribution

The flower thrips, *Frankliniella tritici* (Fitch) is one of the most abundant species of flower thrips (Thysanoptera: Thripidae) in the eastern United States (Reitz 2008). The official common name established by the Entomological Society of America for this species is flower thrips, although the name flower thrips is often applied generically to the numerous species in the genus *Frankliniella* that inhabit flowers. For this reason, it is frequently referred to as the eastern flower thrips, presumably for its distribution in the eastern United States.

Several species in the genus *Frankliniella* are considered economic pests and cause damage to a wide variety of crops through feeding and oviposition (Childers 1997). Several species are able to vector orthotospoviruses (or tospoviruses), including Tomato spotted wilt virus. However, *Frankliniella tritici* is not a vector of Tomato spotted wilt virus and is considered a pest of secondary importance (de Assis Filho 2005).

2.3.2. Host Plants

Frankliniella tritici infests the flowers of a wide variety of crops including asparagus, blackberry, cotton, eggplant, peach, pepper, rye, soybean, strawberry, and tomato (Funderburk et al. 2015a, 2015b, Cluever and Smith 2016). *Frankliniella tritici* has been recorded from ornamentals such as chrysanthemum and rose (Cluever and Smith 2016). In addition to agricultural crops and ornamentals, *Frankliniella tritici* is found in several species of flowering weeds including morning glory, dandelion, wood sorrel, and clover (Chellemi *et al.* 1994). In a study in northern Florida, *Frankliniella tritici* were collected from 48 plant species over the course of one year with 18 plants identified as reproductive hosts (Paini *et al*. 2007).

2.3.3. Biology and life cycle

Eggs: The eggs of *Frankliniella tritici* are kidney shaped and approximately 0.4 mm in length (Arthurs et al. 2015). Adult females deposit eggs in plant tissue and may lay up to 17 eggs per day (Reitz 2008).

Larva: Larvae are wingless, yellow and resemble adults. They are elongate and oval and approximately 0.5 mm in length (Cluever and Smith 2016).

Pupa: Propupa have wing buds and the antennae are straight, whereas the pupa has the antennae pulled back over the head (Cluever and Smith 2016). Pupa range in size from 0.5 mm to 1mm in length.

Frankliniella tritici larvae and pupae closely resemble other *Frankliniella* species and are not typically identified to species in this stage (Cluever and Smith 2016).

Adults: Adults possess fringed wings and are yellow in color. Adults are elongate, and approximately 1 mm in length (Arthurs *et al*. 2015).

Frankliniella tritici are haplodiploid; males are produced from unfertilized eggs and diploid females are produced from fertilized eggs (Reitz 2009). The life cycle of Frankliniella tritici consists of an egg, two larval stages, prepupa, pupa and adult (Childers 1997). Frankliniella tritici feed on plant tissue during the larval and adult stages, but the pupal stages are found in the soil and do not feed (Arthurs *et al.* 2015). The developmental time from egg to adult is approximately two to three weeks (Reitz 2008) with a minimum development temperature of 10°C (Toapanta 2001). Adults lay eggs in plant tissue and can lay up to 17 eggs per day (Reitz 2008). Larvae and adults are highly mobile and found in the flower or on the fruit of host plants (Funderburk et al. 2015b). Adults live for approximately 38 days (Reitz 2008). Frankliniella tritici have multiple generations per year and

populations develop more rapidly as temperature increase (Funderburk *et al.* 2015a, 2015b).

2.3.4. Nature of damage

In the southeastern United States, *Frankliniella tritici*, along with other *Frankliniella* species, is recognized as an early-season pest of seedling cotton (Reed *et al.* 2006). Adults feed on the new terminal growth and underside of the leaves (Cotton Insect Management Guide 2017) causing silvering of the plant tissue and a reduction in photosynthesis (Kirk 2002). Plants damaged by thrips may be stunted and leaves may be distorted.

In northern Florida, *Frankliniella tritici* is the most common species of thrips found in the flowers of eggplant, pepper and tomato; however, they are not damaging, even at densities of 20 to 25 adults per flower (Demirozer *et al*. 2012, Funderburk et al. 2015a, 2015b). *Frankliniella tritici* has been shown to outcompete the highly damaging western flower thrips, *Frankliniella occidentalis* (Paini *et al*. 2008).

2.4. Cutworm

2.4.1. Distribution

The origin of black cutworm is uncertain, though it is now found in many regions of the world, being absent principally from some tropical regions and cold areas. It is more widespread, and damaging, in the northern hemisphere than the southern hemisphere. It annually reinvades temperate areas, overwintering in warmer or subtropical regions (Busching and Turpin 1976).

Long distance dispersal of adults has long been suspected in Europe, China, and North America. The basic pattern is to move north in the spring, and south in the autumn. Studies in the United States demonstrated northward displacement of moths during the spring in the range of 1000 km in two to four days when assisted by northward flowing wind. Similar displacement to the south and southwest has been documented in the autumn (Busching and Turpin 1977).

2.4.2. Host plants

Black cutworm has a wide host range. Nearly all vegetables can be consumed, and this species also feeds on alfalfa, clover, cotton, rice, sorghum, strawberry, sugarbeet, tobacco, and sometimes grains and grasses. In the midwestern USA it is considered to be a serious corn pest. Among the weeds suitable for larval development are bluegrass, *Poa pratensis*; curled dock, *Rumex crispus;* lambsquarters, *Chenopodium album*; yellow rocket, *Barbarea vulgaris;* and redroot pigweed, *Amaranthus retroflexus.* The preference by black cutworm for weeds is sometimes quite pronounced, and crops will be attacked only after the weeds are consumed. Adults feed on nectar from flowers. Deciduous trees and shrub such as linden, wild plum, crabapple, and lilac are especially attractive to moths (Harris 1962b).

2.4.3. Biology and life cycle

The number of generations occurring annually varies with weather conditions. In North America, there are one to two generations in Canada but two to four in the United States. In Tennessee, USA, moths are present in March-May, June-July, July-August, and September-December. Based on light trap collections, moths are reported to be abundant in Arkansas, USA (a warm climate) during May-June and September-October, and in New York, USA (a cool climate), they occur mostly in June-July. However, light traps are not very effective during the spring flight, and underestimate early season. Thus, the phenology of black cutworm remains uncertain, or perhaps is inherently variable due to the vagaries associated with long range dispersal (Showers *et al*. 1993).

Overwintering has been reported to occur in the pupal stage in most areas where overwintering occurs, but larvae persist throughout the winter in Florida, USA, a subtropical environment. Pupae have been known to overwinter as far north as Tennessee, but apparently are incapable of surviving farther north. Thus, moths collected in the central region of USA in March and April are principally dispersing individuals that are past their peak egg production period (Smelser *et al*. 1991**)**. Nonetheless, they inoculate the area and allow production of additional generations, including moths that disperse north into Canada. Duration of the life cycle is normally 35 to 60 days.

Adult: The adult is fairly large in size, with a wingspan of 40 to 55 mm. The forewing, especially the proximal two-thirds, is uniformly dark brown. The distal area is marked with a lighter irregular band, and a small but distinct black dash extends distally from the bean-shaped wing spot. The hind wings are whitish to gray, and the veins marked with darker scales. The adult preoviposition period is about seven to 10 days. Moths select low-growing broadleaf plants preferentially for oviposition, but lacking these will deposit eggs on dead plant material. Soil is an unsuitable oviposition site.

Egg: The egg is white in color initially, but turns brown with age. It measures 0.43 to 0.50 mm high and 0.51 to 0.58 mm wide and is nearly spherical in shape, with a slightly flattened base. The egg bears 35 to 40 ribs that radiate from the apex; the ribs are alternately long and short. The eggs normally are deposited in clusters on foliage. Females may deposit 1200 to 1900 eggs. Duration of the egg stage is three to six days.

Larva: There are five to nine instars, with a total of six to seven instars most common. Head capsule widths are about 0.26-0.35, 0.45-0.53, 0.61-0.72, 0.90-1.60, 2.1-2.8, 3.2-3.5, 3.6-4.3, and 3.7-4.1 mm for instars one through eight, respectively. Head capsule widths are very similar for instars one through four, but thereafter those individuals that display eight or nine instars show only small increments in width at each molt and eventually attain head capsule sizes no larger than those displaying only six or seven instars.

Larval body length is reported to be 3.5, 5.3-6.2, 7, 10, 20-30, 30-45, 50, and 50 mm for instars one through eight, respectively. Duration of the larval stage is normally 20 to 40 days. Mean duration of instars one through six was reported to be 6.0, 5.0, 4.6, 4.3, 5.6, 4.0 days, respectively, at 22°C. Larval development is strongly influenced by temperature, with the optimal temperature about 27°C. Humidity is less important, but instars one through five thrive best at higher humidity.

In appearance, the larva is rather uniformly colored on the dorsal and lateral surfaces, ranging from light gray or gray-brown to nearly black. On some individuals, the dorsal region is slightly lighter or brownish in color, but the larva lacks a distinct dorsal band. Ventrally, the larva tends to be lighter in color. Close examination of the larval epidermis reveals that this species bears numerous dark, coarse granules over most of its body. The head is brownish with numerous dark spots. Larvae usually remain on the plant until the fourth instar, when they become photo-negative and hide in the soil during the daylight hours. In these latter instars they also tend to sever plants at the soil surface, pulling the plant tissue belowground. Larvae tend to be cannibalistic.

Pupa: Pupation occurs belowground at a depth of 3 to 12 cm. The pupa is 17 to 22 mm long and 5 to 6 mm wide, and dark brown. Duration of the pupal stage is normally 12 to 20 days.

2.4.4. Nature of damage

This species occurs frequently in many crops, and is one of the best-known cutworms. Despite the frequency of occurrence, however, it tends not to appear in great abundance, as is known in some other cutworms and armyworms. Black cutworm is not considered to be a climbing cutworm, most of the feeding occurring at soil level. However, larvae will feed aboveground until about the fourth instar. Larvae can consume over 400 sq cm of foliage during their development, but over 80% occurs during the terminal instar, and about 10% in the instar immediately preceding the last (Story and Keaster 1982). Thus, little foliage loss occurs during the early stages of development. Once the fourth instar is attained, larvae can do considerable damage by severing young plants, and a larva may cut several plants in a single night. Plants tend to outgrow their susceptibility to injury. Corn at the one-leaf stage is very susceptible to damage, but that by the 4 or 5-leaf stage plant yield was not reduced by larval feeding. Leaf feeding and cutting above the soil line are less damaging to corn than cutting at the

soil surface. Subterranean damage is very injurious.

2.5. Neem tree: its pest managing attributes

Attention is increasingly being paid to the use of natural compounds (such as essential oils) as a promising option to replace agrochemicals in agricultural pest control. These odoriferous substances are extracted from various aromatic plants, which are rich sources of biologically active secondary metabolites such as alkaloids, phenolics, and terpenoids (Esmaeili and Asgari, 2015), using extraction methods employing aqueous or organic solvents, or steam distillation. Their mechanisms of action can vary, especially when the effect is due to a combination of compounds (de Oliveira, 2011; Esmaeili and Asgari, 2015). Neem oil is extracted from the neem tree, *Azadirachta indica* Juss., a member of the Meliaceae family that originates from the Indian subcontinent and is now valued worldwide as an important source of phytochemicals for use in human health and pest control. Azadirachta is a fast-growing small-to-medium sized evergreen tree, with wide and spreading branches. It can tolerate high temperatures as well as poor or degraded soil. The young leaves are reddish to purple, while the mature leaves are bright green, consisting of petiole, lamina, and the base that attaches the leaf to the stem and may bear two small lateral leaf-like structures known as stipules (Norten and Pütz, 1999; Forim *et al*., 2014).

Neem oil contains at least 100 biologically active compounds. Among them, the major constituents are triterpenes known as limonoids, the most important being azadirachtin, which appears to cause 90% of the effect on most pests. The compound has a melting point of 160 C and molecular weight of 720 g/mol. Other components present include meliantriol, nimbin, nimbidin, nimbinin, nimbolides, fatty acids (oleic, stearic, and palmitic), and salannin.

The main neem product is the oil extracted from the seeds by different techniques. The other parts of the neem tree contain less azadirachtin, but are also used for oil extraction (Nicoletti *et al*., 2012). It has been suggested that the content of azadirachtin in the seeds can be increased by artificial infection with arbuscular mycorrhiza (Venkateswarlu *et al*., 2008). Among the botanical insecticides currently marketed, neem oil is one of the least toxic to humans and shows very low toxicity to beneficial organisms, so it is, therefore, very promising for the control of many pests. Target insect species include the following: *Anopheles stephensi* (Lucantoni *et al*., 2006), *A. culicifacies* (Chandramohan *et al*., 2016), *Ceraeochrysa claveri* (Scudeler *et al*., 2013, 2014; Scudeler and dos Santos, 2013), *Cnaphalocrocis medinalis* (Senthil Nathan *et al*.,2006), *Diaphorina citri* (Weathersbee and McKenzie,2005), *Helicoverpa armigera* (Ahmad *et al*.,2015), *Mamestra brassicae* (Seljåsen and Meadow, 2006), *Nilaparvata lugens* Stal (Senthil-Nathan *et al*., 2009), *Pieris brassicae* (Hasan and Shafiq Ansari, 2011), and *Spodoptera frugiperda* (Tavares *et al*., 2010). Arachnid targets include *Hyalomma anatolicum* excavatum (Abdel-Shafy and Zayed, 2002) and *Sarcoptes scabie var. cuniculi* larvae (Xu *et al*., 2010).

The oil is considered a contact insecticide, presenting systemic and translaminar activity (Cox, 2002). It has a broad spectrum of action, inhibiting feeding, affecting hormone function in juvenile stages, reducing ecdysone, deregulating growth, altering development and reproduction, suppressing fertility, sterilizing, repelling oviposition, and disrupting molting processes (Brahmachari, 2004). Little is known about the mode of action of azadirachtin as a feeding inhibitor, although it is possible that it stimulates cells involved in feeding inhibition, causing weakness and pest death (Brahmachari, 2004). Azadirachtin, salannin, and other limonoids present in neem oil inhibit ecdysone 20-monooxygenase, the enzyme responsible for catalyzing the final step in conversion of ecdysone to the active hormone, 20-hydroxyecdysone, which controls the insec metamorphosis

process. However, these effects are probably secondary to the action of azadirachtin in blocking microtubule formation in actively dividing cells (Morgan, 2009). Moreover, azadirachtin can inhibit the release of prothoracicotropic hormone and allatotropins from the brain-corpus cardiacum complex, resulting in problems of fertility and fecundity (Mulla and Su, 1999).

2.6. Trichogramma evenescense: an effective controlling agent

2.6.1. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hymenoptera
Family: Trichogrammatidae
Genus: *Trichogramma*
Species: *Trichogramma evanescens*

2.6.2. Overview of *T. evanescense*

There are many biological control agents such as predators, parasitoids, micro-organisms which control the insect pests naturally. Specially, parasitoids have a major impact in natural and ecosystem where they influence or regulate the population density of many of their hosts. In nature, parasitoid can be categorized as egg, larval and pupal parasitoid. Among them different species of *Trichogramma* are considered as the most important egg parasitoid especially for augmentation. *Trichogramma* and other egg parasitoids are generally part of the local ecosystem and often contribute to the control of Lepidopteran pests in absence of disruptive pesticides. *Trichogramma* spp are the tiny wasp belongs to

the family Trichogrammatidae under the order Hymenoptera. *Trichogramma* spp are the most widely used insect enemy in the world (Waage and Ming 1984 and Li-Ying1994). Trichogramma is a facultative gregarious (Rabinovich 1971) polyphagous egg parasitoid that often used in innundative biological control programs (Smith 1996) against a wide range of Lepidopterous eggs (Corrigan and Laing 1994). Trichogramma are used against *Helicoverpa armigera* on a variety of crops in India and are effective biological control agent against the European corn borer *Ostrinia nubilalis* (Lepidoptera: Pyralidae) and they are also used to provide foliage protection in forests (Bai *et al*. 1995). *Trichogramma* spp can be used in rice pest management (Beevi *et al*. 2003). These are often used against Lepidopteran pest in stored grain, where *Trichogramma evanescens* and *T. embryopaga* attack *Ephestia kuehniella* and *E. elutella* (Scholler *et al*.1996). In most crop production system, the numbers of Lepidopteran pest eggs destroyed by native population of *Trichogramma* spp are not sufficient to prevent the pest from reaching the damaging level. So, mass rearing and consequent augmentation is necessary. Although worldwide *Trichogramma* spp have been considered as most important egg parasitoid for innundative biological agents but in Bangladesh very few works have so far been done on the mass rearing as well as its field efficacy.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

The present investigation entitled “Evaluation of some chemical and non-chemical options against the infestation of insect pests of cut flower (gladiolus)” was carried out in the experimental field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during rabi season 2019. The present chapter deals with the material used and methods required. Materials and methods include location of experiment, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection and data analysis procedure that followed in this experiment has been presented under the following headings:

3.1. Description of the experimental site

3.1.1. Geographical location and climate

The experiment was conducted during the period from January 2019 to June 2019.The present piece of research work was conducted in the apiary of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The location of the site is $23^0$74/N latitude and $90^0$035/E longitude with an elevation of 8.2 meter from sea level. The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by heavy scanty rainfall during the rabi season. The soil belonged to “The Modhupur Tract”, AEZ-28 (FAO 1988). The experimental area was flat having available irrigation and drainage system and above flood level.

3.2. Planting materials

Gladiolus was used as the test crop in this experiment. Corms were collected from BARI (Bangladesh Agricultural Research Institute), Gazipur, Bangladesh.

3.3. Treatments of the experiment

Details of treatments are given below:

Table 1. Treatments used in the experiment

Sl	Treatment	Name & Dose
1	T_1	Neem oil @ 3ml/L water were applied 5 times at 15 days intervals
2	T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/L per 6 sq. m were applied 5 times at 15 days intervals
3	T_3	Neem seed kernel @ 200 gm/L water were applied 5 times at 15 days intervals
4	T_4	Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L per 6 sq. m were applied 5 times at 15 days intervals
5	T_5	Ripcord 10 EC @ 2.0 ml/L water were applied 5 times at 15 days intervals
6	T_6	Radial 20 EC @ 3.0 ml/L water were applied 5 times at 15 days intervals
7	T_7	Untreated

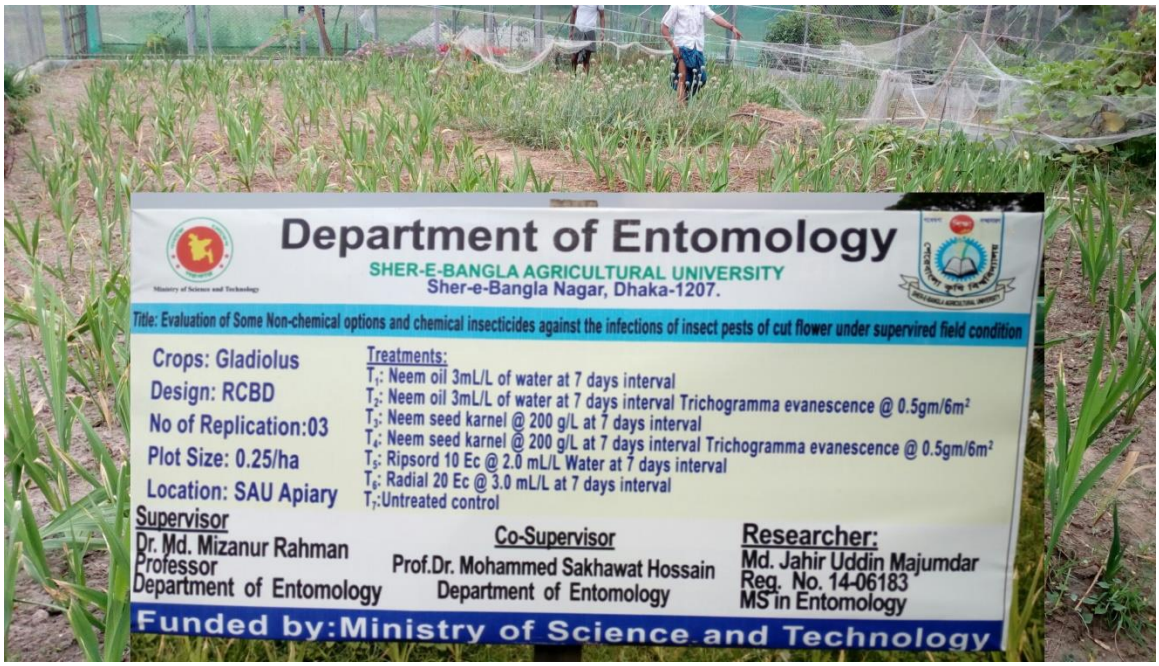

Plate 1. Experimental site

3.4. Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications, where the experimental area was divided into three blocks representing the replications to reduce soil hetero-genetic effects. Each block was divided into seven-unit plots as treatments demarked with raised bunds. Thus, the total numbers of plots were 21. The unit plot size was 3.0 m × 1.5 m. The distance maintained between two blocks and two plots were 0.5 m and 0.5 m, respectively.

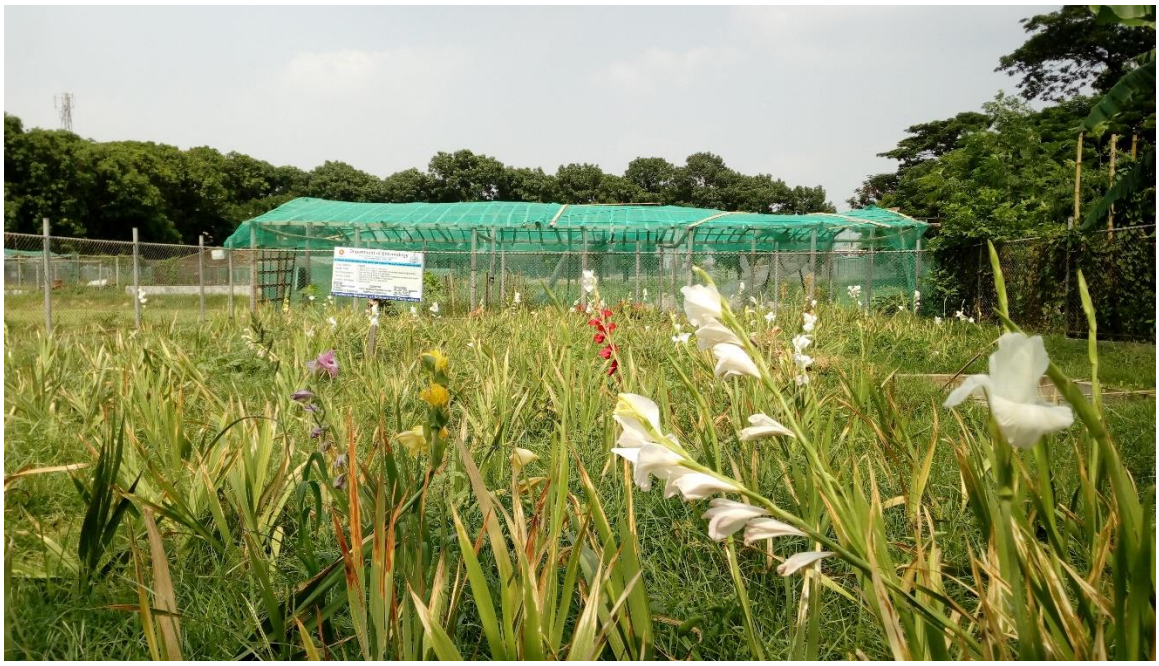

Plate 2. Experimental plots

3.5. Land preparation and intercultural operation

Two varieties were sown on February 10, 2019. The plot selected for conducting the experiment was opened in the 3rd week of January, 2019 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth condition. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot. Corms were transplanted on February 27, 2019. Irrigation (9 times) and drainage were provided when required. Weeding (5 times)

was done to keep the plots free from weeds, which ultimately ensured better growth and development.

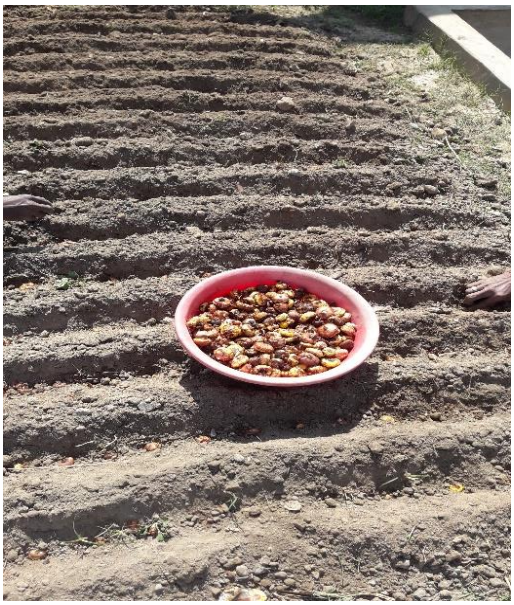

Plate 3. Corm of gladiolus

Plate 4. During corm sowing

3.6. Fertilizers and manure application

The fertilizers N, P, K in the form of Urea, TSP, MoP respectively whereas S, Zn and B in the form of Gypsum, Zinc sulphat and Boric acid were applied as per recommendation of Bangladesh Agricultural Research Institute (Mondal *et al.* 2011). Urea was applied as granule. The entire amount of TSP, MP, gypsum, zinc sulphate and Boric acid were applied during the final preparation of land. The Urea was applied in two equal installments at 20-25 DAT and flowering initiation.

Table 2: Manure and fertilizers applied during experimental period

Manure/Fertilizer	**Dose (Kg/ha)**		
	Basal	**20-25 DAT**	**Flowering**
Cow dung	10000		
Urea	-	150	150
TSP	375		
MP	300		
Gypsum	100		
Zinc Sulphate	8		
Boric acid	12		

Mondal *et al.* (2011)

3.7. Treatment application method, time and instrument

Treatments were sprayed 5 times at 15 days interval with the help of knapsack sprayer. Neem seed kernel were prepared by grinding the neem seed and make them powder and finally soaked it in the water. Other Chemical insectisides and pesticides were collected from market.

3.8. Data recording

3.8.1. Pest incidence in Gladiolus

Regular observations were made immediately after transplantation of plants once in a standard week to record different insects of gladiolus. The insects appearing on the crop right from transplantation up to flower harvest were recorded. The sequence in which the insects appeared was also noted. For data collection 10 plants from each plot were randomly selected and population of different insect pests and natural enemies there on was assessed. Observations on different insect pests were recorded as detailed below:

3.8.2. Aphid

The number of nymphs and adults of aphid, *Aphis gossypi* were counted on six leaves (each from 2 upper, middle and lower leaves per plant) of ten plants by examining each leaf carefully during early morning hours, when the pest was less active.

Plate 5. Aphid on gladiolus

To begin with, aphids on upper surface of the leaves were counted and then the leaf was tilted carefully to count population on the lower surface (Ramrao 2012).

3.8.3. Thrips

Six leaves (each of two from upper, middle and lower canopy per plant) of selected ten plants were carefully examined for the presence of nymph and adults of thrips and the nature of insects were recorded.

3.8.4. Cutworms

Each of selected 10 plants were examined carefully to assess the damage by cutworm and the nature of insects were recorded.

Plate 6. Harvested flower

3.9. Data analysis

Recorded data were put and compiled on MS excel spreadsheet. Later on, data were analyzed by using STATISTICS 10 software for analysis of variance. ANOVA was made by F variance test and the mean value comparisons were performed by Tukey's test.

CHAPTER IV

RESULT AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The results and the subsequent discussion of the present studies conducted are depicted in this section.

4.1. Effect of treatments on the number of Aphid was recorded at early flowering stage

It is evident that the lowest population (15.33) of aphid was recorded from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_3 (Neem seed Kernel @ 200 gm/L water), T_1 (Neem oil @ 3ml/L water), T_5 (Ripcord 10 EC @ 2.0 ml/L water) which was statistically similar to T_6 (Radial 20 EC @ 3.0 ml/L water). However, the highest aphid population (30) was recorded from T_7 (Untreated). The highest decrease over control (48.9%) was found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (11.14%) was found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 3. Effect of treatments on the number of Aphid per ten plants at early flowering

Sl.	Treatment	Number of Aphid	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	24.00 c	20
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	18.00 e	40
T_3	Neem seed kernel @ 200 gm/L water (T_3)	20.66 d	31.14
T_4	Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	15.33 f	48.9
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	26.33 b	12.24
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	26.66 b	11.14
T_7	Untreated Control (T_7)	30.00 a	-
	$LSD_{0.05}$	1.27	
	CV	4.91	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.2. Effect of treatments on the number of Aphid was recorded at mid flowering stage

It is evident that the lowest population (19.75) of aphid was recorded from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_3 (Neem seed Kernel @ 200 gm/L water), T_1 (Neem oil @ 3ml/L water), T_5 (Ripcord 10 EC @ 2.0 ml/L water), T_6 (Ripcord 10 EC @ 2.0 ml/L water). However, the highest aphid population (37.21) was recorded from T_7 (Untreated). The highest decrease over control (46.93%) was found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (1.93%) was found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 4. Effect of treatments on the number of aphid per ten plants at mid flowering stage

Sl.	Treatment	Number of aphid/10 plants	Reduction over control (%)
T_1	Neem oil @ 3ml/L water (T_1)	29.33 d	21.18
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	21.32 f	42.71
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	24.34 e	34.59
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	19.75 g	46.93
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	33.38 c	10.3
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	36.49 b	1.93
T_7	Untreated Control (T_7)	37.21 a	-
	$LSD_{0.05}$	0.63	
	CV	3.76	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.3. Effect of treatments on the number of aphid per ten plants at late flowering stage

It is evident that the lowest population (16.66) of aphid found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_3 (Neem seed Kernel @ 200 gm/L water), T_1 (Neem oil @ 3ml/L water), T_5 (Ripcord 10 EC @ 2.0 ml/L water), T_6 (Ripcord 10 EC @ 2.0 ml/L water). However the highest population found from T_6 (Radial 20 EC @ 3.0 ml/L water) which was statistically similar to T_7 (Untreated Control). The highest decrease over control (49.51%) found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (3.03%) found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 5. Effect of treatments on the number of aphid per ten plants at late flowering stage

Sl.	Treatment	Number of Aphid/10 plants	Reduction over control (%)
T_1	Neem oil @ 3ml/L water (T_1)	25.66 c	22.24
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	19.33 e	41.42
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	22.00 d	33.33
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	16.66 f	49.51
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	29.00 b	12.12
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	32.00 a	3.03
T_7	Untreated Control (T_7)	33.00 a	-
	$LSD_{0.05}$	1.29	
	CV	7.19	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.4. Effect of treatments on the number of thrips per ten plants at early flowering stage

It is evident that the lowest population (9.00) of thrips found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_3 (Neem seed Kernel @ 200 gm/L water), T_1 (Neem oil @ 3ml/L water) which was statistically similar to T_5 (Ripcord 10 EC @ 2.0 ml/L water), T_6 (Radial 20 EC @ 3.0 ml/L water) which was statistically similar to T_7 (Untreated Control). However, the highest thrips population (16.41) obtained from T_7 (Untreated). The highest decrease over control (45.15%) found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (2.12%) found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 6. Effect of treatments on the number of thrips per ten plants at early flowering

Sl.	Treatment	Number of Thrips/10 plants	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	13.00 b	20.78
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	10.33 cd	37.05
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	11.00 c	32.96
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	9.00 d	45.15
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	14.03 b	14.50
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	16.34 a	2.12
T_7	Untreated Control (T_7)	16.41 a	
	$LSD_{0.05}$	1.92	
	CV	4.70	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.5. Effect of treatments on the number of Thrips per ten plants at mid flowering stage

It is evident that the lowest population (15.00) of thrips was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) which was ststistically similar to T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m) followed by T_3 (Neem seed Kernel @ 200 gm/L water), T_1 (Neem oil @ 3ml/L water) which was statistically similar to T_5 (Ripcord 10 EC @ 2.0 ml/L water), T_6 (Radial 20 EC @ 3.0 ml/L water), T_7 (Untreated control). However, the highest thrips population (22.66) was recorded from T_7 (Untreated). The highest decrease over control (33.80%) found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (4.41%) was found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 7. Effect of treatments on the number of Thrips per ten plants at mid flowering

Sl.	Treatment	Number of Thrips	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	19.00 c	16.77
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	15.66 e	30.89
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	16.66 d	26.47
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	15.00 e	33.80
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	19.66 c	13.2
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	21.66 b	4.41
T_7	Untreated Control (T_7)	22.66 a	-
	$LSD_{0.05}$	0.81	
	CV		

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.6. Effect of treatments on the number of thrips per ten plants at late flowering stage

It is evident that the lowest population (12.69) of thrips was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) which was ststistically similar to T_3 (Neem seed Kernel @ 200 gm/L water) and T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m) followed by T_1 (Neem oil @ 3ml/L water), T_5 (Neem oil @ 3ml/L water), T_6 (Radial 20 EC @ 3.0 ml/L water) and T_7 (Untreated control). However, the highest thrips population (20.50) was obtained from T_7 (Untreated). The highest decrease over control (38.09%) was found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (5.46%) was found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 8. Effect of treatments on the number of Thrips per ten plants at late flowering

Sl.	Treatment	Number of Thrips	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	17.12 c	16.48
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	14.30 d	30.24
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	13.66 d	33.36
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	12.69 d	38.09
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	17.49 bc	14.68
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	19.38 ab	5.46
T_7	Untreated Control (T_7)	20.5 a	-
	$LSD_{0.05}$	2.21	
	CV	5.27	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.7. Effect of treatments on the damage percentage by cutworm per plot at 30 DAS

It is evident that the lowest population (6.67) of cutworm was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_3 (Neem seed Kernel @ 200 gm/L water), T_1 (Neem oil @ 3ml/L water), T_5 (Neem oil @ 3ml/L water), T_6 (Radial 20 EC @ 3.0 ml/L water) and T_7 (Untreated control). However, the highest cutworm population (15.20) was obtained from T_7 (Untreated). The highest decrease over control (56.11%) was found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (9.67%) was found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 9. Effect of treatments on the damage percentage by cutworm per plot at 30 DAS

Sl.	Treatment	% Damage by Cutworm	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	9.67 c	36.38
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	8.31 cd	45.32
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	8.33 cd	45.19
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	6.67 d	56.11
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	12.33 b	18.88
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	13.73 ab	9.67
T_7	Untreated Control (T_7)	15.20 a	
	$LSD_{0.05}$	1.83	
	CV	5.11	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.8. Effect of treatments on the damage percentage by cutworm per plot at 60 DAS

It is evident that the lowest damage (6.64) of cutworm was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by T_3 (Neem seed Kernel @ 200 gm/L water) which was statistically similar to T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_1 (Neem oil @ 3ml/L water), T_5 (Neem oil @ 3ml/L water) which was statistically similar to T_6 (Radial 20 EC @ 3.0 ml/L water) and T_7 (Untreated control). However, the highest cutworm population (15.83) was obtained from T_7 (Untreated). The highest decrease over control (58.05%) was found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (15.54%) was found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 10. Effect of treatments on the damage percentage by cutworm per plot at 60 DAS

Sl.	Treatment	% Damage by Cutworm	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	9.66 c	38.97
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	8.42 d	46.81
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	8.33 d	47.37
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	6.64 e	58.05
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	12.33 b	22.10
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	13.37 b	15.54
T_7	Untreated Control (T_7)	15.83 a	-
	$LSD_{0.05}$	1.14	
	CV	6.13	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.9. Effect of treatments on the damage percentage by cutworm per plot at 90 DAS

It is evident that the lowest population (6.52) of cutworm was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by by T_3 (Neem seed Kernel @ 200 gm/L water) which was statistically similar to T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_1 (Neem oil @ 3ml/L water), T_5 (Neem oil @ 3ml/L water), T_5 (Neem oil @ 3ml/L water) which was statistically similar to T_6 (Radial 20 EC @ 3.0 ml/L water) and T_7 (Untreated control). However, the highest cutworm population (15.19) was obtained from T_7 (Untreated). The highest decrease over control (57.07%) was found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) whereas the lowest decrease over control (12.24%) was found from T_6 (Radial 20 EC @ 3.0 ml/L water).

Table 11. Effect of treatments on the damage percentage by cutworm per plot at 90 DAS

Sl.	Treatment	% Damage by Cutworm	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	9.66 c	36.40
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	8.31 d	45.29
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	8.33 d	45.16
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	6.52 e	57.07
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	12.82 b	15.60
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	13.33 b	12.24
T_7	Untreated Control (T_7)	15.19 a	-
	$LSD_{0.05}$	1.14	
	CV	6.12	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.10. Effect of treatments on the number of healthy flower

From this table it is clear that highest number of healthy flower (38.5) was obtained from T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m) which was statistically similar with T_1 (Neem oil @ 3ml/L water), followed by T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m), T_3 (Neem seed Kernel @ 200 gm/L water) and they both are statistically similar. However, the lowest (24.5) number of healthy flower was found from control (untreated) which was statistically similar with of T_6 (Radial 20 EC @ 3.0 ml/L water), T_5 (Ripcord 10 EC @ 2.0 ml/L water). However, the highest increase (57.14%) over control was obtained from T_2 and lowest from T_6 (0.77%)

Table 12. Effect of treatments on the number of healthy flower

Sl.	Treatment	Number of healthy flower	Increase Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	36.66 a	49.38
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	38.50 a	57.14
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	28.77 ab	17.42
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	33.50 ab	36.73
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	25.82 b	5.39
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	24.69 b	0.77
T_7	Untreated Control (T_7)	24.5 b	-
	$LSD_{0.05}$	11.37	
	CV	12.23	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.11. Effect of treatments on the number of infested flower

From this table it is clear that highest number of infested flower (22.5) was recorded from T_7 (Untreated control) followed by T_6 (Radial 20 EC @ 3.0 ml/L water) which was statistically similar to T_5 (Ripcord 10 EC @ 2.0 ml/L water), T_1 (Neem oil @ 3ml/L water), T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_3 (Neem seed Kernel @ 200 gm/L water), T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m). However, the highest decrease (48.31%) over control was obtained from T_4 and lowest from T_6 (16.13%)

Table 13. Effect of treatments on the number of infested flower

Sl.	Treatment	Number of infested flower	Reduction Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	18.00 bc	20
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	15.33 cd	31.86
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	14.23 d	36.75
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	11.63 e	48.31
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	18.71 b	16.84
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	18.87 b	16.13
T_7	Untreated Control (T_7)	22.5 a	-
	$LSD_{0.05}$	2.74	
	CV	6.13	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.12. Effect of treatments on the number of plants per plot

From this table it is clear that the highest number of plants (54.66) was recorded from T_1 (Neem oil @ 3ml/L water) which was statistically similar that T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) followed by T_3 (Neem seed Kernel @ 200 gm/L water) which was also statistically similar to T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m), T_5 (Ripcord 10 EC @ 2.0 ml/L water), T_6 (Radial 20 EC @ 3.0 ml/L water) which was statistically similar to T_7 (Untreated control). However, the lowest (47.00) number of plants was found from T_7 (Untreated control).). However, the highest increase (15.59%) over control was obtained from T_4 and lowest from T_6 (1.59%).

Table 14. Effect of treatments on the number of plants per plot

Sl.	Treatment	Number of plant/plot	Increase Over Control (%)
T_1	Neem oil @ 3ml/L water (T_1)	54.66 d	16.29
T_2	Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m (T_2)	53.33 c	13.46
T_3	Neem seed Kernel @ 200 gm/L water (T_3)	53.00 cd	12.76
T_4	Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m (T_4)	54.33 d	15.59
T_5	Ripcord 10 EC @ 2.0 ml/L water (T_5)	48.33 b	2.82
T_6	Radial 20 EC @ 3.0 ml/L water (T_6)	47.75 a	1.59
T_7	Untreated Control (T_7)	47.00 a	-
	$LSD_{0.05}$	3.47	
	CV	16.45	

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

CHAPTER V

SUMMARY AND CONCLUSION

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The experiment was conducted at the apiary of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from January to June 2019 to study the efficacy of some promising biopesticides against insect pests of gladiolus. The treatments were Neem oil @ 3ml/L water, Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. m, Neem seed kernel @ 200 gm/L water, Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m, Ripcord 10 EC @ 2.0 ml/L water, Radial 20 EC @ 3.0 ml/L water and Untreated. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on number of aphids, thrips, cutworm damage, healthy and infested flower was recorded.

It is evident that the lowest population (15.33) of aphid was found from T4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) at early flowering. It has been shown that the lowest population (19.75) of aphids was found from T_4 (Neem seed karnel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) at mid flowering. And at late flowering it is found that the lowest population (19.75) of aphid was found from T_4 (Neem seed kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m).

It is evident that the lowest population (9.00) of thrips was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) at early flowering. It is also evident that the lowest population (15.00) of thrips found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) at mid flowering. However, at late flowering, it is evident that the lowest population (12.69) of thrips was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m).

In case of cutworm damage, it is evident that the lowest population (6.67) of cutworm was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) at early stage. At 60 DAS, it is evident that the lowest damage (6.64) of cutworm found was from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m). However, it is evident that the lowest population (6.52) of cutworm was found from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) at 90 DAS.

It has been found that highest number of healthy flower (38.5) was obtained from T_2 (Neem oil @ 3ml/L water + *Trichogramma evanescense* @ 0.5 gm/ 6 sq. whereas it is clear that highest number of infested flower (22.5) obtained from T_7 (Untreated control). From the results, it is clear that the highest number of plants (54.66) was obtained from T_1 (Neem oil @ 3ml/L water).

It can be concluded that the best outcomes has been obtained from T_4 (Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m) and lowest outcome came from control.

According to these findings, following recommendations can be made-

1. Neem seed Kernel @ 200 gm/L water + *Trichogramma evanescense* @ 0.5 gm/L 6 sq. m can be used for controlling gladiolus pests.
2. Bio-controlling agents are recommended for sustainable pest management tactics.
3. This experiment should be repeated for several times at different locations of Bangladesh.

CHAPTER VI
REFERENCES

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