MANAGEMENT OF INSECT PESTS IN POTATO BY SOME INSECTIDES AND MULCHING

MD. MAHFUZUR RAHMAN

DEPARTMENT OF ENTOMOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2016

MANAGEMENT OF INSECT PESTSIN POTATO BY SOME INSECTIDES AND MULCHING

BY

MD. MAHFUZUR RAHMAN

Registration No.: 10-03953

A Thesis

Submitted to the Department of Entomology
Sher-e-Bangla Agricultural University, Dhaka, in partial
fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE
IN
ENTOMOLOGY

SEMESTER: JANUARY-JUNE, 2016

Approved by

Supervisor	Co-Supervisor
(Dr. Mohammed Ali)	**(Dr. TahminaAkter)**
Professor	**Professor**
Dept. of Entomology	Dept. of Entomology
Sher-e-Bangla Agricultural University	Sher-e-Bangla Agricultural University
Dhaka-1207	Dhaka-1207

(Dr. Mst. Nur Mohal Akhter Banu)
Chairman
Examination Committee

DEPARTMENT OF ENTOMOLOGY

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **"MANAGEMENT OF INSECT PESTS IN POTATO BY SOME INSECTIDES AND MULCHING"** submitted to the Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. MAHFUZUR RAHMAN**, Registration No. **10-03953** 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 been duly acknowledged.

June, 2016

Dhaka, Bangladesh

Dr. Mohammed Ali

Professor

Department of Entomology

Sher-E-Bangla Agricultural University

Dhaka-1207

Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENT

All praises to the **“Almighty Allah”** who enable me to complete a piece of research work and prepare this thesis for the degree of Master of Science (M.S.) in Entomology.

He feels much pleasure to express his gratefulness, sincere appreciation and heartfelt liability to his venerable research supervisor **Professor Dr. Mohammed Ali**, Dept. of Entomology,Sher-e-Bangla Agricultural University, Dhaka-1207, for his scholastic guidance, support, uninterrupted encouragement, valuable suggestions and constructive criticism throughout the study period.

He also expresses his gratitude and thankfulness to reverend co-supervisor **Professor Dr. Tahmina akter** and Chairman, **Professor Dr. Mst. Nur Mohal Akhter Banu,** Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 for their constant inspiration, valuable suggestions, cordial help, heartiest co-operation and supports throughout the study period.

The author would like to express his grateful thanks to all teachers of the Department of Entomology for their constructive suggestions and advice during the study period.

The author deeply acknowledges the profound dedication to his beloved Father, Mother, Sister and Brother for their moral support, steadfast encouragement and continuous prayer in all phases of academic pursuit from the beginning to the completion of study successfully.

Finally, the author is deeply indebted to his friends and well-wishers for their kind help, constant inspiration, co-operation and moral support which can never be forgotten.

June, 2016

Dhaka, Bangladesh **The Author**

MANAGEMENT OF MAJOR INSECT PESTS IN POTATO BY SOME INSECTICIDES AND MULCHING

Abstract

The experiment was conducted to study the effect of different insecticides in controlling the major potato insect pests (jassid, aphid & cut worm) in potato respective to mulching from October 2015 to April 2016. The potato variety "Golden" was used as the test crop. The experiment consisted of six insecticidal treatments [**T_1**= Furadan 5G @ 9g/plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L (Foliar application), **T_2**= Furadan 5G @ 9.g/plot (soil application) + Imidachloprid (Admire 200SL) @ 1.0ml/L (Foliar application) , **T_3**= Chlorpyriphos (Darsban 20EC)@ 2.0ml/L (soil + Foliar application) + Water hyacinth (Mulching), **T_4**= Diazinon 10G @ 5g/plot (soil application) + Lamda Cyhalothrin (Alion 2.5 EC) @ 1.0ml/L (Foliar application) + Straw (Mulching), **T_5**= Diazinon 10G @ 5g/plot (soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L (Foliar application), **T_6**= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L (Foliar application) + Water hyacinth (Mulching)] along with a untreated control treatment **(T_7).** The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of controlling aphid, significant highest infestation reduction (92.51%) was obtained from T_1 (Furadan 5G with Carbaryl) and lowest (73.69%) from T_4 (Diazinon 10G with Lamda Cyhalothrin). In case of controlling, jassid population, highest infestation reduction (94.83%) was recorded in T_1 (Furadan 5G with Carbaryl) and lowest infestation reduction (87.09%) in T_6 (Chlorpyriphos with Es-fenvalerate). In controlling cutworm, T_4 (Diazinon 10G with Lamda Cyhalothrin) showed best performance (77.78%) followed by (82.22%) in T_5 ((Diazinon 10G with Thiamethoxam) treatment . The lowest reduction in cutworm population (46.77%) was found in T_2 (Furadan 5G with Imidachlorpid). Highest yield was observed in T_5 treatment (Diazinon 10G with Thiamethoxam). Lowest number of cutworm infestation in potato tuber was recorded as 6.66% and 8.74% in T_5 (Diazinon 10G with Thiamethoxam) and T_4 (Diazinon 10G with Lamda Cyhalothrin) treatment respectively .

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

CHAPTER I

INTRODUCTION

Potato is a prominent crop in consideration of production and its internal demand in Bangladesh. It is one of the important crop and plays a significant role in the human diet as a vegetable and supplementary food crop. Bangladesh is the 7th highest potato producing country in the world. Total potato production has been estimated 92, 54,285 metric tons in 2014-2015 (BBS, 2016) and 94,74,098 metric tons of potato in 2015-2016 (BBS, 2016). The potato (*Solanum tuberosum* L.) is a starchy, tuberous crop. According to International year of the potato(2008), potato is the world's fourth-largest food crop, following maize, wheat and rice. The potato was first domesticated in the region of modern-day southern Peru and extreme northwestern Bolivia (Spooner *et al*., 2005). It has since spread around the world and become a staple crop in many countries. Potato due to its high yield, crop safety, low price, diversified use and high nutritive value can play an important role in reducing the dependence on the cereals like rice and wheat.

The potato is rich in water content(78%) and vitamin C (1.7 mg/100g) and its biological value of protein (73mg/100g) is superior to rice or wheat(Rashid and Hossin,1985). The Food and Agriculture Organization of the United Nations reports that the world production of potatoes in 2013 was about 364.808.768 tonnes in 2012. Due to perishability, only about 5% of the world's potato crop is traded internationally and its minimal presence in world financial markets contributed to its stable pricing during the 2007–2008 world food price crisis. Thus, the United Nations officially declared 2008 as the International Year of the potato raise its profile in developing nations, calling the crop a "hidden treasure".

One of the major problem in potato production is the insect pests causing severe damage of tubers every year under both field and storage condition. Potato crop is attacked and damage by a number of insect pests. According to Simpson (1977), potato is attacked by more than 100 arthropod pests.

Of the various insect-pests; white grubs, epilachna beetles, defoliating caterpillars and potato tuber moths are serious and responsible for considerable damage. The importance of aphids and jassid are mainly due to their role in the spread of viruses and mycoplasma respectively. Cutworms and potato aphids are the two devastating insect pest in the spring crop (Sing, 2002).The larvae of the cutworm damage the plant by cutting the stem at the base or leaflets in the early stage of the crop growth before tuber formation. The amount of damage by cutting the plants exceeds the amount by gradual eating. The larvae usually hide in cracks and crevices in the soil or under the clods or debris around the plants during the day time and come out of these places of hiding at night and cut the young plants at ground level and eat only the tender parts. The major damage occurs when the larvae feed on the tubers under the soil soon after the tuber formation to harvest of tubers in the field (Dasheveskii and Rybakov, 1979). At tuberization period, the larvae bore into the tubers and consume the inner contents of tubers reducing the yield and market value of potato to a great extent. Cutworm damage to the tubers varied from 5 to 75% in India (Lal, 1990; Saxena, 1974). Several different aphids can be found in potato fields. Aphids of themselves can cause wilting damage by sucking out nutrients from foliage and stem tissues and this may be a problem especially in nursery crops. But, the real problem caused by aphids in commercial fields is their ability to carry pathogenic viruses. In potato fields, the common viruses are potato leaf roll virus (PLRV), the mosaic viruses (e.g., PVA, PVY) and alfalfa mosaic virus (AMV, “calico virus”). The peach potato or green peach aphid, *Myzus persicae* Sulzer is the most important as a potential vector of potato viruses (Verma and Misra, 1975).

Scientists have reported that the use of pesticides to control pest and maximize the production of potato may be essential, but these toxic chemicals should be applied carefully and judiciously. The aim is to control the variety of pests for a longer period with the minimum use of pesticides. Other potent and recommended methods of cultural, mechanical, physical and biological control should be given equal importance in controlling pests and developing an effective and economic instruction management programme (EIMP) against potato pests.

Under the above consideration, the present study was undertaken to fulfill the following objectives-

1. To study the incidence of different insect pests in different growth stages of potato.
2. To find out the effectiveness of some promising insecticides against the major potato insect pests.
3. To know the impact of insecticides on potato yield.

CHAPTER II

REVIEW OF LITERATURE

The potato is one of the world's most important food crops. The potato plant develops through four clearly defined growth stages: (1) vegetative growth, (2) tuber initiation, (3) tuber growth and (4) plant maturation (Johnson, 2008). Each stage is affected by different groups of insect pests. The degree of the damage will depend on the timing of events, cultivar characteristics, and the intrinsic characteristics of each pest.

Potato is attracted by a number of insect pests. Commonly the major potato insects are cutworm, aphid, jassid etc seen in Bangladesh. The relevant literature of these insects is shown on below-

2.1 Potato aphid (Homoptera: Aphididae)

Although many insects can vector viruses, aphids are the most important vectors for potatoes. The green peach aphid, *Myzus persicae*, is the most common aphid species in potatoes and the most efficient at transmitting potato viruses (Radcliffe and Ragsdale 2002). Other aphid species such as the potato aphid, *Macrosiphum euphorbiae*, cuckthorn aphid, *Aulacorthum solani*, and melon aphid, *Aphis gossypii*are also of concern (Radcliffe and Ragsdale 2002). Viruses can be divided into two groups - persistent and non-persistent viruses. Distinguishing the virus transmission process between persistent and non-persistent viruses is crucial in order to evaluate potential vector controls. When an aphid feeds on a plant infected by a persistent virus (e.g. potato leaf roll virus), it can take hours of probing and incubation before the aphid acquires the virus and has the potential to transmit to another plant. For these viruses, contact insecticides are a good tool to prevent aphids from infecting healthy plants (Radcliffe and Ragsdale, 2002). Consequently, aphids carrying non-persistent viruses have the potential to infect other plants very quickly. For non-persistent viruses, most insecticides do not prevent virus transmission (Perring *et al.* 1999) because they do not act fast enough to prevent aphids from inserting their mouthparts into plants .

The aphid population in western North America, north of Mexico, is comprised of 1,020 species in 178 genera in 15 subfamilies (Pike *et al*., 2003).

Several aphid species are known to be pests of potatoes, but the green peach aphid, *Myzus persicae* (Sulzer), and potato aphid, *Macrosiphum euphorbiae* (Thomas), are two of the most important vectors of diseases in the Pacific Northwest. Aphids are important due to their ability to transmit viruses. According to Hoy *et al*. (2008) there are six commonly found potato viruses transmitted by aphids which are potato leaf roll virus (PLRV), multiple strains of potato virus Y (PVY), potato virus A (PVA), potato virus S (PVS), potato virus M (PVM), and alfalfa mosaic virus (AMV). PLRV and PVY are transmitted by several species of aphids.

2.1.1 Pest description

Green peach aphids are small, usually less than 0.3 cm long. The body varies in color from pink to green with three darker stripes down the back. The head has long antennae which have an inward pointing projection or tubercle at its base. Potato aphids are larger than green peach aphids with a body somewhat elongated and wedge-shaped (Branson *et al.*, 1966).

2.1.2 Damage

In general, aphids injure plants directly by removing sap juices from phloem tissues. They also reduce the aesthetic quality of infested plants by secreting a sugary liquid called "honeydew" on which a black-colored fungus called "sooty mold". The “sooty mold” reduces the photosynthetic potential of the plant. Most importantly, aphids transmit plant diseases, particularly viruses. Aphids on potato are serious pests because of their ability to transmit several plant diseases such as PLRV (transmitted mainly by green peach aphid) and PVY (transmitted by several species of aphids). PLRV causes necrosis while strains of PVY can cause internal brown lesions in the tubers. Srinivasan and Alvarez (2007) reported that mixed viral infections of heterologous viruses occur regularly in potatoes.

2.1.3 Hosts

The green peach aphid, also known as tobacco or spinach aphid, survives the winter in the egg stage on peach trees. Besides potatoes and peaches, other hosts include lettuce, spinach, tomatoes, other vegetables and ornamentals

2.1.4 Biology

Green peach aphid migrates to potatoes in the spring from weeds and various crops where it has overwintered as nymphs and adults or from peach and related trees where it overwinters as eggs. Most aphids reproduce sexually and develop through gradual metamorphosis (overwintering diapause egg, nymphs and winged or wingless adults) but also through a process called 'parthenogenesis' in which the production of offspring occurs without mating (Jensen *et al*., 2011). Potato aphids also overwinter as active nymphs, adults or eggs; eggs are laid on roses and sometimes other plants. Throughout the growing season aphids produce live young, all of which are female and can be either winged or wingless. In some instances, aphids undergo sexual, oviparous reproduction as a response of a change in photoperiod and temperature, or perhaps a lower food quantity or quality, where females produce sexual females and males. In the fall, winged males are produced which fly to overwintering hosts and mate with the egg-laying females produced on that host. Aphids found in the region undergo multiple overlapping generations per year (Jensen *et al*., 2011, Schreiber *et al*., 2010).

2.1.5 Monitoring

Fields should be checked for aphids at least once a week starting after emergence. The most effective scouting method is beating sheets, trays, buckets or white paper. There are no well-established treatment thresholds for aphids in potatoes in the Pacific Northwest but since aphids transmit viruses, producers are encouraged to control aphids early in the season, especially in seed potato producing areas. Schreiber *et al.*(2010) recommend a minimum sample size of ten locations per 100 acre field. For potatoes that are not to be stored, application of foliar aphidicide should begin when 5 aphids per 100 leaves or 5 aphids/plant are detected. Hoy *et al*., (2008) suggests some sampling methods and action thresholds for colonizing aphids on processing potatoes, table stock, and seed potato in different productions thresholds.

2.1.6 Control

Weed control and elimination of secondary hosts are critical. Early aphid infestations commonly occur on a number of weeds including species of mustards and nightshade; therefore, those weeds should be kept under control. Research in Idaho indicates that hairy nightshade is an excellent aphid and virus host (Srinivasan and Alvarez, 2007), thus, control of this weed is highly recommended. In some instances, the number of insects available to infest crops in the spring depends upon winter survival. Thus, the elimination of overwintering sites is commended if possible. Peach trees are the most common winter hosts, although apricots and several species of runus are sometimes infested (Schreiber *et al.,* 2010). A large numbers of generalist predators feed on aphids including the minute pirate bugs, big-eyed bugs, damsel bugs, lady beetles and their larvae, lacewings, flower fly larvae, and aphid-specific parasitoid wasps. If aphids are present, use of insecticides in commercial fields should occur as soon as non-winged aphids are detected. In seed producing areas, preventive methods are recommended. Application of foliar aphidicide should begin just prior to the decline in performance of seed-treatment insecticides applied at planting. (Schreiber *et al.,* 2010) indicated that complete insect control from planting until aphid flights have ceased is the only means to manage diseases in full season potatoes.

2.2 Jassid (Homoptera: Cicadellidae)

2.2.1 Pest description

The leaf hoppers or jassids are also important pests of the potato crop. Several species have been recorded. They include *Alebroidesnigro scutulatus* Dist, *Amrasca biguttula biguttula* Ishida, *Balclutha* Spp., *Exitianus coronatus*, *E. indicus*, *E. nanus*, *Ophiola bicolour* Pruthi,*Phyronomorphus* spp., *Psammotettispro vinciatis* Rib., *P. Striatus* (L.), *Seriana equata* and *Subhimalus melanus.*

2.2.2 Damage

The nymphs and adults suck sap from the mesophyll and cause direct damage to potato foliage. The adults and nymphs of *Empoasca devastans*, *E. Fabae* and *Amrasca biguttula biguttula* Ishida cause hopper burn (Prasad, 1960 and Saxenae*et al.,* 1974). Late nymph stages cause higher yield reductions than adults. The average reduction in potato yield caused by nymphs was about 2-6 times more than that caused by adults (Prasad, 1961). Some leafhoppers are vectors of mycoplasmal diseases such as Witch's broom, purple top roll (PTR) and marginal flavescence (MF). The losses were estimated at 40-70 and 70-80% respectively (Nagaich, 1974). The females of *E. Devastans* lay about 300 eggs in the leaf veins. These eggs hatch in 4-10 days. The nymphs become adults between 17-21 days and 11 generations have been reported in one year (Mohammad *et al.*, 1945; Pruthi, 1969). Razaq *et al*. studied the chemical control of Jassids. Chemical should be used alone but this will give insect pests a chance to develop resistant against a specific group of insecticides so the combination of insecticide can give good results.

2.3 Cutworm, armyworm and loopers

2.3.1 Cutworm, armyworm and loopers infestation

These are several species of moth larvae that affect potato crops. Cutworms, armyworms and loopers are the immature stages of lepidopteran moths. Moths' typically have four defined life stages: egg, larva, pupa and adult. Cutworms *(Agrotis* spp.) are cosmopolitan and polyphagous (Pruthi, 1969). Five species: *Agrotis ipsilon*, *A. interacta*, *A. Flammatra* Schiff, *A. spinnifera* and *A. Segetum.* have been reported damaging the potato crop in India (Srivastava, 1958; Saxena, 1977 and Rataul and Misra, 1979). Two, *A. ipsilon* and *A. segetum*, are the main cause of damage. The former is common in the plains while the latter is more prevalent in the hilly tracts. The other three are of minor importance. Cutworm larvae cut off the stalks of young potato plants. They are nocturnal in habit, living 5 to 8 cm below ground level and cut potato stalks at their base or a few centimeters above the ground level.

They spoil more than they consume. The infested fields sometimes look as if it has been grazed. In grown crops they usually damage tender shoots and branches. After tuberization their damage is confined to the tubers, reducing the market value. In badly infested fields, damage has been reported from 12-40% .

Cutworms are active from October to April in the plains and during Summer in the mountains, and have been reported from almost all the potato growing areas of north India, forming a continuous belt from the Punjab to Bengal. There may be a migration of adults to and from the hills. Moths are generally not found in the north Indian plains from May to September, but appear during October and remain active until March or April. The life-history of *A. ipslon* has been studied in detail. It feeds on potato, barley, maize, mustard, linseed, cabbage, peas, gram and tobacco but gram is the preferred host reported that larval development is faster on Cutworms feed on potato seeds, cut stems, and foliage; armyworms and loopers feed on foliage throughout the season.

Cutworms and armyworms have three pairs of true legs and five pairs of prolegs behind; loopers have only three pair of true legs and three pair of prolegs behind. At planting insecticides protect potato seed from cutworms; however, after the residual effect is gone, the crop is unprotected; in some years, a foliar chemical application may be needed. Potatoes can tolerate some worm defoliation without loss in marketable yield. The period of full bloom is the most sensitive plant growth stage, but even then defoliation on the order of 10% appears to cause little if any yield loss. Applications should be targeted to control small larvae (1st and 2nd instars), rather than larger larvae (Schreiber *et al*., 2010; Jensen *et al*., 2011).

The cut worm is nocturnal in habit. The larvae remain hiding in the clods or cracks of the soil during the day time and cause damage to the crops in the night. The larvae may be observed if the soil is dug within 30 cm area of the cut plants (Rai *et al*., 1988). In India, the losses in yield due to the attack of *A. ipsilon* ranged from 35-40% (Chaudhuri, 1953; Nirula, 1961; Rai *et al.*, 1988). Several researchers reported the feeding behaviour of the cutworm in potato field. Butani and Jotwani (1984) reported that the larvae damage the plants by cutting the stem at the base or the leaflets in the early stage of the crop growth before tuber formation.

The larvae usually hide in cracks and crevices in the soil or underthe clods or debris around the plants during day time and come out of these places of during at night and cut the young plants at ground level and eat only the tender parts.

Panchabhavi *et al.* (1972) reported that cutworm is a polyphagous noctuid and a severe pest of potato in the field. During night the larvae become active and come out of their place, cut the growing plants at the surface of the ground, feed on the leaves leading to the retardation in the growth of the plantsultimately reduce the tuber yields. Nasr *et al*. (1974) and Butani and Verma (1976) also reported similar observations. Naser*et al.* (1990) and Islam *et al.* (1991) reported that Diazinon and Thiamethoxam were effective in reducing the cutworm damage.

Das *et al.* (1996) showed that tuber damage by number and weight and yield of cutworm infested tuber was 73.6%, 77.9% and 24.4 t/ha, respectively in the untreated control plots. The untreated plots showed significantly higher rates of infestation compared with insecticide treated plots. Among the insecticides tested Clorpyriphos gave the best result.

Kareem (1981) observed 25% mortality in *Plutella xylostella* larvae fed on leaves treated with 3% neem oil. High mortality was induced at higher concentrations.

Salem (1990) showed that the 100 ppm concentration of neem seed oil was the most effective against larval feeding of potato tuber moth, *Phthorimaea operculella* Zell. The antifeedant properties of neem oil against several insect pests was also reported by Islam (1984).

2.3.2 Monitoring

Trapping should start early, especially in areas with history of cutworm problems. In the Pacific Northwest trapping starts mid to late March until April to May. Horton (2006) modeled the relationship between bait trap counts and crop damage by *L. canus*in Wapato, WA. Horton's model predicts tuber damage based on number of wire worms collected.

Cutworm presence or absence in a field should be determined before using control measures. Unfortunately, current monitoring methods are time consuming, laborious and often do not accurately reflect field populations of this pest. Historically, wireworms have been monitored by extracting and sifting through soil cores to locate larvae.

Since the distribution of wireworms in a field tends to be patchy and unpredictable, large numbers of samples are required to accurately estimate population size. Baits have largely replaced random soil sampling, since they are less labor intensive and may detect low wireworm populations. Baited traps can be constructed by placing 3-4 tablespoons of a mixed of wheat and corn seeds or rolled oats inside a fine mesh bag or nylon. Dig a hole about 20-25 cm deep and 3.5- 4 cm wide at the soil surface (Horton, 2006). Bury the mixture at the bottom of the hole. Fill the hole and mound a "soil dome" over the covered bait to serve as a solar collector and to prevent standing water. Cover each mound with a sheet of black plastic and cover the edges with soil to hold the plastic sheet down. The plastic collects solar radiation and speeds germination of the mixture. The germinating seeds attract cutworms. A few days later, remove the plastic and soil covering the bait and count the number of cutworm larvae found at each station. There are not specific recommendations as to how many traps per field should be placed. However, placement of the bait stations should represent different areas of a field (Campbell and Stone, 1939; Simmons *et al.*, 1998)

2.3.3 Control

There are no effective natural enemies for cutworm. If one suspect wire worms are present in a field based on rapping, chemical control is the best management option. Fumigants are effective on cutworms that are present at the time of fumigation and within the zone of fumigation (Schreiber *et al*., 2010). Fumigants are sensitive to soil temperatures. In furrow applications are also effective; however, some operational restrictions may apply (Schreiber *et al.*, 2010). Use of contemporary chemicals in other crops suggests that stand protection and wireworm reduction are not covered with current chemicals available (Vernon et al., 2009).

2.4 Potato tuber worm

The potato tuber worm, *Phthorimaea operculella,* is one of the most economically significant insect pest so cultivated potatoes worldwide. The first significant economic damage to potato crops in the Columbia Basin region occurred in 2002 (Rondon, 2010).

2.4.1 Damage

Tuber worm larvae behave as leaf miners. They can also live inside stems or within groups of leaves tied together it silk. The most important damage is to tubers, also a food source for the larvae, especially exposed tubers, or those within centimeters of the soil surface. Larvae can infest tubers when foliage is vine killed or desiccated right before harvest (Clough *et al.*, 2010).

2.4.2 Hosts

Although the potato tuber worm host range includes a wide array of Solanaceous crops such as tomatoes, peppers, eggplants, tobacco, and weeds such as nightshade, the pest has been found only on potatoes in the Pacific Northwest region (Rondon, 2010).

2.4.3 Control

Control efforts should be directed toward tuber worm populations right before or at harvest. The greatest risk for tuber infestation occurs between desiccation and harvest (Clough *et al*., 2010; Rondon, 2010). Most chemical products aim to reduce larva population in foliage but that technique does not provide 100% protection for the tuber. Experiment was conducted at Agriculture Research Institute, Tarnab Peshawar during 2009 for the evaluation of some chemical against Aphids, jassids and Whiteflies in Potato. Six insecticides were applied against these insect/pests of potato. All the insecticides showed above 85 percent mortality against these pests of potato. Tender 10EC and Sharp 25WP caused the highest 96.4 % mortality in Aphids. The efficacy of Tender 10EC against jassid was higher than other insecticide that was about 88.7 percent followed by Sharp 25WP. In case of white flies the highest mortality was caused Sharp 20SL, which was about 86.6 percent and the lowest mortality was caused by Talent which was 85.3 percent. Tender 10EC and Sharp 25WP should be used for controlling aphids, jassid and whiteflies in potato crops

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to study the effect of different insecticides in controlling potato insects during the period from November, 2015 to march, 2016. This chapter includes materials and methods *i.e*. location of experimental site, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection, procedure of data analysis that were used in conducting the experiment and these are presented below under the following headings and sub headings-

3.1 Experimental site

The experiment was conducted in the Plot No.22, Research Farm, Sher-e-Bangla Agricultural University. This area was situated at $23^{0}77'$ N latitude and $90^{0}33'$ E longitude at an altitude of 8.6 meter above the sea level.

3.2 Climatic condition

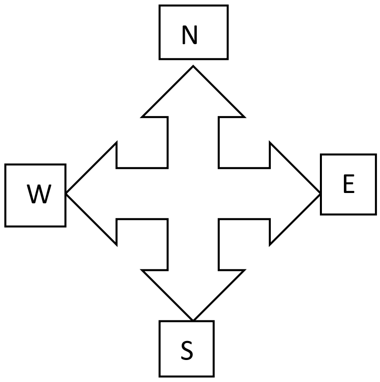
The climate of experimental site is subtropical characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from march to April and the monsoon period from May to October .The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh meteorological Department (Climate Division), Agargaon, Dhaka and presented in Appendix I.

3.3 Characteristics of soil

The experimental plot belongs to the Modhupur Tract which was under the Agro Ecological Zone-28. The analytical data of the soil, collected from the experimental area were determined in SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and presented in Appendix II. The soil of the experimental site was clay loam in texture having pH 6.00-6.63.

3.4 Design of the experiment and layout

The study was conducted considering six insecticidal treatments along with a control for controlling cutworm, aphid, jassid the important harmful insect pests of potato. The experiment was laid out in a Randomized Complete Block design (RCBD). The entire experimental field was divided into three blocks. Every block contains six plot for insecticidal treatment and one for control. The each block was separated 0.5 meter apart from each other. Each experiment plot comprised the area about 6 sq. meter. So the total area was covered by the experiment was 198 sq. meter. Each treatment plots was allocated randomly and replicated three times in respect to local control system.



R_1T_6	**R_1T_4**	**R_1T_2**	**R_1T_7**	**R_1T_5**	**R_1T_3**	**R_1T_1**
R_2T_3	**R_2T_1**	**R_2T_5**	**R_2T_4**	**R_2T_6**	**R_2T_7**	**R_2T_2**
R_3T_7	**R_3T_5**	**R_3T_3**	**R_3T_2**	**R_3T_1**	**R_3T_6**	**R_3T_4**

3.5 Land Preparation

The experimental land was first opened with a country plough. Ploughed soil was then brought into desirable final tilth by four operations of ploughing followed by laddering. The stubbles of the crops uprooted weeds were removed from the field. Then the land was properly leveled. The field layout was properly done on accordance to the design, immediately after land preparation. The plots were raised by furrow-ridge method and contained three lines.

3.6 Manures, Fertilizer and their methods of Application

Manures and fertilizers with their doses and their methods of application followed by the study, well decomposed cow dung was applied to the plots at the rate of 10 tons/ha and incorporated to the soil during final land preparation. In addition, Muriatic of potash (MoP), Gypsum and Triple super phosphate (TSP) were applied to the experimental plot @ 175, 150 and 150 kg/hato supply K, S & P respectively. The total amount of urea (as per treatment) was applied as top dressing around the base of the plant. Top dressing of one third of urea was applied at 15 days after sowing and remaining urea was top dressed in two equal installments at 30 and 45 days after transplanting (DAP). MOP was applied as basal dose and top dressing at 45 DAP in equal split.

TSP was applied as basal dose in the plots. Boric acid was applied as small amount as per reccomendation.

3.7 Collection and sowing of seeds

Seeds were collected from the local farmers of Dinajpur and sown in the experimental plots at the rate 28 seeds/plot (four seed per line). Seeds were sown on 23 November, 2015.

3.8 Treatments of the experiment

Treatments

Therefore, seven treatment combinations were tested in this experiment.

T_1= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L

T_3= Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC) @ 2.0ml/L + Water hyacinth (Mulching)

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching)

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi) @ 1.0ml/L

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching)

T_7= Control.

Application of insecticides

First application of insecticides was sprayed on the potato plant just after one week of germination. Data were counted before spraying, 1days after the spraying, 3 days after the spraying and last data were counted 5 days after the spraying. Insecticides were sprayed on the potato plant on three times at 15 days interval.

3.9 Cultural Operation

Irrigation, Weeding, Draining and fertilizer application and other intercultural operations were done properly during whole cropping season.

3.10 Data Collection

The data on the following parameters were recorded at different time intervals as given below:

- Total number of infested plants per plot.
- Total number of aphid/plant in each plot.
- Total number of jassid/plant in each plot.
- Total number of cutworm/plant in each plot.
- Total potato tuber weight/plot.

3.10.1 Number of aphid per plot

Number of aphid was counted from the sampling potato plant from each plot and mean number expressed as number of aphid per treatment. Data on developed aphids/plant was recorded as the average of 5 plant selected randomly from each plot.

3.10.2 Number of jassid per plot

Number of jassid was counted from the sampling potato plant from each plot and mean number expressed as number of jassid per treatment. Data on developed jassid/plant was recorded as the average of 5 plant selected randomly from each plot.

3.10.3 Number of cutworm

Number of cutworm weas counted from each plot of the field during harvesting time where cutworm seen on the experimental plot and mean number expressed as number of cutworm per treatment.

3.10.4. Number of other insect

Many other insect such as thrips, potato beetle, white fly, wire worm, tuber worm and beneficial insect lady bird beetle were also counted when seen on the field.

Harvesting of the yield

The potato was harvested on 13th March, 2016.

3.10.5 Yield per hectare

Yield per hectare was calculated out from the data of per plot yield data and their average was taken. It was measured by the following formula,

$$\text{Yield per hectare (ton)} = \frac{\text{Yield (kg)} \times 10{,}000}{\text{Area } (m^2) \times 1000}$$

3.10.6 Statistical Analysis

Collected data were statistically analysed using MSTAT-C computer package programme. Mean for every treatments were calculated and analysis of variance for each one of characters was performed by F–test (Variance Ratio). Difference between treatments was assessed by Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

Benefit cost ratio= Net return/cost of pest management

CHAPTER IV

RESULT AND DISCUSSION

The experiment was conducted to study the effect of different insecticides on controlling major potato insects. Data on parameters such as number of insects, number of seed tubers and yields were recorded in this experiment. The findings of the experiment have been presented and discussed with the help of table and possible interpretations with supporting relevant reference were given under the following headings.

4.1 Effect of insecticides on aphid population

The comparative effectiveness of various treatments on aphid infestation by the aphid population has been evaluated in terms of their efficacy in reducing the potato infestation over control expressed in percent as presented in Table 1-4. The population incidence of potato aphid under different treatments has been shown in Table 1. As shown on Table 1, T_1 (Carbaryl) showed the better performance to reduce the aphid population than all the insecticidal treatment plot where as 90% significant highest infestation reduction observed, followed by the T_3 (89.13%) treatments.

Plate 1. Aphid infested Potato plant.

Plate 2. Aphid infested Potato leaf.

Table1. Efficacy of insecticides in controlling the potato aphids after first spraying

Treatments	No. of aphid/plant before spraying	No. of aphid/plant at 3 DAS	Percent aphid reduction
T_1	5.00a	0.50b	90.00a
T_2	4.10cd	1.50b	63.00 c
T_3	4.60 ab	0.50 d	89.13a
T_4	4.50 b	1.50 b	75.00 b
T_5	5.00 a	1.00 c	80.00 b
T_6	4.30 bcd	1.00 c	76.00 b
T_7	4.00 d	4.10 a	0.00 d
SE (±)	**0.13**	**0.11**	**1.55**
Level of significance	**0.05**	**0.05**	**0.05**
CV (%)	**4.99**	**13.44**	**3.98**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control].

The data shows that lowest no of aphid (0.5/plant) was observed in T_1 (Carbaryl) after spraying where as the number of aphid (5.00) was observed before first spraying. T_4

(75%), T_5 (80%), T_6 (76%)showed intermediate results in reducing aphid population. The results of the present study was in accordance with the findings of other scientist like Hussain *et al(*, that the six insecticides showed significant results in controlling aphids as compared to the check plot. The percent mortality of all insecticides was above 95 percent. The maximum mortality was found inTundra 10EC and Sharp 25WP, which was 96.4 percent.

The lowest infestation reduction showed by the T_2 treated with Furadan 5G (soil application) and Emidachloprid where only 63% infestation reduction observed where (4.1) and (1.5) were mean number of aphid before and after spraying respectively. All these treatments differed most significantly from untreated control plot T_7.

Table 2 showed the results of second spraying. Highest level of infestation reduction observed in T_1 (88.88%) and T_3 (88.00%), which was statistically similar followed by T_5 and T_6 where 75.00% and 73.33% significant reduction of infestation observed respectively. Lowest level of infestation reduction observed in T_2 and T_4 (66.66%). The experiment results are in compatibility with Foster *et al.*, (2000) that the insecticides can control the potato aphids effectively. The results are also in similarity with the results of Raqib*et al.* (2010). They managed the aphid population by using different chemicals.

Table2. Efficacy of insecticides in controlling the potato aphids after second spraying

Treatments	No. of aphid/ plant before spraying	No. of aphid/ plant at 3 DAS	Percent aphid reduction
T_1	2.25de	0.25d	88.88a
T_2	3.00c	1.00c	66.66c
T_3	2.50d	1.50b	88.00a
T_4	3.00c	1.00c	66.66c
T_5	2.00e	0.50d	75.00b
T_6	3.75b	1.00c	73.33b
T_7	4.30 a	4.40 a	0.00 d
SE (±)	**0.15**	**0.09**	**0.95**
Level of significance	**0.05**	**0.05**	**0.05**
CV (%)	**8.48**	**11.41**	**2.51**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control].

Statistically significant variation was recorded for number of aphid per plant due to different management practices (Table 3). Highest infestation reduction observed in T_2 (93.33%), followed by T_1 (92.85)and T_6 (92.85%), which was statistically similar. Lowest level of infestation reduction observed in T_3 (78.26%).

All these treatments differed most significantly from untreated control plot T_7 where as the number of aphid/plant (4.75) was highest than all the other insecticides treated plot.

In 2002, Radcliffe conducted a trial to determine efficacy of several insecticides applied as foliar spraying for the control of aphid (*Myzus persicae*) population on potato. Sevin 85Wp (carbaryl) and Admire 200SL (Emidachlorpid) provided excellent control of an extremely high aphid infestation.

Table 3. Efficacy of insecticides in controlling the potato aphids after third spraying

Treatments	No. of aphid/ plant before spraying	No. of aphid plant at 3 DAS	Percent aphid reduction
T_1	3.50 bc	0.25 e	92.85 a
T_2	3.75 b	0.25 e	93.30 a
T_3	3.45 bc	0.75 c	78.26 d
T_4	3.50 bc	1.00 b	87.50 b
T_5	3.00 c	0.50 d	83.33 c
T_6	3.50 bc	0.25 e	92.85 a
T_7	4.50 a	4.75 a	0.00 e
SE (±)	**0.20**	**0.07**	**0.95**
Level of significance	**0.05**	**0.05**	**0.05**
CV (%)	**9.58**	**10.64**	**2.17**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,
T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control]

Statistically significant variation was recorded for aphid reduction per plant on an average of these three spraying from the Table 4. Results from the Table 4, T_1 showed better performance to reduce aphid infestation where 92.51% significant infestation reduction was observed over control , followed by T_5 (85.03%). T_3 showed lowest infestation reduction (73.69%) over control. The highest number of aphid infestation showed on T_7 (untreated control).

Table 4. Efficacy of insecticides in controlling the potato aphid

Treatments	No. of aphid reduction/plant	Percent aphid reduction over control
T_1	0.33 d	92.51 a
T_2	0.91 bc	79.43 c
T_3	0.91 bc	79.36 c
T_4	1.16 b	73.69 d
T_5	0.66 c	85.03 b
T_6	0.75 c	82.99 b
T_7	4.41 a	0.00 e
SE (±)	**0.10**	**0.67**
Level of significance	**0.05**	**0.05**
CV (%)	**13.11**	**1.64**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,
T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),
T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),
T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,
T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and
T_7= Control]

4.2 Effect of insecticides on jassid population

The population incidence of jassid at potato plant under different treatment has been shown in (Table 5). In T_3 treatment, the mean number of jassid was recorded 3.5 and 2.0 before spraying and after spraying respectively. Treatment T_3 showed better performance to reduce the jassid population which was combined treated with chlorpyriphos where 94.28% significant highest infestation reduction was observed followed by T_4 (90.00%)and T_2 (90.00%)treatment there were no significant difference between T_4 and T_2 treatment.

Moreover, 86.60% infestation reduction was observed on T_1 (Furadan 5G with Carbaryl), T_5 (Diazinon 10G with Thiamethoxam), T_6 (Chlorpyriphos with Es-fenvalerate) those were statistically similar. Statistically significant variation was recorded for number of jassid per plant due to different management practices (Table 5).

Table 5. Efficacy of insecticides in controlling the potato jassid after first spraying

Treatments	No. of jassid/ plant before spraying	Mean no. of jassid/plant at 3 DAS	Percent jassid reduction
T_1	3.00 b	0.40 b	86.60 b
T_2	3.50 a	0.35 b	90.00 ab
T_3	3.50 a	0.20 c	94.28 a
T_4	2.00 d	0.20 c	90.00 ab
T_5	3.00 b	0.40 b	86.60 b
T_6	3.00 b	0.40 b	86.60 b
T_7	2.50 c	2.60 a	0.00 c
SE (±)	**0.07**	**0.03**	**1.54**
Level of significance	**0.05**	**0.05**	**0.05**
CV (%)	**4.15**	**7.32**	**3.50**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control **]**

Results of the Table 6 indicate that significant highest infestation reduction observed in T_1 (95.00%), followed by T_2 (85.00%). In T_1 treatment, the number of jassid (1.00) was observed before spraying and lowest number(0.05) was observed after spraying Carbaryl @ 2.0g/L. Lowest level of infestation reduction was observed in T_6 (66.66%) treatment treated with Chlorpyriphos @ 2ml/L with Es-fenvalerate where as the number of jassid (1.00) was observed before spraying and (0.15) was observed after spraying. All these treatments differed most significantly from untreated control plot, T_7 that recorded the highest jassid infestation (3.2) by the number of jassid population.

Plate 3. Jassid infested Potato plant.

Plate 4. Jassid infested Potato leaf.

Table6. Efficacy of insecticides in controlling the potato jassid after second spraying

Treatments	No. of jassid/ plant before spraying	No. of jassid/ plant at 3 DAS	Percent jassid reduction
T_1	1.00 d	0.05 c	95.00 a
T_2	1.00 d	0.15 c	85.00 c
T_3	1.30 cd	0.20 c	84.61 c
T_4	2.00 b	0.50 b	75.00 d
T_5	1.00 d	0.10 c	90.00 b
T_6	1.50 c	0.50 b	66.66 e
T_7	3.00 a	3.20 a	0.00 f
SE (±)	**0.09**	**0.05**	**1.09**
Level of significance	**0.05**	**0.05**	**0.05**
CV (%)	**10.58**	**13.00**	**2.67**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control **]**

The data of Table 7 expressed that significantly highest infestation reduction observed in T_1 (95.83%), followed by T_5 (90.00%). On T_1 treatment the number of jassid (1.20) was observed before spraying and lowest number(0.05) was observed after spraying

Carbaryl @ 2.0g/L. Lowest level of infestation reduction was observed in T_4(72.22%) treatment where as the number of jassid (1.80) was observed before spraying and (0.50) was observed after spraying. From the findings it is revealed Carbaryl was more effective among all the insecticides. All these treatments differed most significantly from untreated control plot, T_7 that recorded the highest jassid infestation (3.50) by the number of jassid population.

Table 7. Efficacy of insecticides in controlling the potato jassid after third spraying

Treatments	No. of jassid /plant before spraying	No. of jassid /plant at 3 DAS	Percent jassid reduction at 3 DAS
T_1	1.20 cd	0.05 e	95.83 a
T_2	1.20 cd	0.30 c	75.00 d
T_3	1.40 c	0.20 cd	85.71 c
T_4	1.80 b	0.50 b	72.22 e
T_5	1.00 d	0.10 de	90.00 b
T_6	1.30 c	0.30 c	76.92 d
T_7	3.40 a	3.50 a	0.00 f
SE (±)	**0.07**	**0.03**	**0.81**
Level of significance	**0.05**	**0.05**	**0.05**
CV (%)	**7.40**	**8.45**	**1.97**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control **]**

Results in Table 8 demonstrated that T_1 treatment showed better performance to reduce jassid infestation where 94.83% significant infestation reduction was observed over control, followed by T_3 and T_5 (93.54%). T_4 showed lowest infestation reduction (87.09%) over control.

Table 8. Efficacy of insecticides in controlling the potato jassid

Treatments	No. of jassid reduction/plant	Percent jassid reduction over control
T_1	0.16 c	94.83 a
T_2	0.26 c	91.61 a
T_3	0.20 c	93.54 a
T_4	0.40 b	87.09 b
T_5	0.20 c	93.54 a
T_6	0.40 b	87.09 b
T_7	3.10 a	0.00 c
SE (±)	**0.03**	**1.11**
Level of significance	**0.05**	**0.05**
CV (%)	**8.30**	**2.46**

In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control]

The result of the present study was in accordence with the findings of other scientists like Mohammed (2007). He state that the efficacy of Sevin 85WP and Admire 200SL was evaluated for two consecutive seasons (2005/06 and 2006/07) at shambat research station farm for the control of aphid and jassid on potato.

These two insecticides namely Sevin 85WP and Admire 200SL significantly reduced aphid population compared to the untreted control.

4.3 Efficacy of insecticides on cutworm and yield of potato tubers

Various insecticide treatments showed significant reduction in loss of potato tubers by weight due to the cutworm damage, showed in Table 9. Among the treatments, T_5 (Diazinon 10G @ 5g/Plot with Thiamethoxam@ 1.0ml/L) showed better performance to reduce the damage potato tuber and reduced 82.22% potato tuber damage over control followed by T_4 treatment where 77.78% tuber reduction was observed over control having significant difference between them.

The total yield of potato (12.00 kg) was highest on T_5 treatment than the other insecticides treatment. T_6 showed 51.11% significantly lowest reduction of damaged potato tuber over control and the number of cutworm (16.07) was observed. 13.69% significant loss of damaged potato tuber found on T_3 (Chlorpyriphos @ 2ml/L with Chlorpyriphos @ 2.0ml/L) treatment where as 10.96 kg yield of potato recorded. The number of cutworm (21.43) was observed on T_3 treatment. Significantly 28.38% loss of damaged potato tuber found on T_1 treatment where 10.57 kg yield of potato was recorded. The highest number of cutworm (24.11) was observed on T_7 treatment. The lambda-cyhalothrin, was evaluated in T_4 treatment during potato growing seasons against potato cutworm. All the lambda-cyhalothrin treatments significantly reduced cutworm infestation(8.925).

Plate 5. Potato Plant damaged by cut worm.

Plate 6. Potato tuber damaged by cut worm

Table 9. Effect of insecticides on cutworm damage and yield of potato

Treatments	Number of cutworm	Damaged potato tuber	Percent damage potato tuber	Total Wt. (kg)/plot	Total Wt. (t/ha)
T_1	21.33 a	3.0	28.38	10.57 a	26.4
T_2	20.32 a	2.0	18.65	10.72 a	26.8
T_3	21.43 a	1.3	13.69	10.96 a	27.4
T_4	8.925 c	1.0	8.74	11.44 a	28.6
T_5	13.40 b	0.8	6.66	12.00 a	30.0
T_6	16.07 b	2.2	19.35	11.37 a	28.4
T_7	24.11 a	4.5	73.41	6.130 b	15.4
SE(±)	1.13			0.62	
Level of significance	0.05			0.05	
CV(%)	12.40			12.12	

Mean value of 3 replications; each replication is derived from 28 plants per treatment. In a column, means having different letters are significantly different at 5% level of probability by DMRT.

[**T_1**= Furadan 5G @ 9g/Plot (soil application) + Carbaryl (Sevin 85WP) @ 2.0g/L,

T_2= Furadan 5G @ 9g/Plot (soil application) + Emidachloprid (Admire 200SL) @ 1.0ml/L,

T_3=Chlorpyriphos @ 2ml/L (soil application) + Chlorpyriphos (Darsban 20EC)@ 2.0ml/L + Water hyacinth (Mulching),

T_4= Diazinon 10G @ 5g/Plot(soil application) + Lamda Cyhalothrin (Alion 2.5 EC @ 1.0ml/L + Straw (Mulching),

T_5= Diazinon 10G @ 5g/Plot(soil application) + Thiamethoxam (Voliam Flexi)@ 1.0ml/L,

T_6= Chlorpyriphos @ 2ml/L (soil application) + Es-fenvalerate (Sumi Alpha 5EC) @1.0 ml/L + Water hyacinth (Mulching) and

T_7= Control]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the rabi season 2015-2016 at Sher-e-Bangla agricultural university, Dhaka to study the effect of different insecticides on controlling the major potato insect Pests. The potato variety Golden was used as the test crop. The experiment is consisted of six insecticidal treatments *viz.*,Furadan 5G @ 9g/Plot with Carbaryl @ 2.0g/L of water (**T_1**), Furadan 5G @ 9g/Plot with Imidacloprid@ 1.0ml/L of water (**T_2**), Chlorpyriphos @ 2ml/L with Chlorpyriphos @ 2.0ml/L of water and Water hyacinth as Mulching (**T_3**), Diazinon 10G @ 5g/Plot with Lamda Cyhalothrin @ 1.0ml/L of water and Straw as Mulching (**T_4**), Diazinon 10G @ 5g/Plot with Thiamethoxam @ 1.0ml/L of water (**T_5**), Chlorpyriphos @ 2ml/L with Es-fenvalerate @1.0 ml/L of water and Water hyacinth as Mulching (**T_6**)and along with an untreated control treatment (**T_7**) to evaluate the efficiency of these insecticides against the major potato insect pests *viz.*, cutworm, aphid, jassid. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

The experiment revealed that the significantly highest infestation reduction of aphid population (90%) was observed in T_1 (Furadan 5G with Sevin 85WP) treatment and lowest infestation reduction (63%) in T_2 (Furadan 5G with Admire 200SL) treatment during first spraying. At second spraying, significant highest infestation reduction (88.88%) was recorded in T_1treatment and lowest infestation reduction (66.66%) in T_2 treatment . At third spraying highest infestation reduction (93.33%) in T_2 treatment and lowest in infestation reduction (77.26%) T_3 treatment. T_1 (Furadan 5G with Carbaryl) showed best performance in significant highest infestation reduction (92.51%) over control and lowest infestation reduction (73.69%) was found in T_4 (Diazinon with Lamda Cyhalothrin).

In case of controlling jassid population, highest infestation reduction (94.28%) was recorded from T_3 treatment and lowest infestation reduction (86.60%) in T_5 treatment at first spraying. At second spraying, highest infestation reduction (95%) was recorded in T_1 treatment and lowest infestation reduction (66.66%) in T_2 treatment.

At third spraying highest infestation reduction (95.83%) in T_2 treatment and lowest infestation reduction (72.22%) in T_3 treatment. T_1 (Furadan 5G with Carbaryl) showed best performance in significant highest infestation reduction (94.83%) over control and lowest infestation reduction (87.09%) was found in T_6 (Chlorpyriphos with Es-fenvalerate).

In controlling cutworm T_5 treatment showed best performance (82.22% reduction in loss of potato tuber) followed by T_4 (77.78% reduction in loss of potato tuber) and the lowest (46.77% reduction in loss of potato tuber) in T_2 . Highest yield (30t/ha) was observed in T_5 treatment. T_5 and T_4 performed superiorly, where lowest number of cutworm infested potato tubers were recorded as 6.66% and 8.74%. Among all the insecticides highest loss of potato tuber (28.38%) was recorded on T_1. Highest number of cutworm (24.11) were recorded from untreated control plot, which showed significant damage (73.4%) in potato tuber and the lowest yield of potato (15.4 t/ha) than all the treatment plots.

From the above findings it was revealed that, Carbaryl @ 2.0 g/L was more realiable to control aphid and jassid population among all other insecticides and Diazinon 10G @ 5g/Plot soil application with Thiamethoxam @ 1.0ml/L of water showed best performance to control cutworm infestation.

Based on the above findings following recommendations may be suggested :

- Such study may be conducted in different agro-ecological zones (AEZ) and seasons of Bangladesh for exploitation of regional adaptability and other performances;
- Some different insecticides may be included in future program for more confirmation of the results.
- Integrated pest management practices may be introduced to get effectiveness of insecticides by changing the use of insecticides formulation and their active ingredient days after days and maintain the general rules of spraying insecticides, use of such insecticides which are not affected as long term on soil and environment, timely used of insecticides on the target pests and sometimes natural and biological control may be added with chemical insecticides for controlling aphid, jassid and cutworm.

CHAPTER VI

REFERENCES

Anonymous. (2004). Annual Internal Review for 2000-2001. Effect of seedling throwing on the grain yield of wart land rice compared to other planting methods. Crop Soil Water Management Program Agronomy Division, BRRI, Gazipur- 1710.

BBS. (2015). Statistical Year Book of Bangladesh. Bangladesh Bureau of statistics. Statistics Division, Ministry Of Planning, Govt. of Peoples Republic of Bangladesh . Dhaka. Bangladesh. p. 71.

BBS. (2016). Statistical Year Book of Bangladesh. Bangladesh Bureau of statistics. Statistics Divison, Ministry of Planning, Govt. Of Peoples Republic of Bangladesh . Dhaka. Bangladesh. p. 71.

Branson, T., Terry, F. and Robert, G. (1966). Effects of a nitrogen deficient host and crowding on the corn leaf aphid. *J. Econ. Entomol.***59**(2): 290-294.

Butani, D.K. and Jotwani, M.G. (1984). Insects in vegetables. Periodical Expert Book Agency, Delhi. 356 p.

Butani, D.K. and Verma, S. (1976). Pest of vegetables and their control. *Pesticides*. **10**(4): 46-51.

Chaudhuri, R.P. (1953). Control of cutworms in potato fields. Indian J. Ent. **15**: 203-206.

Clough, G.H., Rondon, S.I., DeBano, S.J., David, N. and Hamm, P.B. (2010). Reducing tuber damage by the potato tuberworm (Lepidoptera: Gelechiidae) with cultural practices and insecticides. *J. Econ. Entomol.* **103**(4): 1306-1311.

Das, G.P., Elias, M., Haque, M.A. and Miah, M.R.U. (1996). Field screening of insecticides in controlling the cutworm *Agrotis ipsilon* (Hufn.) attaking potato. *Bangladesh J. Zool.***24**(2):133-136.

Dashevskii, S.V. and Rybakov, N.A. (1979). A test on the control of cutworms. *Zashehitarasterii.***2**:34-35.

Foster S.P., Denholm, I. and Devonshire, A.L. (2000). The ups and downs of insecticide resistance in peach-potato aphids (*Myzus persicae*) in the U.K. *Crop Protect*. **19**:873-879

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York.

Hoy, C.W., Boiteau, G., Alyokhin, A., Dively, G. and Alvarez, J.M. (2008). Managing insects and mites. In Potato Health Management. Plant Health Management Series (Ed. D.A. Johnson). AmericanPhytopathological Society, St Paul, Minnesota, USA. Second Edition. pp. 133-147.

Hussain, A. and Rahman, M. (2000). Evaluation of some chemicals against the aphids, jassids and white flies in potato. *J. Pestic. Res*. **12**: 99-102.

International Year of the Potato. (2008). The potato. United Nations Food and Agricultural Organisation. 2009. Retrieved 26 October 2011.

Islam, B.N. 1984. Pesticidal action of neem and certain indigenous plants and weeds of Bangladesh. Proc. of 2nd Intl. Neem conference Rauischholzhausen, FRG, May 25-28, 1983. pp. 263-290.

Islam, M. N, Nessa,Z. and Karim, M.A. (1991). Management of the potato cutworm, *Agrotis ipsilon* Hufn.(Lepidoptera: Noctuidae) with insecticides other than organochlorinated hydrocarbon insecticides. *Bangladesh J. Zool*. **19**: 173-177.

Jensen, A., Schreiber, A. and Bell. N. (2011). Irish potato pests. In Pacific Northwest Insect Management Handbook. Ed. C. Holligsworth. U. Massachusetts Extension.

Johnson, D.A. (2008). *Potato Health Management.* Plant Health Management Series. American Phytopathological Society, St Paul, Minnesota, USA. Second Edition. pp. 259.

Kareem, A.A. (1981). Neem as an antifeedent for certain polyphagous insects and a bruchid on pulse. Proc.1st.Int. Neem conf. RottachEgern. FRG, 16-18 June, 1980. pp. 223-258 .

Lal, L. (1990). Insect pests of potato and their status in north-eastern Indian.*Asian Potato J.***1**: 49-51.

Mohammad, A.(1945). *Proceedings Indian Academy Science* (B) 22 219-224.

Narayanan, E.S. (1954). The greasy cutworm, *Agrotis ypsilon* Rott. A serious pest of rabi crops. *Indian Fmg*. **3**: 8-10.

Nasir, E.S.A, Moaswd, G.M. and Elkifl, A.H. (1974). Behaviour of full grown larvae of *Agrotisipsilon* (Hufn.). *Bulletin de la society Entomologique d' Egypte*. **57**: 279-282.

Nessa, Z., Karim, M.A. and Howlader, M.S.M. (1990). Efficacy of insecticides against the potato cutworm, *Agrotis ipsilon* (Hufn.). *Bangladesh Hort.***18**: 25-31.

Panchabhavi, K.S., Bankapur, V.M., Mutalidessi, K.S. and Malaptol, M.S. (1972). Estimation of loss of potato tubers caused by greasy cutworms, *Agrotis ypsilon* Rott. (Lepidoptera: Noctuidae). *Indian J. Agril. Sci.***42**: 428-429.

Perring,T.M., Gruenhagen, N.M. and Farrar, C.A. (1999). Management of plant viral diseases through chemical control of insect vectors. *Annual Rev. Entomol.* **44**: 457-481.

Pike, K.S., Boysdston, L.L. and Allison, D.W. (2003). Aphids of western North America north of Mexico. Washington State University Extension. MISC0523. pp. 282.

Prasad, S. K. (1961). Quantitative estimation of damage to potatoes caused by potato leaf hopper.*Empoascafabae*(Harris). *Indian Potato J.* **3**: 105-107.

Pruthi, H.S. (1969). *Pests of Solanaceous crops. Text Book of Agricultural Entomology.* ICAR Publ. pp. 651-652.

Radcliffe, E.B. and Ragsdale, D.W. (2002). Invited Review. Aphid-transmitted potato viruses: The importance of understanding vector biology. *American J. Potato Res.* **79**:353-386.

Rai, H. S.; Sharma, H.L. and Awasthi, A.K. (1988). Know your potato pest and control them. *Fmr. Parlian*. **23**(1): 9-10 and 26.

Rataul, H. S. and Misra, S. S., 1979. Potato pests and their control. *Pesticides*.**13**(7): 27-38 and 42.

Razaq, M., Muhammad, A. and Anjum, S. (2006). Synergism of Pyrethroids with Piperonyl Butoxide (pbo) in Jassid,*Amrasca devastans* (dist.) (Homoptera: Cicadellidae) from Pakistan. *Pakistan J. Entomol.* **28**(2): 51-56.

Rondon, S.I. (2010). The potato tuberworm: a literature review of its biology, ecology, and control. *American J. Potato Res*. **87**:149–166.

Roy, N. K. (2002). In: Chemistry of pesticides, CBS Pub., New Delhi, pp. 105-106.

Salem, S.A. (1990). Evaluation ofneem oil as tuber protectant against*Phthorimaeaoperculella Zell. Ann. Agric. Moshtohor.* **29**(1): 589-596.

Saxena, A.P. (1974). Save potato crop from the ravages of pests. *Indian Fmg*. **24**(6): 25-26 and 31.

Saxena, A.P. and Rizvi, S.M.A. (1974). Insect-pests problems of potato in India. *J. Indian Potato Asso.* **1:** 45-50.

Saxena, A.P. and Misra, S.S. (1980). Potato pests in hilly tracts and their control. *Seeds and Farm.* **6**: 43-50.

Schreiber, A., Jensen, A., Pike, K., Alvarez, J. and Rondon, S.I. (2010). Integrated Pest Management guidelines for insects and mites in Idaho, Oregon, and Washington Potatoes.

Simpson, G.W. (1977). Potato insects and their control. In O. Smith, *Potatoes, Production, Storing and Processing.* pp 505-605, AVI Publishing Co. Westport, Connecticut, U.S.A.

Sing, H. (2002). Household and Kitchen- Garden Pest, Kalyani Publisher, New Delhi. 42pp.

Spooner, D.M., McLean, K., Ramsay, G., Waugh, R. Bryan, G.J. (2005). A single domestication for potato based on multilocus amplified fragment leng polymorphism genotyping. *PNAS*. **102**(41): 14694– 99.

Srinivasan, R. and Alvarez, J.M. (2007). Effect of mixed viral infections (potato virus Y-potato leafroll virus) on biology and preference of vectors *Myzus persicae* and *Macrosiphumeuphorbiae* (Hemiptera: Aphididae). *J. Econ. Entomol*. **100**(3): 646-655.

Srivastava, B. K. (1958). A new cutworm pest of potato in Rajasthan. *Current Sci.* **27**: 504-507.

Verma, K.D. and Chandla, V.K. (1977). Chemical control of*Agrotis segetum* D. & S. on potato. *Pesticides.* **11**(4): 53-57.

Verma, K.D.and Misra, S.S. (1975). Be on the watch for green peach aphid. *Indian Fmg*.**25**(2): 7-8.

APPENDICES

Appendix I. Monthly average record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from October 2015 to April 2016.

Month	Air temperature (ºc)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2015	31.6	23.8	78	172.3	5.2
November, 2015	29.6	19.2	77	34.4	5.7
December, 2015	26.4	14.1	69	12.8	5.5
January, 2016	25.4	12.7	68	7.7	5.6
February, 2016	28.1	15.5	68	28.9	5.5
March, 2016	32.5	20.4	64	65.8	5.2
April, 2016	33.7	23.6	69	165.3	4.9

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargaon, Dhaka - 1212

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available P	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka