INSECT PEST DIVERSITY AND RISK ASSESSMENT FOR POTATO IN BANGLADESH

MD. SAIFUL ISLAM

DEPARTMENT OF ENTOMOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR DHAKA-1207, BANGLADESH

JUNE, 2015

INSECT PEST DIVERSITY AND RISK ASSESSMENT FOR POTATO IN BANGLADESH

BY

MD. SAIFUL ISLAM

REGISTRATION NO.: 09-03640

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 (MS)
IN
ENTOMOLOGY

SEMESTER : JANUARY-JUNE, 2015

Approved by:

Supervisor	**Co-Supervisor**
Prof. Dr. Md. Razzab Ali	**Prof. Dr.Md. Abdul Latif**
Professor **Department of Entomology**	**Professor** **Department of Entomology**

Dr. Mohammed Sakhawat Hossain

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, '**INSECT PEST DIVERSITY AND RISK ASSESSMENT FOR POTATO IN BANGLADESH'** 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** embodies the result of a piece of bona fide research work carried out by **Md. Saiful Islam**, Registration No. **09-03640** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2015
Dhaka, Bangladesh

.....
Prof. Dr. Md. Razzab Ali
Supervisor

Dedicated to

My

Beloved Parents

ABBREVIATIONS AND ACRONYMS

Abbreviation		Full meaning
AAEO	:	Assistant Agriculture Extension Officer
AEO	:	Agriculture Extension Officer
BADC	:	Bangladesh Agriculture Development Corporation
BARI	:	Bangladesh Agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
BRAC	:	Bangladesh Rural Advancement Committee
DAE	:	Department of Agricultural Extension
DD	:	Deputy Director
EU	:	European Commission
FAO	:	Food and Agriculture Organization
FGD	:	Focus Group Discussion
FLO	:	Field Level Officer
IPPC	:	International Plant Protection Convention
ISPM	:	International Standard for phytosanitary Measures
JAEO	:	Junior Agriculture Extension Officer
NGO	:	Non Government Organization
UAO	:	Upazila Agriculture Officer
USA	:	United States of America
USDA	:	United States Department of Agriculture
WTO	:	World Trade Organization
SAAO	:	Sub-Assistant Agriculture Officer

ACKNOWLEDGEMENTS

At first the author expresses his deepest and sincerest gratitude to the omniscient, omnipresent and omnipotent **Allah** who enabled him to pursue education in Agriculture discipline and to complete this thesis for the degree of Master of Science (MS) in Entomology.

The author wish to offer his cordial appreciation and best regards to his supervisor, **Professor Dr. Md. Razzab Ali,** Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, who has supported him throughout his thesis writing with his patience and knowledge whilst allowing him the room to work in his own way. Without his encouragement this thesis would not have been completed or written.

The author is very much grateful to his co-supervisor **Professor Dr. Md. Abdul** L**atif**, Department of Entomology, SAU, Dhaka, for his valuable advice, constructive criticism and factual comments in upgrading the research with all possible help during the research period and preparation of the thesis.

The author would like to express his deepest respect and boundless gratitude to his honorable teachers of the Department of Entomology, SAU, Dhaka, for their valuable teaching, sympathetic co-operation throughout of this research work. The author wants to give special thanks to Motahar Hossain, Scientific officer, Entomology division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, who always stimulate the author and give valuable suggestion during his whole research work.

The author also expresses his cordial thanks to some of his seniors, friends and juniors, Md. Kamrul islam, Deen Mohammad Deepo, Towfiqul Anwar, Ferdous Habib, Md. Mostaqur Rahman, Habibur Rahman, Md. Kabirul islam, Mahmud Morshed Shaon, Khalid Syfullah, Jannatur Rahman, for their valuable help during conducting his research.

Last but not least the author is indebted to his beloved parents and friends for their inspiration, blessing and encouragement that opened the gate of his higher studies in his life.

June, 2015 **The Author**

SAU, Dhaka

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ABSTRACT

The study was conducted in the 20 upazila of 10 selected major potato growing districts of Bangladesh during the period from December 2014 to February 2015 to find out the present status and diversity of insect pests of potato, their risks and management options. The data were collected through interview of 500 potato farmers considering 25 potato farmers from each upazila and 60 field level officers of DAE including one UAO, one AEO and one SAAO. The data were analyzed using computer program SPSS 17.0 version. The result shows that BARI Alu-7 (Diamont) variety and BARI Alu-8 (Cardinal) were the most popular potato varieties cultivated by the farmers. The major sources of potato seeds were the self produced seeds, BADC seeds, seed traders/dealers and neighboring farmers. Mostly (89.20%) potato farmers faced problems with lower market price of the produced potato. Other major problems faced during potato cultivation were diseases, insect pest and weed attack. The BARI Alu-7 and BARI Alu-8 were the most susceptible potato varieties to insect pests and diseases, whereas the Lal-pakhri was the least susceptible to pests. Mostly (98.50%) the potato was infested in the field by cutworm, aphid, potato tuber worm, leaf miner, mole cricket, field cricket and leaf hoppers. Among these insect pests, cutworm and aphid were identified as major pests in the field and caused damage with high and moderate infestation intensity, respectively. Others were identified as minor insect pests of potato caused damage with low infestation intensity. The investigation revealed that 73.50% tubers were attacked by the worm in storage condition and it can be the major storage pest of potato in Bangladesh . Currently cutworm and aphid were more damaging pest of potato in field condition, and potato tuber worm was more damaging insect pest in storage.To control the insect pests in the potato fields, 93.40% farmers used to apply insecticides. Additionaly, other control options like application of flood irrigation, hand picking and poison baits in the furrows were observed specially for controlling cutworm. So for, 95%potato farmers got assistance and advices from pesticide dealers while controlling these pests. Moreover, DAE, NGO's and neighboring experienced and skill farmers were helped the farmers.

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CHAPTER I

INTRODUCTION

The potato is the world's most important tuber crop under solanaceae family. It is grown in more than 125 countries and consumed almost daily by more than a billion people. Hundreds of million of people in developing countries depend on potatoes for their survival. Potato cultivation is expanding strongly in the developing world, where the potato's ease of cultivation and nutritive content have made it a valuable food security and cash crop for millions of farmers. Developing countries are now the world's biggest producer-and importers- of potatoes and potato products. Potatoes can be used for a variety of purposes: as a fresh vegetable for cooking at home, raw material for processing into food products, food ingredients, starch and alcohol, feed for animals, and seed tubers for growing the next season's crop. Around the world, consumer demand is shifting from fresh tubers to processed products and ever greater quantities of potatoes are being processed to meet rising demand for convenience food and snacks. The major divers behind this trend include expanding urban populations, rising incomes, diversification of diets, and lifestyle that leave less time for preparing the fresh product for consumption. So the importance of export and import of potato is an important issue of the world trade. The total world potato production is estimated at 364,808,768 tonnes in 2012 (FAO STAT, 2012). The world potato sector is undergoing major changes. Until the early 1990s, most potatoes were grown and consumed in Europe, North America and countries of the former Soviet Union. Since then, there has been a dramatic increase in potato production and demand in Asia, Africa and Latin America, where outpout rose from less than 30 million tonnes in the early 1960s to more than 165 million tonnes in 2007. FAO data show that in 2005, for the first time, the developing world potato production exceeded the developed world. China is now the biggest potato producer, and almost a third of all potatoes is harvested in China and India.

Bangladesh has a primarily agrarian economy. Agriculture is the single largest producing sector of the economy since it comprises about 16.58% of the country's GDP and employs around 45% of the total labor force (BBS, 2012-2013). The performance of this sector has an overwhelming impact on major macroeconomic objectives like employment generation, poverty alleviation, human resources development and food security. Rice is Bangladesh's principle crop with a production of 37.8 million metric tons (BBS, 2013).but potato contributes 8.603 million MT from local production. Potato is now the third most important food item of Bangladesh by tonnage production (FAO STAT 2012). The crop is very widely grown across Bangladesh, with the greatest concentration of area (through generally not the highest yields) occurring in the Northwestern region of the country, especially the districts of Rangpur and Bogra. An area of concentrated cultivation in the vicinity of the capital city, Dhaka, supplies the high demand for potatoes in the largest urban market.

The climate of Bangladesh is characterized by a tropical moonsoon with three main seasons having relatively little variation from month to month. Therefore, favorable agronomical characteristics are prevailing here to cultivate more potato crops in Bangladesh. But the production of potato is attacked by pests like insect, diseases and weeds etc. As Bangladesh being the tropical and humid country, the infestation of insect pests is very common here. But a little information was present regarding the diversity and risk assessment of insect pests of potato in Bangladesh. Therefore, it was felt to undertake the study to find out the present status of insect pests of potato, their diversity, risk and management options for controlling in Bangladesh.

Objectives

Considering the above points view in mind, the present study was undertaken with the following objectives:

1. To find out the major and minor insect pests of potato in Bangladesh;
2. To conduct risk assessment of insect pests of potato in Bangladesh
3. To find out the control options against insect pests of potato commonly used by the farmers in Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

The potato is a starchy, tuberous crop, *Solanum tuberosum* L. belonging to the family Solanaceae. The word "potato" may refer either to the plant itself or the edible tuber. It is the world's fourth-largest food crop, following maize, wheat, and rice. Following centuries of selective breeding, there are now over a thousand different types of potatoes. Over 99% of the presently cultivated potatoes worldwide descended from varieties that originated in the lowlands of south-central Chile, which have displaced formerly popular varieties from the Andean highlands. It remains an essential crop in Europe (especially eastern and central Europe), where per capita production is still the highest in the world, but the most rapid expansion over the past few decades has occurred in southern and eastern Asia. China now leads the world in potato production, and nearly a third of the world's potatoes are harvested in China and India. Bangladesh is now in fourth position in terms of potato production.

The changing global scenario is compelling policymakers to adhere to the regulations and obligations set by the World Trade Organization (WTO). The resulting new economic regime is expected to alter the economics of existing cropping systems, including potato, in terms of production, value added, and trade. To satisfy the prerequisite of WTO for potato trade, it is necessary to conduct pest risk analysis of potato in Bangladesh. Good number of research works has been done on different aspects of potato different parts of the world, but the insect pest risk analysis of potato in Bangladesh is the first step. Although considerable literature dealing with the risk analysis of potato in respect of insect pest identification and their management so far has been scare, some of the works related to the present study have been presented below under the following sub-headings:

2.1 General review on potato

Potatoes are used for a variety of purposes, and not only as a vegetable for cooking at home. In fact, it is likely that less than 50 percent of potatoes grown worldwide are consumed fresh. The rest are processed into potato food products and food ingredients; fed to cattle, pigs, and chickens; processed into starch for industry; and re-used as seed tubers for growing the next season's potato crop.Potatoes are used to brew alcoholic beverages such as vodka, potcheen, or akvavit. They are also used as food for domestic animals. Potato starch is used in the food industry as, for example, thickeners and binders of soups and sauces, in the textile industry, as adhesives, and for the manufacturing of papers and boards (Campbell *et al*., 1997).Many companies are exploring the possibilities of using waste potatoes to obtain polylactic acid for use in plastic products; other research projects seek ways to use the starch as a base for biodegradable packaging (Gopal and Khurana, 2006). Potato skins, along with honey, are a folk remedy for burns in India (POP, 2009). Burn centers in India have experimented with the use of the thin outer skin layer to protect burns while healing.

2.2. Origin and distribution of potato

The potato was first domesticated in the region of modern-day southern Peru and extreme northwestern Bolivia (Spooner *et al*., 2005) between 8000 and 5000 BC (OIA, 1989). It has since spread around the world and become a staple crop in many countries. Sailors returning from the Andes to Spain with silver presumably brought potatoes for their own food on the trip (Ames, 2008). Historians speculate that leftover tubers were carried ashore and planted: "We think that the potato arrived some years before the end of the 16th century, by two different ports of entry. It is generally believed that potatoes entered Africa with colonists, who consumed them as a vegetable rather than as a staple starch (CWHFP, 1994).Shipping records from 1567 show that the first place outside of Central and South America where potatoes were grown were the Canary Islands (Williams, 2007). Edward Terry mentioned the potato in his travel accounts of the banquet at Ajmer by Asaph Khan to Sir Thomas Roe, the British Ambassador in 1675. It is the earliest mention in history of India. The vegetables gardens of Surat and Karnataka had potatoes as mentioned in Fyer's travel record of 1675. The Portuguese introduced potatoes, the called it 'Batata', in India in early seventeenth century when they cultivated it along the western coast of India. The British traders introduced potatoes in Bengal as a

root crop, 'Alu'. By the end of eighteenth century, it was cultivated across northern hill areas of India (CCWPU, 2009). Potatoes were introduced to Tibet by nineteenth century through trade route from India (Srivastava, 2008).

2.3. History of potato in Bangladesh

The Portuguese introduced potatoes; they called it 'Batata', in India in early seventeenth century when they cultivated it along the western coast of India. The British traders introduced potatoes in Bengal as a root crop, 'Alu'. By the end of eighteenth century, it was cultivated across northern hill areas of India (CCWPU, 2009). Potatoes were introduced to Tibet by nineteenth century through trade route from India (Srivastava, 2008). The potato was introduced in the Philippines during the late 16th century and to Java and China during the 17th century. It was well established as a crop in Africa by the mid-20th century (CCWPU, 2009).

2.4. Variety of potato cultivated in Bangladesh

Several hundred varieties of potatoes are grown in the world. These differ in appearance, tuber structure, size and color, time of maturity, cooking and marketing qualities, yield, and resistance to pests and diseases. A variety that grows well in one area may do poorly in another. Potato varieties that are cultivated in Bangladesh are broadly categorized into two groups, local and high yielding. The so-called local varieties are in fact, not strictly native. In the distant past those were brought to this part of the subcontinent but in the absence of varietal improvement efforts, gradually degenerated, showing poor yield performance. In spite of poor yields, some of the local varieties are still being cultivated because of their taste and cooking qualities.

There are about 27 local varieties of potatoes cultivated in different parts of the country. They have familiar local names. The familiar local varieties are (a) *Sheel Bilatee*- mostly cultivated in Rangpur. The tuber is oblong, reddish. Each tuber weighs about 30 g. (b) *Lal Sheel*- primarily cultivated in Bogra with tubers rounded, reddish, each having a weight of about 55 g. This variety is also known as Lal Madda and Bograi. (c) *Lal Pakri* - cultivated widely in Dinajpur, Bogra and Sirajganj districts with tubers reddish and round, each weighing about 30 g. (d) *Duhajari* - mostly cultivated in the Chittagong area.

Tubers appear round and pale, each weighing about 25 g. Among other indigenous varieties Jhau Bilatee and Suryamukhi are notable.

Bangladesh Agricultural Research Institute (BARI) has already released high yielding potato varieties. The HYV and other local potato varieties are presented below:

BARI Alu-1 (Hira)

BARI Alu-4 (Ialsha)

BARI Alu-7 (Diamant)

BARI Alu-8 (Cardinal)

BARI Alu-11 (Chomok)

BARI Alu- 12 (Dhira)

BARI Alu- 13 (Granolla)

BARI Alu-15 (Binella)

BARI Alu-16 (Arinda)

BARI Alu- 17 (Raja)

BARI Alu-18 (Baraka)

BARI Alu- 19 (Binti)

BARI Alu- 20 (Jarla)

BARI Alu-21 (Provento)

BARI Alu-22 (Saikot)

BARI Alu-23 (Utra)

BARI Alu-24 (Dura)

BARI Alu-25 (Aesterix)

BARI Alu-26 (Felsina)

BARI Alu-27 (Spirit)

BARI Alu-28 (Lady Rosetta)

BARI Alu-29 (Courage)

BARI Alu-30 (Meridian)

BARI Alu-31 (Sagita)

BARI Alu-32 (Quiensce)

BARI Alu-33 (Almera)

BARI Alu-34 (Laura)

BARI Alu-35

BARI Alu-36

BARI Alu-37

BARI Alu-38 (Omega)

BARI Alu-39 (Belini)

BARI Alu-40

BARI Alu-41

BARI Alu-42 (Ezila)

BARI Alu-43 (Atlas)

BARI Alu-44 (Elgar)

BARI Alu-45 (Stafy)

BARI Alu-46 (LB-7)

Gurguri

Lal-Pakhri

Shil-Bilati

BARI TPS-1

BARI TPS-2

2.5. National demand-supply scenario for potato seed

In Bangladesh potato is grown in an area of about 8,06,294 acres. For this purpose about 3,50,000 m tons of seed potatoes are necessary. Most of the seeds used are not of high quality. The farmers generally use the tubers they keep for their own consumption as seeds. This results in poor yield in the following season.

Usually, two types of potato seeds are imported by the government, one known as foundation or basic seeds, and the other certified seeds. Bangladesh Agricultural Development Corporation (BADC) distributes certified seeds to the growers produced locally from the imported foundation seeds in their own farms or in lands of farmers on contract basis. Directly imported seeds are also sold to growers through local BADC offices. BARI has now started producing seed potatoes in it own farms at the Debiganj

Breeders Potato Seed Production Centre to make seeds available to growers at a reasonable price. Available quality seeds, however, are not sufficient to meet the demand. During 1997-98, the country imported 396,331kg fresh or chilled potato seeds (BBS, 1998).

2.6. Production of potato in Bangladesh

Potato production in Bangladesh in fiscal year (FY) 2012-13 hit a new record of 8.603 million tonnes surpassing the past record of 8.38 million tonnes in FY'11. The production witnessed a negative growth in FY'12 when it plunged to 8.205 million tonnes--- a 2.08 per cent fall compared to that of FY'11. The government statistics provider Bangladesh Bureau of Statistics (BBS) in its latest release said potato, the most consumed vegetable item of the country was cultivated on 0.444 million hectares of land in FY'13. The acreage had increased by 14,000 hectares compared to that of FY'12 which also helped achieve a higher output. Potato was produced on 4.6 million hectares in FY'11. Bidhan Baral, deputy director at BBS told the FE that per hectare yield has been increasing gradually in the country which is very positive for the production scenario. "In FY'11, per hectare yield was 18.21 tonnes which reached 19.07 tonnes in FY'12 and hit a new record of 19.307 tonnes in fiscal year'13,"he said. "Using balanced fertiliser, modern seed varieties, integrated pest management and a sound weather during the growing stage helped get a record crop,"he added. Directorate General of Food (DGoF) officials said annual demand for the carbohydrate-rich vegetable has now stood at 6.5 to 7.0 million tonnes. That indicates a 1.5m to 2.0m tonnes are surplus production. Experts expressed their opinion that the production may further increase in the current fiscal year (FY'14) as farmers got profitable price for their produce last season. "Ensuring lucrative price for farmers and boosting export after meeting local demand could help maintain the firm growth of the produce", Associate Professor, Faculty of Agricultural Economics and Rural Sociology, Bangladesh Agricultural University A S M Golam Hafeez Kennedy said. He said that the higher price tag during the harvesting season last year would definitely encourage farmers to increase production this year. "The government should ensure profitable price for the farmers to maintain the firm growth in coming years he commented. He said export should be encouraged to use the additional volume of production. He also suggested providing credit to the farmers to introduce community-based small cold storages so that peasants can preserve potatoes and sell the same at a

favorable time. However, the farmers got Tk 5.5 to Tk 6.5 per kg during harvesting season in FY'13 which was only Tk 1.5-Tk 2.0 during FY'11 and FY'12, Department of Agricultural Marketing (DAM) data showed. Production cost was between Tk 4 and Tk 5.5 per kg across the country, according to DAM. The price of potato, mainly Granola variety is now sold at Tk 13-Tk 18 at the country's retail market. The price of per kg potato is 30-35 per cent lower now compared to the corresponding period of last year, according to DAM. The Bangladesh Cold Storage Association (BCSA) said the country has a storage capacity of 4.2 million tonnes of potato in 382 cold storages, which is less than half in terms of the total production.

Bangladesh Cold Storage Association (BCSA) president Md Jasim Uddin told the FE that a huge amount of potato is still lying unsold in cold storages which is alarming. He said the government should provide potatoes along with rice and wheat through relief, rationing, VGF (Vulnerable Group Feeding)-VGD (Vulnerable Group Development) programmes and Open Market Sale (OMS) to benefit the farmers.

2.7.1. Insect pests of potato in Bangladesh

The studies show that cutworm (*Agrotis ipsilon*), Aphid (*Macrosiphum euphorbiae*), Potato tuber worm (*Phthorimaea operculella*), Leaf hopper (*Empoasca fabae*) are the major insect pests of potato in Bangladesh. Among these insect pests, cutworm attacks seedling, Aphids pierce veins, stems, growing tips, and blossoms with their needle-like mouthparts, Potato tuberworm feed on potato leaves, stems, petioles, and more importantly potato tubers in the field and in storage, leaf hopper causes the curling up of leaves. Some other minor insects such as Leaf miner (*Liriomyza huidobrensis*) , Field cricket (*Gryllotalpa pennsylvanicus*), Yellow mites (*Polyphagotarsonemus latus*), Green bug (*Nezera viridula*), White fly (*Bemisia tabaci*), Dash fly.

2.7.2. Insect pests of potato in worldwide

Wireworms are one of the most destructive insect pests in the Pacific Northwest. Nearly 40 species from 12 genera attack potato, but only a few are economically important (Hoy et al., 2008). Wireworms are the larval stage of click beetles. Wireworms can cause damage to potatoes by feeding upon potato seed pieces and sprouts in the spring, facilitating infection by pathogens or other insect pests. The latter damage can result in

reduction in yield and/or rejection of the entire crop. In the U.S. there is zero tolerance for live larvae in tubers. Wireworms tend to be most damaging in potatoes that follow corn or small grains (wheat, barley) and on ground just entering cultivation. Potatoes, corn, wheat and grass are hosts for several species of wireworms in the Pacific Northwest. Also, beans, carrots, peas, and other annual crops may be infested; while melons, beet roots, and strawberry fruits are affected less frequently.

The Colorado potato beetle, *Leptinotarsa decemlineata* (Say), first described in 1824 by Thomas Say, is associated with potato plants and its solanaceous relatives such as nightshade. It is the most important defoliating insect pest of potato. Its remarkable ability to develop insecticide resistance, incredible reproductive potential and sustained feeding by larvae and adults, makes the management of this pest challenging (Hoy et al., 2008). The Colorado Potato Beetle (CPB) is a yellow and black striped beetle, about 1.3 cm long and 0.6 cm wide. They can be found in almost all U.S. potato regions. This beetle can cause complete defoliation and nearly complete crop loss if allowed to reproduce unchecked. Both larvae and adults feed on potato foliage throughout the season. Potatoes and other solanaceous plants such as eggplant, nightshade, horsenettle and buffalobur are preferred hosts of this pest.

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: Potato leafroll 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 but primarily by green peach aphid. The potato aphid transmits PVY and PVA. 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" grows. 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). The green peach aphid, also known as tobacco or spinach aphid, survives the winter in the egg stage on peach trees. They can also overwinter on various perennial, biennials, and winter annual weeds, besides potatoes and peaches, other hosts include lettuce, spinach, tomatoes, other vegetables and ornamentals (Dickson and Laird, 1967; Wallis, 1967; Tamaki et al., 1980; Barry et al., 1982)

The beet leafhopper, *Circulifer tenellus* Baker, is the carrier of the beet leafhopper-transmitted virescence agent (BLTVA) phytoplasma (a.k.a., Columbia Basin potato purple top phytoplasma) that causes significant yield losses and a reduction in potato tuber quality.

Beet leafhoppers must feed in the phloem of the plant. Direct feeding can cause relatively minor damage ("hopperburn"); however, BLTVA is a very destructive and detrimental disease affecting potatoes. BLTVA can cause a wide range of symptoms in potatoes, including leaf curling and purpling, aerial tubers, chlorosis, and early senescence. Most BLTVA infection occurs early in the season, during May and June (Munyaneza, 2003; Munyaneza and Crosslin, 2006). Potato is not a preferred host for BLH and will not spend much time on the crop (however it does spend enough time to transmit BLTVA) (Schreiber et al., 2010). They also thrive on radishes, sugar beet (Meyerdirk and Hessein, 1985), and carrots (Munyaneza, 2003).

The potato tuberworm, *Phthorimaea operculella* Zeller, is one of the most economically significant insect pests of cultivated potatoes worldwide. The first significant economic damage to potato crops in the Columbia Basin region occurred in 2002, when a field in Oregon showed high levels of tuber damage associated with potato tubeworm. By 2003, the pest was a major concern to all producers in the region after potatoes from several fields were rejected by processors because of tuber damage. Since then, potato tubeworm has cost growers in the Columbia Basin millions of dollars through increased pesticide application and unmarketable potatoes (Rondon, 2010). Tubeworm larvae behave as leaf miners. They can also live inside stems or within groups of leaves tied together with 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). Tunnels left by tuber worms in tubers can be full of droppings or excrement that can be a potential source for secondary infections. Although the potato tubeworm 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).

The two-spotted spider mite, *Tetranichus urticae* Koch, is the most abundant mite species found in potatoes in the Pacific Northwest. They can occasionally be considered pests of potatoes when crops such as beans, corn, alfalfa or clover seed are planted nearby (Hoy et al., 2008).

Cutworm, armyworm and loopers 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. The most common species in the Pacific Northwest regions. Cutworms feed on potato seeds, cut stems, and foliage; armyworms and loppers feed on foliage throughout the season.

Potato leaf miner, *Liriomyza huidobrensis* has been a serious problem in the Sandveld , USA since 2000 and has spread to other potato production regions soon after. Once the leaf miner has become established in a potato field, it will spread within a few days and is then almost impossible to control. The management process must therefore start even before the first signs of damage and for it to be truly effective chemical, cultivation and biological measures must be integrated. Mines or tunnels are created as the larvae feed on the mesophyll tissue between the two epidermal layers of the leaf. Flies tend to lay their eggs in punctures situated close to the leaf veins, especially the main vein. The tunnels then spread to the leaf blades. With heavy infestation tunnels can interlink, thus destroying large portions of the functional leaf surface. This can result in serious damage, since photosynthesis is insufficient to meet the plant's energy requirements. Tunnels can also appear in the leaf petioles.

CHAPTER III

MATERIALS AND METHODS

3.1 Study Area

The survey was conducted in some selected major potato growing districts of Bangladesh namely Dinajpur, Thakurgaon, Rangpur, Gaibanda, Bogra, Joypurhat, Munshigonj, Chandpur, Sherpur, Kishoregonj. .

3.2. Study design

The survey study was conducted in the 10 major potato growing districts of Bangladesh. A total of 20 upazilas were selected under 10 sampled districts considering 2 upazila for each district and 25 potato growers were interviewed in each upazila through pre-designed questionnaire (Appendix). Thus, a total of 500 potato growers were interviewed from 10 sampled districts. On the other hand, a total of 60 Field Level Officers (FLO) of DAE were (3 officers from each upzila) also interviewed through pre-designed questionnaire considering one UAO, one AEO and one SAAO from each upazila under 10 sampled districts.

3.3. Study Indicators

The researcher has proposed the following variables/indicators were considered:

1. Demographic **:** Name, age and sex
2. Social **:** Education and profession
3. Study related indicators:

- Farm size, variety of potato cultivated;
- Occurrence and severity of insect pests of potato;
- Potential risk and economic damage caused by these pests;
- Status of insect pests of potato;
- Effective measures practiced by the farmers in controlling the insect pests of potato;
- Suggestions for improving management options for controlling insect pests of potato in Bangladesh.

3.4. Development of questionnaire/instruments for data collection

According to the sample design, 500 respondents were covered under the study, of which 500 respondents participated for face-to face interview and the selection of respondents were made on a stratified sampling technique for sampled districts and simple random sampling technique within the sampled districts. There are two types of questionnaire were prepared for two types of data collection such as (a) respondents' survey for potato farmers and (b) respondents' survey for field level officers of DAE and these are given below:

3.5. Respondents survey

The respondents' survey was conducted in the 20 selected upazila under 10 selected districts of Bangladesh. The face to face interview was conducted among 500 potato farmers and they filled up a set of pre-designed questionnaire (**Appendix-1)** encompassing issues about the above mentioned study indicators. The face to face interview was also conducted among 60 FLOs and they filled up a set of pre-designed questionnaire (**Appendix-2).**

3.6. Respondents distribution in the sampled upazila and districts

The sampled 500 potato farmers and 60 field level officers of DAE were selected from 20 upazila under 10 major potato growing districts of Bangladesh. The distribution of sampled respondents has been presented in the following table:

District	Upazila	No. of potato farmers	No. of field level officers
Dinajpur	1.Sadar	25	3
	2.Birgonj	25	3
Thakurgaon	3.Ranisankail	25	3
	4.Pirgonj	25	3
Rangpur	5.Pirgacha	25	3
	6.Badargonj	25	3
Gaibandha	7.Polashbari	25	3
	8.Gobindagonj	25	3
Bogra	9.Sherpur	25	3
	10.Shibgonj	25	3
Joypurhat	11.Panchbibi	25	3
	12.Khetlal	25	3
Munshigonj	13.Sadar	25	3
	14.Tongibari	25	3
Chandpur	15.Motlab North	25	3
	16.Hajigonj	25	3
Sherpur	17.Sadar	25	3
	18.Nalitabari	25	3
Kishoregonj	19.Sadar	25	3
	20.Pakundia	25	3
Total	20	500	60

3.7. Data collection

Personal interview approach was adopted for collection of primary data. The researcher personally contacted with the potato growers in the respective upazila under 10 sampled potato growing districts. When the target respondents were found the researcher started interview by explaining the objectives of the study to the respondents. After getting respondents, the researcher filled up each question of the questionnaire one by one and obtained desired information. The field level data collection was conducted for a period of potato growing season started from December 2014 to February 2015. After the completion of data collection, all filled up questionnaires were preserved according to the category of respondents for processing and data analysis.

3.8. Data Analysis

Data on different parameters were analyzed through computer software SPSS(version 20). As soon as collected from the field, the filled up questionnaires were coded and data entry were completed using SPSS and MS Access computer packages as well as the data were analyzed for tabulation of the primary data into data tables.

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted in the 20 upazila of 10 selected major potato growing districts of Bangladesh during the period from December 2014 to February 2015 to find out the current status and damage intensity, disease and weedof insect pests of potato, their risks and management options. The data were collected through interview of 500 potato farmers using a pre-designed questionnaire considering 25 potato farmers from each upazila and 60 field level officers of DAE considering one UAO, one AEO and one SAAO of DAE. The results obtained from the studies have been presented below sequentially in various forms and thus interpreted and discussed as to extract the findings systematically in line with the objective of the study.

4.1. Farmers' knowledge on insect pests of potato, their risks and management

The results of the farmers' knowledge on insect pests of potato and their risks have been discussed under the following sub-headings:

4.1.1. Gender of the farmers

The field survey was conducted among 500 potato farmers in 10 major potato growing districts. Out of 500, most (94.5%) of the potato farmers were male, while only 5.5% potato farmers participated in the study were female.

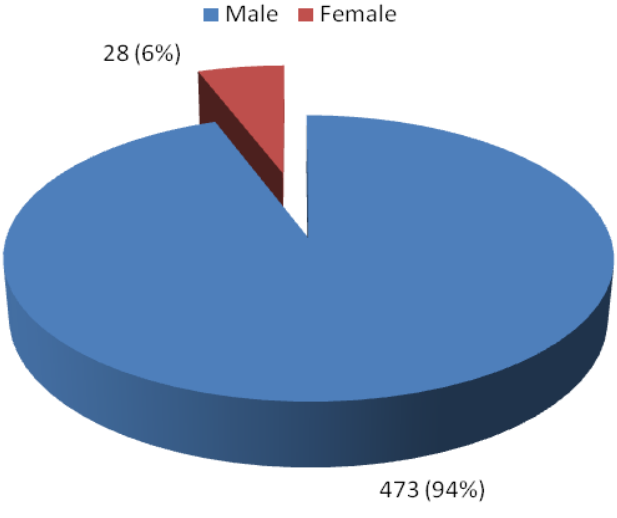

Figure 1. Gender of the potato farmers participated in the field survey

4.1.2. Categories of farmers

Out of 500 potato growers participated in the field study, maximum 40.40% of them (202) were medium farmers, whereas 37.60% farmers (188) were under small category and the lowest proportion (22.00%) of potato farmers were under large farmers category.

Table 4.1.Categories of the farmers participated in the survey

Farmers' category	Number of respondents [N=500]	% response
Small farmers	188	37.60
Medium farmers	202	40.40
Large farmers	110	22.00
Total	500	100.00

4.1.3. Commonly used potato varieties

The maximum (65.4%) Potato growersused Diamant variety of potato for cultivation in their field, whereas 29.6% farmers (148) reported that they used Cardinal variety. This was followed by Granula variety which was cultivated by 25.8% potato farmers (129); while 14.8% farmers used Lal-pakhri variety, 5.4% farmers used BARI Alu-25(Aesterix) variety and only 4.8% farmers used newly imported potato variety to cultivate in their field.

Table 4.2. Commonly used potato varieties cultivated by the farmers

Potato varieties	Response on potato variety cultivation	
	Frequency [N=500]	% response
Diamant	**327**	**65.4**
Cardinal	148	29.6
Granula	129	25.8
Lal-Pakhri	74	14.8
BARI Alu-25(Aesterix)	26	5.2
Newly imported potato	24	4.8
Multiple response		

4.1.4 . Sources of potato seeds used for cultivation

Potato farmers used seed potatoes from different sources for cultivation.Most (89.25%) of them(446) faced problem of lower market price of their produced potato. This was followed by 51.10% farmers (256) used potato seeds collected from BADC. Whereas, 20.9% farmers (104) collected potato seeds from potato seed traders/dealers, 18.40% farmers (92) collected from neighboring farmers; 16.0% farmers collected from local seed producer. Other sources of potato seeds for cultivation were other company seeds (10.9%), importer (14.60%), and NGO 10.70%).

Table 4.3. Sources of seed potatoes usually used for cultivation

Sources of potato seeds	Number of respondents [N=500]	Response (%)
1. Farmers' own seed	**333**	**66.60**
2. Neighbors	92	18.40
3. BADC	256	51.10
4. Other company seed	54	10.9
5. Local seed producer	80	16.00
6. Directly from importer	73	14.60
7. NGO	53	10.70
8. Traders/dealers	104	20.90
9. Other sources	12	2.30
Multiple response		

4.1.5. Major problems faced duringpotato cultivation

Major problem identification of the potato cultivation is one of the most important factors to provide specific advice to the farmers to obtain better yield. Majority (89.20%) Potato farmers asserted their opinion that lower market price of the produced potato was the top most problem for potato cultivation followed by disease (90.20%) weed attack (65.00%), lack of HYV variety (65.80%). Other problems for Potato cultivation were lack of irrigation facilities (21.00%), storage pest (12.20%), lack of marketing facilities (4.20%), lack of farmers training on potato cultivation and high price of pesticides(0.8%).

Table 4.4. Farmers' opinion on major problems faced during potato cultivation

Major problems	Response on major problems	
	No. of respondent [N=500]	% Response
1. Insect pest attack In field	**354**	**70.80**
2. Weed infestation	**325**	**65.00**
3. Disease infection	**451**	**90.20**
4. Lack of HYV	**329**	**65.80**
5. Lack of irrigation facilities	105	21.00
6. Pest attack in storage	61	12.20
7. Lack of marketing facilities	21	4.20
8. Lack of farmers training facilities	11	2.20
9. High price of pesticides	4	0.80
10. Low price of produced potato	**446**	**89.20**

4.1.6. Susceptibility of potato varieties to pests

Susceptibility to insect pests

According to the farmers' opinion, maximum 16.8%farmers reported that the potato variety BARI Alu-7 (Diamont) was susceptible to insect pests followed by newly imported potatoes as reported by only 1.3% farmers, cardinal was susceptible to insect pests as reported only by 1.1% farmers.Whereas, only 1.0% farmers informed that the potato variety Lal-pakhri was susceptible to insect pests.

Susceptibility to diseases

Maximum 26.4%farmers reported that the potato variety BARI Alu-7 (Diamont) was susceptible to diseases. This variety was followed by BARI Alu-8 (Cardinal) as asserted by 18.40% farmers followed by BARI Alu-11 (Chomok) reported by 14.40% followed by newly imported potatoes were susceptible to diseases as reported by only 11.2% farmers. Whereas only 6.8% farmers reported that BARI Alu-13 (Granolla) was susceptible to diseases followed by Lal-pakhri as reported by only 5.4% farmers.

Susceptibility to weeds

There were no significant variations among different potato varieties those had been attacked with weed infestation. Out of 500 farmers, only 3.2 to 6.0% farmers reported that different potato varieties were attacked with weed infestation.

Considering the susceptibility of potato varieties to insect pests, diseases and weeds, the Diamont variety was much susceptible to pests that other varieties followed by Cardinal, whereas the Lal-pakhri (local variety) was least susceptible to insect pests diseases and weeds.

Table 4.5. Farmers' response on susceptibility of potato varieties to pests

Sl. No.	Potato varieties	Response on susceptibility to pests (%)		
		Insect pests	Diseases	Weeds
1.	**BARI Alu-7 (Diamont)**	**16.80**	**26.40**	**6.00**
2.	**BARI Alu-8 (Cardinal)**	5.20	**18.40**	5.40
3.	**BARI Alu-11 (Chomok)**	3.40	**14.40**	3.40
4.	BARI Alu- 13 (Granolla)	1.80	6.80	4.80
5.	Lal-Pakhri	1.80	5.40	3.20
6.	Newly imported potato	3.00	11.20	5.20

4.1.7. Occurrence of insect pests of potato in field condition

According to the opinion expressed by the potato farmers, out of 500, most (98.50%) of the farmers (493) reported that the potato was infested in the field by cutworm, which was followed by aphid infestation as reported by 90.5% farmers. Whereas, 73.0% farmers reported that the potato was attacked by potato tuber worms, followed by leaf miner as reported by 50.1% farmers, followed by mole cricket (54.3%), field cricket (45.80%), leaf hoppers (41.30%) and whitefly (27.15%).

Table 4.6. Farmers' response on occurrence of insect pests of potato in field

Sl. No.	Name of insect pest	Occurrence of insect pest [N=500]	
		Frequency	% response
1	Aphid	452	90.30
2	Cutworm	493	98.50
3	Potato tuber worm	365	73.00
4	Leafhopper	207	41.30
6	Leaf miner	251	50.10
7	Whitefly	136	27.15
8	Field cricket	229	45.80
9	Mole cricket	272	54.30
Multiple response			

4.1.8. Infestation status of insect pests of potato in field condition

According to the opinion expressed by the farmers, out of 500 farmers, the major insect pest of potato in field condition was cutworm stated by 77% farmers. This was followed by aphid stated by 55% farmers. On the other hand, the minor insect pests of potato were potato tuber worm, leaf hoppers, leaf miner, field cricket and mole cricket as stated by 84%, 94.0%, 90.0%, 88%, 89% and 92% farmers, respectively.

Table 4.7. Infestation status of insect pests of potato in field condition

Sl. No.	Name of insect pests	Response on pest status (%)	
		Major pest	Minor pest
1	**Aphid**	**55.00**	45.00
2	**Cutworm**	**77.80**	22.20
3	Potato tuber worm	16.00	**84.00**
4	Leafhopper	5.70	**94.30**
6	Leaf miner	9.60	**90.40**
7	Field cricket	11.70	**88.30**
8	Mole cricket	11.10	**88.90**
Multiple response			

4.1.9. Vulnerable stages of potato plants to insect pests in field condition

According to the opinion expressed by the farmers, Potato plants attacked in different stages by specific pest.Among the insect pests, cutworm and mole cricket attacked potatoes at all stages of the potato plants but mostly at seedling stages as reported by maximum 49.3% and 35.7% farmers, respectively. Whereas aphid, leafhopper, leaf miner and whitefly mostly attacked potato plants at vegetative stages as reported by 74%, 81%, 79% and 76% farmers, respectively.Additionaly potato tuber worm attacked potato at it tuberization stage reported by most (95%) of the farmers.

Table 4.8. Response on vulnerable stages of potato plants to insect pests

Sl. No.	Name of insects pest	Response on vulnerable stages (%)		
		Seedling	Vegetative	Tuberization
1	**Aphid**	24.70	**73.70**	1.60
2	**Cutworm**	**49.30**	**39.0**	11.70
3	Potato tuber worm	0.60	4.50	**95.00**
4	Leafhopper	14.30	**80.70**	5.00
6	Leaf miner	12.10	**78.50**	9.40
7	Whitefly	15.40	**76.18**	8.42
8	Field cricket	**29.70**	31.70	**38.70**
9	Mole cricket	**35.70**	27.50	36.90
Multiple response				

4.1.10. Vulnerable plant potato prone to insect infestation pests in field condition

Farmers informed that the different portion of the plants attacked by various insect pest in field condition The leaves of potato plants were most vulnerable for aphids, leafhoppers, leaf miners and whitefly as reported by most of the farmers (93 to 98%). The stems of potato plants were most vulnerable for cutworm and mole cricket as reported by 86% and 30% farmers. Whereas and the tuber was vulnerable to potato tuber worm reported by (96%) farmers,and the root was vulnerable to field cricket and mole cricket as reported by 29% and 35% farmers, respectively.

Table 4.9. Vulnerable parts of potato plants to insect pests in field condition

Sl. No.	**Name of Insects pest**	**Response on vulnerable parts (%)**			
		Leaf	**Stem**	**Tuber**	**Root**
1	**Aphid**	**97.5**	1.90	1.60	0.00
2	Cutworm	2.80	**86.10**	8.60	2.50
3	Potato tuber worm	1.50	1.90	**96.10**	0.60
4	**Leafhopper**	**94.10**	4.30	1.40	0.20
6	**Leaf miner**	**92.8**	4.60	0.80	1.70
7	**Whitefly**	**98.20**	1.80	-	-
8	Field cricket	18.30	24.00	28.70	29.00
9	Mole cricket	6.00	**30.40**	29.10	**34.50**
Multiple response					

4.1.11. Infestation severity of potato crops by insect pests in field condition

The potato farmers, participated in the field survey, expressed their experienceabout the severity of infestation caused by insect pests to potatoes in the field condition. Majority (72%) farmers expressed that cutworm caused damage potatoes in the field with high infestation intensity. Whereas, aphids caused damage potato plants with moderate to high infestation severity as reported by 49% and 39% farmers, respectively. On the other hand, potato tuber worm, leaf miner, field cricket leafhoppers, mole cricket and whitefly caused damage potato plants with low infestation severity as reported by 52 to 88% potato farmers.

Table 4.10. Infestation severity of potato crops by insect pests in field condition

Sl. No.	Name of insects pest	Response on infestation severity (%)		
		High	Moderate	Low
1	Aphid	39.00	**49.30**	11.70
2	**Cutworm**	**74.20**	5.10	20.80
3	Potato tuber worm	24.20	24.00	51.70
4	Leafhopper	6.20	14.10	**79.70**
6	Leaf miner	7.90	22.10	**70.00**
7	Whitefly	6.25	5.45	**88.30**
8	Field cricket	14.4	10.90	**74.70**
9	Mole cricket	11.30	8.70	**80.00**
Multiple response				

4.1.12.Relationship among insect pest, disease and weed infestation in potato field

Majority (55%) farmers expressed their opinion that relationship of insect pest infestation with disease and weed infestation was observedin case of potato, whereas only 23.75% respondents expressed their negative opinion.

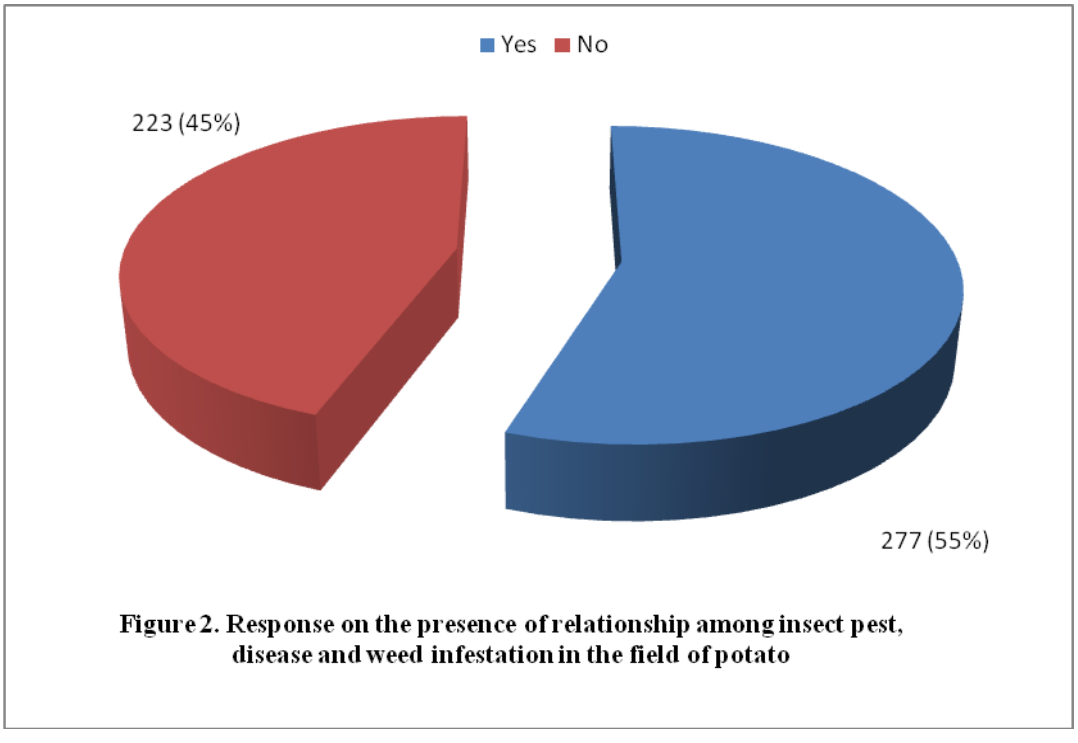

Figure 2. Response on the presence of relationship among insect pest, disease and weed infestation in the field of potato

4.1.13. Degree of relationship among insect pests, diseases and weed infestation in potato field

There was a positive and high degree of relationship among insect pest and disease incidence with weed infestation; as well as disease infection with the incidence of insect vector in the potato field. This result indicated that the insect infestation and disease infection become high when weed infestation become high expressed by the 33.0% and 46.00% potato farmers, i.e., insect infestation and disease infection increased with the increase of the weed infestation. Similarly, disease infection become high when insect vector populations become high expressed by the 21.00% respondents, i.e., disease infection was increased with the increase of the vector population. But in this case, maximum (57.00%) respondents did not reply about the degree of relationship between disease infection and vector population.

Table 4.11. Farmers' response on the degree of relationship among insect pest, disease and weed infestation in potato field

Relationship	Response (%) on the degree of relationship				
	High	Medium	Low	Don't Know	Total
1.High Insect infestation while prevailed weed infestation	**33.0**	15.00	11.00	41.0	100.0
2. High Disease infection while observed weed infestation	**46.0**	25.00	18.00	11.00	100.0
3. High Disease infection when present vector insect	21.0	12.00	10.00	57.00	100.0

4.1.14. Occurrence of insect and vertebrate pests of potato in storage

Most (73.50%) of the farmers stated their opinion that potato tuber worm attacked in storage condition, among them 56.20% stated it as minor pest and 17.30% as major pest. In case of vertebrate pest, most (89.00%) of the farmers stated their opinion that rat attacked in storage, among them 32.40% stated it as minor and 56.60% as major pest.

Table 4.12. Occurrence of insect and vertebrate pests of potato in storage

Sl. No.	Name of pests	Occurrence as pest (%)	
		Yes	No
1	Potato tuber worm	**73.50**	26.40
2	Rat	**89.00**	12.00
5	Others	17.50	82.40
Multiple response			

4.1.15. Infestation status of insect and vertebrate pests of potato in storage

Most (89%) of them stated their opinion that rat attacked the potato tubers in storage condition and caused damage, where as 74% farmers reported that potato tuber worm attacked potato at storage condition. On the other hand, 18% farmers reported other problems caused damage potatoes in storage but they did not specify the problem.

Table 4.13. Infestation status of insect and vertebrate pests of potato in storage

Sl. No.	Name of pests	Pest status (%response)	
		Major pest	Minor pest
1	**Potato tuber worm**	17.30	**56.20**
2	**Rat**	**56.60**	32.40
5	Others	7.40	10.10
Multiple response			

4.1.16. Infestation severity of insect and vertebrate pests of potato in storage

The potato farmers stated that the potato tuber worm caused damage potatoes in storage with low to high infestation intensity, where majority (40.20%) of the farmers reported low infestation intensity. On the other hand, majority (64.20%) of farmers reported that the rat caused damage potato tubers in storage with high infesatation intensity.

Table 4.14. Infestation severity of insect and vertebrate pests of potato in storage

Sl. No.	Name of insects pest	Severity of infestation (% response)		
		High	Moderate	Low
1	Potato tuber worm	25.45	34.30	**40.20**
2	**Rat**	**64.20**	16.30	19.60
Multiple response				

4.1.17.Insect pests which are more damaging at present then previous infestation level.

Majority (56%) of the potato farmers informed thatcutwormwas more damaging insect pest of potato in field condition than previous infestation, which was followed by aphid (19%) and potato tuber worminfestation as reported by 11.2% farmers. However 26% potato farmers did not provide any response about this issue.

Table 4.15. Insect pests which are more damaging at present then previous infestation level.

More damaging insect pests	Number of respondents [N=500]	% response
1.Aphid	95	19.00
2.Cut worm	**279**	**55.80**
3.Potato tuber worm	56	11.20
4. Don't know	130	26.00
Multiple response		

4.1.18.Options for controlling insect pests of potato

Most (93.40%) of them reported that they applied insecticides in potato fields to control insect pests of potato. This control option was followed by application of flood irrigation particularly for controlling cutworm. Whereas 41% farmers used granular insecticides in furrows during planting of seed tubers followed by hand picking of insect pests especially cutworm as reported by 33% farmers. Other methods used by the farmers to control insect pests of potato were perching and IPM.

Table 4.16. Options for controlling insect pests of potato

Sl. No.	Control options	Number [N=500]	% response
1	**Spraying of insecticides in potato field**	**467**	**93.40**
2	Use of granular insecticides in furrows during planting of seed tubers	205	41.00
3	Application of insecticides along with irrigation in the field	49	9.80
4	**Flood irrigation particularly for cutworm**	**269**	**53.80**
5	Hand picking of insect pests especially cutworm	167	33.40
6	Perching	27	5.40
7	IPM method	62	12.40
Multiple response			

4.1.19. Sources of assistance and services received for controlling insect pests of potato

Source of assistance and services is the most important factor that can play the vital role to take the appropriate and effective control options need to be applied for the control of specific insect pest problem infesting crops. In this study, (95%) farmers received assistance and services to control insect pests of potato from pesticide dealers. This source was followed by DAE officials as reported by 67% farmers, neighboring farmers (54.4%) and NGO officials (38.6%). Whilst, the lowest proportion (5%) of potato farmers received assistance and services for controlling insect pests of potato from the officials of research organization.

Table 4.17. Farmers' response on the source of assistance and services received to control insect pests of potato

Source of assistance and services received	Response on source of assistance and services	
	Frequency [N=500]	% Response
1. DAE officials	**335**	**67.00**
2. Officials of research organization	25	5.00
3. NGO officials	193	38.60
4. Pesticide dealers	**475**	**95.00**
5. Neighboring farmers	**272**	**54.40**
Multiple response		

4.2. Knowledge of Field level officer's on insect pests of potato, their risks and management

The results of the field level officer's knowledge on insect pests of potato and their risks have been discussed under the following sub-headings:

4.2.1. Gender of the field level officer's

The field survey was conducted. Among them 60 field level officer's in 10 major potato growing districts. (95%) field level officers (57) were male, while only 5% were female.

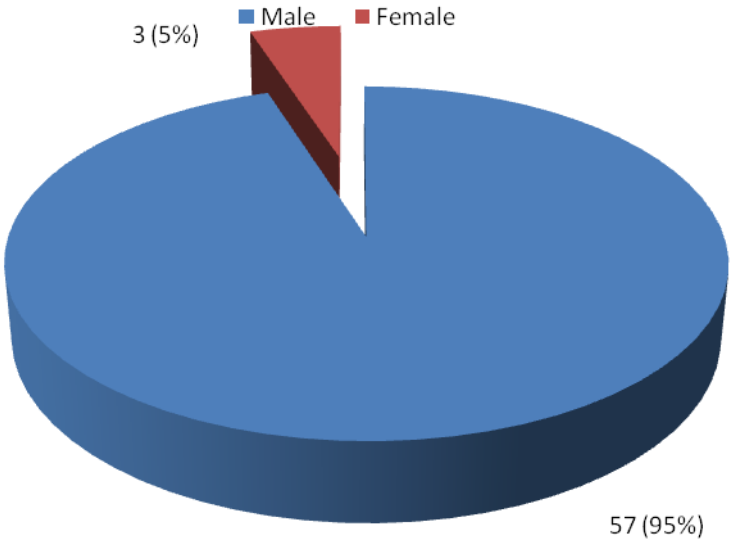

Figure 3. Gender of the field level officers participated in the field survey

4.2.2. Categories of field level officers

In the present research the field study, 33.33% officer (20) were Upazilla Agriculture officer (UAO), whereas 33,33% of them (20) were Agriculture Extension Officers (AEO) and 33.33% of them (20) were Sub-Assistant Agriculture Officers (SAAO).

Table 4.18. Profession designation of the field level officers

Age range	Number of respondents [N=60]	% response
UAO	20	33.33
AEO	20	33.33
SAAO	20	33.33
Total	60	100.00

4.2.3. Commonly used potato varieties

Out of 60 field level officers' participated in the field study; the maximum (76.67%) field level officers (46) informed that farmers used diamant variety of potato for cultivation in their fields, 46.67% field level officers (28) reported that they (farmers) used cardinal variety. This was followed by granula variety (20.00%); while 13.33% field level officer's reported that farmers used lal-pakhri variety, 5.0% used estarise (local) variety and only 10.00% farmers used newly imported potato variety to cultivate in their field.

Table 4.19. Commonly used potato varieties cultivated by the farmers

Potato varieties	Response on potato variety cultivation	
	Frequency [N=60]	% response
Diamant	**46**	**76.67**
Cardinal	**28**	**46.67**
Granula	12	20.0
Lal-Pakhri	8	13.33
BARI Alu-25 (Aestrix)	3	5.0
Newly imported potato	6	10.0
Multiple response		

4.2.4 . Source of potato seeds used by the farmers for cultivation

Potato farmers used seed potatoes from different sources for cultivation. Field level officers (60) reported that, among the potato farmers, most (66.67%) of the farmers used seed potatoes from their own seeds. Other important sources were from BADC (51.67%), Whereas, 18.33% farmers collected seeds from neighbors, 16.67% farmers collected from local seed producer. Other sources of potato seeds for cultivation were importer (15.00%),other company seeds(11.67%), and NGO (11.67%).

Table 4.20. Response on the sources of purchasing seed potatoes usually used for cultivation by the farmers

Sources	Number of respondents [N=60]	Response (%)
1. Farmers' own seed	**40**	**66.67**
2. Neighbors	11	18.33
3. BADC	**31**	**51.67**
4. Other company	7	11.67
5. Local seed producer	10	16.67
6. Directly from importer	9	15.00
7. Research Organization	2	3.33
8. NGO	7	11.67
9. Seed traders/dealers	13	21.67
Multiple response		

4.2.5. Major problems faced duringpotato cultivation

Out of 60 field level officers participated in the field survey, most (96.67%) of them asserted their opinion that lower market price of the produced potato was the top most problem for potato cultivation followed by damage caused by disease (93.33%) followed by weed attack (76.67%) in the field, insect pest attack (66.67%). Other problems for potato cultivation were lack of HYV variety (63.33%), lack of irrigation facilities

(43.33%), lack of farmers training on potato cultivation (36.67%), lack of marketing facilities (28.33%), high price of pesticides(20.00%) and pest attack in storage (16.67%).

Table 4.21. Field level officials' opinion on the major problems for potato cultivation

Major problems	**Response**	
	No. of respondent [N=60]	**% Response**
1. Insect pest attack	40	66.67
2. Weed infestation	46	76.67
3. Disease infection	**56**	**93.33**
4. Lack of HYV	38	63.33
5. Lack of irrigation facilities	26	43.33
6. Pest attack in storage	10	16.67
7. Lack of marketing facilities	17	28.33
8. Lack of farmers training facilities	22	36.67
9. High price of pesticides	12	20.00
10. Low price of produced potato	**58**	**96.67**

4.2.6. Occurrence of the insect pests of potato in field condition

According to the opinion expressed by the field level officers, out of 60, most (100%) of the FLO's reported that the potato was infested in the field by both aphid and cutworm, which was followed by potato tuber worm infestation as reported by 70.0% field level officers. Whereas, 15.0% FLO's reported that the potato was attacked by leaf miner, followed by leaf hopper and mole cricket as reported by 11.67% field level officers, followed by field cricket (10.0%) and whitefly (10.0%).

Table 4.22. Field level officials' response on the Occurrence status of the insect pests of potato in field condition

Sl. No.	**Name of insect pest**	**Occurrence of insect pest [N=60]**	
		Frequency	**% response**
1	**Aphid**	**60**	**100.0**
2	**Cutworm**	**60**	**100.0**
3	**Potato tuber worm**	**42**	**70.00**
4	Leafhopper	7	11.67
6	Leaf miner	9	15.00
7	Whitefly	6	10.00
8	Field cricket	6	10.00
9	Mole cricket	7	11.67
Multiple response			

4.2.7. Infestation status of the insect pests of potato in field condition

According to the opinion expressed by the field level officers', out of 60 FLO's, the major insect pest of potato in field condition was cutworm stated by 87.80% FLO's. This was followed by aphid stated by 85% FLO's. On the other hand, the minor insect pests of potato were potato tuber worm, leaf hoppers, leaf miner, field cricket and mole cricket as stated by 74%, 94.30%, 90.40%, 88.33%, and 89.80%FLO's, respectively.

Table 4.23. Field level officials' response on the infestation status of the insect pests of potato in field condition

Sl. No.	**Name of insect pests**	**Pest status(%response)**	
		Major pest	**Minor pest**
1	**Aphid**	**85.00**	15.00
2	**Cutworm**	**87.80**	12.20
3	Potato tuber worm	26.00	74.00
4	Leafhopper	5.70	**94.30**
6	Leaf miner	9.60	**90.40**
7	Field cricket	11.70	**88.33**
8	Mole cricket	10.20	**89.80**
Multiple response			

4.2.8. Vulnerable stages of potato plants to insect pests in field condition

According to the opinion expressed by the field level officers', vulnerable stages of potato plants to insect pest in field condition.Among the insect pests, cutworm and mole cricket attacked potatoes at all stages of the potato plants but mostly at seedling stages as reported by maximum 54.3% and 39.80% FLO's, respectively. Whereas aphid, leafhopper, leaf miner and whitefly mostly attacked potato plants at vegetative stages as reported by 75.7%, 78.7%, 72.5% and 79.1% FLO's, respectively. On the other hand, potato tuber worm mostly attacked potato at it tuberization stage reported by most (92.5%) of the FLO's.

Table 4.24. Response on vulnerable stages of potato plants to insect pests

Sl. No.	Name of insects pest	Response on vulnerable stages (%)		
		Seedling	Vegetative	Tuberization
1	Aphid	21.70	**75.70**	2.60
2	Cutworm	**54.30**	31.0	14.70
3	Potato tuber worm	0.80	6.70	**92.50**
4	Leafhopper	17.70	**78.70**	3.60
6	Leaf miner	14.10	72.50	13.40
7	Whitefly	13.30	**79.10**	7.60
8	Field cricket	33.10	35.70	31.20
9	Mole cricket	**39.80**	27.10	33.10
Multiple response				

4.2.9. Infestation severity of potato crops by the insect pests in field condition

The field level officers, participated in the field survey, expressed their opinion about the severity of infestation caused by insect pests to potatoes in the field condition. Most (89%) of the farmers expressed that aphid caused damage potatoes in the field with high infestation intensity. Whereas, cutworm caused damage potato plants with high infestation severity as reported by 84.2% FLO's. On the other hand, potato tuber worm, leaf hopper, leaf miner, field cricket and mole cricket caused damage potato plants with low infestation severity as reported by 51.8%, 59.7%, 60.0%, 46.7% and 60.0% FLO's, respectively.

Table 4.25. FLO's response on the infestation severity of potato crops by the insect pests in field condition

Sl. No.	Name of insects pest	Severity of infestation (% response)		
		High	Moderate	Low
1	**Aphid**	**89.00**	5.30	5.7
2	**Cutworm**	**84.20**	5.10	10.7
3	Potato tuber worm	21.20	27.00	51.8
4	Leafhopper	6.20	34.10	**59.7**
6	Leaf miner	7.90	32.10	**60.0**
7	Field cricket	12.4	40.90	46.7
8	Mole cricket	11.30	28.70	60
Multiple response				

4.2.10. Relationship among insect pest, disease and weed infestation in potato field

Out of 60 field level officials of DAE participate in the survey study, most (76.25%) of the them expressed their positive opinion about relationship of insect pest infestation with disease and weed infestation in the potato field, whereas only 23.75% respondents expressed their negative opinion.

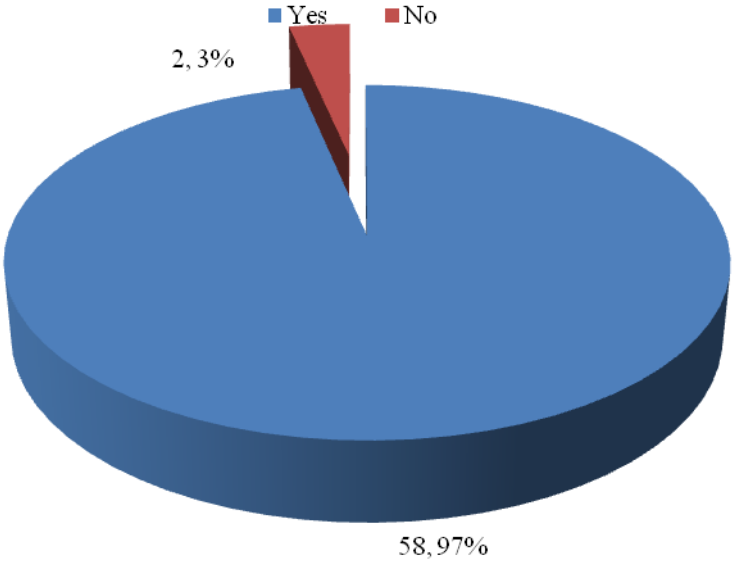

Figure 4. Field level officials' response on the relationship of insect infestation with disease and weed infestation in potato field

4.2.11. Degree of relationship among insect pests, diseases and weed infestation in the potato field

There was a positive and high degree of relationship among insect pest and disease incidence with weed infestation; as well as disease infection with the incidence of insect vector in the potato field. This result indicated that the insect infestation and disease infection become high when weed infestation become high expressed by the 48.0% and 63.0% potato farmers, i.e., insect infestation and disease infection increased with the increase of the weed infestation. Similarly, disease infection become high when insect vector populations become high expressed by the 75.25% respondents, i.e., disease infection was increased with the increase of the vector population.

Table 4.26. Field level officers' response on the degree of relationship among insect pest, disease and weed infestation in the potato field

Relationship	Response (%) on the degree of relationship				
	High	Medium	Low	Don't Know	Total
1. Insect infestation high when weed infestation	47.50	23.00	11.20	18.3	100.0
2. Disease infection high when weed infestation	**63.25**	17.75	4.50	14.5	100.0
3. Disease infection high when vector insect	**75.25**	14.50	7.50	2.75	100.0

4.2.12. Occurrence of insect and vertebrate pests of potato in storage

Most (75%) of the field level officers stated their opinion that potato tuber worm attacked in storage condition, among them 52.7% stated as minor pest and 47.30% stated as major pest. In case of vertebrate pest, most (90.00%) of the field level officers stated their opinion that rat attacked in storage, among them 23.40% stated as minor and 76.60% stated as major pest.

Table 4.27. Field level officials' response on the occurrence of insect and vertebrate pests of potato in storage

Sl. No.	Name of pests	Occurrence as pest (%response)	
		Yes	No
1	Potato tuber worm	75.00	25.00
2	Rat	**90.00**	10.00
5	Others	18.33	81.67
Multiple response			

4.2.13. Infestation status of insect and vertebrate pests of potato in storage

Most (75%) of the field level officers stated their opinion that potato tuber worm attacked in storage condition, among them 52.7% stated as minor pest and 47.30% stated as major pest. In case of vertebrate pest, most (90.00%) of the field level officers stated their opinion that rat attacked in storage, among them 23.40% stated as minor and 76.60% stated as major pest.

Table 4.28. Infestation status of the insect and vertebrate pests of potato in storage

Sl. No.	Name of pests	Pest status (%response)	
		Major pest	Minor pest
1	Potato tuber worm	47.30	52.7
2	Rat	**76.60**	23.4
5	Others	11.40	88.6
Multiple response			

4.2.14. Infestation severity of insect and vertebrate pests in storagepotato.

The field level officers stated that the potato tuber worm caused damage potatoes in storage with low to high infestation intensity, where majority (44.30%) of the FLO's reported moderate infestation intensity. On the other hand, majority (59.20%) of farmers reported that the rat caused damage potato tubers in storage with high infestation intensity.

Table 4.29. Infestation severity of insect and vertebrate pests of potato in storage

Sl. No.	Name of insects pest	Severity of infestation (% response)		
		High	Moderate	Low
1	Potato tuber worm	24.45	44.30	31.25
2	Rat	**59.20**	19.30	21.50
Multiple response				

4.2.15. Insect pests which are more damaging at present than previous infestation level .

According to the field level officers opinion, out of 60, majority (78%) of the FLO's reported thatcutwormwas more damaging insect pest of potato in field condition than previous infestation, which was followed by aphid infestation (70%) and potato tuber worm as reported by 50% FLO's. On the other hand, 20% field level officers did not provide any response about this issue.

Table 4.30. **Insect pests which are more damaging at present than previous infestation level .**

More damaging insect pests	Number of respondents [N=60]	% response
1.Aphid	**42**	**70.00**
2.Cut worm	**47**	**78.33**
3.Potato tuber worm	30	50.00
4. Leaf hopper	13	21.67
5.Don't know	12	20.00
Multiple response		

4.2.16.Currently seen new insect pests in the potato, those were not seen earlier

Considering the opinion expressed by the FLO's, 93.33% responded have no idea about the new insect pest that are currently seen in the field of potato and only 6.67% expressed the positive answer.

Table 4.31. New insect pests currently seen in potato, those were not seen earlier

Type of response	Number of respondents [N=60]	% response
Yes	4	6.67
No	**56**	**93.33**
Total	60	100.0

4.2.17. Newly seen insect pests of potato, those were not seen earlier

According to the opinion expressed by the field level officers, who expressed positive answer about newly seen insect pest of potato, those were not seen earlier. The newly seen insect pests were mite (25%), white fly (50%) and mealy bug (75%) respectively.

Table 4.32. Newly seen insect pests of potato, those were not seen earlier

Newly seen insect pests	Number of respondents [N=4]	% response
1. Mite	1	25.00
2. White fly	2	**50.00**
3. Mealy bug	3	**75.00**
Multiple response		

4.2.18. Options for controlling insect pests of potato

Out of 60 field level officers, participated in the field survey, most (80%) of them reported that farmers applied insecticides in potato fields to control insect pests of potato. This control option was followed byhand picking of insect pests especially cutworm (45%). Whereas 30% farmers used granular insecticides in furrows during planting of seed tubers. Other methods used by the farmers to control insect pests of potato were perching and IPM.

Table 4.33. Options for controlling insect pests of potato

Sl. No.	Control options	Number [N=60]	% response
1	**Spraying of insecticides on the standing potato field**	**48**	**80.00**
2	Broadcasting of granular insecticides in the furrow during planting of seed tubers	18	30.00
3	Broadcasting of granular insecticides before irrigation in the field	9	15.00
4	Application of insecticides along with irrigation in the field	6	10.00
5	Potato tuber treatment through insecticides before planting	15	25.00
6	Irrigation	12	20.00
7	**Hand picking of insect pests especially cutworm**	**27**	**45.00**
8	Perching	12	20.00
9	IPM method	10	16.67
10	Application of balanced fertilizer to prevent insect pest infestation	8	13.33
Multiple response			

Figure 5: Aphids on potato leaf

Figure 6: Potato leaf roll virus disease (right) transmitted by aphids

Figure 7: Potato leaf roll virus disease

Figure 8: Cutworm damaged potato seedling and tuber

Figure 9: Potato leaf hopper and hopper burn disease

Figure 10: Potato tuberworm moth and infested potatoes

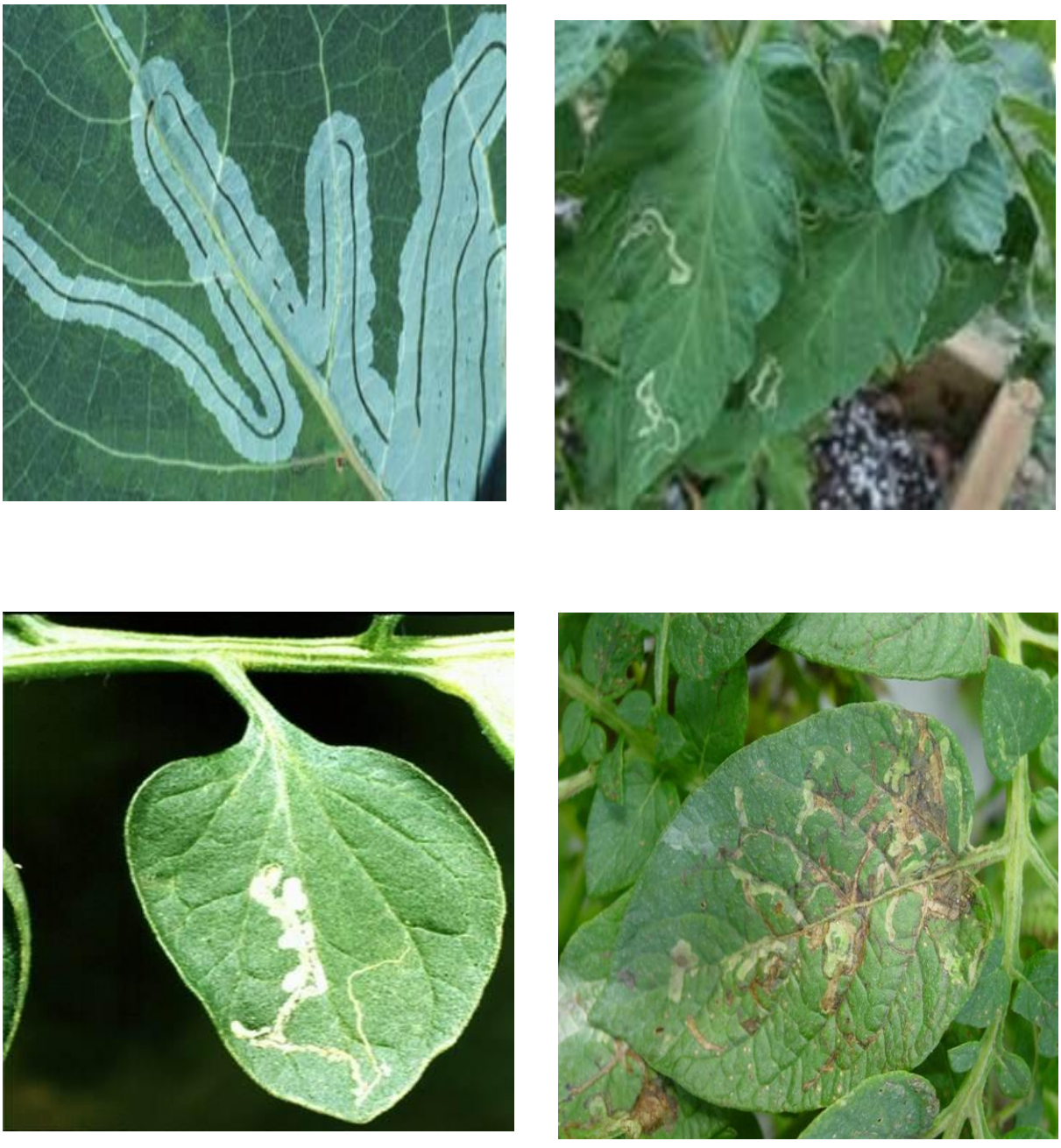

Figure 11: Leaf miner infested potato leaves

Figure 12: Field cricket

Figure 13: Mole cricket

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the 20 upazila of 10 selected major potato growing districts of Bangladesh during the period from December 2014 to February 2015 to find out the present status and diversity of insect pests of potato, their risks and management options. The data were collected through interview of 500 potato farmers considering 25 potato farmers from each upazila and 60 field level officers of DAE considering one UAO, one AEO and one SAAO of DAE. The results obtained from the studies have been summarized and concluded below:

SUMMARY

Majority (65.4%) farmers used Diamont variety of potato for cultivation in their field, whereas 29.6% farmers (148) reported that they used Cardinal variety of potato. Most (67%) of the farmers (333) used their own produced seeds followed by from BADC. Other sources of potato seed were potato seed traders/dealers, neighboring farmers; local seed producer etc.

Most (89.20%) of the potato farmers faced problems with lower market price of the produced potato followed by damage caused by disease, insect pest attack and weed attack in the field during potato cultivation. Other major problems were lack of HYV, lack of irrigation facilities, pest attack in storage etc.

The BARI Alu-7 (Diamont) and BARI Alu-8 were most susceptible potato varieties to insect pests and diseases, whereas the Lal-pakhri was the comparative more susceptible potato variety.

Most (98.50%) of the farmers reported that the potato was infested in the field by cutworm, followed by aphid and potato tuber worm. Other insect pests of potato in the field were leaf miner, mole cricket, field cricket and leaf hoppers. Among these insect pests, cutworm and aphid were identified as major insect pests and others were identified as minor insect pests of potato. Most (72%) of the cases, cutworm caused damage potatoes in the field with high infestation intensity; whereas, aphids caused damage with moderate to high infestation severity and potato tuber worm, leaf miner, field cricket

leafhoppers, mole cricket and whitefly caused damage potato plants with low infestation severity.

Among the insect pests, cutworm and mole cricket attacked potatoes at all stages of the potato plants, whereas aphid, leafhopper, leaf miner and whitefly mostly attacked potato plants at vegetative stages. On the other hand, potato tuber worm mostly attacked potato at tuberization stage of potato. The leaves of potato plants were most vulnerable for aphids, leafhoppers, leaf miners and whitefly. Whereas, the stems of potato plants were mostly vulnerable for cutworm and mole cricket. On the other hand, the tuber was vulnerable to potato tuber worm and the roots of potato plants were vulnerable to field cricket and mole cricket.

Most (73.50%) of the farmers reported that the potato tuber worm attacked potato tubers in storage and it was designated as a major insect pest of potato in storage. This insect pest caused potato in storage with high infestation intensity. Currently cutworm was more damaging insect pest of potato in field condition than previous infestation, which was followed by aphid infestation, but in storage condition potato tuber worm was more damaging insect pests than others.

Majority (55%) of the farmers reported that there was a relationship of insect pest infestation with disease and weed infestation was present in potato. The insect infestation and disease infection increased with the increase of the weed infestation and disease infection increased with the increase of the vector population.

Most (93.40%) of the farmers applied insecticides in potato fields to control insect pests of potato followed by application of flood irrigation and hand picking particularly for controlling cutworm followed by use of granular insecticides in furrows during planting of seed tubers. Most (95%) of the farmers received assistance and advices for controlling insect pests of potato from pesticide dealers. Other sources of services were DAE officials, neighboring farmers and NGO officials.

CONCLUSIONS

- BARI Alu-7 (Diamant) variety and BARI Alu-8 (Cardinal) variety of potato were the most popular potato varieties used by the farmers for cultivation.
- The major sources of potato seeds used by the farmers for cultivation were the own produced seeds, BADC seeds, seed traders/dealers and neighboring farmers.

- Mostly (89.20%) potato farmers faced problems with lower market price of the produced potato. Other major problems faced during potato cultivation were diseases, insect pest attack and weed attack.
- The BARI Alu-7 (Diamant) and BARI Alu-8 were most susceptible potato varieties to insect pests and diseases, whereas the Lal-pakhri was the least susceptible to pests.
- Mostly (98.50%) the potato was infested in the field by cutworm, aphid, potato tuber worm, leaf miner, mole cricket, field cricket and leaf hoppers. Among these insect pests, cutworm and aphid were identified as major insect pests and caused damage with high and moderate infestation intensity, respectively. Others insect pests were identified as minor insect pests of potato caused damage with low infestation intensity.
- Mostly (73.50%) the potato tuber worm attacked potato tubers in storage and designated as a major insect pest of potato in storage and damaged potato with high infestation intensity.
- Currently cutworm and aphid were more damaging insect pest of potato in field condition than previous infestation, and potato tuber worm was more damaging insect pest in storage.
- Mostly (93.40%) potato farmers applied insecticides in potato fields to control insect pests of potato. Other important control options were application of flood irrigation and hand picking particularly for controlling cutworm, use of granular insecticides in furrows during planting of seed tubers.
- Most (95%) of the farmers received assistance and advices for controlling insect pests of potato from pesticide dealers. Other sources of services were DAE officials, neighboring farmers and NGO officials.

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Appendix 1: Questionnaire for potato farmer

Sher-e-Bangla Agricultural University

Department of Entomology

Sher-e-Bangla Nagor, Dhaka-1207.

INSECT PEST DIVERSITY AND RISK ASSESSMENT FOR POTATO IN BANGLADESH

Prepared by:

MD. SAIFUL ISLAM

Department of Entomology

E-mail: saiful.islam2028@gmail.com

Set-1: Questionnaire for potato farmer

Code:						**Mobile**											

A.0 Personal Information of Potato Farmer

A.1 Name: ----------

A.2 Village ---------- **A.3** Agri Block: ----------

A.4 Upazilla: ---------- **A.5** District: ----------

A.6 Educational qualification: ---------- **A.7** Age: ---------- |

A.8 Occupation:[Code: 1= Big farmer, 2= Medium farmer, 3= Small farmer] **A.9** Sex: (Code: 1= Male, 2= Female) ☐

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

Cultivated potato variety	Land utilization for potato cultivation (Decimal)	Yield (sack/acre)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
		* 1 sack = 85 kg

B.4 Name of the Sources of purchasing potato seeds?

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

B.5 Major problems faced during potato cultivation?

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

B.6 Opinion on susceptibility of potato varieties to pests

Sl. No.	Potato varieties	Opinion on susceptibility to pests: [Code: Insect=1, Diseases=2, Weed=3]|
1	BARI Alu-7 (Diamant)	
2	BARI Alu-8 (Cardinal)	
3	BARI Alu-11 (Chomok)	
4	BARI Alu- 13 (Granolla)	
5	Lal-Pakhri	
6	Newly imported potato	

B.7 Insects occurrence in potato field

Name of Insects pest	Type of answer (Code: Yes=1, No=2)|	
Aphid		
Cutworm		
Potato tuber worm		
Leafhopper		
Leaf miner		
Whitefly		
Field cricket		
Mole cricket		
Aphid		

B.8 Infestation status of insect pests of potato in field condition

Sl. No.	Name of insect pests	Opinion on Infestation status of pests: [Code: Major=1, Minor=2]|
1	Aphid	
2	Cutworm	
3	Potato tuber worm	
4	Leafhopper	
5	Leaf miner	
6	Field cricket	
7	Mole cricket	

B.9 Vulnerable stages of potato plants to insect pests in field condition

Sl. No.	Name of insect pests	Opinion on vulnerable stages of pests infestation: [Code: Seedling=1, Vegetable=2. Tuberization=3]|
1	Aphid	
2	Cutworm	
3	Potato tuber worm	
4	Leafhopper	
5	Leaf miner	
6	Field cricket	
7	Mole cricket	

B.10 Vulnerable parts of potato plants to insect pests in field condition

Sl. No.	Name of insect pests	Opinion on vulnerable parts of plants to pests infestation: [Code: Leaf=1, Stem=2. Tuber=3, Root=4]|
1	Aphid	
2	Cutworm	
3	Potato tuber worm	
4	Leafhopper	
5	Leaf miner	
6	Field cricket	
7	Mole cricket	

B.11 Infestation severity of potato crops by insect pests in field condition

Sl. No.	Name of insect pests	Opinion on Infestation severity: [Code: High=1, Moderate=2. Low=3]|
1	Aphid	
2	Cutworm	
3	Potato tuber worm	
4	Leafhopper	
5	Leaf miner	
6	Field cricket	
7	Mole cricket	

B.12 Is there any relationship among insect, disease and weed pest infestations in the potato field? ☐

Yes = 1, No=2]

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

13.1 Insect population high when weed incidence is: ☐

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

13.2 Disease incidence high when weed incidence is: ☐

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

13.3 Disease incidence high when incidence of insect vector is: ☐

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

Appendix 2: Questionnaire for field level officer

Sher-e-Bangla Agricultural University

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

INSECT PEST DIVERSITY AND RISK ASSESSMENT FOR POTATO IN BANGLADESH

Prepared by:
MD. SAIFUL ISLAM
Department of Entomology
E-mail: saiful.islam2028@gmail.com

Set-2: Questionnaire for field level officer

Name of Key Informant…….. ……..…… Designation …….....…….….

Organization:…….…….....…..… Working area: …….....……

Mobile:…….……...…….……

1.0 INFORMATION ABOUT INSECT PESTS OF POTATO

1.1 What are the major insect pests that cause potential damage to potato in Bangladesh (HQ)/your area?

1.2 What are the key insect pests of potato that cause potential damage in every year in Bangladesh/your area?

1.3 What are the minor insect pests that may harm to potato, if not to be controlled?

1.4 What are the insect pests of potato, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh?

1.5 Is there any information about the insect pests of potato available in the exporting country of potato to Bangladesh? If yes, what are those insect pests? Please mention the name of insect pests?

1.6 What are the quarantine insect pests of potato that might already be entered into Bangladesh through importation of potato seeds from other countries or through cross boundary from neighboring countries that were not seen earlier?

1.7 What are the effective options to control the insect pests that are found in the potato field or storage in your area/Bangladesh?

1.8 Give your suggestions for the better management of the insect pests of potato in Bangladesh.