PLANT PROTECTION MANAGEMENT PRACTICES USED BY THE FARMERS IN POTATO CULTIVATION

SHAH MD. APPLE MAHMUD

DEPARTMENT OF

AGRICULTURAL EXTENSION AND INFORMATION SYSTEM

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR, DHAKA-1207.

JUNE, 2016

PLANT PROTECTION MANAGEMENT PRACTICES USED BY THE FARMERS IN POTATO CULTIVATION

BY

SHAH MD. APPLE MAHMUD

REGISTRATION NO.: 10-04114

A Thesis

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE (MS)

IN

AGRICULTURAL EXTENSION

SEMESTER: JANUARY - JUNE, 2016

Approved by

……..……..……
(Mohammad Zamshed Alam)
Supervisor
Associate Professor
Dept. of Agril. Ext. and Info. System
Sher-e-Bangla Agricultural University

……..……..……
(Dr. Ranjan Roy)
Co-Supervisor
Associate Professor
Dept. of Agril. Ext. and Info. System
Sher-e-Bangla Agricultural University

……
(Md. Mahbubul Alam, Ph.D)
Associate Professor and Chairman
Department of Agricultural Extension and Information System
Sher-e-Bangla Agricultural University, Dhaka

Department of Agricultural Extension and Information System
Sher-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

Memo No.: SAU/AEIS Date:

CERTIFICATE

This is to certify that the thesis entitled, **"PLANT PROTECTION MANAGEMENT PRACTICES USED BY THE FARMERS IN POTATO CULTIVATION"** submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science (MS) in Agricultural Extension,** embodies the result of a piece of bona fide research work carried out by **Shah Md. Apple Mahmud**, Registration No. 10-04114, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information, as has been availed of during the course of investigation have been duly acknowledged.

Dated: June, 2016
Dhaka, Bangladesh

……..……..….
(Mohammad Zamshed Alam)
Supervisor
Associate Professor
Dept. of Agril. Ext. and Info. System
Sher-e-Bangla Agricultural University

DEDICATION

LOVINGLY DEDICATED TO MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises, thanks and gratitude are due to the Almighty Allah for his grace bestowed upon the author for accomplishing this research study. With boundless love and appreciation, researcher would like to extend his heartfelt gratitude and appreciation to all who helped him bring this study into reality.

In particular, the researcher takes the opportunity to express thanks to his respectable supervisor **Mohammad Zamshed Alam**, Associate Professor, Department of Agricultural Extension and Information System (AEIS), Sher-e-Bangla Agricultural University (SAU), for his noble guidance, constructive criticism, constant stimulation and encouragement thorough supervision during the course of preparation of this thesis, without which this work would not have been possible. For his unwavering support, I am truly grateful. His insight and practical skill have left a distinct mark on this work.

The author deems it a proud privilege to express his deep sense of gratitude, sincere appreciation and immense thanks to his co-supervisor **Dr. Ranjan Roy,** Associate Professor, AEIS, SAU for his continuous guidance, cooperation, constructive criticism and helpful suggestions in carrying out the research work and preparation of this thesis, without his intense co-operation this work would not have been possible.

The researcher also wishes to express sincere appreciation and heartfelt gratitude to his **Md. Mahbubul Alam, Ph.D,** Associate Professor and Chairman, AEIS, SAU for his valuable suggestions, constant cooperation, inspirations and sincere advice to improve the quality of the thesis throughout the period of this research program.

Heartfelt thanks and appreciations are also expressed to the Upazila Agriculture Officer and SAAO of Rangpur sadar in the study area for their benevolent help and cooperation in data collection period. The researcher is especially grateful to all the respondents in the study area for their cooperation and help in accomplishing the objectives of this research work.

The author expresses his immense indebtedness, deepest senses of gratitude to his beloved parents, brother and sisters who sacrificed all their happiness during the whole study period especially during his MS study.

June, 2016 **The Researcher**

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

LIST OF ABBREVIATIONS AND GLOSSARY

Abbreviation	Full word
AQ	Adoption Quotient
Ag. Ext. Ed.	Agricultural Extension Education
Ag. Ext. and Info. Sys.	Agricultural Extension and Information System
B	Multiple regression
BBS	Bangladesh Bureau of Statistics
BEC	Bangladesh Economic Census
BRRI	Bangladesh Rice Research Institute
CCWPU	Columbus's contribution to world population and Urbanization
CWHFP	Cambridge World History of Food- Potatoes
DAE	Department of Agricultural Extension
et. al	All Others
GDP	Gross Domestic Product
OIA	Office of International Affairs
POP	Potatoes to Plastics

PLANT PROTECTION MANAGEMENT PRACTICES USED BY THE FARMERS IN POTATO CULTIVATION

ABSTRACT

The study examines the status of plant protection management practices in potato cultivation and estimates the contribution of the selected characteristics of the cultivators with their plant protection management practices to potato cultivation. This study is an integration of quantitative data that were collect in Pashuram block of Rangpur sadar. Data were gathered from 112 potato cultivators from 07 February to 06 March, 2017. Descriptive statistics and multiple regression were used for analysis. Most of the farmers (52.7 percent) belong to medium use of plant protection management practices followed by high use of plant protection management practices (39.3 percent). Among the variables- level of education, annual family income from potato cultivation, potato cultivation experience, knowledge on potato cultivation, usages of mass media, training exposure, organizational participation were significant contributor and provided 71.0 percent variation in use of plant protection management practices in potato cultivation. It was also found that lack of cold storage positioned the 1st as per Problem Faced Index (PFI) while getting low service from extension workers ranked at the last position regarding problems faced by farmers in potato cultivation. It is recommended that DAE (Department of Agricultural Extension) should invest on improving growers knowledge on potato cultivation and using diverse mass media to increase the extent of use of plant protection management practices in potato cultivation.

Key words: Plant protection, Management practice, potato cultivation;

CHAPTER I

INTRODUCTION

1.1 General Background

Bangladesh is mainly an agriculture based country dominated by crop production and agriculture is the main stay of Bangladesh`s economy. Bangladesh enjoys generally a sub-tropical monsoon climate with sufficient sunlight and reserved soil moisture that favor crops growth both in summer and winter. Therefore, it is famous for growing large variety of tropical crops including potato. Bangladesh is a densely populated and agro-based developing country. About 76% of the people live in rural areas, and 47.5% of the total manpower is involved in agriculture. In Bangladesh, agriculture contributes 18.82% of the gross domestic product (GDP) of the country in the year of 2014-2015 (BEC, 2016). Around 152.51 million people lives in its 1,47,570square kilometer of land (BBS, 2014).

Potato was introduced in this subcontinent in the sixteenth century. It was grown then in small plots as a vegetable. It has been grown in Bangladesh since at least 19th century. By the 1920s, the first commercial production of this crop was established in the country (Islam, 1983). Potato production is highly profitable and it could provide cash money to farmers. In terms of profitability, potato production was more attractive than any other winter vegetables. Per unit yield and gross return of potato were found higher than other competitive crops (Akhter *et al.*,2001). Low productivity per unit area of cultivated land due to the use of traditional inputs and methods in the production system has been an important constraint on national food self-sufficiency (Hoque, 1978). Hence, it is evident that Bangladesh needs the development of her agriculture sector, so that its population can lead better life. The area of Bangladesh is about 14.29 million hectares of which 66 percent is cultivated. 15 percent is utilized for forest and the rest 19 percent is covered by homesteads, rivers, tidal

creeks, lakes, ponds, roads etc. (Ahmed, 1982). So, there is little scope left to increase agriculture output by putting new land under cultivation. Increase in agriculture output can be attained, however, by using high yielding varieties (HYV) and adopting improves culture management practices. Among all crops, potato is one of the most import crops whose production is high among all the vegetable. The farmers who used quality seeds obtained higher yield and profile. Scarcity of quality seeds compelled some farmers to use the inferior seeds (Hoque, 1998). Potatoes have tremendous potential to be used as substitute for rice and as an industrial crop for export earnings as well as import substitution. Per capita and total production of potatoes in the developed world is much higher than Bangladesh. Per capita potato production in our country is only 23.8 kg, whereas it varies from lowest of 68 kg in Argentina to the highest of 963 kg in Poland. However, the trend of per capita consumption of potatoes in our country is gradually increasing every year (Khan 2002). It is one of the important sources of carbohydrates and it contains an appreciable amount of vitamin B and C and some other materials (Thompson and Kelly, 1957).

The government of Bangladesh has attached much importance on vegetable production in order to meet year-round nutritional and caloric demand of the growing population and also for increasing employment opportunities and income of the farmer. Increasing area allocation to winter potato may fulfill the government objectives. Before giving out policy options on increasing potato production, relevant and adequate information on potato production in farm level is required. Some economic investigation on potato cultivation in Bangladesh were undertaken by private and government organizations in order provide the feed backs to policy makers, researchers, extension workers and farmers which however, were not adequate. In Bangladesh farmers' experience on improved potato variety cultivation is considered limited. Agricultural production policy decisions in Bangladesh are constrained by lack of information on profitability of growing different agricultural crops. In this regard, the present study is an attempt to analysis and compares the relative

profitability of HYV potatoes according to farm size, the effect of varies inputs used in potato production and the cultural practices that are followed by the potato growers.

Bangladesh's potato production hit an all-time-high of 9.47 million tons in the last fiscal year (FY'16), the latest data showed but cold storage facilities showed little progress compared to higher output.While the country maintained its seventh position among top potato-producing countries by showing consecutive bumper production in the last four years, shortfall of storage capacity is hurting farmers and traders. Potato output was a record 9.47 million tons on 4.75 million hectares in FY'16 against 9.254 million tons on 4.62 million hectares in FY'15. The yield growth was measured at 2.33 per cent over that of FY'15, according to provisional estimates by Bangladesh Bureau of Statistics (BBS).The BBS data showed that each hectare yield also increased to 19.9 million tons in the last FY from 19.6 million tons in FY'15.Potato production was 8.95 million tons in FY'14, 8.60 million tons in FY'13 and 8.205 million tons in FY'12, the BBS data showed.Considering area coverage in the country, potato is the third major crop after paddy and wheat. It has become a highly successful October-March winter crop in Bangladesh.

Though Bangladesh has become a major potato producer in the SAARC countries, the status of this crop has remained vegetable in the country. The time has come now to understand and appreciate the role of potato that can play an important role in the present food situation of Bangladesh. Potato is one of the main commercial crops grown all over the country. In Bangladesh, potato is mainly consumed as vegetable. Various other food items (Singara, Samucha,Chop, chips etc.) are also made from potato. Adequate supply of potato stabilizes the vegetable marketall-round the year (Moazzem and Fujita, 2004). Recently, the government has been trying to diversify food habits and encourage potato consumption to reduce pressure on rice. So, potato is becoming an important food for food security in Bangladesh. It is quite pertinent and necessary to know the extent of plant protection management

practices by the farmers in potato cultivation. But a very limited research work has been done on this aspect. Therefore, the researcher felt necessity to conduct a research entitled 'Plant Protection Management Practices Used by the Farmers in Potato Cultivation'.

1.2 Statement of the Problem

Potato (*Solanum tuberosum*) is the third largest food crop in Bangladesh and has recently occupied an important place in the list of major food and cash crops of Bangladesh (Ali and Haque, 2011). The crop ranks first among the vegetables in Bangladesh both in area and production (BBS, 2006). Its area and production are increasing day by day (BBS, 2009). Ensuring food security for all is one of the major challenges in Bangladesh today. So, to ensure adequate food supply, it is necessary to give thrust to increase food production using improved variety and recommended practices.MThe plant protection management practices by the farmers in potato cultivation could easily raise food production and net income of the users. Usually farmers follow different levels of production technologies depending upon their infrastructural facilities and socioeconomic conditions which ultimately resulted in variability in yields of potato (Elias *et al.,* 1992). Farmers' production performance depends on physical resources and technology available to them as well as existing farm management conditions. Efficient use of inputs and technologies could help farmers to get higher production from a given amount of resources.

In order to formulate suitable strategic measures for the improvement of the studied plant protection management practices by the farmers in potato cultivation, this research focuses on socio-economic characteristics of farmers and their existing situation towards plant protection management practices. This was finished by looking for answers to the accompanying queries:

- What is the extent of plant protection management practices used by the farmers in potato cultivation?
- What were the characteristics of the potato farmers?

- Was there any contribution of selected characteristics of the potato farmers on their protection management practices in potato cultivation?

In order to get a clear view of the above questions the investigator undertook a study entitled 'Plant Protection Management Practices Used by the farmers in Potato Cultivation'.

1.3 Objectives of the Study

The aim of the study was to explore the trends of plant protection management practices by the farmers in potato cultivation. This is why the following objectives were taken:

i. To assess the extent of plant protection management practices used by the farmers in potato cultivation

ii. To describe the following selected characteristics of the potato farmers:
    - Age
    - Level of education
    - Effective farm size
    - Land under potato cultivation
    - Annual family income
    - Annual income from potato production
    - Potato cultivation experience
    - Knowledge in potato cultivation
    - Usages of mass media
    - Extension media contact
    - Training exposure
    - Organizational participation

iii. To identify the factors influencing the plant protection management practices used in potato cultivation

iv. To find out the problems faced by the farmers in potato cultivation

1.4 Scope or rationale of the study

The present study was designed to have an understanding attitude, knowledge of farmers and constrains faced by them towards potato cultivation and to explore its contribution with their selected characteristics.

i. The findings of the study will, in particular, be applicable to the study areaat Pashuram block of Rangpur district. The findings may also be applicable to other locale of Bangladesh where socio-cultural, psychological and economic circumstance do not differ much than those of the study areas.

ii. The findings of the study may also be subsidiary to the field worker of extension service to enhance their action strategies on plant protection management practices in potato cultivation.

iii. The findings of the study will be conducive to accelerate the improvement in agriculture, farmers' logistic supports, information needs and the way of dissemination especially tuned to key role players in the society as well as plant protection management practices in potato cultivation. The outcomes might also be helpful to the planners and policy makers, extension workers and beneficiaries of the agriculture.

iv. To the academicians, it may help in the further conceptualization of the systems model for analyzing the plant protection management practices by the farmers in potato cultivation. In addition, the findings of this study may have other empirical evidence to all aspects of plant protection management practices by the farmers in potato cultivationwhich may be used to build an adequate theory of potato cultivation.

1.5 Justification of the study

Potato growing is complex and requires both technical knowledge and management skill. Potato producers must apply this knowledge and skill to ensure profitable yields of quality potatoes for the fresh, processing, or seed

markets. The acquisition of self-sufficiency in food grain production is the main aim of agricultural improvement in Bangladesh. To achieve that objective, it is mandatory to provide thrust to increase food production using plant protection management practices. The plant protection management practices in potato cultivation by the farmers can easily overcome this problem. Research institutes have developed a good number of plant protection management practices but only a few of them practices are practiced by the farmers. Therefore, the researcher needs to enquire about the plant protection management practices in potato cultivation. So, it is logical to investigate about the plant protection management practices by the farmers in potato cultivation. The finding of the study will be especially applicable to the Pashuram block of Rangpur district. Thus, the findings are expected to be useful to extension workers and planners for their preparation of extension programmers for rapid adoption of recommended potato plant protection management practices. The findings of the study are also therefore, expected to be conducive to the researchers, academicians and policy makers who are concerned with of potato cultivation.Keeping the above facts in view, a study entitled 'Plant Protection Management Practices Used by the farmers in Potato Cultivation' is undertaken.

1.6 Assumptions of the study

An assumption is the supposition that an apparent fact or principle is true in the light of available evidence (Goode and Hatt, 1952). The researcher had considered the following assumptions while undertaking the study:

i. The respondents were capable of furnishing proper answers to the questions contained in the interview schedule.
ii. The data collected by the researcher were free from any bias and they were normally distributed.
iii. The responses answered by the respondents were valid, acceptable and reliable.

iv. Information sought by the researcher elicited the real situation was the representative of the whole population of the study area to gratify the objectives of the study.

v. The researcher was well adjusted to himself with the social contiguous of the study area. Hence, the collected data from the respondents were free fromfavoritism.

vi. The selected characteristics and the attitude, knowledge of farmers and constrains faced by them of the study were normally and independently allotted with respective means and standard deviation.

1.7 Limitations of the study

Considering the time, respondents and other necessary resources available to the researcher and to make the study manageable and meaningful, it became necessary to impose certain limitations as mentioned bellow:

i. The study was confined to only one block namely Pashuram block of Rangpur district which may fail to represent the actual scenario of the whole situation.

ii. It is difficult to get exact information on plant protection management practices by the farmers in potato cultivationindicator from the potato farmers as many of them are illiterate.

iii. Characteristics of the potato farmers were many and varied, but only twelve characteristics were selected for the research study.

iv. There were embarrassment situations at the time of data collection. So, the researcher had to manage proper rapport with the respondents to collect maximum proper information.

v. Several methods, scales and statistical tests have been utilized in this study over a relatively short period of time.

CHAPTER II

REVIEW OF LITERTURE

Review of literature gives the clear and concise direction of the researcher for conducting the experiment. In this chapter, review of literatures relevant to the objectives of this study was presented. This was mainly concerned with 'plant protection management practices'. There was serious dearth of literature with respect to research studies on this aspect. So, the directly related literatures were not readily available for this study. Some researchers addressed various aspects of the plant protection management practices and its effect on client group and suggesting strategies for their emancipation from socio-economic deprivations. A few of these studies relevant to this research are briefly discussed in this chapter under the following five sections:

Section 1: General review on and its related issues

Section 2: Review on plant protection management practices in potato cultivation

Section 3: Review on the relationship of farmers' selected characteristics and different agricultural management practice of different agricultural activities

Section 4: Research gap of the study

Section 5: Conceptual framework of the study

2.1 General review on and its related issues

2.1.1 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.

2.1.2 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).

2.1.3 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 17^{th} century. It was well established as a crop in Africa by the mid-20th century (CCWPU, 2009).

2.1.4 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:

Potato varieties	Potato varieties	Potato varieties
BARI Alu-1 (Hira)	BARI Alu-22 (Saikot)	BARI Alu-36
BARI Alu-4 (Ialsha)	BARI Alu-23 (Utra)	BARI Alu-37
BARI Alu-7 (Diamant)	BARI Alu-24 (Dura)	BARI Alu-38 (Omega)
BARI Alu-8 (Cardinal)	BARI Alu-25 (Aesterix)	BARI Alu-39 (Belini)
BARI Alu-11 (Chomok)	BARI Alu-26 (Felsina)	BARI Alu-40
BARI Alu- 12 (Dhira)	BARI Alu-27 (Spirit)	BARI Alu-41
BARI Alu- 13 (Granolla)	BARI Alu-28 (Lady Rosetta)	BARI Alu-42 (Ezila)
BARI Alu-15 (Binella)	BARI Alu-29 (Courage)	BARI Alu-43 (Atlas)
BARI Alu-16 (Arinda)	BARI Alu-30 (Meridian)	BARI Alu-44 (Elgar)
BARI Alu- 17 (Raja)	BARI Alu-31 (Sagita)	BARI Alu-45 (Stafy)
BARI Alu-18 (Baraka)	BARI Alu-32 (Quiensce)	BARI Alu-46 (LB-7)
BARI Alu- 19 (Binti)	BARI Alu-33 (Almera)	Gurguri
BARI Alu- 20 (Jarla)	BARI Alu-34 (Laura)	Lal-Pakhri
BARI Alu-21 (Provento)	BARI Alu-35	Shil-Bilati
BARI TPS-1	BARI TPS-2	

source: (BRRI, 2016)

2.1.5 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 its 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, 2000).

2.1.6 Production of potato in Bangladesh

Potato production in Bangladesh in fiscal year (FY) 2012-13 hit a new record of 8.603 million tons surpassing the past record of 8.38 million tons in FY'11. The production witnessed a negative growth in FY'12 when it plunged to 8.205 million tons- 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. In FY'11, per hectare yield was 18.21 tons which reached 19.07 tons in FY'12 and hit a new record of 19.307 tons in fiscal year'13. Annual demand for the carbohydrate-rich vegetable has now stood at 6.5 to 7.0 million tons. That indicates a 1.5m to 2.0m tons are surplus production. 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 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 country has a storage capacity of 4.2 million tons of potato in 382 cold storages, which is less than half in terms of the total production (DAM, 2015).

2.2 Review on plant protection management practices in potato cultivation

Each technical choice made by the farmers concerning way of growing potatoes play a predominant role on the quantitative and qualitative yield. Plant protection management practices in potato cultivation are described below:

2.2.1 Rotations

The most traditional way to control diseases is to use crop rotations including a non-host plant that can "sanitize" the soil (Alabouvette *et al.,* 1996). Several studies show good results when potatoes are grown only once every 3 or 4 years and, as the other practices, it should be thought in a systemic approach. The beneficial effect of crop rotation depends on the host range of the pathogen and its ability to survive in soil in the absence of its host plant thanks to dormant structures such as sclerotia or chlamydospores. Crop rotation must avoid including alternative hosts for the pathogen (Peters *et al.,* 2004). Susceptible weeds-such as hairy nightshade (*Solanum sarrachoides*)-have to be eliminated as they enable the pathogen to survive during the absence of the main host (Boydston *et al.,* 2008). Crop rotation can also fail to control highly specialized pathogens, such as *Globodera spp.*, *S. endobioticum,* or *S. subterranea*. These organisms are able to survive for long periods, either saprophytically or as dormant structures, in soil, and a very low inoculum density is sufficient to induce disease (Samaliev *et al.*, 1998; Merz and Falloon, 2009). Rotations with potatoes can include very diverse crops. If some of those crops have beneficial effects towards potato crop, other might favor pathogen development and should not enter the rotation, or at least not as the crop preceding the potatoes.

2.2.2 Fertilization and amendments

Supplying plants with micronutrients and macronutrients can be achieved with organic or inorganic fertilizers, either through soil application, foliar spray, or seed treatment (Davis *et al.*, 1994; Panique *et al.*, 1997; Malakouti, 2008). Adapted fertilization and amendment allow strong and healthy crops, which are less susceptible to pathogens (Khomyakov and Kostin , 1981). Fertilization may also indirectly favor diseases by enhancing foliar development that maintains high level of humidity needed for example for the growth of *Pectobacterium spp.* (Rousselle *et al.*, 1996). Amendments contribute to control diseases by modifying soil properties, especially pH and microbial activities. That could result in specific suppression caused by the stimulated specific antagonistic populations or in general suppression caused by increased microbial activities or both (Lazarovits *et al.*, 2001; Steinberg *et al.*, 2007; Termorshuizen *et al.*, 2006). For some diseases, such as stem rot, organic fertilizers are more efficient than mineral ones in terms of disease suppression (Amitava and Maiti, 2006). Among organic fertilizers, composts are known to have the capacity to suppress diseases, depending on their degree of maturity (organic matter content and microbial activities). The causal agents of disease suppression brought into the soil by compost amendment are complexes of bacterial and fungal populations, which invade the pile during curing stage, although some residual activity is probably related to fungistatic compounds occurring in the composts (Raviv, 2008).

2.2.3 Tillage management

Potato cultivation traditionally involves intensive soil tillage throughout the cropping period. Mechanical tillage, ridging, and harvesting entail intensive soil disturbance and modify the environmental conditions especially the microbial characteristics of soil, both on quantitative and qualitative aspects (FAO 2008; Vian, 2009). As an example, plowing contributes to redistribute vertically the inoculums, which increases the probability of infection (Taylor,

2005). Over the last decades, there is a trend to replace plowing by techniques without soil inversion, i.e., no tillage or superficial tillage. It seems that this strategy could lead to some efficient disease suppression by stimulating microbial activity but conversely may limit the nutrient uptake by the plant (Klikocka, 2001; Peters *et al.,* 2004; Vian, 2009). Therefore, a combination of both biotic and abiotic factors should be clearly balanced. Indeed, rotation and conservation tillage practices can improve disease suppression by enhancing the antibiosis abilities of endophytic and root zone bacteria (Peters *et al.,* 2003). On the other side, the plant growth and the macronutrient (N, P, K, Ca, and Mg) contents in potato plant respond positively to a deeper soil caused by plowing (Boligowa and Glen, 2003; Nunes *et al.*, 2006). 4.4 Planting, haulm destruction, lifting, and harvesting Planting, dehaulming, lifting, and harvesting are decisive for disease expression. For example, low planting density increases the yield per plant because the foliage has more space to grow. Also, sparse plants are less exposed to the attacks of pathogens than plants at high densities (Milic *et al.,* 2006). Diseases can be reduced by adjusting planting, dehaulming, and harvesting dates and cultivation of early tuberizing cultivars combined with pre-harvesting desiccation of haulms and treatment of seed tubers with chemicals (Sikka and Singh, 1976). Black scurf development on tubers has a positive correlation with the curing period (time between haulm destruction and harvest) because infection on tubers continues in the soil even after haulm destruction (Lakra 2000).

2.2.4 Pesticides

Pesticides are commonly used to control various pathogens altering potato tubers. They can be applied as soil fumigant (fumigants such as carbamates are not allowed in some European countries), sprayed or powdered directly on seed tubers after harvest or applied as granular (Hide *et al.,* 1995; Tsror *et al.*, 2000; Errampalli *et al.,* 2006). The chemicals have to be carefully chosen, since pathogens can adapt and become resistant. Thiabendazole-resistance was detected in *Fusarium avenaceum, F. culmorum, F. equiseti*, and *F.*

sporotrichioides (Fusarium dry rot; Ocamb *et al.,* 2007), in *P. pustulans* (skin spot; Carnegie *et al.,* 2008) and in *H. solani* (silver scurf). Mefenoxam-resistance is known for *P. erythroseptica* (pink rot) populations (Taylor *et al.,* 2006) and numerous treatments of carbendazim select resistant mutants of *Sclerotium rolfsii* (stem rot; Solunke *et al.,* 2001). Moreover, the use of numerous chemicals is nowadays regulated and many of them are no longer permitted in Europe.

2.2.5 Organic farming versus conventional agriculture

Organic farming relies on agricultural techniques that exclude the use of chemical pesticides and recommend organic fertilization. As a result, the soil and tuber environment is quite different from the one caused by conventional practices and may induce disease suppression. To reduce disease incidence or severity, the best adapted cultural system depends on the pathogen to control and varies strongly according to the soil type (Messiha *et al.,* 2007). It has been reported that farmers who switch from conventional to organic system faced critical pest or disease problems during a transition period of about 5 years but managed to control soil-borne diseases on the long-term (Bruggen and Termorshuizen, 2003). However, organic farmers generally faced more sanitary problems than conventional farmers.

2.2.6 Handling and storage

Inappropriate manipulation of tubers at harvest or during storage can provoke wounds that increase diseases such as black dot, Fusarium dry rots, silver scurf, gangrene, leak, pink rot, black leg, and soft rot (Meredith *et al.,* 1975; Hide, 1994; Vanvuurde and Devries, 1994; Salas *et al.,* 2000; Marcinkowska *et al.,* 2005; *Peters et al.,* 2008a, b). Significant measures of managing potato diseases include: avoiding mechanical damage to potatoes during harvesting, shipping and sorting, curing the harmed parts thereby preventing infection and disease onset, avoiding manipulation of cold potato since potato tubers are more sensitive to injuries when cold, avoiding the exposure of table potato to

light, and continuously providing stored potatoes with fresh air (Milosevic and Alovic, 2006; Scheid, 2006). Most of the storage diseases decrease when the tubers are cured in dry conditions and stored at temperature close to 4°C or 5°C, except gangrene. Once again, for storage as for production, a balance between biotic and abiotic conditions should be carefully setup to preserve yield and quality. Indeed, despite they have less infection when stored in a dry atmosphere, tubers show greater weight losses than stored in a humid atmosphere (Lennard, 1980).

2.2.7 Risk assessment and decision support systems

Disease occurrence and development influenced by abiotic and biotic factors are difficult to predict. However, their prediction would be very useful to assess disease risk and consequently the potential yield loss and to choose the best disease control strategy. Current methods to evaluate yield losses are based on predictive models which commonly assign a value or score to each risk factor, such as cultivar resistance, inoculums density, cultural practices, and environmental factors. The maximum score that can be assigned to each factor depends on the relative importance of the factor in determining the disease.

For example, cultivar resistance is considered to be a major determinant of powdery scab severity, so this factor has a higher score than the zinc content of soil, which is thought to be less important (Burgess and Wale, 1994). Assessment of the risk for each factor and for each disease is performed by bioassays in fields or in growth chambers under controlled conditions. They are generally laborious, time consuming, and costly. Tolerant cultivars are a particular risk factor in potato production as they can maintain and increase the inoculums level in fields (Merz and Falloon, 2009). A tolerance threshold of the crop has to be determined. It takes into account the relationship between inoculums density and disease incidence or severity according to cultivar resistance. A score can also be attributed to each cultural practice in the equation of the model since they have various impacts on yield losses.

For example, incidence and severity of Verticillium wilt decrease with long rotations (Johnston *et al.*, 1994), but mint as a previous crop increases Verticillium wilt (Omer *et al.*, 2008). Consequently, in the equation of the model, rotation length will be negatively correlated to yield losses whereas mint as previous crop will be positively correlated to yield losses due to Verticillium wilt. On the same pattern, some predictable environmental factors such as nutrient contents and soil pH can be scored. However, abiotic environmental factors are difficult to predict. For example, at planting time, rainfall and temperature conditions occurring at the critical growth phase of the disease are almost impossible to foresee. As climatic conditions, cannot be predicted at middle term, models of risk assessment are less reliable. However, no factor alone has a dramatic effect on the disease and the beneficial reduction of a disease is usually achieved by sum of optimized factors (Harrison, 1997).

Mathematical modeling including all the data related to the environmental factors and to the results concerning plant resistance appeared to be helpful to evaluate risk, to overcome the scaling gap between bioassays in growth chamber and field application and to simulate scenario based on crop management (Janvier *et al.*, 2007). Calculation of yield losses enables to identify a damage threshold and to determine the time at which disease control must be initiated. Indeed, yield loss threshold and economic threshold are different. Economic threshold is frequently higher than yield loss threshold; because up to a certain point, losing yield is less penalizing for farmers than spending money to avoid it. Calculation of economic thresholds beyond which control of diseases is profitable takes into account a damage function drift to potato yield, pathogen population density, and crop selling prices. For example, application of control measures is found to be beneficial at an initial density of *G. rostochiensis* higher than eight eggs and larvae per gram of soil and damage threshold is at two eggs per gram of soil (Samaliev and Andreev, 1998).

Economic thresholds allow taking short-term strategic decisions such as choice of the cultivar, cultural practices, timing of crop establishment, seed treatment,

planting density, etc. and long-term strategic decisions such as define research priorities, design the breeding programs, or develop integrated pest management strategies (Savary *et al.*, 2006). Predicting models are used by farmers as decision support systems (DSS) and generally provide a theoretical yield to be obtained at the end of the cropping period, a monitoring of pest populations and comments and advices in order to increase the theoretical yield as much as possible (Been *et al.,* 2005). Some DSS are able to send real time alerts to farmers when several risk factors are combined and when control measures have to be taken immediately (Dubois and Duvauchelle, 2004). DSS are environmental and farmer friendly as they enable to increase economical yields by applying the right chemical doses at the right time and when disease pressure requires it, in order to reduce unnecessary environmental pollutions and treatment cost.

2.2.8 Methods

Ways to control diseases are evolving since the use of chemicals is supposed to be reduced. In many cases, the most efficient long-term strategy is to use resistant cultivars when available. Otherwise, management strategies consist either in exclusion, avoiding contact between plant and pathogens, or by pest eradication, and leading to complete elimination or partial reduction of pathogen populations. For the potato crop, which is multiplied vegetative, exclusion methods begin with the use of healthy tubers. Many soil-borne pathogens can be carried on by seed tubers and the use of certified seed potatoes is a major way to control or restrict the movement of pathogens of potato crops (Andrade *et al.,* 2008).

Seed certification programs aim at warranting seed tuber quality to potato producers and favor the diffusion of genetic progress. Certification systems have been developed in most of the seed producing countries to cover the production of certified seed potatoes free from pathogens and pests (McDonald, 1995; Grousset and Smith, 1998; Sahajdak and Uznanska, 2003).

Application of fungicides and nematicides are protecting strategies whose application time and doses can be advised. However, pesticides are sometimes inefficient against pathogens, such as *Pectobacterium carotovorum* (Latour *et al.,* 2008), or their use is limited by environmental regulations. Consequently, alternative methods based on adapted cultural practices have to be recommended. Some crops either susceptible or resistant may serve as baiting crop, for example, resistant potato cultivars cropped just before the main potato crop decreased black scurf (Scholte, 2000). Likewise, alfalfa can be used to avoid TRV transmitted by stubby root nematode, as this crop is a host for stubby root nematode but immune to TRV (Stevenson *et al.,* 2001). Cultivar precocity can be used to avoid some diseases. Since black dot and charcoal rot damages occur late in the growing season, early cultivars are generally recommended to control these diseases (Stevenson *et al.,* 2001). When a disease is established in a production site, its spread must be avoided as much as possible. All diseased plants have to be eliminated or burned and tools should be properly disinfected before use in another field (Salas *et al.,* 2000; Latour *et al.,* 2008).

Natural interactions of plants and microorganisms with the pathogens are used as biological control to protect potato crops. There is a continuum from a conducive soil to a suppressive one (Alabouvette *et al.,* 1996) what means that in each soil, almost each pathogen can be potentially controlled by other microorganisms either by a specific antagonism or by competition with total microbial biomass. Appropriate agricultural practices, should stimulate this potential to enhance or to maintain the soil suppressive to potato diseases. Another approach consists in applying biocontrol agents. However, the choice of a biological control agent must take into account the potential risks to human health. Even if *Serratia grimesii* and *Burkholderia cepacia* decrease dry rot and black scurf and stem canker, respectively, they can cause human infections and are not recommended for biological control (Grosch *et al.,* 2005; Gould *et al.,* 2008). Moreover, indirect control such as strengthening of potato plants by

mycorhization increases tuber yield and allow an integrated management of potato cyst nematode and root-knot nematode (Sankaranarayanan and Sundarababu, 2001; Ryan *et al.,* 2003). Biological control may also include the use of natural toxic compounds for pathogenic agents. Fumigation of essential oils is studied to control dry rot, gangrene, black scurf, and stem canker (Bang, 2007). Fish emulsion and crushed crab shell are used against *Verticillium dahliae,Verticillium albo-atrum,* and *S. endobioticum*, respectively (Hampson and Coombes, 1995; Abbasi *et al.,* 2006).

Soil can be disinfected from pathogens by bio fumigation or solar heating or both. For example, Brassica crops used in crop rotations and as green manure have been associated with reductions in soil-borne pests and pathogens. These reductions have been attributed to the production of volatile sulfur compounds through the process of bio fumigation and to changes in soil microbial community structure (Janvier *et al.,* 2007). Composting is also a sanitizing method which combines temperature, time, and toxic compounds to control potato diseases. The composts the most frequently used on potato crop are organic wastes (sludge, manure, tea, etc.) that have undergone long, thermophilic and, aerobic decomposition. The most effective compost composition and combinations of temperature and time have to be determined for each pathogen. As it decreases the pathogenic population and/or favors microbial enrichment of the soil, compost has generally a positive or neutral effect on disease suppression and only rarely a disease stimulating effect (Termorshuizen *et al.,* 2006). Sanitization is also performed on tubers before planting by hot water (Janvier *et al.,* 2007) or during storage with chemical treatments at high temperatures (Secor *et al.,* 1988).

However, heating may damage tubers resulting in fewer sprouts. Biocontrol can also be performed by disrupting pathogens molecular pathways. *P. carotovorum* quorum-sensing mechanism is controlled by a quorum-quenching strategy aiming at interrupting the quorum-sensing by using compounds or organisms able to cause interferences in the bacterial signal (Latour *et*

*al.,*2008). Finally, it is also possible to enhance plant defense reactions against soil-borne pathogens by foliar spraying with different inducers such as salicylic acid, di-potassium hydrogen phosphate, and tri-potassium phosphate (Mahmoud, 2007). The different methods that were presented above are not items that have to be taken at random. Their combination generally gives better results than each of the method applied alone. Decision support systems developed to predict yield losses allow choosing good control methods such as use of healthy seeds, pesticides, cultural practices, biological control agents for each potato diseases.

2.3 Review on the relationship of farmers' selected characteristics and different agricultural management practice of different agricultural activities

2.3.1 Age and practice of agricultural activities

After reviewing the related literature, it was found that some studies showed age having negative and some studies showed age having no relationship with different agricultural management practice of different agricultural activities.

Researcher and Year	Independent Variable	Dependent Variable	Relationship/ contribution/effect
Rahman (2004)	Age	Practice on Boro rice cultivation	No significant relationship
Akhter (2003)	Age	Practice on agricultural activities	Significant relationship
Saha (2003)	Age	Practice on poultry production	No relationship

2.3.2 Education and practice of agricultural activities

Reviewing the related literature, it was found that some studies showed education having negative and some studies showed positive relationship with practice on different agricultural management practice of different agricultural activities, but some studies did not show any significant relationship.

Researcher and Year	Independent Variable	Dependent Variable	Relationship/ contribution/effect
Roy (2006)	Education	Practice of Boro rice cultivation	Significant and positive relationship
Islam (2005)	Education	Practice of IPM in crop production	Negative relationship
Rahman (2004)	Education	Practice of Boro rice cultivation	No relationship
Akhter (2003)	Education	Practice of agricultural activities	Negative relationship
Hossain (2003)	Education	Practice of modern Boro rice cultivation	Significant and positive relationship
Saha (2003)	Education	Practice of poultry production	No relationship

2.3.3 Annual family income and practice of agricultural activities

After reviewing the related literature, it was found that some studies showed annual family income having significant positive and some studies showed age no relationship with different agricultural management practice of different agricultural activities.

Researcher and Year	Independent Variable	Dependent Variable	Relationship/ contribution/effect
Rahman (2006)	Annual family income	Practice of prawn culture	Significant and positive relationship
Roy (2006)	Annual family income	Practice of Boro rice cultivation	Significant relationship
Islam (2005)	Annual family income	Practice of IPM in crop production	Significant relationship
Rahman (2004)	Annual family income	Practice of Boro rice cultivation	No relationship

2.3.4 Training exposure and practice of agricultural activities

Reviewing the related literature, it was found that three studies showed training exposure having significant positive relationship and one study showed no relationship with different agricultural management practice of different agricultural activities.

Researcher and Year	Independent Variable	Dependent Variable	Relationship/ contribution/effect
Rahman (2006)	Training exposure	Practice of prawn culture	Significant and positive relationship
Islam (2005)	Training exposure	Practice of IPM in crop production	No relationship
Hussain (2001)	Training exposure	Practice of crop cultivation	Significant and positive relationship
Sana (2003)	Training exposure	Practice on shrimp culture	Significant and positive relationship

2.3.5 Extension contact and practice of agricultural activities

It was found that one study showed extension contact having negative relationship and four studies showed significant relationship with different agricultural management practice of different agricultural activities.

Researcher and Year	Independent Variable	Dependent Variable	Relationship/ contribution/effect
Sana (2003)	Extension contact	Practice on shrimp culture	Significant and positive relationship
Kaur (1988)	Extension contact	Practice of selected program among the farmers	Significant relationship
Roy (2006)	Extension contact	Practice of Boro rice cultivation	Significant and positive relationship
Islam (2005)	Extension contact	Practice of IPM in crop production	Negative relationship
Hussain (2001)	Extension contact	Practice of crop cultivation	Significant and positive relationship

2.3.6 Other selected characteristics of farmers and different agricultural management practice of different agricultural activities

There was found a very little or no review on effective farm size, land under potato cultivation,annual income from potato production**,** potato cultivation experience, knowledge in potato cultivation, usages of mass media,organizational participation of the farmers and different agricultural management practices of different activities.

2.4 Research gap of the study

There are lots of researches on potato production to enrich the food safety but very few researches had been done to solely assess the plant protection management practices used by the farmers in potato cultivation. Moreover, among the limited studies on potato production practices along with other crops production practices has studied but only a few researchers followed systematic method. Therefore, the systematic method to assess plant protection management practices used by the farmers in potato cultivation has also limited. This was one of the research gaps of the study. Hence, the researcher carried out the present study to assess the plant protection management practices used by the farmers in potato cultivation of Pashuram block under Rangpur district following the method which is important to be able to identify and understand the research approach suitable for any given study because the selection of a research approach influences the methods chosen, the statistical analyses used, the inferences made and the ultimate goal of the research (Creswell, 1994). Furthermore, according to Bryman (2001) an area can be explored in two ways, with an unstructured approach to data collection in which participants' meaning are the focus of attention, and more structured approach of quantitative research to investigate a specific set of issues.

Therefore, no research was undertaken previously following the methodology which was followed by the researcher. This was also a significant research gap of the study. The methodology of the present work was very unique in this

regard. So, the researcher implemented the research program following the methodology as mentioned.

Additionally, no research was carried out taking the indicators of plant protection management practices used in potato cultivation into consideration which were carried out by the researcher in the present study. This is another research gap of the present work. Hence, the researcher followed the current research program using those indicators to assess the plant protection management practices used by the farmers in potato cultivation. Lastly, very few researches were conducted to assess the plant protection management practices used by the farmers in potato cultivation taking the variables which were used in the present study. This is also a research gap of the present research. Therefore, the researcher carried out the present study using the variables as mentioned.

2.5 Conceptual framework of the study

In scientific research, selection and measurement of variables constitute an important task. Studies on individual, group and society revealed that acceptance of modem technologies is conditional upon many factors. Some of these are social, personal, economical and situational factors and the behavior of potato cultivators are influenced by these characteristics. The hypothesis of a research while constructed properly consist at least two important elements i.e.: a dependent variable and an independent variable. A dependent variable is that factor which appears, disappears or varies as the researcher introduces, removes or varies the independent variables (Townsend, 1953)**.** An independent variable is that factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. Variables together are the causes and the phenomenon is effect and thus, there is cause effect relationship everywhere in the universe for a specific events or issues.

This study is concerned with the ‘Plant protection management practices used by the farmers in potato cultivation’. Thus, use of plant protection management practices were the dependent variable and 12 selected characteristics of the potato cultivators were considered as the independent variables under the study. Plant protection management practices used in potato cultivation may be affected through interacting forces of many independent variables. It is not possible to deal with all of the independent variables in a single study. It was therefore, necessary to limit the independent variables, which age, level of education, effective farm size, land under potato cultivation, annual family income**,**annual income from potato production,potato cultivation experience, knowledge in potato cultivation, usages of mass media, extension media contact, training exposure and organizational participation for this study.

Considering the above-mentioned situation and discussion, a conceptual framework has been developed for this study, which is diagrammatically presented in the following Figure 2.1.

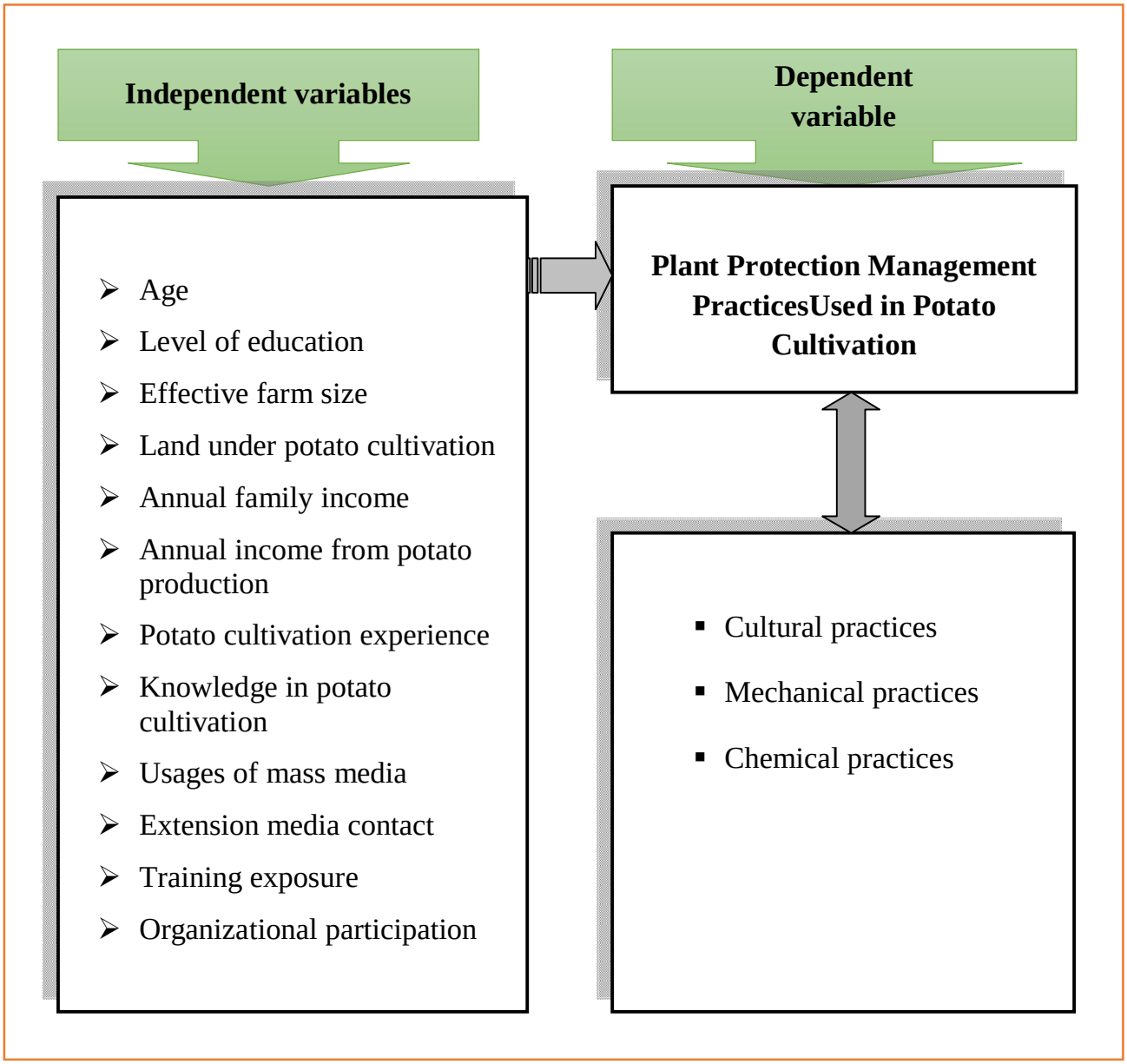

Figure 2.1 The conceptual framework of the study

CHAPTER III

METHODOLOGY

Methods play an important role in a scientific research. To fulfill the objectives of the study, a researcher should be very careful while formulating methods and procedures in conducting the research. According to Mingers (2001), research method is a structured set of guidelines or activities to generate valid and reliable research results. This chapter of the thesis illustrates the research methods and procedures used to collect and analyze the data for answering the research questions and attaining the purposes. The methods and operational procedures followed in conducting the study e.g. selection of study area, sampling procedures, instrumentation, categorization of variables, collection of data, measurement of the variables and statistical measurements.A chronological description of the methodology followed in conducting this research work has been presented in this chapter.

3.1 Research Design

A research design is detailed plan of investigation. It is the blueprint of the detailed procedure of testing the hypothesis and analysis of the obtained data. The research design followed in this study was *ex-post facto,* because of uncontrollable and non-manipulating variables. This is absolute descriptive and diagnostic research design. A descriptive research design is used for fact findings with adequate interpretation. Diagnostic research design, on the other hand, is concerned with testing the hypothesis for specifying and interpreting the relationship of variables

.

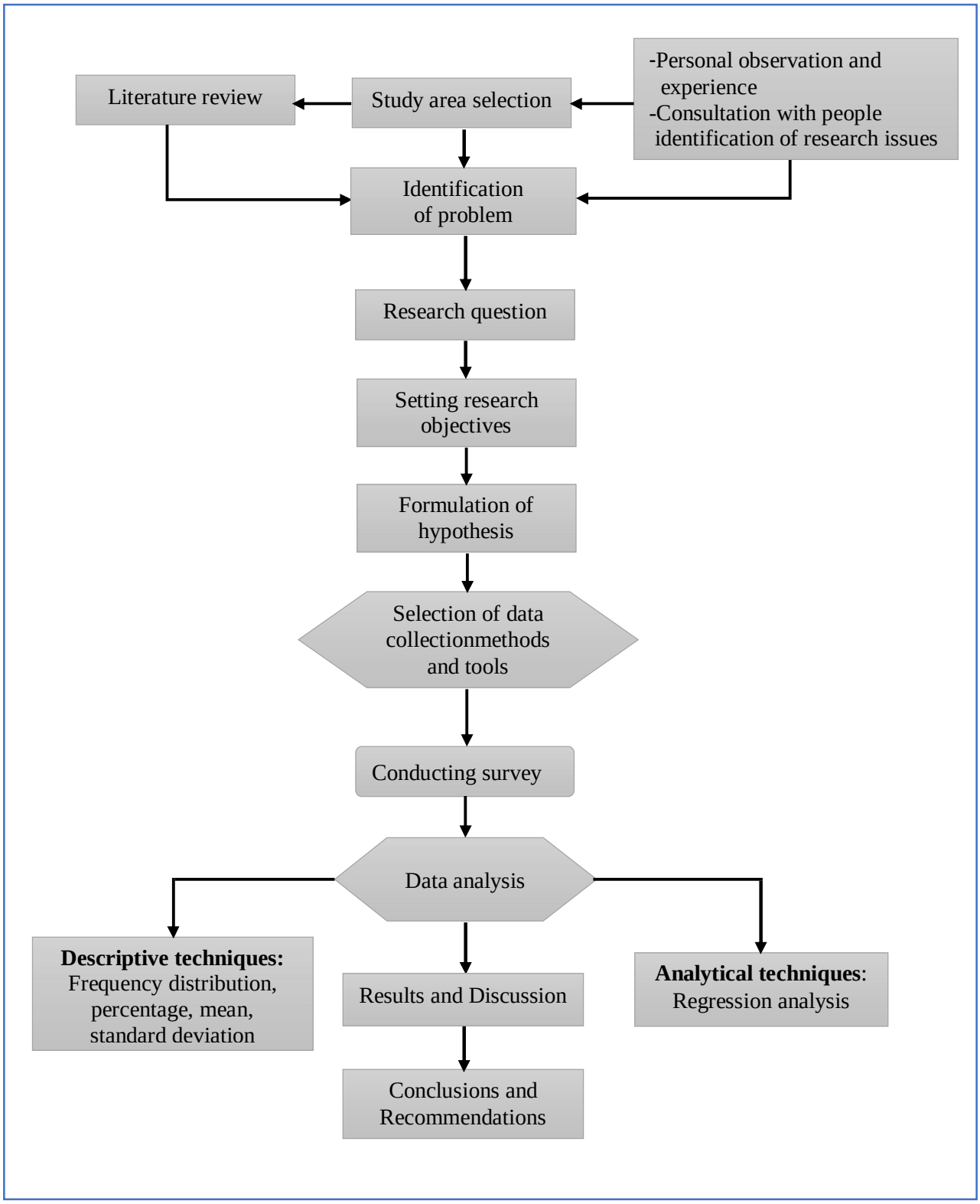

Figure 3.1 Schematic presentations of research

3.2 Locale of the study area

The study was conducted in the Rangpur Sadar upazila under Rangpur district. Rangpur Sadar (Rangpur district) area 330.33 sq km, located in between 25°39' and 25°50' north latitudes and in between 89°05' and 89'20' east longitudes. It is bounded by Gangachara upazila on the north, Mithapukur upazila on the south, Kaunia and Pirgachha upazilas on the east, Taraganj and Badarganj upazilas on west. The features of the farmers and agriculture at Rangpur Sadar are like- ownership of agricultural land: landowner 41.39%, landless 58.61%; agricultural landowner: urban 52.17% and rural 47.83%; main crops: paddy, jute, potato wheat, onion, garlic, ginger, chilli, sugarcane, tobacco, vegetables; Main fruits: mango, jackfruit, blackberry, banana, papaya. Rangpur Sadar has several blocks segmented by Department of Agricultural Extension (DAE) in which Paushuram block was selected randomly as the study area.

The present study was conducted at Rangpur sadar based on the population size in the selected area. The farmers of the study area are involved in potato cultivation. The number of farmers who involves in potato cultivation in the study area are 2115.

The map of the Rangpur district has been presented in Figure 3.2. and the specific study location namely Rangpur Sadar have also been shown in Figure 3.3.

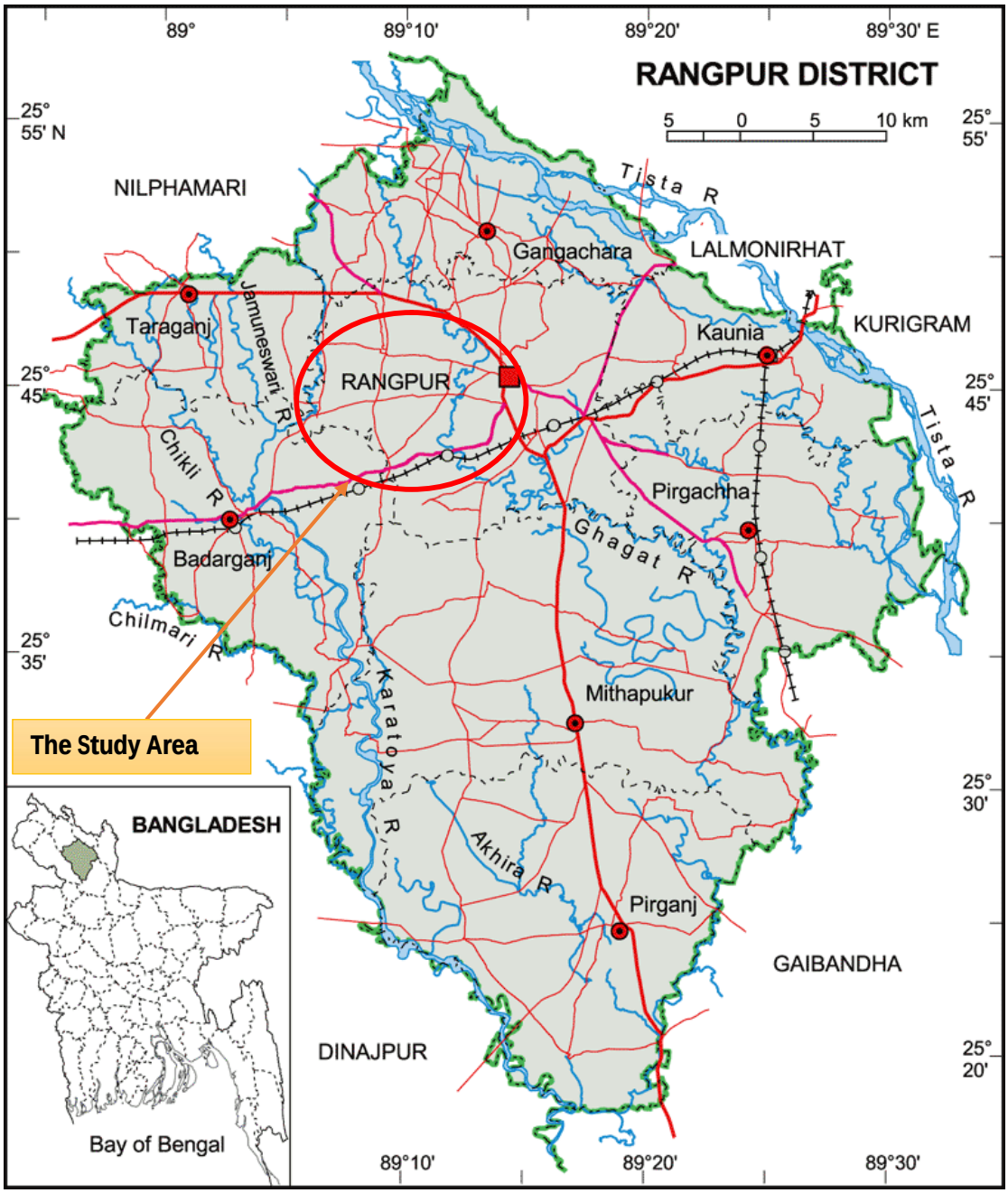

Figure 3.2 Map of Rangpur district showing the study area-Rangpur sadar

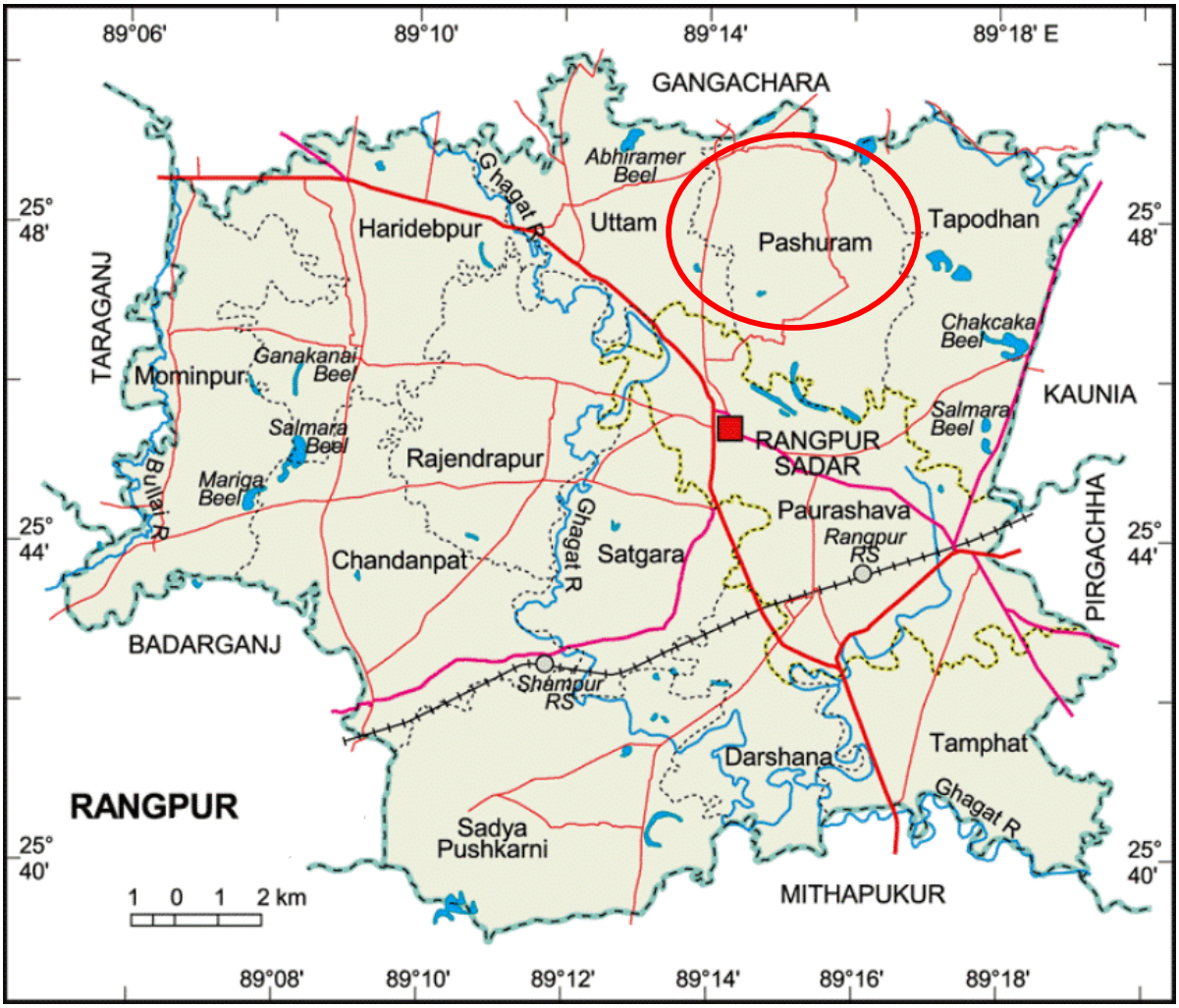

Figure 3.3 Map of Rangpur sadar showing the study area-Pashuram block

3.3 Fundamental attributes of the study area

The population of the study areas consists of small, subsistence-based farmers and nearly everyone is directly or indirectly involved in the production or processing of agricultural goods and related activities like livestock rearing, fisheries and forestry. The economy of the study area primarily depends on agricultural production, principally of potato, potatoes, oilseeds, pulses, wheat, jute and some vegetables. The people of the study area are largely self-sufficient in potato, but other agricultural products are not sufficient to meet their demand. In addition to agricultural products some households produce handicrafts that are being sold further away, reaching regional and national markets. However, households in general face a economic crisis. Many households depend on income from urban areas for their livelihoods.

Generally, people of the study area build their house in a cluster form called ‘Bari’ and many generations (2 to 3) live together within a ‘Bari’. Houses in in the study area are situated on high land and linked to walking roads. The shape of the house is commonly rectangular and usually made of dried mud, bamboo, straw, iron sheet or bricks with thatched roofs. The interior decoration is very simple and furniture is minimal, often consisting only of low stools. People sleep on wooden or bamboo platform like as a cot. Houses have verandas usually in the interior front, and many of the activities of daily life take place under the eaves of verandas. Most commonly, a kitchen (ranna ghor) is separated from the living house and during the dry season particularly in winter many women construct hearths in the household courtyard for cooking. The houses of the study area are simple and functional, but are not generally considered aesthetic showcases. On average, a household consists of 5 - 6 persons. Most of the households have a pond used for daily household needs, a nearby river that provides fish, trees that provide fruit and timber (mainly mango and jackfruit), and a piece of garden.

The landowning status mainly reflects socio-economic class position in of the study area, although occupation and education also play a role. Larger farm

owners are at the top of the socioeconomic scale, small subsistence farmers are in the middle, and the landless households are at the bottom of the socio-economic class position. Another most obvious symbol of class status is dress. The traditional garment for men is lungi and shirt; for women, the sari. The poor people usually wear cheap, rough green or dark colored cotton cloth, while the rich people wear bright colored with elaborate and finely worked cloths. Gold jewelry indicates a high social standing among women as very few households have gold purchasing capacity. Islam is the predominant religion in study area.

Physical infrastructures for public and health services are inadequate. Most of the roads are earthen roads and auto-rickshaw 'tempo' and tractors are the main means of transportation. Also, sanitation and water facilities are not adequate. Residents use unsanitary pond water for washing, bathing and cooking. Open defecation beside the pond is a common practice and most of the toilets are also situated within close distance of the ponds. There are very limited electrification facilities in the study area and people are mainly dependent on petroleum oil for lighting during the night and lifting ground water for irrigation. To reduce fuel costs, people go to bed as early as possible after sunset. Almost all the children at school age are deprived of education. There are many GOs, NGOs and civil society organizations in the study areas which are working for development and improving the livelihood of the people of the study area.

3.4 Population and sample of the study

People who permanently reside in the selected block constituted the active population of this study. As all population of the study area could not possible to measure, people of Pashuram block of Rangpur Sadar were the population of the study. However, representative sample from the population were taken for collection of data following random sampling technique. One farmer (who mainly operated the farming activities of the family) from each of the farm families was considered as the respondent. Updated lists of all farm families

who cultivated potao of the selected block were prepared with the help of SAAO and local leader. A random sampling procedure was followed to select one district from the whole of Bangladesh, and the same method was used to select the area of the district as well as the block as the study group. The total number of potato cultivators in this block was 2115; where 790 farm family heads from Word No. 7, 645 farm family heads from Word No. 8,680 farm family heads from Word No. 9 under the Pashuram block which constituted the population of the study. Thus, 2115 potato cultivators constituted the population of the study which is shown in the following table 3.1.

Table 3.1 Population of the study area

Name of the selected district	Name of the selected block	Name of the selected area	Number of the respondents
Rangpur	Pashuram	Word No. 7	790
		Word No. 8	645
		Word No. 9	680
Total			2115

3.4.1. Determination of sample size

There are several methods for determining the sample size; here, the researcher used Yamane's (1967) formula for study group:

$$n = \frac{z^2 P(1-P)N}{z^2 P(1-P) + N\,(e)^2}$$

Where, n = Sample size;

N, Population size = 2115;

e, The level of precision = 9%;

z = the value of the standard normal variable given the chosen confidence level (e.g., z = 1.96 with a confidence level of 95 %) and

P, The proportion or degree of variability = 50%;

The sample size (n) is = 112.

3.4.2 Distribution of the population, sample size and reserve list

According to Yamane's formula, the respondents comprised of 112 potato cultivators. A reserve list of 12 potato cultivators (ten percent of the sample size) were also prepared so that the potato cultivators of this list could be used for interview if the potato cultivators included in the original sample were not available at the time of conduction of interview. The farmers of the block were measured according to the proportionate of the total sample size (112) which was calculated using Yamane's (1967) formula. The distribution of the population, the number of sample size and number of respondents along with the reserve list are given in Table 3.2.

Table 3.2 Distribution of the potato cultivators according to population and reserve list

Selected district	Selected block	Selected area	Population	Sample size	Reserve list
Rangpur	Pashuram	Word No. 7	790	42	4
		Word No. 8	645	34	4
		Word No. 9	680	36	4
Total			2115	112	12

3.5 Methodological design

There are different types of quantitative and qualitative approaches available for data collection, and each approach is suitable for a particular situation and purpose. Qualitative methods are appropriate when the phenomena of the study are complex and social in nature and little pre-informative exists (Liebscher, 1998). Participatory research methods are useful when the respondents are mostly illiterate and unable to provide information through a structured set of questions. Both quantitative and qualitative approaches have their strengths and weaknesses and the possibilities of integrating both perspectives are characteristic for complex social studies (Bannan-Ritland, 2003). Begley (1996) expresses the view that the final choice of method should depend on the research questions to be answered. However, the constraints of time and resources and the researcher's particular skills may also influence the decision.

It is therefore important to be able to identify and understand the research approach suitable for any given study because the selection of a research approach influences the methods chosen, the statistical analyses used, the inferences made and the ultimate goal of the research (Creswell, 1994). Furthermore, according to Bryman (2001) an area can be explored in two ways, with an unstructured approach to data collection in which participants' meaning are the focus of attention, and more structured approach of quantitative research to investigate a specific set of issues. A triangulation method is used to analyze a given phenomenon, with information coming from different methods, researchers, places and time, and opinions (Denzin, 1978). There are different scenarios for combining qualitative and quantitative methods (Tashakkori and Teddlie, 2003). Some of these are as follows:

a) Qualitative measures to develop quantitative tools;

b) Qualitative methods to explain quantitative results;

c) Quantitative methods to enlarge on a qualitative study; and

d) Qualitative and quantitative methods equal and parallel.

According to Bryman (2001) qualitative research can be used to improve the design of survey questions for structured interviewing. This study employs both quantitative and qualitative techniques to explore the factors and underlying facts influencing potato farmers' livelihood. Thus, two kinds of data were obtained: qualitative data on the general perspectives of the people studied; and quantitative data that allow exploring specific issues in which the researcher was interested. In selecting a suitable approach for the present study, the merits and demerits of various methods were considered and an integrated approach was chosen based on the complexity and sensitivity of the research subject matter. The principal purpose of the current research is to identify the existing livelihood status of potato farmers and to measure the extent of plant protection management practices in potato cultivation.

3.5.1 Data collection methods and tools

3.5.1.1 Data collecting methods

The survey method was used to collect quantitative data that allow to answer the research questions framed and to gain an understanding of the determinants of potato farmers' plant protection management practices in potato cultivation. Individual interviews were used in the survey and were conducted in a face-to-face (Bryman, 2001) situation by the researcher.

3.5.1.2Data collecting tools

Structured interview schedules were prepared to reach the objectives of the study. The schedule was prepared containing both open and closed questions. The open questions allowed for the respondents to give answers using their own language and categories (Casley and Kumar, 1998). The questions in this schedule were formulated in a simple and unambiguous way and arranged in a logical order to make it more attractive and comprehensive. The instruments were first developed in English and then translated into Bengali. The survey tools were initially constructed based on an extensive literature reviews and pre-tested. The schedule was pre-tested with 10 randomly selected potato growers in the study area. The pre-test was helpful in identifying faulty questions and statements in the draft schedule. Thus, necessary additions, deletions, modifications and adjustments were made in the schedule on the basis of experiences gained from pre-test. The questionnaires were also checked for validity by supervisor and educational experts at Sher-e-Bangla Agricultural University (SAU). Finally, based on background information, an expert appraisal and the pre-test, the interview schedule was finalized. Data were gathered by the researcher personally. During data collection, necessary cooperation was obtained from field staff of different GOs and NGOs and local leader. The pre-test was done from 01February to 05February, 2017 for the purpose of pre-test. Books, journals and internet documents were used as

secondary sources of data supporting the empirical findings of the study. Final data collection was started from 07February and completed in 06 March, 2017.

3.6 Variables and their measurement techniques

The variable is a characteristic, which can assume varying, or different values in successive individual cases. A research work usually contains at least two important variables viz. independent and dependent variables. An independent variable is that factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. A dependent variable is that factor which appears, disappears or varies as the researcher introduces, removes or varies the independent variable (Townsend, 1953). In the scientific research, the selection and measurement of variable constitute a significant task. Following this conception, the researcher reviewed literature to widen this understanding about the natures and scopes of the variables relevant to this research. At last he had selected 12 independent variables and one dependent variable. The independent variables were: age, level of education, effective farm size, land under potato cultivation, annual family income,annual income from potato production**,** potato cultivation experience, knowledge in potato cultivation, usages of mass media, extension media contact, training exposure and organizational participation. The dependent variable of this study was the 'plant protection management practices by the farmers in potato cultivation'.

The methods and procedures in measuring the variables of this study are presented below:

3.6.1 Measurement of independent variables

The 12 characteristics of the potato farmers mentioned above constitute the independent variables of this study. The following procedures were followed for measuring the independent variables.

3.6.1.1 Age

Age of the farmers was measured in terms of actual years from their birth to the time of the interview, which was found on the basis of the verbal response of the rural people (Rashid, 2014). A score of one (1) was assigned for each year of one's age. This variable appears in item number 1 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (MoYS, 2012).

Category	Years
Young age	≤ 35
Middle age	36 to 50
Old age	≥ 51

3.6.1.2 Level of Education

Education was measured by assigning score against successful years of schooling by a farmer. One score was given for passing each level in an educational institution (Roy, 2015).

For example, if a farmer passed the final examination of class five or equivalent examination, his/her education score has given five (5). Each farmer of can't read & write has given a score of zero (0). A person not knowing reading or writing but being able to sign only has given a score of 0.5. If a farmer did not go to school but took non-formal education, his educational status was determined as the equivalent to a formal school student. This variable appears in item number 2 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into five categories.

Category	Education (year of schooling)
Can't read & write	0
Can sign only	0.5
Primary education	1 to 5
Secondary education	6 to 10
Above secondary	> 10

3.6.1.3 Effective farm size

Effective farm size of a farmer referred to the total area of land on which his/her family carried out the farming operation, the area being in terms of full benefit to the family. The term refers to the cultivated area either owned by the farmer or cultivated on sharecropping, lease or taking from other including homestead area and measured using the following formula (Rashid, 2014):

$$EFS = A + B + \frac{1}{2}(C + D) + E$$

Where, EFS = Effective Farm size,

A = Homestead area including garden and pond,

B = Own land under own cultivation,

C = Land taken from others as borga

D = Land given to other as borga,

E = Land taken from others on lease,

The data was first recorded in terms of local measurement unit i.e. kani or decimal and then converted into hectare. The total area, thus, obtained is considered as his farm size score (assigning a score of one for each hectare of land). This variable appears in item number three (3) in the interview schedule as presented in Appendix-I. Based on their total farm size, the farmers were classified into five categories according to Department of Agricultural Extension (DAE, 1999).

Category	Area (hectare)
Landless	≤ 0.020
Marginal farmer	0.021 to 0.20
Small farmer	0.21 to 1.00
Medium farmer	1.01 to 3
Large farmer	3 and above

3.6.1.4 Land under potato production

The land under potato production was measured to the total area of land on which his/her family carried out the farming operation, the area being in terms of full benefit to the family through potato cultivation. It was expressed in hectare. In measuring this variable, total area under potato cultivation was converted into local unit to hectare (assigning a score of one for each hectare of land). This variable appears in item number 4 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'small', 'medium' and 'large' land under potato production.

3.6.1.5 Annual family income

The term annual income refers to the annual gross income of potato cultivators and the members of his family from different sources. It was expressed in taka. In measuring this variable, total earning taka of an individual potato cultivator was converted into score. A score of one was given for every one thousand taka. The method of ascertaining income involved three phases. Firstly, the income from agricultural crops in the preceding year was noted and converted into taka. Secondly, Income from animals and fish resources. Thirdly, other source income included earning form small business, service, other family members' income, day laborer, fishing and others if any. This variable appears in item number 5 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into

three categories (Mean ± Standard Deviation) namely ‘small’, ‘medium’ and ‘large’ annual income.

3.6.1.6 Annual income from potato production

Annual income from potato production refers to the total financial return from potato production in one year. It will be expressed in Taka. One score was given for 1000 taka. For an amount, less than Tk.1000, a fraction score was computed and added with the main score. This variable appears in item number six (6) in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely ‘small’, ‘medium’ and ‘large’ annual income from potato production.

3.6.1.7 Potato cultivation experience

Potato cultivation experience of potato cultivators was determined by the total number of year involved in Potato cultivation. A score of one (1) was assigned for each year Potato cultivation experiences. This variable appears in item number 7 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely ‘low’, ‘medium’ and ‘high’ Potato cultivation experience.

3.6.1.8 Knowledge on potato cultivation

Potato cultivation knowledge of a farmers was measured by asking him/her 15 questions related to different components of potato cultivation e.g. name two popular varieties of potato in your locality, how to identify quality seed potato?, how to cut seed potato to sow in the field?, mention the plant spacing for potato cultivation, mention fertilizers application method in potato cultivation, what is earthing-up technique? what is solanization of potato?, how can you protect salinization? etc. It was measured assigning weightage two (2) for each question. So, the total assigned scores for all the questions became

thirty. The score was given according to response at the time of interview. Answering a question correctly an individual could obtain full score. While for wrong answer or no answer he obtained zero (0) score. Partial score was assigned for partially correct answer. Thus, the agricultural knowledge score of a farmer could range from zero (0) to thirty (30), where zero indicates no knowledge and thirty indicates highest knowledge. This variable appears in item number eight (8) in the interview schedule as presented in Appendix-I. Based on the information cited by farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'small', 'medium', 'high' knowledge in potato cultivation.

3.6.1.9 Usages of mass media

Usages of mass media referred to the total usages for getting benefits from mass media services. It was expressed in the score. In measuring this variable, a score of one was given for rare use of mass media. This variable appears in item number nine (9) in the interview schedule as presented in Appendix-I. The usages of mass media scoring of the farmers were done in following manner:

Category	Score
Regularly	4
Frequently	3
Occasionally	2
Rarely	1
Not at all	0

Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' usages of mass media.

3.6.1.10Extension media contact

It was defined as one's extent of exposure to different communication media related to potato production. Agricultural extension media contact of a farmer was measured by computing extension media contact score on the basis of their

nature of contact with nine extension media. Each farmer was asked to indicate his nature of contact with five alternative responses, like regularly, frequently, sometimes, rarely and not at all basis to each of the seven media and score of four, three, two, one and zero were assigned for those alternative responses, respectively. These five options for each medium were defined specially to each medium considering the situation, rationality and result of pre-test. Logical frequencies were assigned for each of the four-alternative nature of contact. Extension media contact of the farmers was measured by adding the scores of seven selected source of information. Thus, extension media contact score of a farmer could range from 0 to 28, where zero indicated no extension media contact and twenty-eight indicated highest level of extension media contact. This variable appears in item number 10 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' extension media contact.

3.6.1.11 Training exposure

Training exposure of a potato cultivator was determined by the total number of day when he attended in different training programs in his life regarding potato cultivation. A score of one (1) was assigned for each day of training attended. This variable appears in item number eleven (11) in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' training exposure.

3.6.1.12 Organizational participation

Organizational participation of a respondent was computed on the basis of his/her participation in different organizations. This variable appears in item number twelve (12) in the interview schedule as presented in Appendix-I. Scoring of the organizational participation was done using the following formula and in the following way-

OP= $P_{om} + P_{em} + P_{eo}$

Where, OP = Organizational participation score,

P_{om} = Participation as ordinary committee member,

P_{em} = Participation as executive committee member and

P_{eo} = Participation as executive committee officer (president/secretary).

Nature of participation	Score assigned
No participation	0
Participation as ordinary member	1
Participation as executive member	2
Participation as secretary/ president	3

For example, if a respondent participated as an executive committee member of school committee, an ordinary member at NGO organized society and no participation in other organizations, that respondent would have a total score 3. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'less', 'medium' and 'high' organizational participation.

3.6.2 Measurement of dependent variable

3.6.2.1 Plant Protection Management Practices

Plant protection management practices is the dependent variable. To reveal this management practices, the researcher considered three (02) components: cultural, mechanical and chemical practices. All the major components were measured with the help of identified subcomponents. Each subcomponent was measured against the identified items, collected through the process of review of relevant literature, focused discussion with the officials, experts, experienced farmers. Plant protection management practice (PPMP) was calculated by using the formula:

PPMP = CP + MP + CP

Where,

PPMP = Plant Protection Management Practice

CP= Cultural Practice

MP= Mechanical Practice

CP= Chemical Practice

3.6.2.2 Cultural practice

Cultural practice of a respondent was determined by providing score. Score one was provided for very low cultural practice. Cultural practice of a farmer was measured by computing cultural practice score on the basis of their nature of cultural practices with six cultural practice. Each farmer was asked to indicate his nature of cultural practice with five alternative responses, like high, medium, low, very low and not at all basis to each of the six-cultural practice and score of four, three, two, one and zero were assigned for those alternative responses, respectively. These five options for each medium were defined specially to each medium considering the situation, rationality and result of pre-test. Logical frequencies were assigned for each of the five-alternative nature of practice. Cultural practice of the farmers was measured by adding the scores of seven selected cultural practice. Thus, cultural practice score of a farmer could range from 0 to 24, where zero indicated no cultural practice and twenty-four indicated highest level of cultural practice. This variable appears in item number 13.1 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely ‘low’, ‘medium’ and ‘high’ cultural practice.

3.6.2.3 Mechanical practice

Mechanical practice of a respondent was determined by providing score. Score one was provided for very low mechanical practice. Mechanical practice of a farmer was measured by computing cultural practices score on the basis of their

nature of mechanical practice with four cultural practices. Each farmer was asked to indicate his nature of mechanical practice with five alternative responses, like high, medium, low, very low and not at all basis to each of the four cultural practices and score of four, three, two, one and zero were assigned for those alternative responses, respectively. These five options for each medium were defined specially to each medium considering the situation, rationality and result of pre-test. Logical frequencies were assigned for each of the five-alternative nature of practice. Mechanical practice of the farmer was measured by adding the scores of four selected mechanical practice. Thus, mechanical practice score of a farmer could range from 0 to 16, where zero indicated no mechanical practice and sixteen indicated highest level of mechanical practice. This variable appears in item number 13.2 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' mechanical practice.

3.6.2.4 Chemical control

Chemical practice of a respondent was determined by providing score. Score one was provided for very low chemical practice. Chemical practice of a respondent was determined by providing score. Chemical practice of a farmers was measured by computing chemical practices score on the basis of their nature of chemical practice with four chemical practices. Each farmer was asked to indicate his nature of chemical practice with five alternative responses, like high, medium, low, very low and not at all basis to each of the four-chemical practice and score of four, three, two, one and zero were assigned for those alternative responses, respectively. These five options for each medium were defined specially to each medium considering the situation, rationality and result of pre-test. Logical frequencies were assigned for each of the five-alternative nature of practice. Chemical practice of the farmer was measured by adding the scores of four selected chemical practice. Thus, chemical practice score of a farmer could range from 0 to 16, where zero indicated no mechanical

practice and sixteen indicated highest level of chemical practice. This variable appears in item number 13.3 in the interview schedule as presented in Appendix-I. Based on the available information cited by the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' chemical practice.

3.7 Problem faced by farmers in potato cultivation

Problem in potato cultivation was measured on the basis of extent of problems faced by the farmers on different aspects of potato cultivation. The following scores were assigned against each of the problems:

Extent of problems	Score
Very High problem	4
High problem	3
Moderate problem	2
Low problem	1
No problem	0

Potato cultivation problem of a farmers was measured by asking her 12 questions related to different components of potato cultivation problems. Thus, problems in potato cultivation score of a respondent could range from 0 to 48 where 0 indicated very low and 48 indicated very high problem in potato cultivation.

3.7.1 Rank order of problem faced by farmers in potato cultivation

To ascertain the best problem confrontation strategies Problem Faced Index (PFI) was computed. There were twelve problem faced strategies for coping with 12 selected items by the potato farmers in potato cultivation. The potato farmers implement different extent of problem confrontation strategies against different problems. They are presented below in rank order. A Problem Faced Index (PFI) was computed for each problem faced strategies by using the formula:

PFI = PVH×4 + PH×3 + PM×2 + PL×1 + PNA×0

Where,

PVH = Very High extent of Problem

PH = High extent of Problem

PM = Medium extent of Problem

PL = Low extent of Problem

PNA = Not at All of Problem

Problem Faced Index (PFI) for each problem confrontation strategies could range from 0 to 448, where 0 indicating lowest extent and 448 indicating highest extent of problem faced by farmers in potato cultivation.

3.8 Hypothesis of the study

According to Kerlinger (1973) a hypothesis is a conjectural statement of the relation between two or more variables. Hypothesis are always in declarative sentence form and they are related, either generally or specifically from variables to variables. In broad sense hypotheses are divided into two categories: (a) Research hypothesis and (b) Null hypothesis.

3.8.1 Research hypothesis

Based on review of literature and development of conceptual framework, the following research hypothesis was formulated:

“Each of the 12 selected characteristics (age, level of education, effective farm size, land under potato cultivation, annual family income,annual income from potato production**,** potato cultivation experience, knowledge in potato cultivation, usages of mass media, extension media contact, training exposure and organizational participation)of the farmers has significant contribution on plant protection management practices used by the farmers in potato cultivation.”

3.8.2 Null hypothesis

A null hypothesis states that there is no contribution between the concerned variables. The following null hypothesis was formulated to explore the contribution of the selected characteristics to plant protection management practices used by the farmers in potato cultivation. Hence, in order to conduct tests, the earlier research hypothesis was converted into null form as follows:

"There is no contribution of the selected characteristics (age, level of education, effective farm size, land under potato cultivation, annual family income**,**annual income from potato production**,** potato cultivation experience, knowledge in potato cultivation, usages of mass media, extension media contact, training exposure and organizational participation) of farmers to plant protection management practices used by the farmers in potato cultivation."

3.9 Data processing and analysis

Bogdan and Biklen (2006) insist that data analysis is an on-going part of data collection. Initially, all collected data were carefully entered in Access, exported to Microsoft Excel. Exported data were checked randomly against original completed interview schedule. Errors were detected and necessary corrections were made accordingly after exporting. Further consultation with research assistants and in some cases with the community people were required. Finally, data were exported from the program Microsoft Excel to SPSS/windows version 22.0, which offered statistical tools applied to social sciences. Qualitative data were converted into quantitative numbers, if required, after processing, scaling and indexing of the necessary and relevant variables to perform subsequent statistical analysis for drawing inferences.

As outlined earlier, there are many different forms and methods that can be used to analyze both quantitative and qualitative data in accordance with the objectives of the study. Both descriptive and analytical methods were employed in order to analyze the data. Descriptive techniques have been used

to illustrate current situations, describe different variables separately and construct tables and graphs presented in results. These included: frequency distribution, percentage, range, mean and standard deviation.

In most cases the opinions of respondents were grouped in broader categories. Analytical techniques have been utilized to investigate the contribution of the selected characteristics of the farmers on their plant protection management practices in potato cultivation. Statistical test like regression was used in this study. Each statistical technique is used under specific conditions and depends on the measurement scale of different variables.

3.10 Statistical analysis

Regression analysis was used to identify the linear combination between independent variables used collectively to predict the dependent variables (Miles and Shevlin, 2001). Regression analysis helps us understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. Ordinary Least Squares (OLS) is used most extensively for estimation of regression functions. In short, the method chooses a regression where the sum of residuals, ΣUi is as small as possible (Gujarati, 1995). The factors that contribute to the potato farmers' use of plant protection management practices are analyzed using a regression model. The overall quality of fit of the model has been tested by ANOVA specifically F and R^2 test.

The data were analyzed in accordance with the objectives of the proposed research work. The factors that contribute to the plant protection management practices used in potato cultivation are analyzed using a regression model, multiple regression analysis (B) was used. Throughout the study, five (0.05) percent and one (0.01) percent level of significance were used as the basis for rejecting any null hypothesis. If the computed value of (B) was equal to or greater than the designated level of significance (*p*), the null hypothesis was rejected and it was concluded that there was a significant contribution between

the concerned variable. Whenever the computed value of (B) was found to be smaller at the designated level of significance (*p*), the null hypothesis could not be rejected. It was concluded that there was no contribution of the concerned variables.

The model used for this analysis can be explained as follows:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + b_{10}x_{10} + b_{11}x_{11} + b_{12}x_{12} + e$$

Where, Y= is the plant protection management practices in potato cultivation;

Of the independent variables, x_1 is the age of potato cultivator, x_2 is level of education, x_3 is effective farm size, x_4 is land under potato cultivation, x_5 is annual family income, x_6 is annual income from potato production, x_7 is potato cultivation experience, x_8 is knowledge in potato cultivation, x_9 is usages of mass media, x_{10} is extension media contact, x_{11} is training exposure and x_{12} is organizational participation. On the other hand, b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9, b_{10}, b_{11}, and b_{12} are regression coefficients of the corresponding independent variables, and e is random error, which is normally and independently distributed with zero mean and constant variance.

CHAPTER IV

RESULTS AND DISCUSSION

The recorded observations in accordance with the objective of the study were presented and probable discussion was made of the findings with probable justifiable and relevant interpretation under this chapter. The findings of the study and their interpretation have been presented in this chapter. These are presented in four sections according to the objective of the study. The first section deals with the selected characteristics of the farmers, while the second section deals with the plant protection management practices. The third section deals with contribution of the farmers' selected characteristics on their plant protection management practices by the farmers in potato cultivation, while the fourth section deals with the problem confrontation potato cultivation.

4.1 Characteristics of the farmers

Behavior of an individual is determined to a large extent by one's personal characteristics. There were various characteristics of the farmers that might have consequence to potato cultivation. But in this study, twelve characteristics of them were selected as independent variables, which included their age, level of education, effective farm size, land under potato cultivation, annual family income, annual income from potato production**,** potato cultivation experience, knowledge on potato cultivation, usages of mass media, extension media contact, training exposure and organizational participation that might be greatly influenced the plant protection management practices by the farmers in potato cultivation are presented below:

4.1.1 Age

The age of the farmers has been varied from 24 to 64 years with a mean and standard deviation of 39.89 and 9.60, respectively. Considering the recorded age farmers were classified into three categories namely 'young', 'middle' and

'old' aged following Rashid (2014). The distribution of the farmers in accordance of their age is presented in Table 4.1.

Table 4.1 Distribution of the farmers according to their age

Category	Range (years)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Young aged	18 to 35	24-64	44	39.3	39.89	9.60
Middle aged	36-50		53	47.3		
Old aged	Above 50		15	13.4		
Total			112	100.0		

Table 4.1 reveals that the middle-aged farmers comprised the highest proportion (42.7 percent) followed by young aged category 39.3 percent) and the lowest proportion were made by the old aged category (13.4 percent). Data also indicates that the middle and young aged category constitute 47.3 percent of total farmers. The young and middle aged farmers were generally more involved in farm activities than the older. Data also indicates that the middle and young aged category constitute 86.6 percent of total farmers. Young and middle aged farmers were generally more involved in farming than the older due to their energetic, enthusiastic nature.

4.1.2 Level of education

The level of educational scores of the farmers ranged from 0 to 16 with a mean and standard deviation of 6.71 and 4.68, respectively. Based on the educational scores, the farmers were classified into five categories. The distributions of farmers according to their level of education are presented in Table 4.2.

Table 4.2 Distribution of the farmers according to their level of education

Category	Range (years)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Can't read and sign	0	0-16	5	4.5	6.71	4.68
Can sign only	0.5		26	23.2		
Primary education	1-5		18	16.1		
Secondary education	6-10		43	38.4		
Above secondary	>10		20	17.9		
Total			112	100.0		

Table 4.2 shows that farmers under secondary education category constitute the highest proportion (38.4 percent) followed by can sign only (23.2 percent) category. On the other hand, the lowest 4.5 percent in can't read and sign category followed by primary education (16.1 percent) and 17.9 percent respondents were above secondary category. Education broadens the horizon of outlook of farmers and expands their capability to analyze any situation related to adopt the potato cultivation.

4.1.3 Effective farm size

The effective farm size of the farmers ranged from 0.18 ha to 4.71 ha with a mean and standard deviation of 1.38 and 0.99, respectively. Based on their farm size, the farmers were classified into five categories following the categorization according to DAE. The distribution of the farmers according to their farm size is presented in Table 4.3.

Table 4.3 Distribution of the farmers according to their effective farm size

Category	Range (ha)		Farmers		Mean	SD
	Score (ha)	Observed	Number	Percent		
Landless	≤ 0.02	0.18-4.71 (ha)	-	-	1.38	.99
Marginal	0.021-0.20		1	.9		
Small	0.21-1.00		41	36.6		
Medium	1.01-3.0		61	54.5		
Large	> 3		9	8.0		
Total			112	100.0		

Table 4.3 indicates that the medium farm holder constitutes the highest proportion (54.5 percent) followed by small farm holder (36.6 percent). The findings of the study reveal that majority of the farmers were small to medium sized farm holder. The average farm size of the farmers of the study area (1.38 ha) was higher than that of national average (0.60 ha) of Bangladesh (BBS, 2014). The cultivator with marginal farm size has very little scope to experiment about new technologies as their earnings depend on mainly in

agriculture. Due to the enhancing the economic status of the farmers, the farmers are likely to motivate to buy the land.

4.1.4 Land under potato cultivation

Land under potato cultivation of the farmers ranged from .13 to 4.63 ha with the mean and standard deviation of 1.12 and .90, respectively. According to land under potato cultivation of the farmers, they were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' land under potato cultivation. The distribution of the cultivators according to their land under potato cultivation is presented in Table 4.4.

Table 4.4 Distribution of the farmers according to their land under potato cultivation

Category	Range (Number)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Landless	≤ 0.02	0.13-4.63			1.12	.90
Marginal	0.021-0.20		15	13.4		
Small	0.21-1.00		38	33.9		
Medium	1.01-3.0		54	48.2		
Large	> 3		5	4.5		
Total			112	100.0		

Table 4.4 indicates that the medium category of land under potato cultivation constitute the highest proportion (48.2 percent) followed by the small category of land under potato cultivation (33.9 percent). Only 4.5 percent farmers had large category of land under potato cultivation. The average farm size category of land under potato cultivation of the farmers of the study area (1.12 ha) was higher than that of national average farm land (0.60 ha) of Bangladesh (BBS, 2014). The cultivator with marginal farm size has very little scope to experiment about new technologies as their earnings depend on mainly in agriculture. Due to the more profitability of potato cultivation as well as the suitable crop adjusted with the environment of the study area, the farmers are likely to motivate to cultivate potato in their land.

4.1.5 Annual family income

The score of annual family income of the potato cultivators ranged from 65 to 840 thousand (BDT) with a mean and standard deviation of 253.34 and 175.27, respectively. On the basis of annual income, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely 'low', 'medium' and 'high' annual family income. The distribution of the potato cultivators according to their annual family income is presented in Table 4.5.

Table 4.5 Distribution of the farmers according to their annual family income

Category	Range ('000' BDT)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low income	≤ 77	65-840	13	11.6	253.34	175.27
Medium income	78-428		83	74.1		
High income	> 428		16	14.3		
Total			112	100.0		

Data reveals that the potato cultivators having medium annual family income constitute the highest proportion (74.1 percent), while the lowest proportion in low income (11.6 percent) followed by high income (14.3 percent). Overwhelming majority (88.4 percent) potato cultivators have medium to high level annual income. The suitable agricultural production and income generating activities moves the farmers behind this scenario in the study area where most of the farmers (88.4 percent) were in medium to high annual family income category.

4.1.6 Annual income from potato production

Annual income from potato production of the potato farmers ranged from 30 to 610 thousand taka with a mean and standard deviation of 172.56 and 128.05 respectively. On the basis of annual income from potato production, the potato farmers were classified into three categories (Mean ± Standard Deviation) viz. low, medium and high annual income from potato production. The distribution

of the potato farmers according to their annual income from potato production is presented in Table 4.6.

Table 4.6 Distribution of the farmers according to annual income from potato production

Category	Range ('000' BDT)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low income	≤ 44	30-610	22	19.6	172.56	128.05
Medium income	45-300		78	69.6		
High income	> 300		12	10.7		
Total			112	100.0		

Data reveals that potato farmers having medium annual income from potato production constitute the highest proportion (69.6 percent), while the lowest proportion in low annual income from potato production (19.6 percent) followed by high income (10.7 percent) from potato production. Overwhelming majority (89.7 percent) potato farmers have medium to low annual income from potato production. Due to the more profitability of potato cultivation as well as the suitable crop adjusted with the environment of the study area, the majority (89.7 percent) potato farmers are likely to motivate to cultivate potato which was expressed in this study.

4.1.7 Potato cultivation experience

Score of potato cultivation experience of potato cultivators could range from 5 to 34 with mean and standard deviation of 15.36 and 7.20, respectively. On the basis of potato cultivation experience scores, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely 'low, 'medium' and 'high' experience. The distribution of the potato cultivators according to their farming experiences is given in Table 4.7.

Table 4.7 Distribution of the farmers according to their potato cultivation experiences

Category	Range (year)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low experience	≤ 8	5-34	24	21.4	15.36	7.20
Medium experience	9-23		65	58.0		
High experience	>23		23	20.5		
Total			112	100.0		

Table 4.7 reveals that the majority (58.0 percent) of the potato cultivator fell in medium farming experience category, whereas only 21.4 percent in low experience category followed by 20.5 percent in high potato cultivation experience category. The findings of the present study reveal that around 79.5 percent of the potato cultivators in the study area had low to medium potato cultivation experiences. The socio-economic characteristics move the farmers in this scenario.

4.1.8 Knowledge on potato cultivation

Potato cultivation knowledge scores of the farmers ranged from 17 to 25 against possible score of 0 to 30. The average score and standard deviation were 21.33 and 2.16, respectively. Based on the potato cultivation knowledge scores, the farmers were classified into three categories (Mean ± Standard Deviation) namely low knowledge, medium knowledge and high knowledge on potato cultivation (Table 4.8).

Table 4.8 Distribution of the farmers according to their knowledge on potato cultivation

Category	Range		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low knowledge	≤ 18	17-25	16	14.3	21.33	2.16
Medium knowledge	19-23		74	66.1		
High knowledge	≥ 23		22	19.6		
Total			112	100.0		

Table 4.8 reveals that 66.1 percent of the farmers had medium potato cultivation knowledge, 14.6 percent had low knowledge and 19.6 percent had high knowledge on potato cultivation. Thus, an overwhelming majority (66.1percent) of the farmers had medium knowledge. This lead to understanding that potato cultivation knowledge would reflected more by the medium knowledge on agriculture group in the present study. Knowledge on potato cultivation of the farmers is definitely affected by the education of the farmers because education helps to enhance the eagerness to be acquainted with new variety or technology. They must require skill and modern knowledge to bring more yield and profit to ensure adoption of potato cultivation.

4.1.9 Usage of mass media

Usages of mass media score of the farmers ranged from 11 to 19. The average and standard deviation were 14.41 and 2.37 respectively. Bases on usages mass media, the respondents were categorized into three classes' (Mean ± Standard Deviation) namely low usages, medium usage and high usage. The distribution of farmers according to their usages of mass media is presented in Table 4.9.

Table 4.9 Distribution of the farmers according to their usages of mass media

Category	Range (score)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low usages	≤ 12	11-19	34	30.4	14.41	2.37
Medium usages	13-16		54	48.2		
High usages	> 16		24	21.4		
Total			112	100.0		

The observed data shows that most of the farmers (48.2 percent) had medium usage while 30.4 and 21.4 percent of them had low, high usage of mass media respectively (Table-4.9).

4.1.10 Extension media contact

The observed score of agricultural extension contact of the farmers ranged from 15 to 25 against a possible range of 0 to 28. The average score of the farmers was 19.45 with a standard deviation 2.40 (Table 4.10). The farmers were classified into three categories on the basis of their exposure to farming information through communication exposure scores and distribution of the three categories (Mean ± Standard Deviation) namely 'less', 'medium' and 'high' agricultural extension media contact of the farmers. Data showed that the highest proportion (57.1 percent) of the farmers had medium agricultural extension contact as compared to 22.3 percent of them having less agricultural extension contact and 20.5 percent fell in high extension contact (Table 4.10).

Table 4.10 Distribution of the farmers according to their extension media contact

Category	Range		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low contact	≤17	15-25	22.3	22.3	19.45	2.40
Medium contact	18-21		57.1	57.1		
High contact	>21		20.5	20.5		
Total			112	100.0		

From this table, it might be said that majority of the farmers had medium extension contact. It could be sated that extension agent or media of the study area were available to the farmers. The finding was interesting but logical because in general the farmers in the rural areas of Bangladesh are less cosmopolite in nature and less exposed to different information sources. Finding reveals that 22.3 percent of the farmers had low extension contact which demands for strengthening and improving the communication strategy. Low extension contact might be the reason that some respondent may think that they have enough knowledge about farming activities. They receive information from their neighbors, relatives and workmates etc.

4.1.11 Training exposure

Training exposure score of the potato cultivators ranged from 0 to 14 with a mean and standard deviation of 5.59 and 3.46, respectively. Based on the training exposure score, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely 'no training', 'low', 'medium' and 'high' training exposure. The distribution of the potato cultivators according to their training exposure is presented in Table 4.11.

Table 4.11 Distribution of the potato cultivators according to their training exposure

Category	Range (score)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low training	≤ 2	0-14	15.2	15.2	5.59	3.46
Medium training	3-9		67.9	67.9		
High training	> 9		17.0	17.0		
Total			112	100.0		

Table 4.11 indicates that the highest proportion (67.9 percent) of the potato cultivators had medium training exposure compared to 17.0 percent in high training exposure and 17.0 percent in low training exposure category, respectively. Training makes the potato cultivators skilled and helps them to acquire deep knowledge about the respected aspects. Trained potato cultivators can face any kind of challenges about the adverse situation in their cultivation. So, they show favorable attitude toward potato cultivation.

4.1.12 Organizational participation

Organizational participation score of the potato cultivators ranged from 0 to 9 with a mean and standard deviation of 4.42 and 2.65, respectively. Based on organizational participation score, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely less, medium and high participation. The distribution of the potato cultivators as per their organizational participation is presented in Table 4.12.

Table 4.12 Distribution of the farmers according to their organizational participation

Category	Range		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Less participation	≤ 1	0-9	16	14.3	4.42	2.65
Medium participation	2-7		77	68.8		
High participation	> 7		19	17.0		
Total			112	100.0		

Data reveals that the highest proportion (68.8 percent) of the potato cultivators had medium organizational participation, while 17.0 percent had high organizational participation and the lowest 14.3 percent had less organizational participation.

4.2 Plant Protection Management Practices in Potato Cultivation

4.2.1 Cultural practice

Score of cultural practice of the potato cultivators could range from 10 to 18 with mean and standard deviation of 13.41 and 2.36, respectively. On the basis of cultural practice scores, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely 'low, 'medium' and 'high' cultural practice. The distribution of the potato cultivators according to their cultural practice is given in Table 4.13.

Table 4.13 Distribution of the farmers according to their cultural practice

Category	Range (score)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low practice	≤11	10-18	33	29.5	13.41	2.36
Medium practice	12-15		55	49.1		
High practice	>15		24	21.4		
Total			112	100.0		

Table 4.13 reveals that the majority (49.1 percent) of the potato cultivator fell in medium cultural practice category, whereas only 29.5 percent in low cultural

practice category followed by 21.4 percent in high cultural practice in potato cultivation. The findings of the present study reveal that around 78.68 percent of the potato cultivators in the study area had low to medium cultural practice in potato cultivation.

4.2.2 Mechanical practice

Score of mechanical practice of the potato cultivators could range from 6 to 11 with mean and standard deviation of 9.11 and 1.38, respectively. On the basis of mechanical practice scores, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely 'low, 'medium' and 'high' mechanical practice. The distribution of the potato cultivators according to their mechanical practice is given in Table 4.14.

Table 4.14 Distribution of the farmers according to their mechanical practice

Category	Range (score)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low practice	≤ 7	6-11	24	21.4	9.11	1.38
Medium practice	8-10		72	64.3		
High practice	>10		16	14.3		
Total			112	100.0		

Table 4.14 reveals that the majority (64.3 percent) of the potato cultivator fell in medium cultural practice category, whereas only 21.4 percent in low mechanical practice category and 14.3 percent in high mechanical practice in potato cultivation. The findings of the present study reveal that majority farmers (64.3 percent) of the potato cultivators in the study area had medium mechanical practice in potato cultivation.

4.2.3 Chemical practice

Score of chemical practice of the potato cultivators could range from 9 to 14 with mean and standard deviation of 12.11 and 11.96, respectively. On the basis of chemical practice scores, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely 'low, 'medium' and

'high' chemical practice. The distribution of the potato cultivators according to their chemical practice is given in Table 4.15.

Table 4.15 Distribution of the farmers according to their chemical practice

Category	Range (score)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low practice	≤ 10	9-14	10	8.9	12.11	1.38
Medium practice	11-13		75	66.9		
High practice	>13		27	24.2		
Total			112	100.0		

Table 4.15 reveals that the majority (66.9 percent) of the potato cultivator fell in medium chemical practice category, whereas only 8.9 percent in low chemical practice category followed by 24.2 percent in high cultural practice in potato cultivation. The findings of the present study reveal that majority farmers (66.9 percent) of the potato cultivators in the study area had medium chemical practice in potato cultivation.

4.2.4 Plant Protection Management Practices used by the potato farmers

Score of plant protection management practices of the potato cultivators could range from 25 to 43 with mean and standard deviation of 35.26 and 4.91, respectively. On the basis of plant protection management practices scores, the potato cultivators were classified into three categories (Mean ± Standard Deviation) namely 'low, 'medium' and 'high' plant protection management practices. The distribution of the potato cultivators according to their plant protection management practices is given in Table 4.16.

Table 4.16 Distribution of the farmers according to their plant protection management practices

Category	Range (score)		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low practice	≤ 27	25-43	9	8.0	35.26	4.91
Medium practice	28-37		59	52.7		
High practice	> 37		44	39.3		
Total			112	100.0		

Table 4.16 reveals that the majority (52.7 percent) of the potato cultivator fell in medium plant protection management practices category, whereas only 8.0 percent in low plant protection management practices category followed by 39.3 percent in high plant protection management practices in potato cultivation. The findings of the present study reveal that around 92 percent of the potato cultivators in the study area had medium to high plant protection management practices in potato cultivation.

4.3. Factors influencing the plant protection management practices by the farmers in potato cultivation

In order to estimate the plant protection management practices by the farmers in potato cultivation from the independent variables, multiple regression analysis was used which is shown in the Table 4.17.

Table 4.17 shows that there is a significant contribution of respondents' level of education, Annual income from potato production, potato cultivation experience, knowledge on potato cultivation, usages of mass media, training exposure and organizational participation. Of these, potato cultivation experience, knowledge on potato cultivation, training exposure and organizational participation were the most important contributing factors (significant at the 1percent level of significance). Level of education, Annual income from potato production and usages of mass media significant at the 5 percent level of probability and coefficients of other selected variables don't have any significant contribution on the plant protection management practices by the farmers in potato cultivation.

Table 4.17 Multiple regression coefficients of contributing factors related to the farmers' plant protection management practices in potato cultivation

Dependent variable	Independent variables	B	*p*	R^2	Adj. R^2	F	*p*
Farmers' plant protection management practices in potato cultivation	Age	-.006	.938	0.710	0.674	20.15	0.000**
	Level of education	0.303	.046*				
	Effective farm size	0.113	.792				
	Land under potato cultivation	0.845	.764				
	Annual family income	0.029	.983				
	Annual income from potato production	0.005	.016*				
	Potato cultivation experience	0.054	.007**				
	Knowledge on potato cultivation	0.644	.001**				
	Usages of mass media	0.693	.027*				
	Extension media contact	0.107	.564				
	Training exposure	0.061	.001**				
	Organizational participation	0.170	.004**				

** Significant at $p < 0.01$;

* Significant at $p < 0.05$

Seventy one (71.0) percent ($R^2 = 0.710$) of the variation in the respondents changed plant protection management practices by the farmers in potato cultivation can be attributed to their level of education, annual income from potato production, potato cultivation experience, knowledge on potato cultivation, usages of mass media, training exposure and organizational

participation, making this an excellent model (Table 4.17). The F value indicates that model is significant ($p<0.000$). This ratio indicates that the regression model significantly improved the ability to predict the outcome variable.

The b-values indicate the individual contribution of each predictor to the model. Almost all predictors have positive b-values indicates if scores/ values of predictors (e.g. level of education) increases so do the extent of plant protection management practices used by the farmers in potato cultivation. Knowledge on potato cultivation (b=.644), this value indicates that as knowledge on potato cultivation increase by one unit, plant protection management practices used by the farmers in potato cultivation increase by 0.644 units. This interpretation is true only if the effects of all other predictors are held constant.

However, each predictor may explain some of the variance in respondents' plant protection management practices in potato cultivation conditions simply by chance. The adjusted R-square value penalizes the addition of extraneous predictors in the model, but values of 0.674 still show that the variance in respondents' plant protection management practices in potato cultivation can be attributed to the predictor variables rather than by chance, and that both are suitable models (Table 4.17). In summary, the models suggest that the respective authority should consider farmers' level of education, Annual income from potato production, potato cultivation experience, knowledge on potato cultivation, usages of mass media, training exposure and organizational participation.

4.4 Problem faced by farmers in potato cultivation

Problem faced by farmers in potato cultivation scores ranged from 21 to 33 against possible score of 0 to 40. The average score and standard deviation were 26.71 and 2.88 respectively. Based on the problems in potato cultivation scores, the potato farmers were classified into three categories (Mean ±

Standard Deviation) namely low, medium and high problems in potato cultivation (Table 4.18).

Table 4.18 Distribution of the farmer according to their problems in potato cultivation

Category	Range		Farmers		Mean	SD
	Score	Observed	Number	Percent		
Low problem	≤ 23	21-33	15	13.4	26.71	2.88
Medium problem	24-29		75	67.0		
High problem	≥ 21		22	19.6		
Total			112	100.0		

Table 4.18 reveals that 67.0 percent of the potato farmers had medium problems in potato cultivation, 19.6 percent had high problems in potato cultivation and 13.4 percent had high problems in potato cultivation. Thus, an overwhelming majority (86.6percent) of the potato farmers had medium to high problems in potato cultivation.

4.4.1 Rank order of problem faced by farmers in potato cultivation

Rank order of the twelve strategies of problem faced by farmers in potato cultivation is presented in the following Table 4.19. As per Problem Faced Index (PFI) lack of cold storage positioned the 1st, lack of marketing amenities in 2nd, high price of inputs in 3rd and subsequently getting low service from extension workers at the last position regarding problems in respect of potato cultivation.

The problems faced by farmers in cultivation of potato according to descending order through the analysis of the received data from farmers are lack of cold storage, lack of marketing amenities, high price of inputs, insects and diseases infestation, lack of credit in time, lack of irrigation facilities in time, transportation problem in potato marketing, lack of improved propagating materials. environmental hazards and getting low service from extension workers respectively.

Table 4.19 Rank order of problem faced by farmers in potato cultivation

Sl. No.	Nature of problems	Problem Faced Index (PFI) score	Rank
1.	Lack of cold storage	355	1st
2.	Lack of marketing amenities	348	2nd
3.	High price of inputs	337	3rd
4.	Insects and diseases infestation	312	4th
5.	Lack of credit in time	302	5th
6.	Lack of irrigation facilities in time	292	6th
7.	Transportation problem in potato marketing	278	7th
8.	Lack of improved propagating materials	265	8th
9.	Environmental hazards	256	9th
10.	Getting low service from extension workers	246	10th

The results shows that the highest problem faced by farmers in potato cultivation is lack of cold storage. This is caused that the potato requires cold storage for the supply of long time found in the study area. The lowest cause in potato cultivation at the study area is getting low service from extension workers. This happens because the extension workers are sincere to deliver their service in the study area.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The study was conducted in the Pashuram block of Rangpur sadar to find out the plant protection management practices by the farmers in potato cultivation. Total 2115 potato cultivators were selected from the study area as the population and according to Yamane's formula, the respondents comprised of 112 potato cultivators constituted the sample of the study. A well-structured interview schedule was developed based on objectives of the study for collecting information. The independent variables were: age, level of education, effective farm size, land under potato cultivation, annual family income, annual income from potato production**,** potato cultivation experience, knowledge on potato cultivation, usages of mass media, extension media contact, training exposure and organizational participation. The dependent variable of this study was the plant protection management practices in potato cultivation. Data collection was started in 07 February, 2017 and completed in 06 March, 2017. Various statistical measures such as frequency counts, percentage distribution, average, and standard deviation were used in describing data. In order to estimate the contribution of the selected characteristics of potato cultivators in the plant protection management practices in potato cultivation, multiple regression analysis (B) was used. The major findings of the study are summarized below:

5.1 Major Findings

5.1.1 Selected characteristics of the potato cultivators

Age: The middle-aged potato cultivators comprised highest proportion (47.3 percent) and the lowest proportion by the old aged category (13.4 percent).

Level of education: Secondary education constituted the highest proportion (38.4 percent) and the lowest 4.5 percent in can't read and sign category.

Effective farm size: The medium farm holder constituted the highest proportion (54.5 percent), whereas the landless farm holder was not found.

Land under potato cultivation: The medium farm holder constituted the highest proportion (48.2 percent), whereas the landless farm holder was not found in land under potato cultivation.

Annual family income: Medium annual income constituted the highest proportion (74.1 percent), while the lowest proportion in low income (11.6 percent) category among the potato cultivator of the study area.

Annual income from potato production: Medium annual income constituted the highest proportion (69.6 percent), while the lowest proportion in low annual income from potato production (10.7 percent) category.

Potato cultivation experience: The majority (58.0 percent) fell in medium farming experience category, whereas only 20.5 percent in high experience category in potato cultivation.

Knowledge on potato production: The majority (66.1 percent) of the potato cultivators fell in medium knowledge category, whereas and the lowest is 14.3 percent in low knowledge category in potato cultivation.

Usage of mass media: The majority (48.2 percent) of the potato cultivators fell in medium usages of mass media category, whereas and the lowest is 21.4 percent in high usages of mass media category in potato cultivation.

Extension media contact: The highest proportion (57.1 percent) of the farmers had medium agricultural extension contact as compared to 22.3 percent of them having less agricultural extension contact and 20.5 percent fell in high extension contact

Training exposure: The highest proportion (67.9 percent) had medium training exposure category and the lowest proportion (15.2 percent) had low training exposure category in potato cultivation.

Organizational participation: The highest proportion (68.8 percent) of the respondents had medium organizational participation and the lowest 14.3 percent had high organizational participation.

5.1.2 Plant protection management practices in potato cultivation

Cultural practice: The highest proportion (49.1 percent) of the respondents had medium cultural practice and the lowest 21.4 percent had high cultural practice category in potato cultivation.

Mechanical practice: The highest proportion (64.3 percent) of the respondents had medium mechanical practice and the lowest 14.3 percent had high mechanical practice category in potato cultivation.

Chemical practice: The highest proportion (66.9 percent) of the respondents had medium chemical practice and the lowest 8.9 percent had low chemical practice category in potato cultivation.

Plant protection management practices: The highest proportion (52.7 percent) of the respondents had medium plant protection management practices and the lowest 8.0 percent had low plant protection management practices category in potato cultivation.

5.1.3 Factors influencing the plant protection management practices by the farmers in potato cultivation

There is a significant contribution of respondents' level of education, Annual income from potato production, potato cultivation experience, knowledge on potato cultivation, usages of mass media, training exposure and organizational participation. 71.0% (R^2 = 0.710) of the variation in the respondents changed plant protection management practices in potato cultivation was attributed to the significant independent.

5.1.4 Problem faced by farmers in potato cultivation

The Majority (67.0 percent) of the potato farmers had medium problems in potato cultivation whereas the lowest 13.4 percent had low problems in potato cultivation category.

5.1.5 Rank order of problem faced by farmers in potato cultivation

Rank order of the twelve strategies of problem faced by farmers in potato cultivation was measured. As per Problem Faced Index (PCI) lack of cold storage positioned the 1st, and getting low service from extension workers at the last position regarding problems in respect of potato cultivation.

5.2 Conclusions

The findings and relevant facts of research work prompted the researcher to draw following conclusions.

i. The findings revealed that maximum (92 percent) of the potato cultivators had medium to high adoption in modern plant protection management practices. However, to meet the ever-growing demand of food, there is a need to sustain the plant protection management practices among the farmers in potato cultivation. It may be concluded that composite plant protection management practices are adequate and needs to maintain.

ii. Level of education of the farmers showed the important contributing factor on plant protection management practices by the farmers in potato cultivation. This means that high literacy and educational level among the farmers might have influenced high plant protection management practices in potato cultivation. Conclusion could be drowned that these farmers could be more ameliorated in all aspects of socio-economic life if government takes more educational project to make more educated.

iii. Maximum 89.7 percent potato cultivators had medium to high annual income from potato production category and regression analysis revealed that annual income from potato production of the potato cultivators was a contributing factor on plant protection management practices. Therefore, it may be concluded that high annual income from potato production encourages the farmers to practice plant protection management.

iv. Maximum 79.5 percent potato cultivators had low to medium potato cultivation experience category and regression analysis revealed that potato cultivation experience of the potato cultivators was a contributing factor on plant protection management practices. Therefore, it may be concluded that potato cultivation experience encourages the farmers to practice plant protection management in potato cultivation.

v. Potato cultivation knowledge of the had a significant contribution on plant protection management practices by the farmers in potato cultivation. Through potato cultivation knowledge an individual farmer became aware of the information on the various aspect of selected potato production practices. Consequently, they became motivated practice plant protection management in potato cultivation. The above facts lead to the conclusion that necessary arrangements should be made increase the knowledge of farmers which would ultimately increase the plant protection management practices in potato cultivation.

vi. The findings revealed that usages of mass media by the farmers had a significant contribution on plant protection management practices in potato cultivation. Usages of mass media by the farmers increases the outlook of the farmers which lead them to practice plant protection management.

vii. Maximum 79.6 percent potato cultivators had low to medium training exposure category and regression analysis revealed that training exposure of the potato cultivators was a contributing factor on plant protection management practices. Therefore, it may be concluded that training exposure encourages the farmers to practice plant protection management.

viii. Maximum 85.7 percent potato cultivators had medium to high organizational participation category and regression analysis revealed that organizational participation of the potato cultivators was a contributing factor on plant protection management practices. Therefore, it may be concluded that organizational participation encourages the farmers to practice plant protection management practices used by the farmer in potato cultivation.

5.3 Recommendations

5.3.1 Recommendations for policy implications

On the basis of observation and conclusions drawn from the findings of the study following recommendations are made:

i. An increased rate and extent of plant protection management practices in potato cultivation are vitally important for increasing the yield of potato production. It is revealed from the plant protection management practices that a considerable proportion (92 percent) of the farmers had medium to high plant protection management practices in potato cultivation. This is very much encouraging. This rate and extent of plant protection management practices should be maintained at all along. It is, therefore, recommended that an effective step should be taken by the Department of Agricultural Extension (DAE) and Non-Government Organizations (NGOs) for strengthening the farmers' qualities in favor of plant protection management practices in potato cultivation to a higher degree.

ii. Level of education of the farmers had a significant contribution on plant protection management practices in potato cultivation. It indicates the importance of education of the potato cultivators for more plant protection management practices in potato cultivation. It may be recommended that arrangements should be made for enhancing the education level of the potato cultivator by the concerned authorities through the establishment of night school, adult education and other extension methods as possible.

iii. Annual family income from potato cultivation of the potato cultivators was important contributing factors on the plant protection management practices in potato cultivation. Therefore, it is recommended that the extension workers should work with the farmers and motivate them to enhance the annual family income from potato cultivation which would help to the plant protection management practices in potato cultivation.

iv. Potato cultivation experience of the potato cultivators was important contributing factors on the plant protection management practices in potato cultivation. Therefore, it is recommended that the extension workers should work with the experienced farmers to enhance the plant protection management practices in potato cultivation.

v. Farmers having medium to high knowledge about potato cultivation. It should be selected on priority basis for any motivational training by Department of Agricultural Extension (DAE) and Non-Government Organizations (NGOs) for gaining sustainable potato production.

vi. The concerned authorities should take necessary steps to increase the usages of mass media in agriculture by the farmers. Therefore, it is recommended that the extension worker should provide supplementary supports to use mass media in potato cultivation so that farmers themselves could come in contact with mass media.

vii. The concerned authorities should take necessary steps to increase the training facilities for the farmers in potato cultivation. Therefore, it is recommended that the extension workers should encourage the farmers to participate the farmers in training program so that farmers themselves could come in contact training facilities.

viii. The concerned authorities should take necessary steps to increase the organizational participation for the farmers in potato cultivation. Therefore, it is recommended that the extension workers should encourage the farmers to participate the farmers in organizational participation so that farmers themselves could come in contact with organizational participation facilities.

5.3.2 Recommendations for further study

On the basis of scope and limitations of the present study and observation made by the researcher, the following recommendations are made for future study.

i. The present study was conducted in Pashuram block of Rangpur sadar under Rangpur district. It is recommended that similar studies should be conducted in other areas of Bangladesh.

ii. This study investigated the contribution of twelve characteristics of the farmers with their plant protection management practices in potato cultivation as dependent variables. Therefore, it is recommended that further study should be conducted with other characteristics of the farmers with their plant protection management practices in potato cultivation.

iii. The present study was concern only with the extent of plant protection management practices in potato cultivation. It is therefore suggested that future studies should be included more reliable measurement of concerned variable is necessary for further study.

iv. The study was based on the farmers' plant protection management practices in potato cultivation. Further studies may be conducted in respect of plant protection management practices of other crop production.

REFERENCES

Abbasi, P.A. and Conn, K.L., Lazarovits, G. (2006). Effect of fish emulsion used as a preplanting soil amendment onVerticilliumwilt, scab, and tuber yield of potato. *Canadian J. of Plant Pathol.* **28**:509-518.

Ahmed, K.U. (1982). Consumption of Potato, Proceeding of the 5th workshop of Potato research workers, Joydebpur, BARI.

Akhter, S.M.M., Anwar and Asaduzzaman, M. (2001). Potato production in some selected areas of Bangladesh. TCRC. BARI, Joydebpur, Gazipur, Bangladesh.

Akther, S. (2003). Comparison between Knowledge and Skill of Women Led FFS of RDRS and Non-FFS Farmers. M.S. (Ag. Ext. Ed.) Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Alabouvette C, Hoeper H, Lemanceau P, Steinberg C (1996) Soil suppressiveness to diseases induced by soilborne plant pathogens. *Soil Biochem.* **9**:371-413.

Alabouvette, C., Hoeper, H., Lemanceau, P. and Steinberg, C. (1996). Soil suppressiveness to diseases induced by soil borne plant pathogens. *Soil Biochem.* **9**:371-413.

Ali, M.S. and Hoque, A. (2011). Potato for food Security in SAARC Countries; SAARC Seed Congress and Fair 2011, Dhaka, Bangladesh.

Amitava, B., Maiti, M.K. (2006). Role of host nutrition and varieties on the development of stem rot of potato. *Ann. Plant Prot. Sci.* 14:479-480.

Andrade SN, Contreras MA, Castro UI (2008) Effect of using certified and uncertified potato seeds on the yield and sanitary conditions of a potato crop. *Agro. Sur.* **36**:63–66

Arif, A. (1998). An Economic Study of Potato Production in Selected Areas of Comilla Districts. M.S. (Ag. Econ.) Thesis. Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.

Bang, U. (2007). Screening of natural plant volatiles to control the potato (*Solanum tuberosum*) pathogens Helminthosporium solani, Fusarium solani, Phoma foveataand Rhizoctonia solani. *Potato Res.* **50**:185-203. doi:10.1007/s11540-008-9044-y.

Bannan-Rittand, B. (2003). The Role of Design in Research: The Integrative Learning Design Framework. *Educational Researcher* **32**(1): 21-24.

BARI (2016). The varieties of Potatoes in Bangladesh. Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. Retrieved from: http://www.bari.gov.bd/

Barry, A., Berry, R.E. and Tamaki, G. (1982). Host preference of the green peach aphid, Myzus persicae (Hemiptera: Aphididae). *Environ. Entomol.* **11**(4): 824-827.

BBS (2000). The Yearbook of Agricultural Statistical of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Been, T.H., Schomaker, C.H. and Molendijk, L.P.G. (2005). NemaDecide: a decision support system for the management of potato cyst nematodes. In: Haverkort, A.J. and Struik, P.C. (eds.) Potato in progress: science meets practice, Potato 2005, Emmeloord, NL, 5-7 Sept 2005:143-155.

Begley, C.M. (1996). Using Triangulation in Nursing Research. Journal of Advanced Nursing, **24**(1): 122-128.

Bogdan, R.C. and Biklen, S.K. (2006). Qualitative Research for Education: An Introduction to Theory and Methods (5th ed.). Boston: Allyn & Bacon.

Boligowa, E. and Glen, K. (2003). Yielding and quality of potato tubers depending on the kind of organic fertilization and tillage method. *Electronic J. of Polish Agril. Universities, Agronomy* **6:**1-7.

Boydston, R.A., Mojtahedi, H., Crosslin, J.M., Brown, C.R. and Anderson, T. (2008). Effect of hairy nightshade (*Solanum sarrachoides*) presence on potato nematodes, diseases, and insect pests. *Weed Sci.* **56**:151-154. doi:10.1614/ws-07-035.1.

Bruggen, A.H.Cv. and Termorshuizen, A.J. (2003). Integrated approaches to root disease management in organic farming systems. *Australis Plant. Pathol.* **32**:141-156. doi:10.1071/ap03029

Bryman, A. (2001). Social Research Methods. Oxford: Oxford University Press.

Burgess, P.J. and Wale, S.J. (1994). Development of an integrated control strategy for powdery scab of potatoes. Brighton Crop Protection Conference. *Pest Dis.* **1-3**:301-306.

Campbell, G.M., Webb, C. and McKee, S.L. (1997). Cereals: Novel Uses and Processes.

Carnegie, S.F., Cameron, A.M. and Haddon, P. (2008). Effects of fungicide and rate of application on the development of isolates of *Polyscytalum pustulans* resistant to thiabendazole and on the control of skin spot. *Potato Res.* **51**:113-129. doi:10.1007/s11540-008- 9094-1

Casley, D.J. and Kumar, K. (1998). The Collection, Analysis and Use of Monitoring and Evaluation Data. Washington DC: World Bank/Johns Hopkins University Press.

CCWPU (2009). Columbus's contribution to world population and Urbanization (CCWPU): A natural experiment examining the Introduction of Potatoes. Harvard University.

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.

Creswell, J.W. (1994). Research Design: Qualitative and Quantitative Approaches. London: Sage Publications.

CWHFP (1994). The Cambridge World History of Food- Potatoes (CWHFP).

DAE (1999). Agriculture Extension Manual. Department of Agricultural Extension, Ministry of Agriculture, Government of the People's Republic of Bangladesh. Retrieved from: http://www.dae.gov.bd/

DAM (2015). Marketing Status of Agricultural Goods: Potato. Department of Agricultural Marketing (DAM). Ministry of Agriculture, Government of the People's Republic of Bangladesh. Retrieved from: http://dam.portal.gov.bd/

Davis, J.R., Stark, J.C., Sorensen, L.H. and Schneider, A.T. (1994). Interactive effects of nitrogen and phosphorus on Verticillium wilt of Russet Burbank potato. *American Potato J.* **71**:467-481.

Denzin, N.K. 1978. The Research Act: A Theoretical Introduction to Sociological Methods. New York: McGraw-Hill.

Dickson, R. and Laird, E.F. (1967). Fall dispersal of green peach aphids to desert valleys. *Annals Entomol. Soci. America.* **60**(5): 1088-1091.

Dubois, L. and Duvauchelle, S. (2004). Integrated control of potato late blight: MILPV, a new French decision support system. *Phytoma.* **575**:11-13.

Elias, S.M., Miah, M.R.U., Hossain, M.J. Torofder, G.S. and Islam, M. S. (1992). Effect of potassium on the growth and yield of potato. *Bangladesh J. Agril. Res.* **17**(7): 91-93.

Errampalli, D., Peters, R.D., MacIsaac, K., Darrach, D., Boswall, P. (2006). Effect of a combination of chlorine dioxide and thiophanatemethyl pre-planting seed tuber treatment on the control of black scurf of potatoes. *Crop Prot.* 25:1231-1237. doi:10.1016/j. cropro.2006.03.002

FAO (2008). Potato Statistics. Food and Agriculture Organization (FAO), Rome, Italy. Available from: www.potato2008.org.

Gerster-Bentaya, M. (2005). Instruments for the Assessment and Analysis of the Food and Nutrition Security Situation at Micro and Meso Level. In: KLENNERT, K. (Ed.): Achieving Food and Nutrition Security. Actions to Meet the Global Challenge A Training Course Reader. InWEnt, Feldafing, German.

Goode, W.J. and Hatt, P.K. (1952). Methods in social research. New York: McGraw-Hill Book Company, Inc.

Gopal, J. and Khurana, S.M.P. (2006). Handbook of Potato Production, Improvement, and Postharvest. Haworth Press.

Gould, M., Nelson, L., Waterer, D. and Hynes, R. (2008). Biocontrol of *Fusarium sambucinum*, dry rot of potato, by *Serratia plymuthica* 5-6. *Biocontrol Sci. Technol.* **18**:1005-1016. doi:10.1080/ 0958315080247 8189.

Grosch, R., Faltin, F., Lottmann, J., Kofoet, A. and Berg, G. (2005). Effectiveness of 3 antagonistic bacterial isolates to control *Rhizoctonia solanikuhn* on lettuce and potato. *Canadian J. Microbiol.* **51**:345-353. doi:10.1139/w05-002.

Grousset, F. and Smith, I.M. (1998). EPPO certification scheme for seed potatoes. *Bull OEPP* **28**:561-567.

Gujarati, D.N. (1995). Basic Econometrics, McGraw-Hill International.

Hampson, M.C. and Coombes, J.W. (1989). Pathogenesis ofSynchytrium endobioticum7. Earthworms as vector of wart disease of potato. *Plant Soil* **116**:147-150.

Harrison, J.G. (1997). Powdery scab disease of potato-a review. *Plant Pathol.* **46**:1-25.

Hide, G.A. (1994). Effects of wounding fungicide-treated potato seed tubers on silver scurf disease on daughter tubers at harvest. *Potato Res.* **37**:287-290.

Hide, G.A., Welham, S.J., Read, P.J. and Ainsley, A.E. (1995). Influence of planting seed tubers with gangrene (*Phoma foveata*) and of neighboring healthy, diseased and missing plants on the yield and size of potatoes. *J Agric. Sci*. **125**:51-60.

Hoque MA, Hasan MK, Islam MR, Siddique MSJ, Rahman MF (2006) Effect of cut size and spacing on yield and profitability of potato. *Bangladesh J. of Agril. and Environ.* **2**(1): 9-15.

Hoque, A.S.M.A. (1998). Comparative Profitability of Potato under Different Situation in Dinajpur. *Bangladesh J. of Agril. Res.* **23**(1):10-15.

Hoque, Z. (1978). A Proposal for the Extension of the Bangladesh Rice Research Cropping System Project, Project Proposal Submitted to the International Development Research Centre, BRRI, Joydebpur.

Hossain, M.M. (2003). Farmers' Knowledge and Adoption of Boro Rice Cultivation Practices. M.S. (Ag. Ext. Ed.) Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh

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). American Phyto pathological Society, St Paul, Minnesota, USA. Second Edition., pp:133-147.

Hussen, M.A.M. (2001). Farmers' Knowledge and Adoption of Modem Sugarcane Cultivation Practices. M.S. (Ag. Ext. Ed.) Thesis, Department of Agricultural Extension Education Bangladesh Agricultural University, Mymensingh.

IIED (1994). Special Issue on Livestock. PLA Notes CD-ROM. RRA Notes 20, 11-36.

Islam, M.A. (1983). Report on Potato Production in Bangladesh. International Potato Course: Production, Storage and Seed Technology. Report of Participants. International Agricultural Center, Wageningen, The Netherlands.

Islam, M.A. (2005). Farmers' Knowledge and Practices in Using IPM Crop Production. M.S. (Ag. Ext. Ed.) Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Janvier, C., Villeneuve, F., Alabouvette, C., Edel-Hermann, V., Mateille, T. and Steinberg, C. (2007). Soil health through soil disease suppression: which strategy from descriptors to indicators? *Soil Biol. Biochem.* **39**:1–23.

Janvier, C., Villeneuve, F., Alabouvette, C., Edel-Hermann, V., Mateille, T., Steinberg, C. (2007). Soil health through soil disease suppression: which strategy from descriptors to indicators? *Soil Biol. Biochem.* **39**:1-23.

Johnston, H.W., Celetti, M.J., Kimpinski, J., Platt, H.W. (1994) Fungal pathogens and Pratylenchus penetransassocited with preceding crops of clovers, winter-wheat, and annual ryegrass and their influence on succeeding potato crops on Prince Edward Island. *American Potato J.* **71**:797-808.

Kabeer, N. (2003). Gender Mainstreaming in Poverty Eradication and the Millennium Development Goals. A handbook for Policymakers and Other Stakeholders. Commonwealth Secretariat, London.

Kaur, M.R. (1988). An Evaluation Study of Women Development Programme Under Indo- German Dhauhadhar Project Palampur District Kumgra, H.P. Thesis Abstract. Harayana Agricultural University, Hissar, India. *Thesis Abstract.* **16**(4): 258.

Khan, M.R. (2002). Value Added Agro-processing Opportunities in Bangladesh, Paper presented at the Asia Regional Conference held in Dhaka in 2-4 October, 2002.

Khomyakov, M.T. and Kostin, N.P. (1981). The effects of potato saturation in rotations and of dosage rates of fertilizers on the development of diseases of tubers in storage. *Trudy Vsesoyuznogo NauchnoIssledovatel'skogo Instituta Zashchity Rastenii,* 66-70.

Klikocka, H. (2001). The influence of soil tillage systems and crop cultivation methods on potato tubers infection with Rhizoctonia solani Kuhn. Biuletyn Instytutu Hodowli i Aklimatyzacji Roslin, 243-247.

Lakra, B.S. (2000). Effect of planting time and curing period on black scurf development and yield of potato. *Haryana J. Horticultural Sci.* **29**:121-122.

Latour, X., Faure, D., Diallo, S., Cirou, A., Smadja ,B., Dessaux, Y. and Orange, N. (2008). Control of bacterial diseases of potato caused by

Pectobacterium spp. (*Erwinia carotovora*). *Cahiers Agricultures* **17**:355-360. doi:10.1684/agr.2008.0210.

Latour, X., Faure, D., Diallo, S., Cirou. A., Smadja, B., Dessaux, Y. and Orange, N. (2008) Control of bacterial diseases of potato caused by *Pectobacterium spp.* (*Erwinia carotovora*). Cahiers Agril. **17**:355-360. doi:10.1684/agr.2008.0210

Lazarovits, G., Tenuta, M. and Conn, K.L. (2001). Organic amendments as a disease control strategy for soilborne diseases of high-value agricultural crops. *Australis Plant Pathol.* **30**:111-117.

Lennard, J.H. (1980). Factors affecting the development of silver scurf (*Helminthosporium solani*) on potato-tubers. *Plant Pathol.* **29**:87-92.

Liebscher, P. (1998). Quantity with Quality? Teaching Quantitative and Qualitative Methods in an LIS Master's Program. Library Trends, **46**(4): 668-680.

Mahmoud, S.M. (2007). Management of brown rot disease of potato. *Arab Universities J. Agric. Sci.* **15**:457-463

Malakouti, M.J. (2008). The effect of micronutrients in ensuring efficient use of macronutrients. *Turkish J. Agric. For.* **32**:215-220.

Marcinkowska, J., Roze-Kauzny, I., Kauzny, W. (2005) Pathogenicity of somenm *Phoma exigua* var. nexiguaisolates. *Phytopathol. Pol.* 38; 35-44 Marshall, K.C. (1975) Clay mineralogy in relation to survival of soil bacteria. *Annu. Rev. Phytopathol.* **13**:357-373.

McDonald, J.G. (1995). Disease control through crop certification: herbaceous crops. *Canadian J. Plant. Pathol.* **17**:267–273.

Meredith, D.S., Logan, C., Copeland, R.B., Meijers, C.P., Henriksen, J.B. and McIntosh, A.H. (1975). Session 8C. Control of fungal diseases of potatoes. Proceedings of the Eighth British Insecticide and Fungicide Conference, Brighton, England, 17–20 November, 1975. Vols. 1 and 2, Research Reports, pp:581-623.

Merz, U. and Falloon, R.E. (2009). Review: powdery scab of potato-increased knowledge of pathogen biology and disease epidemiology for effective disease management. *Potato Res.* **52**:17-37. doi:10.1007/s11540-008-9105-2.

Messiha, N.A.S., Bruggen, A.H.Cv., Diepeningen, A.Dv., Vos, O.Jd., Termorshuizen, A.J., Tjou-Tam-Sin, N.N.A. and Janse, J.D. (2007).

Potato brown rot incidence and severity under different management and amendment regimes in different soil types. *European J. Plant Pathol.* **119**:367-381. doi:10.1007/s10658-007-9167-z

Meyerdirk, D.E. and Hessein., N.A. (1985). Population dynamics of the beet leafhopper, Circulifer tenellus (Baker), and associated *Empoasca spp.* (Homoptera: Cicadellidae) and their egg parasitoids on sugar beets in southern California. *J. Econ. Entomol.* **78**: 346-353.

Miles, J. and Shevlin, M. (2001). Applying Regression and Correlation: A Guide for Students and Researchers. London: Saga Publications.

Milic, V., Bogdanovic, M., Uric, M., Kovacevic, D. and Crnogorac, M. (2006). Influence of mineral nutrition and additional space upon yield of potato. *Agroznanje Agroknowledge J.* **7**:67–74.

Milosevic, D. and Alovic, I. (2006). Some most important potato diseases and their control. Radovi Poljoprivrednog Fakulteta Univerziteta u Sarajevu (Works of the Faculty of Agriculture University of Sarajevo) **51**:103-120.

Mingers, J. (2001). Combining IS Research Methods: Towards a Pluralist Methodology. *Information System Research* **12**(3): 240-259.

Moazzem, K.G. and Fujita, K. (2004). Potato marketing system and its changes in Bangladesh: From the perspective of village study in Comilla district. *The Developing Econ.* **42** (1): 63-94.

MoYS (2012). The Population Category in Bangladesh. Ministry of Youth and Sports, Government of the People's Republic of Bangladesh. Retrieved from: http://www.moysports.gov.bd/

Munyaneza, J.E. (2003). Leafhopper identification and biology. In Pacific Northwest Vegetable Association Proceedings. pp: 89-91.

Munyaneza, J.E., and Crosslin., J.M. (2006). The beet leafhopper (Hemiptera: Cicadellidae) transmits the Columbia basin potato purple top phytoplasma to potatoes, beets, and weeds. *J. Econ. Entomol.* **99**(2):268-272.

Narayan, D. (1996). Toward Participatory Research. World Bank Technical Paper No. 307, Washington DC: World Bank.

Nunes, J.C.S., Fontes, P.C.R., Araujo, E.F. and Sediyama, C. (2006). Potato plant growth and macronutrient uptake as affected by soil tillage and irrigation systems. *Pesqui Agropecuaria Bras* **41**:1787-1792.

Ocamb, C.M., Hamm, P.B., Johnson, D.A. (2007). Benzimidazole resistance of Fusarium species recovered from potatoes with dry rot from storages located in the Columbia basin of Oregon and Washington. *American J. Potato. Res.* **84**:169-177.

OIA (1989). Office of International Affairs. Lost Crops of the Incas: Little Known Plants of the Andes with Promise for Worldwide Cultivation.nap.edu. p:92.

Omer, M.A., Johnson, D.A., Douhan, L.I., Hamm, P.B. and Rowe, R.C. (2008). Detection, quantification, and vegetative compatibility of *Verticillium dahliae* in potato and mint production soils in the Columbia Basin of Oregon and Washington. *Plant Dis.* **92**:1127-1131. doi:10.1094/pdis-92-7-1127.

Panique, E., Kelling, K.A., Schulte, E.E., Hero, D.E., Stevenson, W.R. and James, R.V. (1997). Potassium rate and source effects on potato yield, quality, and disease interaction. *American Potato J.* **74**:379-398.

Peters, J.C., Lees, A.K., Cullen, D.W., Sullivan, L., Stroud, G.P. and Cunnington, A.C. (2008a). Characterization ofFusariumspp. responsible for causing dry rot of potato in Great Britain. *Plant Pathol.* **57**:262-271.

Peters, R.D., MacLeod, C., Seifert, K.A., Martin, R.A., Hale, L.R., Grau, C.R., MacInnis, S. (2008b). Pathogenicity to potato tubers of *Fusarium spp.* isolated from potato, cereal and forage crops. *American J. Potato Res*. **85**:367–374. doi:10.1007/s12230-008-9037-z.

Peters, R.D., Sturz, A.V., Carter, M.R. and Sanderson, J.B. (2003). Developing disease-suppressive soils through crop rotation and tillage management practices. *Soil Tillage Res.* **72**:181-192

Peters, R.D., Sturz, A.V., Carter, M.R. and Sanderson, J.B. (2004). Influence of crop rotation and conservation tillage practices on the severity of soil-borne potato diseases in temperate humid agriculture. *Canadian J. Soil Sci.* **84**:397-402.

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

POP (2009). Potatoes to Plastics. University of Maine.

Rahman, M.S. (2004). Extent and Level of Knowledge of Farmers on HYV Boro Rice Cultivation Practices. M.S. (Ag. Ext. Ed) Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Rashid, S.M.M. (2014). Empowering Farmers through e-Agriculture. MS (Ag. Ext.) Thesis, Department of Agricultural Extension and Information System. Sher-e-Bangla Agricultural University, Dhaka.

Raviv, M. (2008). The use of compost in growing media as suppressive agent against soil-borne diseases. Proceedings of the International Symposium on Growing Media, 39-49.

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

Rousselle, P., Robert, Y. and Crosnier, J-C. (eds.) (1996). La pomme de terre: Production, amélioration, ennemis et maladies, utilisations, Paris.

Roy, K.K. (2006). Farmers' Knowledge on Boro Rice cultivation in some Selected Areas of Dinaajpur District. M.S. (Ag. Ext. Ed.) Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Roy, R. (2015). Modelling and Policy Integration of Sustainable Rice Farming Systems in Bangladesh. PhD Thesis, University Sains Malaysia. p. 269.

Ryan, N.A., Deliopoulos, T., Jones, P. and Haydock, P.P.J. (2003). Effects of a mixed-isolate mycorrhizal inoculum on the potato–potato cyst nematode interaction. *Ann. Appl. Biol.* **143**:111–119.

Saha, B. (2003). A Comparative Analysis of Farmers' Communication Exposure and Knowledge in Rice and Poultry Farming. M.S. (Ag. Ext. Ed.) Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Sahajdak A, Uznanska B (2003) Potato health requirements arising from EU regulations and the Treaty of Accession. *Ochrona Roslin* **47**:20-23.

Salas, B., Stack, R.W., Secor, G.A. and Gudmestad, N.C. (2000). The effect of wounding, temperature, and inoculum on the development of pink rot of potatoes caused by *Phytophthora erythroseptica*. *Plant Dis.* **84**:1327-1333.

Samaliev, H. and Andreev, R. (1998). Relationship between initial population density of potato cyst nematode *Globodera pallida* Thorne and the yield of partially resistant potato varieties. *Bulgarian J. Agric. Sci.* **4**:421-427.

Samaliev, H., Grigorov, P. and Samalieva, A. (1998). Influence of population density of *Globodera rostochiensis* (Nematoda: Heteroderidae) on potato yield. *Rasteniev"dni Nauki*, **35**:235-238.

Sankaranarayanan, C. and Sundarababu, R. (2001). Influence of moisture and pH on the efficiency of VA-mycorrhiza, Glomus mosseae (Nicol and Gerd.) Gerd. and Trappe against Meloidogyne incognita (Kofoid and White) Chitw. on blackgram (*Vigna mungo* L.) Hepper. *J. Biol. Control* **15**:69–72.

Savary, S., Teng, P.S., Willocquet, L., Nutter, F.W. (2006). Quantification and modeling of crop losses: a review of purposes. *Annu. Rev. Phytopathol.* **44**:89-112. doi:10.1146/annurev. phyto.44.070505.143342.

Scheid, L. (2006.) What to do against storage diseases? Kartoffelbau, 362-365.

Scholte, K. (2000). Effect of potato used as a trap crop on potato cyst nematodes and other soil pathogens and on the growth of a subsequent main potato crop. *Ann. Appl. Biol.* **136**:229-238.

Secor, G.A., Debuhr, L. and Gudmestad, N.C. (1988). Susceptibility of Corynebacterium sepedonicumto disinfectants in vitro. *Plant Dis.* **72**:585-588

Sikka, L.C. and Singh, A.K. (1976). Factors influencing quality of ware potatoes. *J. Indian Potato Assoc.* **3**:24-28.

Solunke BS, Kareppa BM, Gangawane LV (2001) Survival ability of carbendazim resistant Sclerotium rolfsii in mixed population. *Indian Phytopathol.* **54**:486-487

Spooner, D.M., Karen, M., Gavin, R., Robbie, W., Bryan, G.J. (2005). A single domestication for potato based on multilocus amplified fragment length polymorphism genotyping. *PNAS*, **102** (41): 14694-99.

Srivastava, V. C. (2008). History of Agriculture in India, Up to C. 1200 A.D. Concept Publishing Company. p:150.

Steinberg, C., Edel-Hermann, V., Alabouvette, C. and Lemanceau, P. (2007). Soil suppressiveness to plant diseases. In: van Elsas, J.D., Jansson, J., Trevors, J.T. (eds.) Modern soil microbiology. CRC, New York, pp:455-478.

Stevenson, W.R., Loria, R., Franc, G.D. and Weingartner, D.P. (2001). Compendium of potato diseases. The American Phytopathological Society, St. Paul, MN, USA.

Tamaki, G., Fox, L. and Chauvin, R.L. (1980). Green peach aphid: orchard weeds are host to fundatrix. *Environ. Entomol.* **9**(1):62-65.

Tashakkori, A. and Teddlie, C. (2003). The past and Future of Mixed Methods Research: From Data Triangulation to Mixed Model Designs. In: Tashakkori, A.; Teddlie, C. (eds.): Handbook of Mixed Methods in Social and Behavioural research. Thousand Ocks, London, New Delhi: Sage, 671-701.

Taylor, R.J. (2005). Influence of tillage and method of metam sodium application on distribution and survival of *Verticillium dahliae* in the soil and the development of Verticillium wilt of potato. *American J. Potato Res.* **82**:451-461.

Termorshuizen, A.J., van-Rijn, E., Van-der-Gaag, D.J., Alabouvette, C., Chen, Y., Lagerlof, J., Malandrakis, A.A., Paplomatas, E.J., Ramert, B., Ryckeboer, J., Steinberg C. and Zmora-Nahum, S. (2006). Suppressiveness of 18 composts against 7 pathosystems: variability in pathogen response. *Soil Biol. Biochem.* **38**:2461-2477.

Thompson, H.C. and Kelly, W.C. (1957). Vegetable Crops, Tata McGrow Hill Publishing Company Ltd., New Delhi 110020.

Townsend, J.C. (1953). Introduction to experimental methods. International Student Edition. New York: McGraw Hill Book Company, Inc.

Tsror, L., Erlich, O., Cahlon, Y., Hadar, A., Cohen, Y., Klein, L. and Peretz-Alon, I. (2000). Control of *Verticiilium dahliae* prior to potato production by soil fumigation with chloropicrin. Proceedings of the International Symposium on Chemical and Non-Chemical Soil and Substrate Disinfestation, 201-204.

Vanvuurde, J.W.L. and Devries, P.M. (1994). Population dynamics of *Erwinia carotovora* subsp. atrosepticaon the surface of intact and wounded seed potatoes during storage. *J. Appl. Bacterio.* **76**:568-575.

Vian, J. (2009). Comparaison de différentes techniques de travail du sol en agriculture biologique: effet de la structure et de la localisation des résidus sur les microorganismes du sol et leurs activités de minéralisation du carbone et de l'azote. Institut des Sciences et Industries du Vivant et de l'Environnement (Agro Paris Tech). Agro Paris Tech, Paris, p: 130.

Wallis, R.L. (1967). Some host plants of the green peach aphid and beet western yellow virus in the Pacific Northwest. *J. Econo. Entomol.* **60**(4): 904-907.

Werner, J. (1993). Participatory Development of Agricultural Innovations, Procedures and Methods of On-Farm Research. Schriftenreihe der GTZ Nr. 234. TZ- Verlagsgesellschaft, Roßdorf, Germany.

Williams, S.C.P. (2007). The Secret History of the Potato – Science NOW. Retrieved from: http://www.news.sciencemag.org.

Yamane, T. (1967). Statistics: An introductory analysis, 2nd Ed., New York: Harper and Row.

APPENDIX-I

ENGLISH VERSION OF THE INTERVIEW SCHEDULE

Department of Agricultural Extension and Information System

Sher-e-Bangla Agricultural University

Dhaka-1207

An Interview Schedule for the Study Entitled

Plant Protection Management Practices Used by the Farmers in Potato Cultivation

Name of the respondent: …… Serial No: ……

Union: …….

Village: …….…….….

(Please provide following information. Your information will be kept confidential and will be used for research purpose only)

1. Age

How old are you? _____ years.

2. Level of education

Please mention your level of education.

a) I can't read and write ☐

b) I can sign only ☐

c) I have passed…….class.

d) I took _____ years non-formal education.

3. Effective farm size

What is your total farm size according to use?

Sl. No.	Use of land	Land possession	
		Local unit	Hectare
1.	Homestead area (A_1)		
2.	Own land own cultivation (A_2)		
3.	Land taken from others on borga system (A_3)		
4.	Land given to others on borga system (A_4)		
5.	Land taken from others on lease (A_5)		
Total			

Total farm size = $A_1 + A_2 + 1/2 (A_3 + A_4) + A_5$

4. Land under potato cultivation

Please mention the amount of land in hectare that you use for potato cultivation:

Land size **…**…… ha

5. Annual family income

Please mention the amount of annual income from the following sources:

a) Income from agricultural crops

SL. No.	Crop Name	Production (Kg or Maund)	Cost/Kg or Maund	Total Cost
1.	Rice			
2.	Wheat			
3.	Maize			
4.	Jute			
5.	Potato			
6.	Pulse crop			
7.	Oil crop			
8.	Spice crop			
9.	Vegetables			
10.	Fruits			
Total				

b) Income from animals and fish resources

Sl. No.	Income resources	Production (Kg or Maund/Number)	Cost/Unit (Tk)	Total Cost(Tk)
1.	Livestock			
2.	Poultry			
3.	Fish resources			
Total				

c) Income from other resources

Sl. No.	Income resources	Total Income (Tk.)
1.	Service	
2.	Business	
3.	Day labor	
4.	Other family members	
5.	Others income source	
Total		

6. Annual income from potato production

Please mention your annual income from potato production:

Sl. No.	Source of income	Amount of income (Taka)
1.	From tuber	
2.	From residues, as (FYM)	
3.	From seed	
4.	Others (write down specific)	
	Total	

7. Potato cultivation experience

What is your present age of potato cultivation experience? ..... Years

8. Knowledge in potato cultivation

Please answer the following questions regarding potato cultivation:

Sl. No.	Questions	Assigned Mark	Obtain Mark
1.	Name two popular varieties of potato in your locality.	2	
2.	How to identify quality seed potato?	2	
3.	How to cut seed potato to sow in the field?	2	
4.	Mention the plant spacing for potato cultivation.	2	
5.	Mention fertilizers application method in potato cultivation.	2	
6.	What is earthing-up technique?	2	
7.	What is solanization of potato? How can you protect solanization?	2	
8.	Mention two harmful insects of potato plants.	2	
9.	Mention the name of pesticide and its dose for controlling cut worm.	2	
10.	Mention two viral diseases of potato with symptoms.	2	
11.	Which weather condition is vulnerable for the infestation of late blight of potato?	2	
12.	Mention the name of fungicide and its dose for controlling late blight of potato.	2	
13.	How many days it takes for the maturity of potato?	2	
14.	What are the grades of potato?	2	
15.	How do you store potato in ambient condition?	2	

9. Usages of mass media

Please mention about your usages of mass media:

Sl. No.	Mass media	Extent of usages of mass media				
		Regularly (4)	Frequently (3)	Sometimes (2)	Rarely (1)	Not at all (0)
1.	Radio					
2.	Television					
3.	Newspaper					
4.	Poster					
5.	Books, Magazines					
6.	Others (if any)					
Total						

10. Extension media contact

Please state the extent of your contact with the following ones:

Sl. No.	Name of information sources	Extent of contact				
		Regularly (4)	Frequently (3)	Sometimes (2)	Rarely (1)	Not at all(0)
1.	Ideal farmer/ 3 months	8 or more times	6-7 times	4-5 times	1-3 times	
2.	Fertilizer dealer/3 months	≥ 10 times	8-9 times	4-7 times	1-3 times	
3.	Insecticide dealer/3 months	≥ 10 times	8-9 times	4-7 times	1-3 times	
4.	Seed dealer/3 months	≥ 10 times	8-9 times	4-7 times	1-3 times	
5.	Agricultural magazine, poster, leaflets/3 months	≥ 10 times	8-9 times	4-7 times/ 3 months	1-3 times	
6.	Sub Assistant Agricultural Officer/3 months	≥ 10 times	8-9 times	4-7 times	1-3 times	
7.	Upazila level Agricultural Officers/3 months	≥ 10 times	8-9 times	4-7 times	1-3 times	
Total						

11. Training exposure

Please mention about your training exposure on livestock rearing:

Sl. No.	Name of the training course	Organization	Days
01.			
02.			
03.			
04.			
05.			

12. Organizational participation

Please mention the nature of your participation:

Sl. No.	Name of organizations	Not involved (0)	Nature of participation		
			Ordinary Member (1)	Executive Member (2)	President/ Secretary (3)
1.	Religious committee				
2.	School committee				
3.	Farmers' association				
4.	Bazar Committee				
5.	Co-operative society				
6.	NGO organized society				
7.	Youth club				
8.	Union council				
9.	Social welfare organization				
10.	Others (please specify…….)				

13. Plant Protection Management Practices

13.1 Cultural practices

Sl. No.	Name of practices	Extent of cultural practices				
		High (4)	Medium (3)	Low (2)	Very low (1)	Not at all (0)
01.	Use of resistant variety					
02.	Fertilization and manuring					
03.	Earthing-up					
04.	Crop sanitation					
05.	Crop rotation					
06.	Selection of disease free planting material					

13.2 Mechanical practices

Sl. No.	Name of practices	Extent of mechanical practices				
		High (4)	Medium (3)	Low (2)	Very low (1)	Not at all (0)
01.	Mulching					
02.	Perching					
03.	Irrigation					
04.	Hand picking of insect pests especially cutworm					

13.3 Chemical practices

Sl. No.	Name of chemicals	Extent of chemical practices				
		High (4)	Medium (3)	Low (2)	Very low (1)	Not at all (0)
01.	Use of insecticides					
02.	Use of fungicide					
03.	Tuber treatment					
04.	Soil treatment					

14. Problem faced by farmers in potato cultivation

Please express your opinion on the following problems:

Sl. No.	Nature of problem	Extent of problems				
		Very High (4)	High (3)	Medium (2)	Low (1)	Not at all (0)
1.	Lack of cold storage					
2.	Lack of credit in time					
3.	Insects and diseases infestation					
4.	Lack of improved propagating materials					
5.	Environmental hazards					
6.	Lack of marketing amenities					
7.	High price of inputs					
8.	Getting low service from extension workers					
9.	Transport problem in potato marketing					
10.	Lack of irrigation facilities in time					

Thanks for your kind co-operation.

Dated: (Signature of interviewer