ADOPTION DETERMINANTS OF INTEGRATED PEST MANAGEMENT PRACTICES ON TOMATO CULTIVATION IN NARSINGDI DISTRICT OF BANGLADESH

SANJIDA ISLAM

DEPARTMENT OF AGRICULTURAL ECONOMICS

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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BY

SANJIDA ISLAM

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APPROVED BY:

…….	**…….**
Dr. Rokeya Begum **Professor** **Dept. of Agricultural Economics** **Sher-e-Bangla Agricultural University** **Supervisor**	**Dr. Ripon Kumar Mondal** **Associate Professor** **Dept. of Agricultural Economics** **Sher-e-Bangla Agricultural University** **Co-Supervisor**

…….

Dr. Monoj Kumar Majumder
Chairman
Dept. of Agricultural Economics
Sher-e-Bangla Agricultural University

DEPARTMENT OF AGRICULTURAL ECONOMICS
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Website: www.sau.edu.bd

CERTIFICATE

This is to certify that the thesis entitled **"ADOPTION DETERMINANTS OF INTEGRATED PEST MANAGEMENT PRACTICES ON TOMATO CULTIVATION IN NARSINGDI DISTRICT OF BANGLADESH"** submitted to the Department of Agricultural Economics, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Agricultural Economics,** embodies the result of a piece of bona fide research work carried out by **SANJIDA ISLAM**, Registration Number: **15-06858** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

…...……..

Dr. Rokeya Begum
Supervisor
Professor
Dept. of Agricultural Economics
Sher-e-Bangla Agricultural University

Dedicated

To

My Beloved Parents

ADOPTION DETERMINANTS OF INTEGRATED PEST MANAGEMENT PRACTICES ON TOMATO CULTIVATION IN NARSINGDI DISTRICT OF BANGLADESH

ABSTRACT

Integrated Pest Management (IPM) practices are one of the most important technologies which are available in Bangladesh agriculture now-a-days. The present study was undertaken mainly to identify the determinants affecting the adoption of IPM practices by the tomato producers. For achieving the objectives, the study was conducted on 120 tomato farmers of Palash upazila (60) and Shibpur upazila (60) of Narsingdi district, of which 60 were considered as IPM users and 60 as IPM non-users. Descriptive statistics and binary logistic regression were used to achieve the objectives of the study. Majority of the tomato producers who produced tomato through IPM practices constituted middle aged farmers with middle family size and low farming experience and having small farm size, where most of the tomato producers who did not use IPM had medium farming experience with marginal farm holding and most of them were old aged with medium family size. The determinants that significantly affects adoption decision of IPM were age, education, societal membership, use of hired labor, livestock, training on IPM and distance to local market. Among these variables, training on IPM was the most influencing factor. Therefore, age and distance to local market have negative significance on adoption. Lack of credit, expensive inputs, unavailability of organic fertilizer, inexperienced trainers were some of the constraints faced by the tomato producers for both non-IPM and IPM practices. Government should give more emphasis on training and raising awareness on IPM to influence in using IPM.

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ABBREVIATIONS

AEO: Agricultural Extension Officer

BBS: Bangladesh Bureau of Statistics

BER: Bangladesh Economic Review

DAE: Department of Agricultural Extension

et al.: and others (at elli.)

FY: Fiscal Year

FAO: Food and Agricultural Organization

FFS: Farmer Field Schools

GDP: Gross Domestic Product

Ha.: Hectare

IPM: Integrated Pest Management

SAAO: Sub-assistant Agriculture Officer

USDA: United States Department of Agriculture

VIF: Variance Inflation Factor

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Bangladesh is an agrarian country and has been an agrarian economy. The country is overpopulated with the growth rate of 1.37% (BER, 2022) and it has a scarce land area of 147,570 square kilometers. The per capita income is $2723 with GDP growth rate of 7.25% (BER, 2022). About 20.5 percent people live under poverty line in terms of their per day calorie intake (BBS, 2019).

The GDP contribution from agricultural sectors are decreasing day by day. Agriculture contributes 11.50% of total gross domestic product (GDP) in FY 2021-22 which was 12.91% in previous year and 40.6% of total employment come from agricultural sector in fiscal year 2021-22 (BBS, 2021). In spite of the declining contribution of the agricultural sector in GDP, total value is rising in Bangladesh economy. As Bangladesh economy is agro-based, the maximum part of the agricultural production are from crop sector.

In Bangladesh, vegetables play a significant role in the economy and food security. Vegetables are cultivated in 4.22% of the total cultivable land in Bangladesh. 3.2% of the agricultural GDP comes from vegetables (BBS, 2021). To ensure the food security, food production needs to be increased. In spite of rice being staple food of Bangladesh, government have tried to give incentives to vegetables production. It is very significant steps to the diversification of food to ensure food security as well as revenue.

Vegetables are herbaceous plants. About 100 different types of vegetables are produced in Bangladesh consists of local and hybrid varieties. The climatic condition and soil are suitable for the production of vegetables year-round in Bangladesh. Vegetables are essential source of vitamins and minerals. Vegetables has a significant contribution in increasing the foreign currency and has a vital position among those items that are exported from the developing nation as Bangladesh. Vegetables are generally labor-intensive crops and can helps in employment generation.

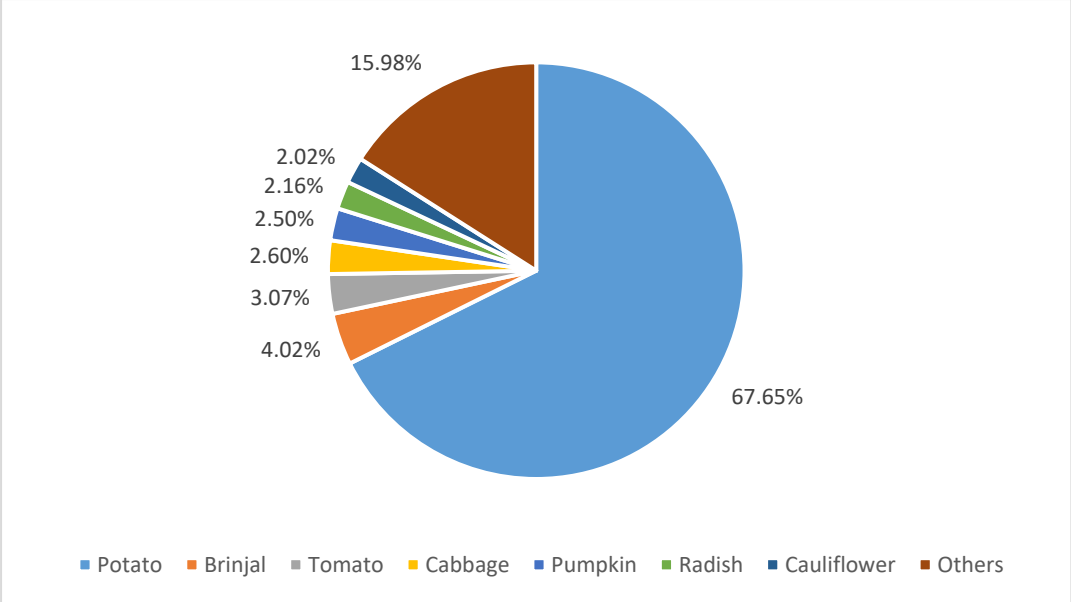

Figure: Area under Vegetables cultivation in Bangladesh

Source: BBS, 2021

Among the vegetables Tomato (*Solanum Lycopersicum*) is one of the most important vegetables in terms of area, production, yield, commercial use and consumption. It is the most produced vegetable crop after potato and brinjal which covers 3.07% of vegetable cultivable area (BBS, 2021). It is cultivated all over the country due to its adoptive capability to wide range of climatic conditions and soil.

1.2 Nutritional value of Tomato

According to Live Science journal, tomato is good for skin, heart and bone health. It contains cancer preventive properties and decreases the chance of stroke.

Tomatoes are rich in potassium, a mineral that helps in communication between nerves and muscles. It also helps in movement of nutrients into cells remove waste products from cells.

The vegetable is a very good source of several vitamins, minerals, anti-oxidant and phytonutrients, especially carotenoid lycopene.

Tomatoes are high in fiber and a good source of vitamin A, C, B_2 and chromium. There are also a variety of carotenoids including lycopene and beta-carotene that are thought to play a vital role in chronic disease prevention.

People who consume tomatoes on regular basis can be benefitted in different ways as the following:

- Tomatoes have inflammatory properties
- Boost immune system
- Contains anti-oxidants, which fight cancer
- Promote bone health and fight against osteoporosis

- Improve digestion
- Help in controlling blood pressure
- Promote skin and health care
- Help in controlling bad cholesterol

According to USDA (2020), 100g of raw tomatoes contains the following:

Table 1.1 Nutrients from per 100g tomato

Components	Amount
Water	94.52g
Energy	18kcal
Protein	0.88g
Lipid	0.2g
Carbohydrate	3.89g
Sugars	2.63g
Fiber	1.2g
K	237mg
Ca	10mg
Mg	11mg
P	24mg
Vitamin-C	13.7mg

Source: USDA, 2020

1.3 Importance of tomato in the economy of Bangladesh

Tomatoes are high value crop. It requires severe cultural practices. Labor inputs and financial inputs included in it are higher than those for more staple food. Tomato has a great implication in nationalized economy.

The small landholder farmers are poverty stricken and normally practice subsistence agriculture. They do not have much financial assets and lands to grow major grains like rice, wheat, pulses etc. because of long development periods of crops. There is an urgency of income to ensure food security and poverty alleviation. Tomato has a favorable effect on economy of small farmers who are the main bone of agriculture of Bangladesh. Tomato production has an advantage to the small farmers as vegetables cultivation is labor intensive and there is abundance of labor on small landholders. Short duration crop like tomatoes provide regular income flow as tomatoes are labor intensive and can grow on small amount of land.

Farming of tomato are being popular day by day everywhere and the production of tomato are increasing.

The last eight years tomato production in Bangladesh are presented in the figure.

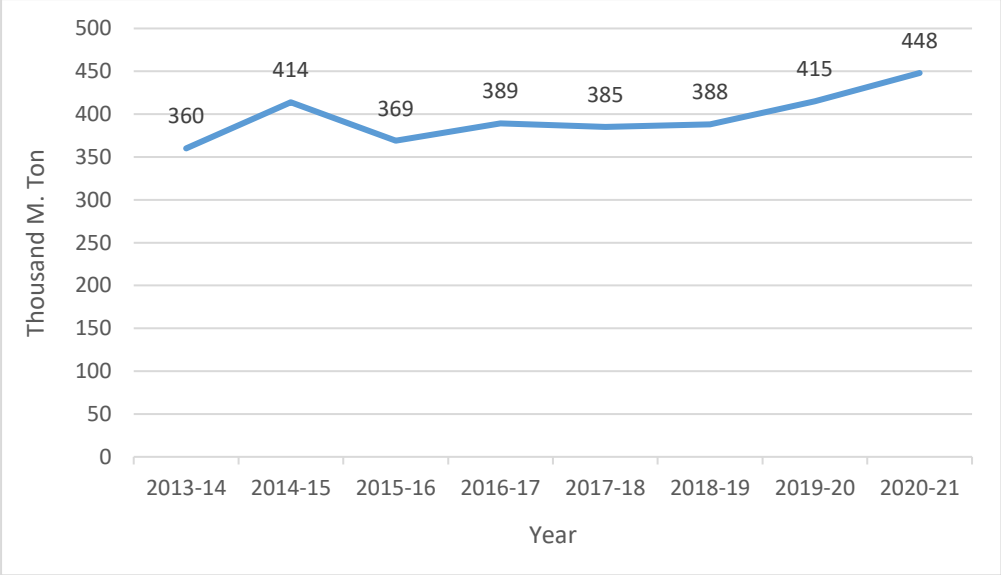

Figure 1.2: Tomato production in Bangladesh

Source: BBS, 2021

As production of tomatoes have created income sources for the educated and uneducated unemployed youths, these youths are engaging in tomato cultivation. To improve the socio-economic status of the farmers who are poor, cost-effective and environment friendly technologies should be ensured on tomato cultivation.

1.4 Pest Management Challenges and Use of Pesticides

Pest infestation is a big problem for vegetable production. A significant amount of production is lost every year due to pest infestation. Crop production is lost by 32.1% on average globally due to pest infestation (Dhawan, 2010). About 90% of pest infestation occurs during vegetable production. Pesticides are a noticeable innovation for agriculture now-a-days to decrease crop losses caused by pest infestation.

Chemical control means use of pesticide is not effective in social, economic and environmental aspect. Through contaminating soil, surface water and ground water, pesticides use contaminates the environment (Kabir & Rainis, 2012). Pesticides can easily dissolve with water and pollutes surface and ground water through infiltration and percolation. Pesticides can mix with rain water and thus damage natural resources. In developing countries, the way of applying pesticides cause several diseases (Cuyno, 1999). It creates health hazards to consumers also. It creates resistance to pest and destroys the insects that are beneficial to crop production. To avoid all these problems, an alternative way is necessary for pest management which will be environment friendly way.

Organic agriculture is an alternative solution as it has no bad impact on health and environment. But less productivity is a significant limitation of organic agriculture. To ensure food security to all, there should be no compromise with production.

The best alternative pest management strategy is Integrated Pest Management (IPM). IPM is a system where the effort to control pest emphasizes given on non-chemical or organic way and chemicals are only applied when there are no alternatives. IPM will ensure productivity as well as environmental safety.

1.5 Integrated Pest Management

Including the crop storage at every stage of production and the basis of sound ecological balance, IPM plays a great role on crop production. IPM ensures environmental issues by not using chemical pesticides or using pesticides only where it has no alternatives. It also helps in preserving soil, water from harmful chemicals as well as improving not only farmers health but also community health. As by using IPM practices productivity is not affected, it makes rising farm productivity and income on a sustainable way without affecting environment.

IPM is a considerable integration of appropriate measures of all available pest control practices by minimizing pest population. IPM practices emphasizes on growing healthy crops through appropriate soil, water and pest management, by biological control with beneficial insects, bacteria, nematodes etc., physical control using barriers, wind etc., chemical control, behavioral control by manipulating the behavior of pest using pheromone traps, cultural control with biosecurity and sanitation etc.

According to FAO, "A pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury"(FAO, 2017). In the context of a developing country like Bangladesh, the term IPM contains elements that contribute to a sound crop protection strategy that are economically and environmentally effective, safe, sustainable.

In Bangladesh, IPM activities first introduced in 1981 in rice crop for the introduction of a program related to IPM named FAO’s inter-country program (ICP). Those IPM program which was introduced in rice field began to expand and became very familiar to the farmers and all types of people. For making expert trainers and strong training capacity of the Department of Agricultural Extension (DAE), FAO’s ICP program provided training on IPM and to train the farmers, they introduced Farmers Field School (FFS).

With all these projects and activities, a large numbers of core trainers on IPM have been established who have further been used to train farmers level for applying in field. They have established IPM field school for testing and usage of bio-pesticides, bio-control agents etc. Government have given a strong support on these activities for making IPM familiar and popular to farmers and Bangladesh has now established an effective IPM policy.

However, there is a strong and effective IPM policy in Bangladesh, for ensuring a positive significant effect of IPM at a broader sense, proper support and more training facilities should be given for a sustainable IPM program in Bangladesh.

1.6 Justification of the Study

Tomato farming is pesticide intensive and exposure of pesticide is becoming a problem. In many countries, public objections are growing to the use of chemical pesticides because pesticides have negative impact on human health and natural environment. In Bangladesh, the pesticides use on vegetables especially on tomato cultivation in have increased drastically in past few years. Pesticide use is high on tomato. The agricultural labors, small and marginal farmers and women are most exposed to the chemicals owing to occupational factors, neglect the health hazards of pesticide exposure due to either lack of awareness or financial reasons.

The Government of Bangladesh has begun to give importance on Integrated Pest Management (IPM) technologies in the country. Income generation and additional income would be possible from potential adoption of IPM technologies. By reducing import of pesticides, foreign exchanged can be saved. But very little is known about the adoption determinants of IPM technologies for tomato cultivation.

This study will give core information on socio-demographic characteristics and socio-economic status of IPM and non-IPM tomato producers, factors affecting adoption of IPM of tomato producers and problems associated with IPM tomato production. Some economic investigations have conducted on IPM by government and private institutions to give feedback to the researchers, policy makers, extension workers and officials and farmers which were not enough to implement any policy or decision making.

This study will help in finding problems associated with IPM adoption in tomato production which will help farmers in decision making. The findings of the study will create basic economic information on IPM adoption factors on tomato.

1.7 Objectives of the study

a. To explore the socio-economic status of the tomato producers using IPM and non-IPM practices.

b. To identify the determinants affecting the adoption of IPM practices by the tomato producers.

c. To identify the problems faced by the farmers and suggest some policy recommendation.

1.8 Research Questions

The following research questions were set to address the research objectives:

a. What is the livelihood condition of the tomato producers?
b. What are the determinants that influence farmers' decision to adopt IPM?
c. What type of factors influence more in IPM adoption?
d. What are the barriers to adopt IPM?

1.9 Organization of the thesis

This thesis contains a total of seven chapters which have been organized in the following sequence. Chapter 1 comprises introduction. The review of literature is introduced in Chapter 2. Methodology of the relevant study is included in Chapter 3. Chapter 4 contains the socio-economic profile of the IPM and non-IPM tomato producers. Chapter 5 deals with the adoption determinants of IPM tomato production. Chapter 6 represents problems of tomato cultivation. At last, Chapter 7 represents the summary, conclusion and recommendations of the study.

CHAPTER 2

REVIEW OF LITERATURE

The main objective of this chapter is to review some studies related with the present study. To find out the gap in literature, a study of previous literature is very important. Literature review will provide guideline for future research work and validation of new finding. A number of studies have been found relevant to cultivation of tomato and IPM adoption. But only a few studies have close relevancy to the present study. In this chapter, the review of the past research works which are relevant to the objectives of the present study are presented chronologically. This review was predominantly related with the findings of adoption determinants of IPM tomato producers in Bangladesh.

Mohiuddin et al. (2007) conducted a study about adoption as well as profitability of improved varieties of tomato in Chittagong region of Bangladesh. They use tabular method and Cobb-Douglas frontier model to satisfy the objectives. This study showed that per hectare yield was increased in case of improved varieties. Increasing adoption of improved varieties lies behind some major reasons like high yield, long durability, thickness of fruits skin, larger size, and high price for their attractive color and size. The adopters faced some constraints as lack of quality seeds, lack of good fertilizers and pesticides, high prices of inputs and unfavorable weather.

Karim et al. (2009) studied profitability of summer BARI Hybrid tomato cultivation in Jessore district in Bangladesh. BCR was found 4.19 at full cost basis and yield was 32.7 ton/ha. Fertilizers like MP, TSP had positive significance while labor, hormone, seed, irrigation had negative significance to yield. The study had found increased socio-economic status of the sampled farmers.

Tijani et al. (2010) studies the profitability of tomato production and constraints in Ogun state of Nigeria. They used descriptive statistics with enterprise budgetary analysis to conduct the research. The results showed that tomato production was profitable for those study area.

Khatun et al. (2012) conducted a study on post-harvest loss assessment of tomato in Bangladesh. The study found that farmers were forced to sell their crops at a cheap rate in the harvesting season as there was no facility for proper storage and marketing facilities was absent. Major constraints of the tomato producers were absence of proper storage facility, low price of tomato and unfavorable transportation system.

Adenuga et al. (2013) studied to examine the economical annalysis of dry season tomato production in Kwara state, Nigeria. They used two-staged random sampling technique to select the sampled respondents. It estimated the cost and return and technical efficiency of dry season tomato. The Gross margin was found 120.74 US dollar per hectare.

Saleh et al. (2014) studied about yield performance of local and exotic hybrid tomato varieties in Bangladesh where 13 different hybrid and local varieties are evaluated to see their performance. The results showed that local varieties of tomato had greater yield performance compared to hybrid varieties. The maximum and minimum yield performance were obtained from BARI F1 Tomato-4 and Delta variety respectively.

Kabir et al. (2014) analyzed the level of IPM adoption and the intensity of IPM practices by vegetables farmers of Narsingdi district in Bangladesh. They used logistic regression model and linear regression model to fulfill the objectives. The study found that 30% farmers were IPM adopters. The IPM adoption were influenced by various factors including training facilities, land ownership status, perception toward IPM frequency of extension contact and use of improved varieties. The majority of adopters used two to three practices of IPM.

Ghimire et al. (2014) conducted research on Integrated Pest Management Practices and adoption determinants among Apple farmers in Mustang district of Nepal. They used probit regression model to find the adoption determinants which revealed that training and membership in farmers groups had positive significant effect on IPM adoption. The level of IPM adoption would increase by 45.8% and 3.3% if farmers are provided training and membership on farmers group respectively. They stated that more extension programs should be given emphasis for higher adoption of IPM practices.

Shamsunnahar et al. (2016) carried out a field survey to analyze the profitability, contribution of factors in yield and socio-economic condition of small-scale tomato producers in Bangladesh. From the three farm size groups, small landholder tomato farmers earned the maximum profit where gross return were Tk. 104180, 95000 and 82600 per acre for the small, medium and large farms respectively. The inputs like human labor and tillage had significant positive impact on tomato production.

Hasan & Bai (2016) have examined the profitability of tomato production in three districts of Bangladesh. The study published that cultivation of tomato was profitable in the study area where benefit cost ratio (BCR) was 1.5 on average for the three districts. To find out the problems which were faced by the tomato farmers, the author used problem confrontation index (PCI). PCI indicated low prices of tomato as the first ranked problem ad lack of capital as second in the study areas.

Akter et al. (2016) analyzed comparative profitability analysis of IPM and non-IPM technology on vegetables cultivation in Kishoregonj district of Bangladesh. The study stated that IPM farmers were in better-off conditions than non-IPM farmers. Tomato cultivation was more profitable for IPM based cultivation than non-IPM based cultivation.

Haque et al. (2016) conducted research on determinants of rice farmers' adoption of Integrated Pest Management practices in Bangladesh. The study revealed that majority of the rice farmers (82.3%) were medium users of IPM practices on rice field. There were four factors which had significant influence on adoption of IPM. The factors are training exposure, experiences of IPM practices, extension media contact and knowledge on IPM.

Hajong et al. (2018) assessed a study on adoption and profitability of summer tomato cultivation in Jeshore district in Bangladesh. The study assessed the level of adoption at farm level. It has found in the study that farmers adopted three summer tomato varieties i.e., BARI Hybrid Tomato-4, BARI Hybrid Tomato-8 and ACI Summer King. There was higher level of adoption of most to the crop management technologies. The gross return, Net return and BCR were Tk. 1542300 per hectare, Tk. 957478 per hectare and 2.64, respectively which were high as well.

Akter et al. (2018) conducted a study on financial analysis of IPM and non-IPM technology used on brinjal production in some areas of Bangladesh. The study found that cost of brinjal production through IPM is lower than non-users. Cost of production are Tk. 193105 per hectare for IPM users and Tk. 221625 per hectare for non-IPM users. IPM users gained more income compared to non-users. The results indicated that IPM users had cost advantage and non-users had yield advantage which made IPM users to gain more profit through low-cost advantage. Experience, family size and distance to market had a significant impact on IPM adoption.

Khatun (2019) conducted a study on profitability and resource use efficiency of tomato production in Narsingdi district in Bangladesh. The study showed that tomato production was profitable in Narsingdi district. The gross return was Tk. 933160 per hectare and the net return was Tk. 545637 per hectare. The BCR for tomato production was found to be 2.4. Irrigation cost, fertilizer cost, human labor cost and manure cost had positive significance on tomato yield. Efficiency analysis revealed that most of the farmers were inefficient in using their inputs. Most of the farmers had reported labor shortage in time of harvest. Some other problems like pricing, difficulty on supply of credit, transportation problem also faced by the tomato producers in the study area.

Rahman & Norton (2019) assessed a study on adoption and impacts of IPM on smallholder bitter gourd growers in Bangladesh. They used binary and multinomial probit regression for adoption analysis and stochastic frontier model to estimate productivity and efficiency impact of IPM. The results showed that IPM training and the decisions of adoption of other farmers had positive influence on adoption of small farmers. There is a scope for improving technical efficiency by additional training sessions and field demonstrations. Moreover, IPM adopters received marginally higher yield than non-adopters.

Fuad et al. (2019) conducted a study on impacts of IPM practices on tomato cultivation in Gazipur district in Bangladesh. The result revealed that 14.6% land were used in tomato production and farmers generally used eight IPM practices on their field. 65% farmers were in medium to high adoption category. The average pest infestation was lower in IPM users than non-IPM users. The yield in IPM adoption field was 51.34 ton per hectare which is higher than non-adopters' field (42.24 ton/ha). The gross return was also high in the field of IPM adopters. The BCR was 2.41 for IPM adopters which is higher than non-adopters (1.44).

The discussion mentioned above and the reviews indicate that a major part of the studies dealt with the profitability of tomato cultivation and socio-economic status of the farmers. Some studies show the present scenario of IPM adoption and intensity of IPM adoption and others examines the adoption determinants of IPM on vegetables or others crops. But few of the studies dealt with the adoption determinants of IPM of tomato producers. Some studies used Probit model to identify determinants. But very few studies used binary logistic model to identify the determinants of adoption of IPM. The result of the present study would overcome the limitations of past studies and would help researchers for further investigations.

CHAPTER 3

METHODOLOGY

Methodology is an principal part of any study. Methodology is very important to find out the proper results of any study. Inappropriate methodology can lead to a misleading result. So, care should be taken on selection of study area, selecting samples and sample size, analytical technique etc. for carrying out a proper study and fulfilling the objectives. The study in mainly based on primary data and followed farm survey data.

3.1 Selection of Study Area

Selection of study area is very important in the study. It indicates the area where agricultural survey will be conducted. Keeping the objectives in mind, the present study was conducted in Narsingdi where vegetables specially tomato are cultivated at a greater extent. Two upazilas named Palash and Shibpur of Narsingdi district were selected purposively for the study.

The main reasons behind the selection of the area

- This type of study was not undertaken previously in those areas
- Availability of tomato cultivating farmers in the study areas
- Those upazilas were selected purposively because of availability of tomato production under IPM technologies
- Those areas have easy accessibility and good communication facilities
- High cooperation of the respondents and opportunity of gaining reliable information.

The map of upazilas of Narsingdi district has shown in figure 3.1.

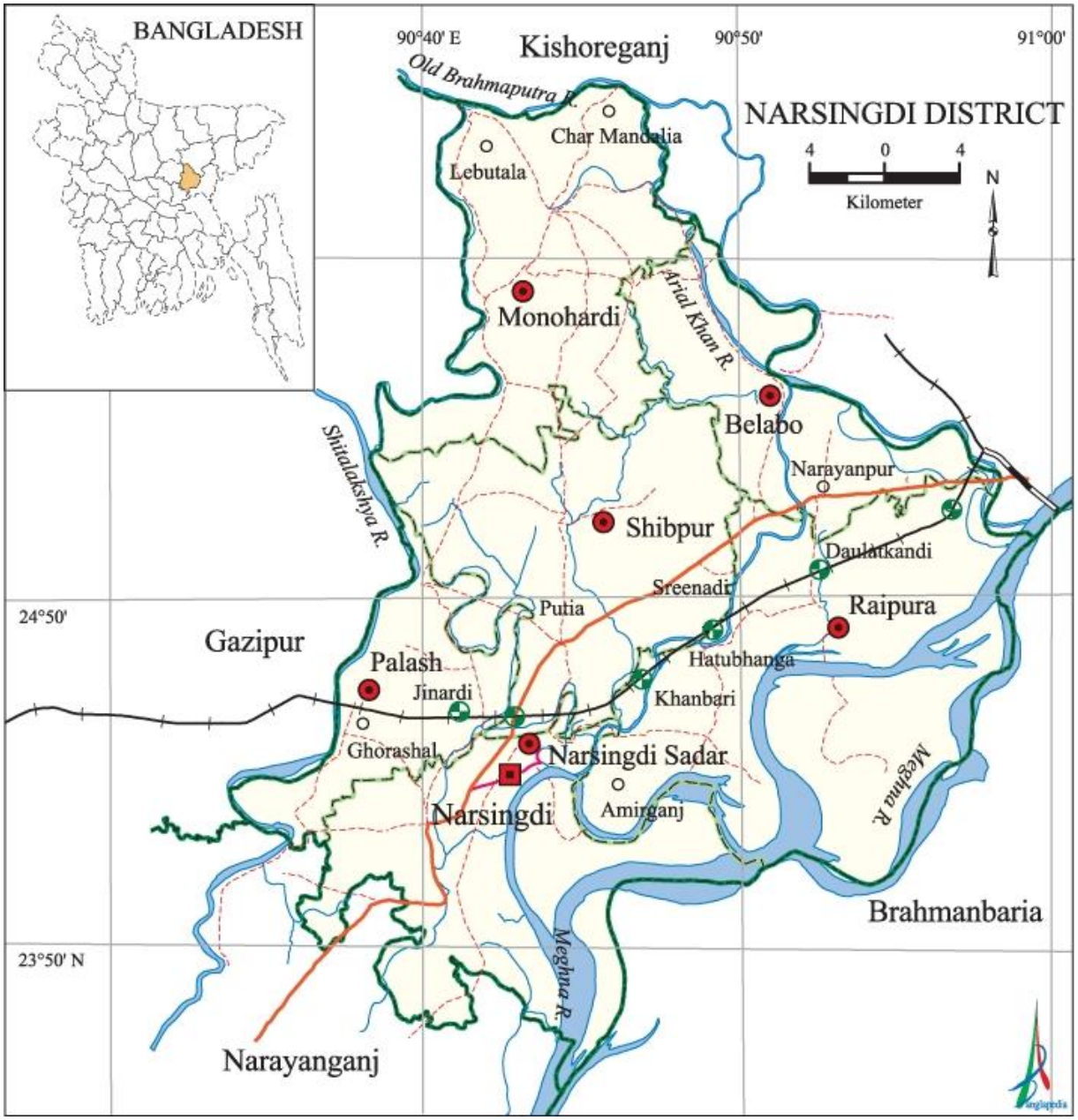

Figure 3.1: Map of Narsingdi district

Source: Banglapedia

3.2 Description of Study Areas

3.2.1 Palash Upazila

The area of Palash upazila is 94.43 square km and located in between 23°53' and 24°03' north longitude and in between 90°34' and 90°43' east longitudes. It is surrounded by Shibpur and Kapasia upazila in the North, Rupgonj and Narsingdi sadar upazila in the south, Shibpur and Narsingdi sadar upazila in the east and Kapasia nad Rupgonj upazila on the west. The mainwater bodies of Palash upazila is Shitalakshya river. According to the report Banglapedia, The status of the farmers and agriculture of Palash upazila are given below:

- Income sources: Agriculture 28.28%, non-agricultural labor 2.86%, industry 5.14%, commerce 16.87%, transport and communication 2.14%, service 26.26%, construction 5.8% and others 12.65%.
- Agricultural land ownership: Landowner 53.36%, landless 46.64%
- Major crops: Paddy, Jute, Wheat, Sugarcane, onion, garlic, vegetables.

Figure 3.2: Map of Palash Upazila

Source: Banglapedia

3.2.2 Shibpur Upazila

The area of Shibpur upazila is 206.98 square km and located in between 23°56' and 24°07' north longitudes and on between 90°38' and 90°50' east longitudes. It is bounded by Monohordi upazila on the north, Raipura, Narsingdi Sadar and Palash upazila on the south, Belabo and Raipura upazila on the east and Palash and Kapasia upazila on the west. The main water bodies of Shibpur Upazila are Shitalakshya, Bhahmaputra, Arial Kha and Paharia rivers and Chinadi beel. According to the report of Banglapedia, the main characteristics of farmers and agriculture of Shibpur upazila are as follows:

- Income sources: Agriculture: 54.55%, non-agricultural labor 2.08%, industry 3.16%, commerce 15.07%, service 8.21%, communication 4.77%, rent and remittance 2.41% and others 9.56%.
- Agricultural land ownership: Landowner 67.42% and landless 32.58%.
- Major crops: Paddy, Jute, Ginger, Turmeric and vegetables.

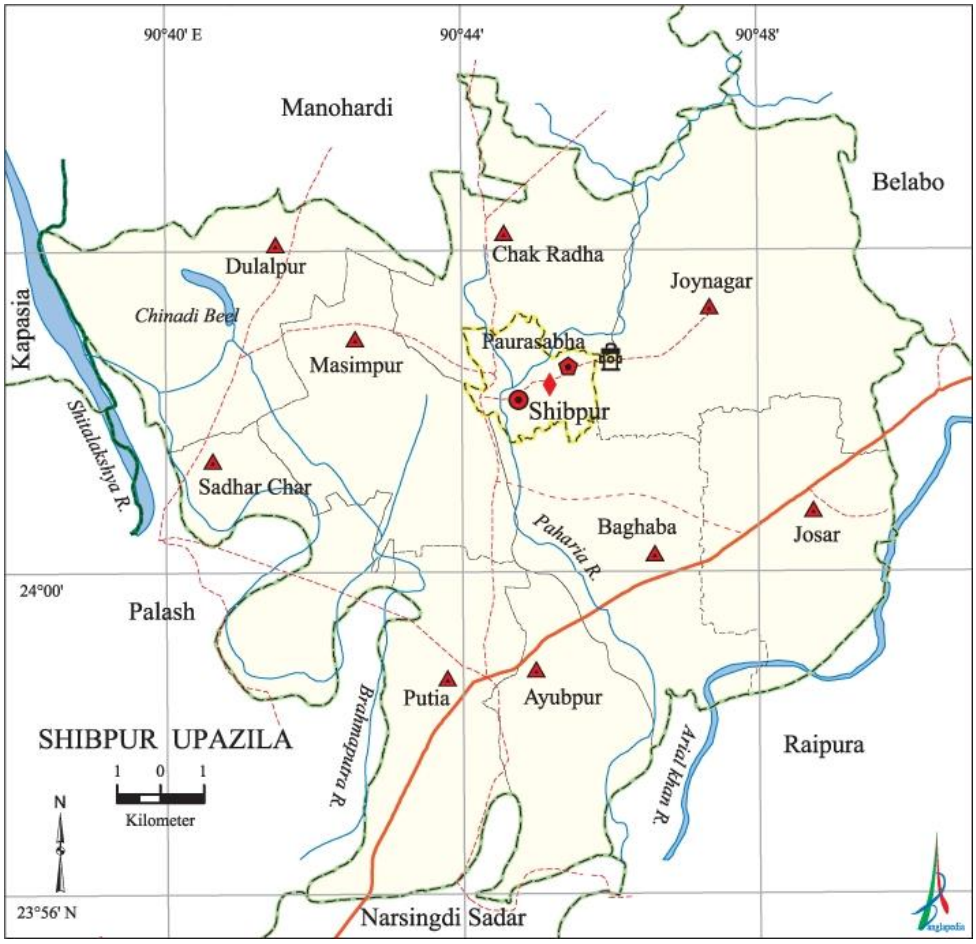

Figure 3.3: Map of Shibpur Upazila

Source: Banglapedia.

3.3 Population of the Study

Every farmer who cultivates tomato at Palash and Shibpur upazila are the population of the study. To obtain the objectives of the study, an approximate number of farmers who produce tomato were estimated with the help of agriculture extension officer (AEO), field level sub-assistant agricultural officers (SAAO) of the Department of Agricultural Extension (DAE) and local farmers. This approximate number of farmers help in determining the sample size of this study.

3.4 Sample Size and Sampling Technique

Sampling is the selection of a part of the population that represents the population. It was impossible to cover all the farmers of the study area because of limitation of time, money and personnel. In total 120 farmers were selected randomly of which 60 farmers from Palash upazila and 60 farmers from Shibpur upazila. Among them, 30 farmers were IPM users and 30 are IPM non-users in Palash upazila as well as 30 farmers are IPM users and 30 were IPM non-users in Shibpur upazila. For minimization of cost, time and for achieving the final objectives of the study, a purposive random sampling technique was followed in the present study.

3.5 Sources of Data

Data are collected from the primary and secondary sources which are necessary for the present study. Primary data were collected from the farmers through interview schedule and various articles, journals and others published sources including Bangladesh Bureau of Statistics (BBS), Bangladesh Economic Review, internet and other relevant sources were used for secondary data collection.

3.6 Preparation of Survey Questionnaire

A survey schedule was planned to record the expected information to satisfy the objectives of the study. After generating a related questionnaire, the drafted copy was revised and fixed dates for face-to-face interview with the farmers for desired information. The questionnaire includes the following things:

- Present socio-economic status of the farmers
- Income and expenditure statement of the respondents
- The factors that can affect the adoption of IPM
- Constraints faced by the farmers at production time.

3.7 Period of Data Collection

The researcher herself conducted the data collection during the month of June to July, 2022. Data were collected through several visits by the researcher.

3.8 Collection of Data

Accurate and reliable data collection from the field is a complicated task. Data reliability mostly depends on the methods by which data were collected. For ensuring accuracy and reliability, data collection were held by direct interview from the sample farmers with designed questionnaire for the study. In time of interview, respondents were given a summery about the study for free response. Care was taken to capture accuracy and reliability in time of data collection.

3.9 Processing and Analysis of Data

The responses were checked to estimate errors involved in it. After collecting data, it was coded, tabulated, summarized and processed for analysis. The data had been transformed into SPSS sheet from the interview schedule with MS Excel.

3.10 Analytical Technique

Data were analyzed for fulfilling the objectives of the study. For this study, the given technique were studied:

a. Descriptive statistics
b. Statistical Analysis

Descriptive Statistics

Tabular technique is generally used to find out the socio-demographic status of the respondents, livelihood condition, demographic profile, perception on IPM and barriers to adoption. It was used to get the simple measures like mean, average, percentage etc.

Statistical Analysis

The main objective of the study is to identify the adoption determinants of IPM practices of tomato producers. Here, the adoption of IPM is a binary dependent variable, whereas the influencing factors are the independent variables. Since the adoption of IPM is a binary dependent variable, with the option of either ‘adoption’ or ‘non-adoption’, the binary logistic regression model is considered to be the most appropriate tool for investigating how each independent variables affects the probability of adoption (Raut et al. 2011; Thapa et al. 2011).

The binary logistic regression model for identifying the influencing determinants of IPM adoption is mentioned in the following:

$$\log[P/1-P] = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + e$$

Where,

P= Probability of the outcome

β_0= Intercept

β_1…….. β_{14}= Coefficients of the independent variables

X_1= Age

X_2= Education

X_3= Income

X_4= Family size

X_5= Farming Experience

X_6= Farm size

X_7= Tomato cultivable land

X_8= Societal membership

X_9= Use of hired Labor

X_{10}= Livestock

X_{11}= Training on IPM

X_{12}= Distance to local market

X_{13}= Frequency of Extension contract

e= Random error term.

Table 3.1: Description of the variables use in the model

Variables	Description	Types of variables
Age (X_1)	Farmers age in years.	Continuous
Education (X_2)	Farmers' education in years.	Categorical
Income (X_3)	Total income in tk.	Continuous
Family Size (X_4)	Total number of family members.	Categorical
Farming experience (X_5)	Farmer's farming experience in years.	Continuous
Farm size (X_6)	Total farm size in hectares.	Continuous
Tomato cultivable land (X_7)	Total tomato cultivable land in hectares.	Continuous
Societal membership (X_8)	A dummy variable that takes a value of 1 if farmers have any societal membership, and 0 otherwise.	Dummy
Use of Hired labor(X_9)	A dummy variable that takes a value of 1 if farmers use hired labor, and 0 otherwise.	Dummy
Livestock (X_{10})	A dummy variable that takes a value of 1 if farmers have livestock, and 0 otherwise.	Dummy
Training on IPM (X_{11})	A dummy variable that takes a value of 1 if farmers have training on IPM, and 0 otherwise.	Dummy
Distance to local market (X_{12})	Total distance of local market from home in kilometers.	Continuous
Frequency of Extension contact (X_{13})	Number of times of extension contact.	Categorical

CHAPTER 4

SOCIO-ECONOMIC PROFILE OF THE FARMERS

This chapter deals with the socio-economic status of the sample farmers. Socio-economic status of the farmers are significant in influencing the production planning and adoption decision. The socio-economic characteristics considered in the present study were age, education level, family size, farming experience, training on IPM, housing pattern, income level etc.

4.1 Age Distribution of the Farmers

Age of the responded IPM and non-IPM tomato producers varied from 20-75 years. Considering the recorded age, IPM and non-IPM tomato producers were classified into 3 groups 'young', 'middle' and 'old' aged as classified to MoYS (2012). The distribution of the respondents in conformity with their age is presented in Table 4.1. Results revealed that middle aged people comprised the major proportion (58.33%) followed by old (26.67%) and young (15.00%) aged category for IPM tomato producers. On the other hand, for non-IPM tomato producers, old aged people comprised the major proportion (43.33%) followed by middle (41.67%) and young (15.00%) aged people.

Table 4.1 Age distribution of the responded IPM and non-IPM tomato producers

Age (Years)	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
Young (20-35)	26.67	0.00	3.33	30.00	15.00	15.00
Middle (36-50)	63.33	30.00	53.33	53.33	58.33	41.67
Old (50-75)	10.00	70.00	43.34	16.67	26.67	43.33
Total	100	100	100	100	100	100

Source: Field Survey, 2022

However, in Palash upazila, in case of IPM tomato producers, 26.67%, 63.33% and 10.00% respondents fall under young, middle and old aged category, respectively whereas these percent were 0.00%, 30.00% and 70.00% for non-IPM tomato producers. Again, in Shibpur upazila, in case of IPM tomato producers, 3.33%, 53.33% and 43.34% respondents fall under young, middle and old aged category, respectively whereas these percent were 30.00%, 53.33% and 16.67% for non-IPM tomato producers. These findings indicate that majority of the sample farmers were in the most active age group of 36-50 years for IPM tomato producers as they have more ability and risk adoption capacity whereas old aged farmers are more active on non-IPM tomato production as they are weak and have less ability and risk adoption capacity than middle aged people.

4.2 Educational Status

The level of education of the responded IPM and non-IPM tomato producers ranged from 0 to 17 years. On the basis of educational years, the tomato producers were classified into 4 groups. The distribution of producers in accordance with their level of education is represented in Table 4.2. The results reveal that about half of the respondents (45%) are in secondary education category in IPM tomato production followed by higher (31.67%), Illiterate (13.33%) and primary (10%) education level where about half of the respondents (43.34%) are in primary education category in non-IPM tomato production followed by secondary (33.33%), higher (8.33%) and illiterate (15%). The study also finds that 86.67% of IPM tomato producers and 85% of the non-IPM tomato producers were educated that is higher than the average literacy rate (74.40%) in Bangladesh (BER, 2022).

Table 4.2 Educational status of the responded IPM and non-IPM tomato producers

Education (Years)	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
Illiterate	0.00	23.33	26.67	6.67	13.33	15.00
Primary (1-5)	0.00	50.00	20.00	36.66	10.00	43.34
Secondary (6-10)	46.67	26.67	43.33	40.00	45.00	33.33
Higher (above 11)	53.33	0.00	10.00	16.67	31.67	8.33
Total	100	100	100	100	100	100

Source: Field Survey, 2022

However, in Palash Upazila, literacy rate was 100% for IPM tomato producers and 76.67% for non-IPM tomato producers. Again, in Shibpur Upazila, literacy rate was 73.33% for IPM tomato producers and 93.33% for non-IPM tomato producers. Besides, percentage of respondents in secondary and higher category of education, IPM tomato producers were higher than non-IPM tomato producers as educated people are more aware and concern about any new technologies and want to take risk to adopt any new thing.

4.3 Income Level

Annual household income of the sample farmers included all the incomes from various income sources i. e, crop farming, livestock rearing, fish farming, agricultural day labor, non-agricultural day labor, service, business and others. Annual household income of the respondent ranged from 1.1 to 10 lakh Tk in the study area. Findings of the study disclosed that average monthly household income of the respondents were Tk. 20,800 for non-IPM tomato producers and Tk. 20864 for IPM tomato producers which were higher than the national average of Tk.15,998 (HEIS, 2016). The IPM and non-IPM tomato producers are classified based on their annual household income into (<2 lakh Tk.), (2-4 lakh Tk.) and (>4 lakh Tk.). The distribution of the IPM and non-IPM tomato producers in conformity with their annual household income is represented in table 4.3.

Table 4.3 Distribution of the farmers according to their annual income

Income (in lac tk.)	Palash Upazila		Shibpur Upazila		Overall	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
< 2	16.67	36.67	30.00	40.00	23.33	38.33
2-4	83.33	50.00	60.00	56.67	71.67	53.33
> 4	0.00	13.33	10.00	3.33	5.00	8.34
Total	100	100	100	100	100	100

Source: Field Survey, 2022

Results show that in Palash upazila, for IPM tomato producers, 16.67%, 83.33% and 0% respondents are fall under <2, 2-4 and >4 lac tk. income category, respectively. Again, for non-IPM tomato producers, 36.67%, 50% and 13.33% respondents are fall under <2, 2-4 and >4 lac tk. income category, respectively. Again, in Shibpur upazila, for IPM tomato producers, 30%, 60% and 10% respondents are fall under <2, 2-4 and >4 lac tk. Income category, respectively. Again, for non-IPM tomato producers, 40%, 56.67% and 3.33% respondents are fall under <2, 2-4 and >4 lac tk. income category, respectively. The study also reveals that majority of the IPM tomato producers (71.67%) and non-IPM tomato producers (53.33%) fall into 2-4 lac tk. income group.

4.4 Family Size

Family size scores of the farmers extended from 2 to 11. Average family size is 5.8 for on-IPM tomato producers and 5.2 for IPM tomato producers which is more than the national average of 4.06 (HEIS, 2016). Under family size, the farmers are categorized into 3 groups as (2-4members), (5-6 members) and (above 6 members) shown in figure 4.4.

Table 4.4 Distribution of the farmers in accordance with their family size.

Family size	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
(2-4)	33.33	30.00	33.33	13.33	33.33	21.66
(5-6)	56.67	43.33	43.33	50.00	50.00	46.67
Above 6	10.00	26.67	23.33	36.67	16.67	31.67
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The study reveals that in Palash upazila, for IPM tomato producers, 33.33%, 56.67% and 10% are fall under (2-4) members, (5-6) members and above 6 members family size and for non-IPM tomato producers, 30%, 43.33% and 26.67% are fall under (2-4) members, (5-6) members and above 6 members family size, respectively. Again, in Shibpur upazila, for IPM tomato producers, 33.33%, 43.33% and 23.33% are fall under (2-4) members, (5-6) members and above 6 members family size and for non-IPM tomato producers, 13.33%, 50% and 36.67% are fall under (2-4) members, (5-6) members and above 6 members family size,

respectively. The results also show that majority of the respondents have (5-6) members family size (50% and 46.67%) for both IPM and non-IPM tomato producers, respectively.

4.5 Gender Status

In the agricultural labor force, the ratio of women has increased from less than 20% to 33.6% of the total labor force (Asaduzzaman, 2010). Table 4.5 depicts that for IPM tomato producers, 83.33% of farmers were male and 16.67% of farmers were female. Again, for non-IPM tomato producers, 85% of farmers were male and 15% of farmers were female. It indicates that women were less involved in agriculture compared to national data that means the empowerment of women were limited here.

Table 4.5 Distribution of farmers in accordance with their gender

Gender	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
Male	86.67	93.33	80.00	76.67	83.33	85.00
Female	13.33	6.67	20.00	23.33	16.67	15.00
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The results show that in Palash upazila, for IPM tomato producers, 86.67% of farmers were male and 13.33% were female, on the other hand, for non-IPM tomato producers, 93.33% of farmers were male and 6.67% were female. Again, in Shibpur upazila, 80% of farmers were male and 20% of farmers were female for IPM tomato production. For non-IPM tomato production, 76.67% and 23.33% were male and female, respectively.

4.6 Farm size

Farm size of the household of sampled IPM and non-IPM tomato producers ranged from 0.17 to 1.7 ha with an average of 0.678 and 0.529 ha, respectively. Tomato farmers are classified into five categories according to their farm size as (0-0.20 ha), (0.21-0.50 ha), (0.51-1.00 ha), (1.01-2.00 ha) and (>2.00 ha). The distribution of the sample farmers is presented in table 4.6.

Table 4.6 Distribution of IPM and non-IPM tomato producers according to their farm size

Farm size (Ha)	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
(0-0.2)	0.00	1.67	1.67	0.00	0.83	0.83
(0.21-0.5)	46.67	48.33	31.66	53.33	39.17	50.84
(0.51-1)	33.33	40.00	56.67	36.67	45.00	38.33
(1.01-2)	20.00	10.00	10.00	10.00	15.00	10.00
(Above 2)	0.00	0.00	0.00	0.00	0.00	0.00
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The results show that in Palash upazila, for IPM tomato producers, 0%, 46.67%, 33.33%, 20.00% and 0% are fall under (0-0.2) ha, (0.21-0.5) ha, (0.51-1) ha, (1.01-2) ha and above 2 ha farm size and for non-IPM tomato producers, 1.67%, 48.33%, 40% 10% and 0% are fall under (0-0.2) ha, (0.21-0.5) ha, (0.51-1) ha, (1.01-2) ha and above 2 ha farm size, respectively. Again, in Shibpur upazila, for IPM tomato producers, 1.67%, 31.66%, 56.67%, 10.00% and 0.00% are fall under (0-0.2) ha, (0.21-0.5) ha, (0.51-1) ha, (1.01-2) ha and above 2 ha farm size and for non-IPM tomato producers, 0%, 53.33%, 36.67%, 10% and 0% are fall under (0-0.2) ha, (0.21-0.5) ha, (0.51-1) ha, (1.01-2) ha and above 2 ha farm size, respectively. The study also reveal that a major part of the respondents holds (0.51-1) ha (45%) for IPM tomato producers and (0.21-0.5) ha farm size (50.84%) for non-IPM tomato producers.

4.7 Farming experience

IPM and non-IPM tomato farming experience of the respondents ranged from 3 to 60 years. Farming experience is categorized into 3 groups as (3-20 years), (21-35 years) and (>35 years). The distribution the respondents in conformity with their farming experience is presented in the table 4.7.

Table 4.7 Distribution of IPM and non-IPM tomato producers in conformity with their farming experience

Experience (Years)	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
(3-20)	56.67	13.34	60.00	56.67	58.33	35.00
(21-35)	43.33	43.33	33.33	33.33	38.33	38.33
(Above 35)	0.00	43.33	6.67	10.00	3.34	26.67
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The result shows that majority of the respondents have 3-20 years farming experiences (58.33%) for IPM tomato producers followed by 21-35 years (38.33%), and above 35 years (3.34%) farming experience where majority of the respondents have 21-35 years farming

experiences (38.33%) for non-IPM tomato producers followed by 3-20 years (35.00%), and above 35 years (26.67%) farming experience.

4.8 Societal membership

The distribution of the sample farmers according to their societal membership on different organization is shown in table 4.8.

Table 4.8 Distribution of IPM and non-IPM tomato producers according to their societal membership

Membership	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
Yes	96.67	30.00	90.00	53.33	93.33	41.67
No	3.33	70.00	10.00	46.67	6.67	58.33
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The results revealed that for IPM tomato producers, 93.33% of respondents have engaged in societal membership and 6.67% have no engagement of societal membership. On the other hand, for non-IPM tomato producers, 41.67% of respondents have engaged in societal membership and 58.33% have no engagement of societal membership.

4.9 Livestock

The distribution of the sample farmers according to their presence of livestock is shown in table 4.9.

Table 4.9 Distribution of IPM and non-IPM tomato producers according to livestock

Livestock	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
Yes	86.67	50.00	76.67	63.33	81.67	56.67
No	13.33	50.00	23.33	36.67	18.33	43.33
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The results revealed that for IPM tomato producers, 81.67% of respondents have livestock and 18.33% have no livestock. On the other hand, for non-IPM tomato producers, 56.67% of respondents have livestock and 43.33% have livestock which indicates that the farmers who use IPM technique on their tomato land rear more livestock than the farmers who do not use IPM.

4.10 Training on IPM

Training on any agricultural activities can improve farmers' knowledge on good seed use, use of resistant varieties, insecticides and pesticides application, management of water and soil, and so on. The distribution of the sample farmers on their training on IPM is shown in table 4.10.

Table 4.10 Distribution of IPM and non-IPM tomato producers in accordance with their training on IPM

Training on IPM	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
Yes	70.00	13.33	83.33	10.00	76.67	11.67
No	30.00	86.67	16.67	90.00	23.33	88.33
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The study showed that for IPM tomato producers, 76.67% of respondents have training on IPM and 23.33% have no training on IPM. On the other hand, for non-IPM tomato producers, 11.67% of respondents have training on IPM and 88.33% have no training on IPM which indicates that the farmers who have training on IPM are more likely to use IPM technique on their field than who have not.

4.11 Housing pattern

Housing pattern are classified into 3 groups, i.e., tin shed, building and others. The distribution of the sample farmers according to their housing pattern is shown in table 4.11.

Table 4.11 Distribution of IPM and non-IPM tomato producers in conformity with their housing pattern

Housing pattern	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
Building	83.33	66.67	70.00	63.33	76.67	65.00
Tin shed	16.67	33.33	26.67	36.67	21.66	35.00
Others	0.00	0.00	3.33	0.00	1.67	0.00
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The study showed that for IPM tomato producers, 76.67% of respondents have building on their house and 21.66% have tin shed and 3.33% have others housing pattern. On the other hand, for non-IPM tomato producers, 56% of respondents have building and 35% have no tin shed on their house.

4.12 Distance from home to AEO office

Distance from home to AEO office can be categorized into 3, which are (below 5.5 km), (5.5-7 km) and (above 7 km). The distribution of the respondent farmers in accordance with their distance from home to AEO office is shown in table 4.12.

Table 4.12 Distribution of IPM and non-IPM tomato producers in accordance with their distance from home to AEO office

Distance in km.	Palash Upazila		Shibpur Upazila		All Areas	
	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)	IPM (%)	Non-IPM (%)
(Below 5.5)	0.00	40.00	10.00	0.00	5.00	20.00
(5.5-7)	6.67	36.67	73.33	16.67	40.00	26.67
(Above 7)	93.33	23.33	16.67	83.33	55.00	53.33
Total	100	100	100	100	100	100

Source: Field Survey, 2022

The results showed that majority of the both of the sampled farmers' lives in a large distance from home to AEO offices. For IPM tomato producers, 5%, 40% and 55% respondents live in below 5.5 km., 5.5-7 km. and above 7 km. distance from home to AEO office, respectively. For non-IPM tomato producers, 20%, 26.67% and 53.33% respondents live in below 5.5 km., 5.5-7 km. and above 7 km. distance from home to AEO office, respectively.

CHAPTER 5

ADOPTION DETERMINANTS OF IPM TOMATO PRODUCTION

To assess the determinants that affect adoption of tomato cultivation through IPM practices, Binary Logistic model was initiated in the study area. Findings of the research are being discussed in this chapter.

5.1 Adoption determinants of IPM tomato production

To conduct the binary logistic model, both continuous and dummy variables are treated as independent variable. Sometimes, there may be correlation between the variables chosen for the analysis. For the authenticity of the research, it is very important to eliminate the correlation between the independent variables. VIF (Variance Inflation Factor) test is used to detect the multicollinearity. VIF test is used in this study to test multicollinearity. Test results show that VIF value is between 1.11 to 4.51 which is under the cut off value of 10 (Appendix-2).

Estimated value of the binary logistic regression analysis

a. The goodness of fit is measured by LR Chi-square and Pseudo R-square.
b. P-values were examined for significance level at 1% ,5% and 10% level.
c. Marginal effects were calculated for the result estimation.
d. VIF was used to test the multicollinearity.

The estimated values and coefficient of adoption have been represented in Table 5.1 and marginal effect have been represented in Table 5.2.

Table 5.1 Estimated values and co-efficient of binary logistic regression

Explanatory Variables	Coefficient	Standard Error	z statistic	P-value
Intercept	-1.678	4.078	-0.41	0.681
Age (X_1)	-0.183**	0.091	-2.01	0.045
Education (X_2)	0.337**	0.143	2.35	0.019
Income (X_3)	0.016^{*}	$3.51e^{-06}$	1.86	0.063
Family size (X_4)	0.122	0.343	0.36	0.722
Farming experience (X_5)	0.027	0.07	0.38	0.704
Farm size (X_6)	-2.301	3.119	-0.74	0.461
Tomato farm land (X_7)	12.301	16.921	0.73	0.467
Societal membership (X_8)	3.791***	1.305	2.90	0.004
Use of hired labor (X_9)	2.045	1.271	1.61	0.108
Livestock (X_{10})	2.277**	1.077	2.11	0.034
Training on IPM (X_{11})	3.363***	1.076	3.12	0.002
Distance to local market (X_{12})	-2.159***	0.781	-2.77	0.006
Frequency of extension contact (X_{13})	0.729	0.893	0.82	0.414
LR Chi-square	125.91			
Pseudo R-square	0.7569			

Source: Field survey, 2022

Note: *, ** and * indicate significant at 1%, 5% and 10% level, respectively.**

Table 5.2 Marginal effects after logistic regression

Variables	dy/dx	Standard Error	Z statistic	P-value
Age (X_1)	-0.045**	0.023	-1.98	0.048
Education (X_2)	0.082**	0.035	2.37	0.018
Income (X_3)	0.004*	0.0	1.89	0.059
Family size (X_4)	0.029	0.084	0.36	0.722
Farming experience (X_5)	0.006	0.017	0.38	0.704
Farm size (X_6)	-0.559	0.763	-0.73	0.463
Tomato farm land (X_7)	2.992	4.112	0.73	0.467
Societal membership (X_8)	0.658***	0.144	4.57	0.000
Use of hired labor (X_9)	0.401**	0.187	2.14	0.032
Livestock (X_{10})	0.462***	0.165	2.80	0.005
Training on IPM (X_{11})	0.685***	0.142	4.80	0.000
Distance to local market (X_{12})	-0.525***	0.195	-2.69	0.007
Frequency of extension contact (X_{13})	0.462	0.218	0.81	0.416

Source: Field survey, 2022

Note: *, ** and * indicate significant at 1%, 5% and 10% level, respectively.**

5.2 Interpretation of the variables based on marginal effect

Age (X_1)

The results found that age was negatively significant at 5% level. This implies that increase in age by 1 year will decrease probability of adoption of IPM on tomato production by 4.46%.

Education (X_2)

The marginal effect of education was positive and significant at 5% level, which implies that increase in education by 1 year will increase probability of adoption of IPM on tomato production by 8.2%

Income (X_3)

The marginal effect of societal membership was positive and significant at 10% level, which implies that increase in income by 1 tk. Will increase probability of adoption of IPM on tomato production by 0.004%.

Societal membership (X_8)

The marginal effect of societal membership was positive and significant at 1% level, which implies that farmers having societal membership are 65.8% more likely to adopt IPM on tomato production compared to those farmers having no membership.

Use of hired labor (X_9)

The marginal effect of use of hired labor was positive and significant at 5% level, which implies that farmers who used hired labor are 40.14% more likely to adopt IPM on tomato production compared to those who did not use hired labor.

Livestock (X_{10})

The marginal effect of livestock was positive and significant at 1% level, which implies that farmers having livestock are 46.2% more likely to adopt IPM on tomato production compared to those farmers having no livestock.

Training on IPM (X_{11})

The marginal effect of training on IPM was positive and significant at 1% level, which implies that farmers who have taken training on IPM are 68.5% more likely to adopt IPM on tomato production compared to those farmers who have not taken training.

Distance to local market ($X1_2$)

The marginal effect of distance to local market was negative and significant at 1% level, which implies that increase in distance to local market from home by 1 kilometer will decrease probability of adoption IPM on tomato production by 52.5%.

5.3 Conclusion

Among the factors, age, education, income, societal membership, use of hired labor, livestock, training on IPM and distance to local market have most influence on adoption of IPM on tomato production. Therefore, age and distance to local market have negative significance on adoption. This finding may give importance on more training facilities on larger farmers groups and creating more awareness on IPM.

CHAPTER 6

PROBLEMS OF TOMATO CULTIVATION

6.1 Introduction

The focus of this chapter is to identify the extent of constraints faced by the tomato farmers. Farmers faced a lot of constraints in cultivating tomato through Integrated Pest Management practices and with chemical pesticides. The problems were social, cultural, economical and technical. This chapter aims at representing some socioeconomic problems and constraints of cultivating tomato through IPM and non-IPM technologies. The problems and constraints faced by the farmers were identified according to opinions given by them. The major problems and constraints related to tomato cultivation are discussed below:

6.2 Problems faced by non-IPM tomato producers

6.2.1 Lack of quality seed

High quality of seed is the primary input for tomato production. Farmers very rarely get high quality seed and the germination rate of those seed are very poor. About 66.67% farmers faces this problem of lack of quality seed which ranks 2nd for the non-IPM tomato producers.

6.2.2 Expensive inputs

Inputs other than seed which are used in cultivation and for IPM technology like pheromone trap, biological control agents etc. are rare and expensive to buy. Some farmers can't afford these types of inputs which ranks 3rd constraint against using IPM and about 63.33% farmers responded in this problem.

6.2.3 Inexperienced trainer

Training based on IPM is a main factor on adopting IPM of tomato cultivation. Some farmers claims that trainer are inexperienced as they have no more practical information on IPM. About 48.33% respondent claim on this and it ranks 4th constraint.

6.2.4 Unavailability of organic fertilizer

Organic fertilizer are not available for the farmers in the right time. So the use chemical fertilizers to the field which is very risky for health. About 41.67% respondents reported this problem which ranks 5th.

6.2.5 Lack of resistant variety

Resistant variety can protect from insects and pest which cause more productivity and low cost of production as pesticide cost are low. Lack of resistant variety is a problem which can discourage farmers from using IPM technique and encourage to use more pesticide. About 33.34% farmers reported this problem that rank 6th position.

Table 6.1 Problems faced by non-IPM tomato producers

Problems	No. of Farmers	Percent of Farmers	Rank
Lack of quality seed	40	66.67%	1st
Expensive inputs	38	63.33%	2nd
Inexperienced trainer	29	48.33%	3rd
Unavailability of organic fertilizer	25	41.67%	4th
Lack of resistant variety	20	33.34%	5th
Lack of storage	19	31.67%	6th
Lack of credit	15	25.00%	7th

Source: Field survey, 2022

6.2.6 Lack of storage

Lack of storage facilities is another major problem for tomato cultivation. Storage meets the utility of time requirement and removes the time gap barrier between producers and consumers. As tomato is perishable in nature, it has to store properly in time of peak season. About 31.67% respondents faces this problem which rank 7th position.

6.2.7 Lack of credit

Credit facilities of agricultural uses can influence farmers to adopt new technology. Due to lack of credit facilities about 25% farmers faces problems in tomato production.

6.3 Problems faced by IPM tomato producers

IPM tomato producers faces some problems in producing tomato through IPM. Majority (63.33%) of the farmers faces the problem of low price of yield followed by lack of credit, lack of storage, unavailability of organic fertilizer, lack of quality of seeds etc. Problems faced by the tomato producers using Integrated Pest Management practices with rank are given on the following table.

Table 6.2 Problems of tomato cultivation through Integrated Pest Management practices

Problems	No. of Farmers	Percent of Farmers	Rank
Lack of credit	35	58.33%	1st
Lack of storage	34	56.67%	2nd
Unavailability of organic fertilizer	29	48.33%	3rd
Lack of quality seeds	20	33.33%	4th
Expensive inputs	17	28.33%	5th
Lack of resistant variety	14	23.33%	6th
Inexperienced trainer	11	18.33%	7th

Source: Field survey, 2022

6.4 Conclusion

According to the table 6.1 and table 6.2, it is cleared that majority of the farmers who use IPM and who do not use IPM faces the same problem of low price of yield which ranks first. Here, 63.33% IPM users and 73.33% IPM non-users faces low price of yield. Lack of credit is another problem where 58.33% of IPM users and 25% of IPM non-users faces this problem. Lack of storage faces by 56.67% and 31.67% of IPM user and IPM non-users, respectively. Unavailability of organic fertilizer is a major problem where 48.33% and 41.67% IPM and non-IPM users faces this problem, respectively. 66.67% non-IPM tomato producers faces the problem of lack of quality seeds which ranks second, on the contrary only 33.33% of IPM tomato producers faces this problem. Expensive inputs is other problem faced by 63.33% of IPM non-users and 28.33% of IPM users. Lack of resistant variety is faced by 33.34% of IPM non-users, where it is 23.33% for IPM users. Lastly, 18.33% of IPM tomato producers faces problem for inexperienced trainer, where this is 48.33% for non-IPM tomato producers. After the above discussion, it can be said that non-IPM tomato producers face more problem than IPM tomato producers.

CHAPTER 7

SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter represents the major findings, conclusions and recommendations of the study. The summery of the study reveals the findings in brief. By conclusion, the main point of the repost can be identified quickly. Recommendation attracts the attention of the related authority to implement some strategies for encouraging the farmers to cultivate tomatoes through Integrated Pest Management practices.

7.1 Summary

Tomatoes are cultivated in all around the country. Palash upazila and Shibpur upazila of Narsingdi district were selected for this research to investigate the socio-demographic status of the tomato producers using IPM and non-IPM techniques, to identify the determinants affecting the adoption of IPM practices by the tomato producers and to recommend some policy implications from the study.

Moreover, extensive study on all the secondary sources, 120 farmers (60 farmers from IPM technology and 60 farmers from non-IPM) from two upazila were purposively selected for surveying on the field level for collecting primary data. An interview schedule which was structured schedule was developed on the basis of the background information, expert's evaluation and pre-test questionnaire.

After administering interviews with the respondents', obtained data were coded properly and put into a database system using Microsoft Excel. At last, dataset which were obtained from field survey were analyzed using STATA software. Descriptive statistics (percentage, mean, average etc.) were used to describe the socio-economic variables.

The socio-economic status of the IPM tomato producers shows that the major (58.33%) proportion were middle aged (36-50 years) followed by old (26.67%) and young aged (15%) category and for non-IPM tomato producers shows that the major (43.33%) proportion were old aged (50-75) followed by middle aged (41.67%) and young aged (15%) category.

Among the IPM tomato producers under educational status, the highest (45%) proportion were secondary education level followed by higher (31.67%) and primary (10%) education level. On the contrary, 13.33% respondents were found to be illiterate. The non-IPM tomato producers under educational status, the highest (43.34%) proportion were primary education level followed by secondary (33.33%) and higher (8.33%) education level. On the contrary, 15% respondents were found to be illiterate.

The majority of the IPM tomato producers were in medium (71.67%) income group followed by low (23.33%) and high (5%) income group same as the non-IPM tomato producers. For non-IPM tomato producers, low, medium and high-income group were 38.33%, 53.33% and 8.34%, respectively.

The average family size for IPM tomato producers were 5.8 and 5.2 for non-IPM tomato producers. The medium family size constituted the highest (50%) proportion followed by small (33.33%) and high ((16.67%) family size for IPM tomato producers. The medium

family size constituted the highest (46.67%) proportion followed by high (31.67%) and small (21.66%) family size for non-IPM tomato producers.

For IPM tomato producers, there were 83.33% male and 16.67% female. Again, For non-IPM tomato producers, there were 85% male and 15% female.

In IPM tomato production, small farm holder constituted the highest (45%) proportion followed by marginal (40%) and medium (5%) farm holder. In non-IPM tomato production, marginal farm holder constituted the highest (51.67%) proportion followed by small (38.33%) and medium (10%) farm holder. Here, none of the group have the large farm size.

Most of the farmers had low (58.33%) farming experience followed by medium (38.33%) and high (3.34%) farming experience in IPM tomato production. In non-IPM tomato production, majority had medium (38.33%) farming experience followed by low (35%) and high (26.67%) farming experience.

For IPM tomato production, 93.33% had societal membership where 6.67% had no membership. On the other hand, 41.67% had societal membership and 58.33% had no membership for non-IPM tomato producers.

For IPM tomato production, 81.67% had livestock where 18.33% had no livestock. On the other hand, 41.67% had livestock and 58.33% had no livestock for non-IPM tomato producers.

76.67% had training on IPM where 18.33% had no training on IPM for those who use IPM technique. On the other hand, 11.67% had training on IPM and 88.33% had no training on IPM for those who do not use IPM technique on their tomato field.

76.67%, 21.66% and 1.67% IPM tomato producers had building, tin shed and others housing pattern, respectively, where 65% and 35% non-IPM tomato producers had building and tin shed housing. No non-IPM tomato producers had others housing pattern.

Majority of the IPM tomato producers had large (55%) distance from home to AEO office followed by medium (40%) and low (5%) distance. Where majority of the non-IPM tomato producers had the same condition as IPM tomato producers. 20%, 26.67% and 53.33% respondents have low, medium and high distance, respectively from home to AEO office for non-IPM tomato producers.

Thirteen inputs were used in Binary Logistic Regression for identifying the determinants that affects the adoption decision of IPM. Among the thirteen inputs, seven inputs were significant. Age, Education, Societal membership, use of hired labor, Livestock, Training on IPM and Distance to local market comprise the co-efficient of marginal effects of 0.045, 0.082, 0.658, 0.401, 0.462, 0.684 and 0.525, respectively, where age and distance to local market had negative significant effects. The value of LR chi-squared was 125.91 and pseudo-R-square was 0.76.

Constraints faced by the IPM and non-IPM tomato producers were inquired by offering open ended question concerning the constraints of tomato production. Among the constraints indicated by the farmers, maximum proportion (66.67%) of respondents faced the problem of

lack of quality seed for non-IPM tomato production as well as 58.33% of respondents faced the problems of lack of credit facilities for IPM tomato production. Other problems faced by the tomato producers are expensive inputs, lack of storage, lack of organic fertilizer etc.

7.2 Conclusion

The socio-economic profile to the IPM tomato producers indicates the domination of middle-aged farmers with medium family size, where maximum number of non-IPM tomato producers constitutes with old aged farmers with medium family size. Majority of the IPM tomato producers had secondary education level with medium income, whereas non-IPM tomato producers had majority on primary education level with medium income. Most of the IPM tomato producers were small farm holder with low farming experience and non-IPM tomato producers were marginal far holder with medium farming experience. IPM tomato producers were more engaged in societal organization than non-IPM tomato producers, where same for livestock ad training on IPM. Both for IPM and non-IPM tomato producers had high distance to AEO office from home.

Age, Education, Societal membership, uses of hired labor, Livestock, Training on IPM and Distance to local market had significant effects on adoption determinants of IPM.

Among the various problems mentioned by the farmers, majority of the IPM tomato producers' complaint on lack of credit facilities and major parts of non-IPM tomato producers' complaint on lack of quality seeds.

7.3 Recommendation

Based on the analysis presented above, the given recommendations are made as broad guidelines for tomato cultivation through Integrated Pest Management practices in the study area with all over the country:

- Lack of credit access on agricultural uses is one of the major problems found on the study area. So, credit access should be increased by the government.
- Low price of tomato on peak season can discourage farmers from producing tomato. For increasing productivity, price support should be given on peak season by the government.
- Inputs used on Integrated Pest Management practices like, pheromone trap, biological agent etc. are expensive that many farmers cannot afford. So, inputs must be subsidized.
- Supply of quality seeds should be ensured.
- Different awareness program on IPM should be taken.
- Trainer should be more expert and experienced.
- As tomato is a perishable food, storage facilities should be increased.

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APPENDICES

Appendix-A: Research Questionnaire

DEPARTMENT OF AGRICULTURAL ECONOMICS

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR, DHAKA-1207

Interview Schedule

ADOPTION DETERMINANTS OF INTEGRATED PEST MANAGEMENT PRACTICES ON TOMATO CULTIVATION IN NARSINGDI DISTRICT OF BANGLADESH

Serial no.:

Respondent's Information

1. Respondent's name: ……
2. Address: Village: …….. Post Office: ……
   Upazilla: …… District: ……..
3. Mobile: ……..
4. Household Characteristics:

Sl. no	Name	Relation with Respon-dent	Age	Sex	Years of Schooling	Occupation (Use Code)		Yearly Income	
						Main	Subsid-iary	Main	Subsid-iary
i.	Respondent	Self							
					Total				

(Use Code: Crop Farming=1, Livestock rearing=2, Fish Farming-3, Agricultural Day labor=4, Non-agricultural Day Labour=5, Service=6, Business=7, others=8)

5. Agricultural Farming Experience: …….. years
6. Tomato Production Experience through IPM: …… years

7. Total Farm Size:

SI. No.	Types of Land Use	Area of Land (decimal)
i.	Homestead Area	
ii.	Land Under Own Cultivation	
iii.	Mortgage In	
iv.	Mortgage Out	
v.	Leased In	
vi.	Leased Out	
vii.	Fallow Land	
viii.	Ponds	
	Total	

8. Farm size under Tomato cultivation through IPM: …… decimals
9. Annual Expenditure:

Purpose	Expenditure (TK)
Consumption Expenditure (Weekly)	
a. Food	
Non-food Expenditure (Yearly)	
a. Housing	
b. Cloths	
c. Education	
d. Medicine	
e. Festivals	
f. Others	

10. Distance from home to local market: …… km
11. Distance from home to agricultural extension office: …… km
12. Frequency of Extension contact:……no.
13. Housing Pattern (Use code): ……..
    (Use code: Building=1, Tin shed=2, Others=3)
14. How many months in a year you can consume from your own production?
    .....months
15. Do you have membership on societal organization? YES/ NO
16. Do you ever use IPM technique? YES/ NO
17. Are you currently using IPM? YES/ NO
18. Do you use hired labor in your farm? YES/ NO
19. Do you receive any training on IPM? YES/ NO
20. Do you ever receive any agricultural credit? YES/ NO
21. Do you have irrigation facilities? YES/ NO
22. Do you have livestock? YES/ NO
23. Do you want to take risk on agricultural production? YES/ NO

24. Do any of your family member include in social safety net program? YES/ NO
25. Problems regarding IPM vegetables production:
    a. Lack of quality seeds
    b. Lack of experienced trainer
    c. Expensive in using IPM
    d. Lack of institutional credit
    e.
    f.
    g.
26. Suggestions for solving the problems regarding IPM vegetables production
    a.
    b.
    c.
    d.
    e.

Thank you for your cooperation

Appendix-B: Variance Inflation Factor (VIF)

Variable	VIF
Age	4.51
Expenditure	3.66
Farm size	2.72
Risk	2.60
Tomato land	2.10
Education	2.00
Income	1.73
Extension contacts	1.67
Training	1.65
Membership	1.58
Distance from home to local market	1.46
Family	1.39
Labor	1.25
Livestock	1.11
Mean VIF	2.10