COMPARATIVE STUDY ON INTEGRATED PEST MANAGEMENT (IPM) USERS AND NON-USERS: CASE OF BITTER GOURD GROWERS IN NARSINGDI DISTRICT OF BANGLADESH

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COMPARATIVE STUDY ON INTEGRATED PEST MANAGEMENT (IPM) USERS AND NON-USERS: CASE OF BITTER GOURD GROWERS IN NARSINGDI DISTRICT OF BANGLADESH

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This is to certify that the thesis entitled "**COMPARATIVE STUDY ON INTEGRATED PEST MANAGEMENT (IPM) USERS AND NON-USERS: CASE OF BITTER GOURD GROWERS IN NARSINGDI DISTRICT OF BANGLADESH**" submitted to the Department of Development and Poverty studies, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in DEVELOPMENT AND POVERTY STUDIES**, embodies the result of a piece of bona fide research work carried out by **SAGIRA KHATUN**, Registration No. **14-06281** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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TO

MY BELOVED PARENTS

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Date: **Author**

ABBREVIATIONS

BBS:	Bangladesh Bureau of Statistics
BER:	Bangladesh Economic Review
BCR:	Benefit Cost Ratio
DAE	Department of Agricultural Extension
DANIDA:	Danish International Development Agency
et al.:	and Others
etc.:	and the Rest
FAO:	Food and Agriculture Organization
FFS:	Farmer Field Schools
GDP:	Gross Domestic Product
Ha:	Hectare
HSC:	Higher Secondary School Certificate
i.e.:	That is
ICP:	Inter-Country Programme
IPC:	Integrated Pest Control
IPM:	Integrated Pest Management
IPM CRSP:	IPM Collaborative Research Support Program
IPM IL:	IPM Innovation Lab
IPW:	Inverse Probability Weighting
IRR:	Internal Rate of Return
Kg:	Kilogram
ln:	Natural Logarithm
No.:	Number
NGOs:	Non-Government Organizations
PCI:	Problem Confrontation Index

SSC:	Secondary School Certificate
SPSS:	Statistical Package for the Social Sciences
TFC:	Total Fixed Cost
TVC:	Total Variable Cost
TC:	Total Cost
UNDP:	United Nations Development Program
USAID:	United States Agency for International Development
%:	Percentage

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Comparative Study on Integrated Pest Management (IPM) Users and Non-users: Case of Bitter Gourd Growers in Narsingdi District of Bangladesh

ABSTRACT

The present study was designed to assess the comparative profitability and factors affecting production of bitter gourd growers with IPM and without IPM. In total, 160 farmers were randomly selected from four villages under Shibpur Upazila in Narsingdi district. Apart from descriptive statistics, profitability analysis, an independent sample t-test and Cobb-Douglas production function were employed to achieve specific objectives of the study. To get a complete picture of Bitter gourd production using both IPM and non-IPM technology, the socio-economic profile of farmers was examined and compared. The study found that IPM farmers were in better-off condition than that of non-IPM farmers in almost all types of socioeconomic characteristics. The major findings of the study revealed that production of Bitter gourd was profitable for both IPM users and non-IPM users. But IPM users earned more profit than non-IPM users on bitter gourd production. The average total cost of bitter gourd production per hectare was estimated at about Tk. 2,90,492 and Tk. 3,24,307 for IPM and Non-IPM users, respectively. The average yield for the IPM and non-IPM users was found 22.01 ton per hectare and 21.53 ton per hectare respectively. The average gross returns per hectare were found at about Tk 6,60,329 for IPM users and the same were Tk 6,46,076 for non-IPM users. The estimated BCR was higher for IPM users (2.27) than non-IPM users (1.99). From independent sample t-test, it was concluded that mean yield, mean gross return and mean net return for IPM users were significantly higher than non-IPM users of bitter gourd. Cobb-Douglas production function analysis suggested that the coefficient of seed, urea, TSP, irrigation and cow dung had positive and significant effect on the yield of Bitter gourd. On the other hand, human labor, power tiller and MoP had negative and significant effect on the yield of Bitter gourd production. Although bitter gourd production was profitable, farmers faced several problems such as lack of proper training facilities and technological knowledge, weak extension services, labor scarcity, lack of awareness etc. in adopting and practicing IPM technology.

CHAPTER I

INTRODUCTION

1.1 Background of the Study

Being an agrarian country, Bangladesh's economy is largely based on agriculture which contributes about 13.47 % to the national GDP (gross domestic product), and employs around 40.60 % of the total labor force (BER, 2021). As it possesses a diverse agroecosystem and its soils are made up of nutrient-rich alluvium, numerous types of tropical and sub-tropical crops are grown in Bangladesh throughout the year. Although rice is the most important crop, vegetable crops play an important role in the economic development of Bangladesh. Millions of farmers earn their living by growing vegetables. Vegetables are herbaceous plant whose fruits, seeds, roots, tubers, leaves, etc. are used as food. Climate and soil of Bangladesh are also very much suitable for growing vegetables round the year. Vegetable is important for nutrition, economy and food security as well. Vegetables can be identified as a significant one for this economy for its noteworthy contribution in raising the foreign exchange earnings and occupies an important position among the items exported from Bangladesh (INFS, 2013). The importance of vegetable can be realized from two stand points such as, economic point of view and nutritional point of view. Vegetable production contributes about 3.2% to the agricultural GDP (BBS, 2020). Over 100 kinds of vegetables are grown in the summer (Kharif) and winter (Rabi) seasons. Presently, however, improved vegetable varieties and cultivation practices developed by the Bangladesh agricultural research institute and made it possible for farmers to cultivate more than 20 types of vegetables throughout most of the year. As a result, vegetable cultivation acreage and its production have increased significantly in recent years. During the 2019–2020 crop year, vegetable cultivation area occupied 1,111,000 acres that produced a total of 4,574,000 metric tons of vegetables (BBS, 2021). Vegetable cultivation acreage during the last decade has increased annually at the rate of 5 %, and there has been a five-fold increase in vegetable production since the independence of Bangladesh (FAO, 2017). Bangladesh at present exports about 0.07 million to 0.10 million tons of vegetables to 54 different kinds of vegetables to 52 different countries. (The Financial Express of September 26, 2021). During 2020–2021 fiscal year, Bangladesh earned about Tk. 96,390 lakh (US$ 1190 lakh) by exporting fresh vegetables (BBS, 2021). Thus, Bangladesh has secured 3rd position in global vegetable production, next to China and India (FAO, 2020). In one hand, vegetables are generally labor-intensive crops and thus offer a considerable promise for generating increased rural employment opportunities (Akhi *et al.,* 2020). It also creates a great opportunity of employment for the large number of unemployed women of Bangladesh. On the other hand, Vegetables compared to other food items provide low-cost nutrition source. By this way, the country can reduce dependence on cereals gradually and release more land for production of crops and vegetables. Bangladesh is an advantageous position as it has abundant labor supply and natural resources endowment like land and climate (Akter *et al.,* 2016).

Nearly 100 different types of vegetables comprising both of local and foreign origins are grown in Bangladesh. In Bangladesh vegetables are not equally produced throughout the year. vegetables are grown mainly in summer and winter seasons. In summer the major vegetables grown are cucurbits. In Bangladesh summer vegetable cultivated 1.27% of total cultivated area (BBS, 2020) and among them bitter gourd was important vegetable produced in this season. Bitter gourd **(***Momordica charantia L.*) is one of the most popular cucurbitaceous vegetables in Bangladesh for its nutritive and medicinal value (Islam *et al.,* 2013). It is grown extensively throughout Bangladesh. The seed is sown from January to March for summer season crop, June-July for rainy season crop in the plains and March to June in the hills. The best medium for seeds is a fertile, well- drained soil with a pH ranging from 5.5 to 6.7, enriched with organic matter, such as compost or dried manure but it will tolerate any soil that provides a good drainage system (sandy loam soil). It will prefer the climate with dynamic temperatures between 24℃-35℃. Previously it was considered as homestead vegetable but now it is grown as field crop. It is grown extensively throughout the country during Kharif season which was cultivated in 26490.75 acres and total production of 59371.35 metric tons (BBS, 2021) per annum. Table 1.1 shows area and production of Bitter gourd by division from fiscal year 2017-2018 to 2019 to 2020 in Bangladesh.

The production of bitter gourd is hindered due to several factors like insect, pests and disease (Akter *et al*., 2018). Many insects viz., cucurbit fruit fly, red pumpkin beetles, and epilachna beetle are the major constraints to the successful production of bitter gourd (Siddiqua, 2021). For bitter gourd the cucurbit fruit fly *Bactrocera cucurbitae* (Coquillett) damage is the major limiting factor in obtaining high yield (Rabindranath

& Pillai, 1986). Among all cucurbits, fruit fly prefers bitter gourd, the extent of losses varies between 30 to 100%, depending on the cucurbit species and the season. Now a day's farmers in Bangladesh solely rely on the use of toxic insecticides to control the insect pest in bitter gourd. In some areas, farmers spend about 25% of the cultivation cost in bitter gourd production only to buy toxic pesticides (Anonymous, 2003). In an experiment, the residues of pesticide in bitter gourd were found next to brinjal, which was the cause of export reduction of vegetables because of serious concern of the importing countries (Quasem, 2003). Moreover, repeated use of toxic insecticides has created a hazardous situation for the environment as well as health of the farmers and consumers.

Table 1.1: Area and production of Bitter gourd by division, 2017-2018 to 2019-2020

Division	2017-2018		2018-2019		2019-2020	
	Area (acre)	Production (MT)	Area (acre)	Production (MT)	Area (acre)	Production (MT)
Dhaka	4347	6620	4316	6850	4353	6847
Barishal	1614	2209	1637	2226	1748	2388
Chattogram	4602	8663	4358	8443	4713	9370
Khulna	4057	14132	4081	9489	4153	9439
Mymensingh	2047	4028	2092	4175	2354	6938
Rajshahi	5335	13379	5428	14125	5526	14800
Rangpur	3737	7991	3792	7986	3813	8448
Sylhet	751	1086	787	1149	824	1141
Total	26490	57908	26491	54443	27484	59371

Source: BBS, 2021

Wilson *et al.,* (2001) considered that the most restricting factor to accelerated crop production is pests and diseases. Annually, an average of 32.1 % of the global crop production is lost because of pests (Dhaliwal *et al.,* 2010). Africa's overall crop losses as a result of pests are the highest among other factors (Bonabana-Wabbi *et al.*, 2006). The scenario in Asia is not that different from the African context. In Bangladesh, estimates showed that annually, 25 % of vegetables, 20 % of sugarcane, 16 % of rice, 15 % of jute and 11 % of wheat produced in the country are lost because of pest infestation (MoA 2010; Kabir and Rainis 2013a). Albeit, there is no formal record, it is assumed that this loss is higher than those caused by various natural disasters such as flood, drought and cyclones (Kabir and Rainis, 2013b). To adjust this mammoth loss, farmers rely heavily on chemical pesticides.

Pesticides frequent use causes the pests to become resistant and emerge as new pests. Besides, the frequent use of pesticides pollutes the environment through contamination of soil, ground and surface water (Kabir and Rainis, 2012). Moreover, the way and how a pesticide is applied in developing countries, causes several diseases (Cuyno, 1999). By considering these issues, it is assumed that a certain approach is needed to increase food production without causing harm to the environment and health. Organic farming is a system that can control pests by using non-chemical methods. Thus, this system is better in social (health) and environmental aspect but has its limitations to increase in productivity (Rattanasuteerakul, 2009). On the other hand, IPM is a system where the effort to control pest, emphasizes on non-chemical methods and chemicals are only applied when there are no alternatives. The approach is viable in all three important dimensions of sustainability, such as social, economic and environment (Kabir and Rainis, 2013c). In countries, where there is an utmost need to increase food production in a sustainable way; a farming system based on IPM is better than the conventional and organic agriculture (Kabir & Rainis, 2013c). Therefore, to arouse the sense of awareness among the farmers regarding sustainability of food production, the government of Bangladesh, with the assistance of FAO, promoted IPM in vegetable farming in 1996.

1.2 Importance of Bitter gourd Production

Bitter gourd fruit is wormicidal and good for rheumatism. The nutritive value of bitter gourd in 100 g of edible portion are carbohydrate 4.2 g, calcium 20 mg, phosphorus 55 mg, protein 2.1 g and iron 1.8 g. It is also rich in Vitamin A 210 IU and Vitamin C 88 mg, which plays a vital role in human nutrition (Singh and Kirtiraj, 2012). It has great appeal to the diabetes patient. They favor it for controlling diabetes. Bitter gourd is relatively rich in food value compared to other summer vegetable.

As a rich source of antioxidants, flavonoids, and other polyphenol compounds, bitter gourd may help to reduce the risks for a number of health issues. Bitter gourd is packed with polyphenols. These compounds are known for their ability to lower inflammation in the body. The more of them there are, the greater the anti-inflammatory effects could be. The presence of various vitamins and minerals like iron and magnesium in bitter gourd makes it a great food for skin and hair care diet.

Bitter gourd contains bioactive compounds called saponins and terpenoids. These compounds are responsible for the vegetable's bitter taste, but may also play a role in lowering blood sugar levels in people with diabetes. The saponins and terpenoids in bitter gourd may help move glucose from the blood to the cells while also helping your liver and muscles better process and store glucose. Regular consumption of bitter gourd contributes to relieving constipation and indigestion.

Although Bitter gourd provides many nutritional and health benefits, it also generates steady return which inspire farmers to cultivate it in their valuable land year after year. According to Sarker (2017), around 500 poor farmers of five villages under Shribordi upazila of Sherpur district have become self-reliant and changed their lives through cultivating bitter gourd. These five villages are Kornajura, Megadal, Chandapara, Malakuchua, and Hariakona villages. As the farmers got much profit through bitter gourd cultivation after getting repeating bumper production with fair prices, the farmers are cultivating it during the last several years. So, they are getting more interest in bitter gourd cultivation instead of other crops such as paddy, jute, and wheat.

1.3 Importance of IPM

Integrated Pest Management (IPM) is an appropriate package of technology for pest management, which is most economical and less hazardous to the environment. As most of the farmers of Bangladesh are poor, they could hardly spare the money for expensive toxic pesticides. IPM educates the farmers to utilize the readily available sources of biological control agents, tolerant genetic resources, modern cultivation practice and mechanical means of control. Above all, IPM has ample scope of making less reliant on chemical control. Through imparting practical IPM field training, the

FFS farmers become aware of the harmful effect of pesticides used.

Presently a large number of farmers in different regions of Bangladesh are producing huge amount of vegetables by using eco-friendly pheromone trap instead of harmful pesticides and are being financially benefited by using the trap at lesser cost compared to that of using pesticides (Anonymous, 2015).

1.4 IPM Technology Used in Bitter gourd

Integrated Pest Management (IPM) is a broad ecological approach to pest control using various pest control tactics in a compatible manner. Among all other agricultural practices IPM is the best practice to increase the crop production by effecting the human health and environment as less as possible (Rahman, 2010). The available techniques for controlling individual insect pest are numerous. They conveniently categorized in increasing order of complexity, as cultural, mechanical, physical, biological, chemical, genetic, regulatory, biotechnical methods etc. Cultural practices include use of resistant varieties, crop rotation, tillage of soil, variation in time of planting or harvesting, pruning, fertilization, sanitation, water management, planting of trap crops. Mechanical methods include hand destruction, exclusion by screens, barriers, crushing and grinding. Physical methods include heat, cold, humidity, energy- light traps, light regulation, sound etc. Biological methods include protection and encourage agent of natural enemies, propagation and dissemination of specific bacterial, virus, fungus, and protozoan diseases. Chemical methods include attractants, repellents, insecticides, sterilant and growth hormone.

Bitter gourd production is hindered by several insect pests such as cucurbit fruit fly, aphids, powdery mildew, spider mites, fruit borer, pumpkin beetle, mosaic etc. The cucurbit fruit fly is a highly damaging pest of almost all the cucurbit vegetables (Nasiruddin *et al*., 2015). To combat these pests, a combination of different IPM practices have been recommended: these include the use of pheromone and mashed sweet gourd traps to manage fruit fly infestations, collection and destruction of affected fruits with larvae, yellow sticky traps for aphids, and poultry refuse for soil amendment, larval or egg parasitoids, sanitation and rouging of virus infected plants (Alam, 2013; Mian *et al.,* 2016).

1.5 Brief History of IPM in Vegetable Crops in Bangladesh

In Bangladesh, Integrated Pest Management (IPM), which was then termed Integrated Pest Control (IPC), began in 1981 with the introduction of the first phase of Food and Agricultural Organization's (FAO) Inter-country Program (ICP) on rice.

Extension-based programs for IPM in vegetable crops were initiated in Bangladesh during 1995 when five Farmer's Field Schools (FFSs) were conducted on eggplant and other vegetables under the umbrella of the Rice IPM-ICP project. The results from these FFSs showed significant reductions in pesticide use by eggplant IPM farmers. As a result, a sister project to the rice IPM-ICP, the Vegetable IPM-ICP, began in Bangladesh in August of 1996 and it was carried out for 3 years. The process of developing IPM in vegetables continued from 1996 to 2001 through a DAE-UNDP/FAO IPM Project, and from 1997 to 2006 through the DAE-DANIDA Strengthening Plant Protection Services (SPPS) Project in addition to the Rice IPM Project (FAO 2000).

For the first time in Bangladesh a research-based IPM program for vegetable crops was started in October, 1998 under the project name IPM CRSP (Integrated Pest Management Collaborative Research Support Program) with funding from USAID. The Virginia Polytechnic Institute and State University, (Virginia Tech), USA, has been acting as the management entity since the inception of the IPM CRSP project. Recently the name of the IPM CRSP has been changed to IPM IL (IPM Innovation Lab). From the very beginning of this project, the Bangladesh Agricultural Research Institute (BARI) has been associated as the main partner of the IPM IL (CRSP, 2008). Recently, the IPM Innovation Lab started its fifth phase (2014–2019) in Bangladesh. Since the inception of the IPM CRSP project, the BARI scientists associated with the project developed a number of IPM technologies and packages for several crops e.g., eggplant, cabbage, cauliflower, tomato, beans, and different cucurbit crops. These packages are now being utilized in the farmers' fields throughout the major vegetable growing areas of the country, and these packages are also being demonstrated in different areas, under the auspices of the current IPM IL program, to promote farmers' acceptance. It is important to mention that before the inception of the IPM IL project no IPM technologies for farmer adoption were available in Bangladesh (NIP, 2002).

1.6 Justification of the Study

Vegetable farming is pesticide intensive and pesticide exposure is becoming a problem. In many countries there are, however, growing public objections to the use of chemical pesticides because of their negative impact on human health and the environment. The uses of pesticides on vegetable crops in Bangladesh have increased dramatically in recent years. Use of pesticide is particularly high in vegetables. The farm workers, small and marginal farmers and women, who are the most often exposed to the chemicals owing to occupational factors, neglect the health hazards of pesticide exposure due to either lack of awareness or due to financial reasons. So, it is really important to adopt new alternative method which will not only ensure the vegetable production but also secure the health and environment of the vegetable growers and use of IPM is the best alternative till now in this regard. Now it is also evident that potential adoption of the IPM technologies would generate employment and additional income for the rural poor and can save foreign exchange by reducing the quantity of pesticide import. Considering all those issues researcher was interested to carry a study on the IPM users and non-IPM users of Bitter gourd as it is one of the major summer vegetables and wanted to examine the situation in the selected areas.

This study generates farm level information on socio-economic characteristics of bitter gourd producing farmers, level of input use and its pricing, cost and returns, factors affecting productivity of bitter gourd cultivation and problems associated with bitter gourd growers in practicing and adopting IPM technology. This study adds some valuable information to the existing body of knowledge regarding bitter gourd production particularly with respect to the area under study. This study finds out the need of conducting and analyzing the impact of IPM in bitter gourd production in Bangladesh within the current development context, which will help the policy makers to understand the current situation and take programs to increase bitter gourd production and improving the livelihood of rural people in Bangladesh. At the same time the farm level adoption of IPM has already created a wide range of socio-economic impacts that need to be evaluated properly to understand the output of research and development. Now it is essential to assess the impacts of the IPM technologies for Bitter gourd on pesticide cost and return. These factors can be compared at the farm level for IPM users and non-users to provide feedback to scientists, policy makers and

Government for further improvement in the technologies. On the other hand, researcher believed that the findings of this study would provide useful updated information, which would help the policy makers and researcher for further investigation. Hence, the present study "comparative study on IPM users and non-users: case of Bitter gourd growers in Narsingdi district of Bangladesh" has undertaken.

1.7 Objectives of the Study

The specific objectives of the study were as follows-

a) To compare the socio-economic status of the users and non-users of IPM;

b) To compare the profitability of bitter gourd production between IPM users and non-IPM users in the study area;

c) To identify the factors affecting the production of bitter gourd cultivation for IPM users and non-IPM users and

d) To find out problems face by Bitter gourd growers in adopting and practicing IPM technology in the study area.

1.8 Outlines of the Study

This paper contains a total of eight chapters which have been organized in the following sequence. Chapter I includes introduction. The review of literature is presented in Chapter II. Methodology of the relevant study is discussed in Chapter III. Chapter IV contains the socio-economic profile of the bitter gourd producing farmers. Chapter V deals with the costs and returns of Bitter gourd cultivation in case of IPM users and non-IPM users. Chapter VI describes the factors affecting yield of bitter gourd production. Chapter VII presents problems face by bitter gourd growers in adopting and practicing IPM technology. Finally, Chapter VIII represents the summary, conclusion and policy recommendations to increase the use of IPM in bitter gourd production.

1.9 Limitation of the Study

It is very common that there is no study without some limitations. The study researcher has made is of great importance. During preparing this paper, researcher have tried her best. But while conducting this study researcher had to face a number of problems. Those are as follows-

- Most of the data collected through interview of the farmers, sometimes they were not well-cooperated with the interviewer.

- For some cases, the researcher faced unexpected interference from the over interested side talkers while collecting data from the target respondents.
- Due to shortage of time the study could not cover wide areas for collecting necessary information for avoiding inverse relation of the profit.
- The shortage of money and time did not allow taking a large number of samples to show the real significances among all category's farmers.
- The farmers always remained busy in field work and it was difficult to collect information from their wife and child without consulting their husband.
- The information was collected mostly through the memories of the respondents which may not always be correct.

CHAPTER II

REVIEW OF LITERATURE

2.1 Introduction

A review of the literature is an attempt to examine the findings in order to provide suitable guidance in the creation of future research problems and the validation of new findings. It also assists in the successful completion of the research task by supplying diverse expertise and information linked to the suggested investigation. The literature and research of important previous works in connection with the current study were searched since this knowledge and information can be used to help design future research problems and validate new findings. However, the review of literature was not restricted to Bangladeshi works; it was also expanded to other countries in order to gain a broader perspective.

2.2 IPM and Bitter Gourd Related Studies

Khanal *et al.* (2021) carried out a atudy on major vegetable growing areas in Nepal which is namely Banke and Surkhet districts to access the impact of IPM technology on pesticides use and yield of vegetable crops.The results indicated that IPM practicing farmers were significantly younger and more educated than control farmers. Similarly, there were significant differences in average total land holdings and average area under cucumber, eggplant, bitter gourd and cauliflower cultivations between IPM practicing and control farmers. It was also concluded that use of IPM has positive and significant effect on the net revenue from the vegetables and seed treatment, bio-fertilizers, jholmol, pheromone traps and mulching practices inputs significantly increased the yield of bitter gourd in those study area.

Akhi & Islam (2020) conducted a study where socioeconomic profile of farmers was examined and compared and found that IPM farmers were in better off condition than that of non-IPM farmers. The researcher also found that Cucumber production was profitable for both IPM and non-IPM farmers, but IPM farmers were more beneficial than that of non-IPM. The researcher identified that a weak socioeconomic profile of the farmers, inadequate training facilities, few NGOs participation and poor IPM disseminating staff and farmers' ratio as the challenges of sustaining IPM technology in the study areas.

Hajong *et al.* (2020) was designed research to assess the extent of pesticide use and profitability of bitter gourd production at farm level in selected areas of Jashore district during January-May, 2019.The researcher found that ninety-nine percent farmers sprayed insecticides and fungicides in their fields to protect crops from different insect pests and diseases and thirty-nine percent farmers used pheromone trap for crop protection. The average yield of bitter gourd was 16.74 tons/ha for non-IPM farmer and 16.16 tons/ha for IPM farmer. Benefit cost ratio was 1.91 and 1.89 for non-IPM and IPM farmer, respectively that means bitter gourd production was profitable in the examined area.

Sadique (2020) was conducted a study in Jessore and Narsingdi districts of Bangladesh with a view to contributing to the literature by categorizing vegetable IPM practices on the basis of complexity of use and based on this categorization, identifies the determinants of adoption. The study also revealed that the adoption of IPM was positively associated with farmers' education, spouses' education, large farm size, mass media coverage, and high perception of pesticide applications cost. More than 70% of the high adopters had access to credit and received training on IPM which was found in the study and higher percentage of women was observed in the high adopters' families work in vegetable farm compared to the other groups, which may encourage adoption in the study area.

Rahman & Norton (2019) studied on "Adoption and Impacts of Integrsted Pest Management in Bangladesh: Evidence from Smallholder Bitter Gourd Growers". They attempted to measure the determinants of integrated pest management (IPM) adoption, productivity and efficiency of bitter gourd growers in Bangladesh. The result indicated that IPM training and other farmers decisions to adopt can significantly influence the adoption decision of the primary farmers. The findings also revealed that IPM adoption reduced the pesticide applications in case of bitter gourd, which may result in environmental benefits and IPM adopters received marginally higher yield than non-adopters, which may have a positive effect on the income of the growers.

Fuad *et al.* (2019) studied on the impact of Integrated Pest Management (IPM) practices on tomato cultivation in Gazipur district of Bangladesh". They identified that the average infestation of insect and disease was significantly lower in the fields of IPM adopter (9.7%) than IPM non-adopter (11.8%). The average frequency of chemical use in the season was also significantly lower in the fields of IPM adopter (2.14 times) than

IPM non-adopter (3.44 times) and yield was found significantly higher in the fields of IPM adopter (51.34 t/ha) than in the fields of IPM non-adopter (42.24 t/ha). The average gross return was also significantly higher in case of IPM adopter (526,143 taka/ha) than IPM non-adopter (472,647 taka/ha). The Benefit-Cost Ratio (BCR) of IPM adopter (2.41) was also found significantly higher than the BCR of IPM non-adopter (1.44) in the study.

Rahman *et al.* (2018) studied on "Economic impacts of integrated pest management on vegetables production in Bangladesh". This study was mainly undertaken to explore the impacts of integrated pest management (IPM) which was assessed for six vegetables. They observed that IPM adoption significantly reduced the number of pesticide applications and pesticide costs for eggplant, bitter gourd and tomato. For all vegetables together, pesticide costs per hectare were Tk. 1990.42 ($24.88 USD), Tk. 2039.63 ($25.50 USD), and Tk. 2017.53 ($ 25.21 USD) less for adopters than for non-adopters based on nearest neighbor, kernel and radius matching, respectively. The highest market level benefits were obtained for eggplant IPM research and training in the experimented area. IRR was also highest for eggplant IPM research (42%) followed by tomato (39%). They recommended some Policy implication which included measures for more extension efforts and increased investment in IPM research and development.

Akter *et al.* (2018) was undertaken a study to determine the production of Brinjal and to compare the financial profitability between IPM and non-IPM Brinjal growers in the study areas. The findings of the study suggested that cost of Brinjal production was higher for non IPM farmers compared to IPM farmers. Findings also suggested that IPM farmers had cost advantage compared to non IPM farmers in the study areas. This analysis also suggested that the coefficient of human labor and cow dung had positive and significant effect on the yield of Brinjal. On the other hand, irrigation and fertilizer had negative effect on the yield. The study recommended policy like undertaking more training and research activities to overcome the problems of IPM technology for Brinjal.

Islam *et al.* (2018) focused on the detailed financial analysis by comparing between IPM and Non-IPM technologies in the cultivation of major agricultural crops in four regions (Jessore, Comilla, Narsingdi and Bogra) of Bangladesh. They revealed that IPM farmers incurred fewer variable costs and total costs and obtained higher gross return, gross margin, net return and benefit cost ratios than the non-IPM farmers in rice and vegetable production. They also identified that the farmers practicing IPM earned extra profit by selling their products at higher prices because the consumers prefer IPM products which is healthier than non-IPM products. The factors like age of the farmers, education level of the cultivators, degree of information source, technology-related training, etc. affected the adoption of IPM technology in rice and vegetable production in the study area.

Rakib Mohammad (2018) carried out a study to determine the level of profitability of vegetable cultivation by the Integrated Pest Management (IPM) farmers and to identify the factors that significantly influence profitability of vegetable cultivation. The findings of the research revealed that majority (74.8 percent) of the respondents had medium level of profitability while 14.8 percent and 10.4 percent of them had high and low profitability respectively. It was also found that out of selected eleven characteristics, number of vegetables grown, training in vegetable cultivation, organizational participation, annual family income and education had significant positive contribution to their profitability of IPM vegetable cultivation.

Gautam *et al*. (2017) evaluated the impact of vegetable integrated pest management in Bangladesh. The results confirmed that IPM training reduced the frequency of pesticide spraying which was 22% for eggplant and 28% for bitter gourd. Eggplant farmers that received the IPM training obtained significantly higher crop yields than non-trained farmers in the research area. They also found that bitter gourd farmers who received the training obtained a significantly lower crop yield (2.0 tons/ha), but the difference was only significant for the IPW method, not for PSM. There was no significant difference in production costs between trained and non-trained farmers in case of bitter gourd in the study area.

Islam *et al.* (2017) carried out a study and the study revealed that majority of the farmers had moderately favorable attitude towards IPM technology for producing bitter gourd and IPM farmers earned more profit than non-IPM farmers on bitter gourd production. The average total cost of bitter gourd production per hectare was estimated at about Tk 3,68,335 and 4,44,508 for IPM and Non-IPM farmers, respectively. The average gross returns per hectare were found at about Tk 8,60,016; 8,55,642; and 8,15,947 for marginal, small and medium IPM farmers, respectively. The same were Tk 8,22,654; 7,53,373 and 7,48,255 for marginal, small, and medium non-IPM farmers, respectively. The estimated BCR was higher for IPM farmers (2.29) than non-IPM farmers (1.69) in the study area. They indicated some problems which was faced by the farmers such as lack of training and technical knowledge, inadequate extension services etc. in using IPM technology.

Akter *et al.* (2016) revealed that production of some selected vegetables which was papaya, okra and wax gourd were profitable for both IPM and non-IPM farmers. But, IPM based cultivation was more profitable than that of non-IPM based cultivation. Average gross returns were Tk. 257293.3 and Tk.235788.8 for IPM and non-IPM farmers, respectively. The average net return for IPM farmers was Tk.170940.5 and for non-IPM farmers it was estimated at Tk. 135727.3. The average benefit cost ratio for IPM farmers was 2.9 and for non-IPM farmers it was estimated at 2.3. Most of the farmers were in the categories of low to medium problem confrontation in using IPM practices in the study area. Thus, they recommended that massive extension facility including training is needed in the study areas to increase the extent of use of IPM technology.

Das *et al.* (2016) had done a study to determine the extent of use of IPM practices by the farmers and to examine relationships between farmer's selected characteristics and their use of IPM practices. The findings of the study revealed that 61.10% of the farmers were medium users of IPM practices while 21.40% were high users and 17.50% were identified as low users of IPM practices. The results also indicated that farmer's age, education, farming experience, knowledge on IPM practices and attitude towards IPM practices revealed significant positive relationships while problem faced in IPM practices displayed a significant negative relationship.

Jahan *et al.* (2016) designed a study to assess the relative economic performance of two summer vegetables, namely okra and bitter gourd. Descriptive statistics, profitability analysis and Cobb-Douglas production function were employed to achieve the specific objectives of the study. The major findings of the study revealed that production of the two selected vegetables were profitable. Per hectare gross costs of production of okra and bitter gourd were Taka 1,24,992 and Tk. 1,47,126, respectively and the corresponding gross returns were Tk. 2,15,010 and Tk. 2,32,000, respectively. Per hectare net returns of producing okra and bitter gourd were found to be Tk. 90,018 and Tk. 84,874, respectively. The results of Cobb-Douglas production function indicated that per hectare gross returns of okra and bitter gourd were significantly influenced by the use of human labor, tillage operation, seed, fertilizers, irrigation and insecticides.

Sharma *et al.* (2016) attempted a study at the subtropical vegetable-growing areas of the state of Jammu and Kashmir and employed to examine the impact of an integrated pest management (IPM) program which was implemented from 2008 to 2010.No significant change was observed in the adoption of cultural and mechanical practices by the farmers trained under the IPM program except for using raised nursery beds in cauliflower and cabbage crops to drain the excess water and the installation of pheromone traps in okra in the research.

Ahuja *et al.* (2015) was conducted research in Northern India during the late-winter seasons of 2008–2009 and 2009–2010 to develop and validate an Integrated Pest Management (IPM) approach for cauliflower. The researcher found that yields for both seasons were consistently greater in the IPM treatment, averaging 24 tons/ha (10% greater yields) in the IPM treatment than in the non-IPM treatment. They also revealed that compared to the non-IPM treatment, growers using IPM reduced the amount of pesticide by 63.8% and the number of pesticide applications by more than 50%.

McCarthy *et al.* (2015) evaluated the effectiveness and impacts of USAID's IPM IL vegetable technology transfer subproject in Bangladesh. The results from the adoption analysis suggested that the number of years of agricultural experience of the household head, the number of IPM adopters known by the household, and learning agricultural information from media sources and farm training events such as field days significantly increase the likelihood of IPM adoption. The impacts of IPM adoption on vegetable yields, pest management costs, and the number of pesticide applications were non- significant for vegetable crops in this study.

Mila *et al.* (2015) studied on "Profitability of bitter gourd production in some areas of Narsingdi District". The study focused on the estimation of profitability and investigated the factors affecting the yield of bitter gourd production at Narsingdi district in 2013. The study divulged that bitter gourd production was profitable and average yield of bitter gourd was found to be 27.5 ton per hectare and average gross return was Tk. 5,50,000 per hectare. Total cost of production was found to be Tk. 3,06,810 per hectare. Net return and BCR was found to be Tk. 2.43,190 per hectare and 1.79, respectively. The functional analyses of the study suggested that human labor, Urea, TSP, cow dung and irrigation had positive and significant effect on the yield of bitter gourd in the study areas.

Kabir *et al.* (2015) studied on "Adoption and intensity of integrated pest management (IPM) vegetable farming in Bangladesh: an approach to sustainable agricultural development". This study made an attempt to analyze the level of IPM adoption and the intensity of IPM practices by vegetable farmers of Narsingdi district, Bangladesh. It was showed that vegetable cultivation area, farmers' age, household size, land ownership status and perception toward IPM were necessary in the adoption intensity of IPM practices. The study also made an attempt to clarify the role of these factors in the adoption behavior of IPM practices in vegetable farming.

Islam *et al.* (2013) conducted a study on the existing IPM practices on sweet gourd cultivation and cost comparison with non-IPM (NIPM) farmers in Jessore, Magura, Comilla and Bogra districts during 2012. The yield of sweet gourd was found 20.10 t/ha and 18.20 t/ha in IPM and NIPM farmers, respectively. It was found that the cultivation of sweet gourd was profitable since BCR were 2.17 for the IPM and 1.93 for non-IPM farmers. Gross return and gross margin of IPM farmers were 10 percent and 20 percent higher than non-IPM farmers. It was evident from the study that 84 percent of the IPM farmers were willing to increase the IPM practices in near future. Highest 89 percent of the respondents mentioned that less harmful to health was the major reason behind the increase of IPM practices in future followed by reduction in pesticide cost (86 percent) and higher income (78 percent).

Harris (2011) and Rickert-Gilbert (2005) conducted a study on cost effectiveness of IPM dissemination techniques covering 7 districts where rice and vegetables are plenty grown and IPM practices are present. Both of them found the adoption of IPM practices is low after having different initiatives by the government and other organization and agencies.

Hristovska (2009) conducted a study on economic impacts of integrated pest management in developing countries: evidence from the IPM CRSP. This thesis summarized previous IPM CRSP impact studies, and provided additional impact assessments of IPM practices developed on the program based on additional secondary information on elasticities, prices and quantities, economic surplus analyses were conducted.

Hoque *et al.* (2009) explored the relationships between the selected characteristics of the FFS farmers with their problem confrontation. The findings highlighted that the maximum proportion (43.34 %) of respondents had high while 30.83 % medium and 25.83 % low problem confrontation in practicing IPM. It was found that the literacy and knowledge of the farmers about IPM and agricultural knowledge had significant negative correlation with their problem confrontation in practicing IPM. The variable farm size and annual income had a significant positive correlation with their problem confrontation. Rest of the variables, namely age, family size, contact with change agent, Cosmo politeness and organizational participation had no significant relationship with problem confrontation in the study.

Akter *et al.* (2008) conducted a study on returns to investment on research and development of soil borne disease management strategy for brinjal in Bangladesh. The study estimated the economic returns to the past investment on the development of two IPM practices. The study showed that about 20.10% more brinjal production was made available due to adoption of IPM practices (i.e., use of poultry refuses and mustard oilcake) during 2002-2003. The yields of brinjal under IPM practices were 33% and 34% higher, respectively, over the non-IPM practices.

Mauceri *et al.* (2005) carried out a study and identified factors affecting farmers' intention to adopt IPM in Serbia, confirming that attitudes, norms, and farm size can explain farmers' intention to adopt IPM.

Mahmoud & Shively (2004) studied on "Agricultural diversification and integrated pest management in Bangladesh". The study focused on factors associated with a shift toward diversified, high-valued vegetable crops and the incentives associated with the use of IPM methods for vegetable producers in Bangladesh. The findings of the study showed that access to IPM technology and IPM availability combined with access to credit increase household welfare and lead to higher rates of vegetable adoption and Off-farm employment opportunities work against vegetable cultivation and IPM use by risk-averse farmers. Implications for policy and extension efforts were also highlighted in the study.

2.3 Concluding Remarks

Most of the previous researches were conducted on the impacts, adoption and attitudes towards IPM technology by vegetable growers especially brinjal, tomato, sweet gourd and cucumber growers. Therefore, special attention needed to the economic benefit of using IPM technologies for bitter gourd cultivation. Some of the previous study focused on the factors like education, farm size, farming experience, training, extension contact etc. affecting IPM adoption but most of the time factors effecting yield of bitter gourd ignored. Though many study have been conducted but the economic and social issues are very often avoided. For this reason, present study makes an attempt to determine the profitability of IPM based bitter gourd production and compare that with the non-IPM users of bitter gourd production as well as to find out some problems which is often faced by a bitter gourd grower during IPM practices and provide some policy implications for sustaining IPM practices in bitter gourd production. In a word, this study is a modest attempt to find a way of sustainability in bitter gourd production as well as agriculture.

CHAPTER III

METHODOLOGY

3.1 Introduction

This Chapter deals with the methodology used for the study. The reliability of a scientific research depends to a great extent on the appropriate methodology used in the research. Farm management research usually involves collection of primary data from the operating farmers. The method of data collection, however, depends upon the nature, aims and objectives of the study. Methodology mainly covers issues like selection of the study area, selection of the samples, preparation of the interview schedule, collection of data, tabulation, analysis and interpretation of the data. A sequential description of the methodology used for this study is presented below:

3.2 Method of Investigation

A survey-based research deals with collection of information from individual respondents. There are three main methods by which farm survey data can be gathered. These are:

- Direct observing,
- Interviewing respondents and
- Record kept by respondents.

In this study, survey method was followed to collect information from the respondents to fulfill the objectives of this study. There are two major advantages of the survey method, such as: quick investigation of large number of cases and wider applicability. The shortcoming of the survey method is to rely solely on the memory of the respondents. Usually, the farmers of Bangladesh don't keep any written records and account for their farm operations. Moreover, a lot of the rural people of Bangladesh are still illiterate. So, it is a difficult task to conduct a survey for any scientific farm management study. To minimize errors, repeated visits were made to collect data and in the case of any omission or contradiction, the farmers were revisited to obtain the correct information.

3.3 Selection of the Study Area

Selection of the study area is an important step. To achieve the objectives of the present study, a preliminary survey was conducted in Shibpur upazila under Narsingdi district.

On the basis of preliminary information, two villages namely Nahola and Khorogmara under Baghaba union and two villages under Masimpur union which is namely Masimpur and Dhanua were selected for the study which is shown in Figure 3.1. The selection of the study area was based on the following considerations:

- Farmers of these villages were involved in Bitter gourd cultivation and they used IPM on their vegetable production.
- From the view point of time and available resource, this area was suitable for the study.
- Accessibility to the area was good due to developed communication system and
- Expectation of good co-operation from the respondents to obtain reliable data.

3.4 Selection of the Sample and Sampling Technique

It is generally not possible to make a survey covering all farmers and it is not worthwhile to include too many farmers in a survey, because of requiring more time and money to complete the survey. In the present study a total of 160 Bitter gourd farmers were selected randomly of which 80 farmers were IPM users and 80 of them were non-IPM users. Four villages from two union which was namely as Baghaba and Masimpur under Shibpur upazila of Narsingdi district were selected. From each village 20 IPM users and 20 non-IPM users of Bitter gourd were selected randomly (Table 3.1) The simple random sampling technique was used to select the farmers who cultivate Bitter gourd in the study area for collecting the data.

Table 3.1: Distribution of sample size of respondents in four selected villages of Shibpur upazila

Upazilas' name	Unions' name	Villages' name	Sample size	
			IPM users	Non-IPM users
Shibpur	Baghaba	Nahola	20	20
		Khorogmara	20	20
	Masimpur	Masimpur	20	20
		Dhanua	20	20
Total			80	80

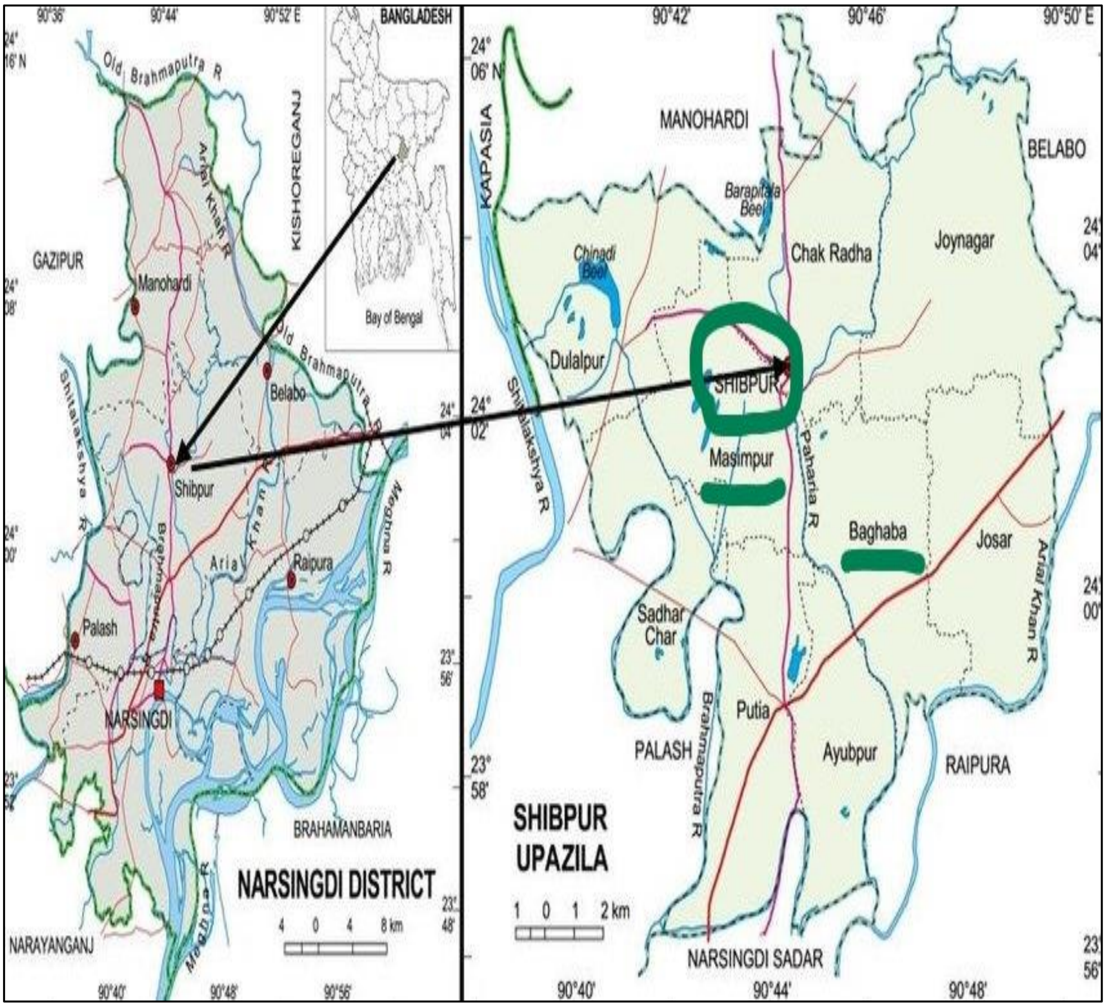


Figure 3.1: A map of Narsingdi district showing selected two unions under Shibpur upazila

3.5 Preparation of the Survey Schedule

To meet the objectives of the study a preliminary survey schedule was designed for collecting data. The draft schedule was pre-tested in the study area by the researcher herself. Thus, some parts of the draft schedule were improved, rearranged and modified in the light of the actual and practical experiences gathered from pre-testing. The following items were taken into account while preparing the questionnaire:

- Identification of the respondent and their family composition along with information on education, occupation, annual income and expenditure
- Land utilization pattern
- Input costs including human labor cost, land preparation cost, seed cot, all

fertilizer cost, irrigation cost, insecticide cost and different IPM material cost

- Returns from bitter gourd cultivation
- Problem faced by the bitter gourd growers

3.6 Collection of Data

To satisfy the objectives of the study, necessary data were collected by visiting each farm personally and by interviewing them with the help of a pretested interview schedule. Before going to an actual interview, a brief introduction of the aims and objectives of the study was given to each respondent. The questions were asked systematically in a very simple manner and the information was recorded on the interview schedule. When each interview was over the interview schedule was checked and verified to be sure that information to each of the items had been properly recorded. In order to minimize errors, data were collected in local units. These were subsequently converted into appropriate standard unit wherever necessary.

Because of the nature of the variables and types of respondents, both qualitative and quantitative data collection procedures were used. The study drew on two types of data: primary and secondary data. Interviewing the chosen respondents were used to collect primary data. The data was collected over a two-month period. Data collection period was 1st August to 31st October, 2020. Data has been properly edited and analyzed after it has been collected.

3.7 Editing and Tabulation of Data

After collection of primary data, the filled schedules were edited for analysis. These data were verified to eliminate possible errors and inconsistencies. All the collected data were summarized and scrutinized carefully. For data entry and data analysis, the Microsoft Excel programs, SPSS programs were used. For data entry and profitability analysis, Microsoft Excel programs was used, SPSS was used for socio-economic profile analysis of the Bitter gourd growers and to determine the factors affecting the Bitter gourd production. It might be observed here that information was collected initially in local units and after checking the collected data, it was converted into standard units. Finally, a few relevant tables were prepared according to necessity of analysis to meet the objectives of the study.

3.8 Analytical Technique

Data were analyzed with the purpose of fulfilling the objectives of the study. Both descriptive and statistical analysis was used for analyzing the data.

3.8.1 Descriptive analysis

Tabular and graphical analysis was generally used to find out socio-economic profile of the respondent. The tabular technique of analysis was used to determine the cost, returns and profitability of bitter gourd cultivation for IPM users and non IPM users. It is simple in calculation, widely used and easy to understand. It was used to get the simple measures like average, percentage and ratio. Tabular technique included production practices and input use, cost and returns of Bitter gourd production.

3.8.2 Production function analysis

The production function represents the relationship between output and factor inputs. To estimate the production function, one requires development of its properties leading to specification of an explicit functional form.

One of the most widely used production function for empirical estimation is the Cobb Douglas production. This function was originally used by C.W. Cobb and P.H. Douglas in twenties to estimate the marginal productivities of labor and capital in American manufacturing industries. Their main purpose was to estimate the shares of labor and capital in total product; hence they used this function with the constraint that the sum of elasticities or regression coefficients should total one. Later on, they relaxed this restraint. Cobb and Douglas originally fitted the function to time series 1930s and 1940s. This form of the function was subsequently used in many production function studies for technical units (crops, livestock) and farm-firms in agricultures have since used this form of the function. The popularity of this function can be attributed to the following characteristics:

- It directly provides the elasticities of production with respect to inputs;
- It allows more degrees of freedom than other algebraic forms (like quadratic function) which allow increasing or decreasing marginal productivities, and
- It simplifies the calculations by reducing the number of regressions to be handled in regression analysis.

In agriculture, the form of function has not been used in its original form. Neither the sum of elasticity’s is kept equal to one nor is the number of variables limited to two.

Even then as the basic idea of functional form was provided by Cobb and Douglas, various forms of this function have continued to be called as Cobb-Douglas production function.

The Cobb–Douglas production function, in its stochastic form, may be expressed as

$Y_i = \beta_1 X_2{}^{\beta}{}_i{}^2 X_3{}^{\beta}{}_i{}^3 e^{ui}$……………….…………… (3.1)

Where, *Y* = Output

X_2= Labor input, X_3= Capital input, u = Stochastic disturbance term, e = Base of natural logarithm.

From Equation (3.1) it is clear that the relationship between output and the two inputs is nonlinear. However, if we log-transform this model, we obtain:

$\ln Y_i = \ln\beta_1 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + u_i$ ………………………. (3.2)

Where, $\beta_0 = \ln\beta_1$.

Thus written, the model is linear in the parameters β_0, β_2, and β_3 and is therefore a linear regression model. In short, (3.2) is a log-log, double-log, or log-linear model, the multiple regression counter part of the two-variable log-linear model.

The properties of the Cobb–Douglas production function are quite well known:

- β_2 is the (partial) elasticity of output with respect to the labor input that it measures the percentage change in output for say, 1 percent change in the labor input, holding the capital input constant.
- Here, β_3 is the (partial) elasticity of output with respect to the capital input, holding the labor input constant.
- Sum of (β_2+ β_3) gives information about the returns to scale, that is, the response of output to a proportionate change in the inputs. If this sum is 1, then there are constant returns to scale, that is, doubling the inputs will double the output, tripling the inputs will triple the output, and so on. If the sum is less than 1, there are decreasing returns to scale—doubling the inputs will less than double the output. Finally, if the sum is greater than 1, there are increasing returns to scale—doubling the inputs will more than double the output.

Whenever there is a log–linear regression model involving any number of variables the coefficient of each of the X variables measures the (partial) elasticity of the dependent variable Y with respect to that variable. Thus, if there is a k-variable log-linear model,

$$\ln Y_i = \beta_0 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \ldots \ldots + \beta_k \ln X_{ki} + u_i \qquad \ldots\ldots\ldots\ldots.. (3.3)$$

Each of the (partial) regression coefficients, β_2 through β_k, is the (partial) elasticity of Y with respect to variables X_2 through X_k. Assuming that the model (3.2) satisfies the assumptions of the classical linear regression model; we obtained the regression by the OLS. (Acharya, 2010).

3.8.3 Specification of the Cobb-Douglas production function

The input-output relationships of bitter gourd production were analyzed with the help of Cobb-Douglas production function approach. To determine the contribution of the most important variables in the production process of bitter gourd production, the Cobb-Douglas production function was transformed into following logarithmic form so that it could be solved by Ordinary Least Squares (OLS) method.

$$\ln Y = a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + b_{11} X_{11} + Ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3.4)$$

Where, $\ln Y$ = Yield (Kg/ha)

$\ln X_1$ = Human labor (man-days/ha)

$\ln X_2$ = Power tiller cost (Tk./ha)

$\ln X_3$= Trellis making cost (Tk./ha)

$\ln X_4$ = Seed (kg/ha)

$\ln X_5$ = Urea (kg/ha)

$\ln X_6$ = TSP (kg/ha)

$\ln X_7$= MoP (kg/ha)

$\ln X_8$= Gypsum (kg/ha)

$\ln X_9$= Cow dung (kg/ha)

$\ln X_{10}$ = Irrigation cost (Tk/ha)

X_{11}= Adoption of IPM (1=if adopt IPM, 0=Otherwise)

a = Intercept, b_1, b_2 -------- b_{11} = Coefficients of the respective variables to be estimated, Ui = Error term.

3.9 Profitability Analysis

To determine per hectare profitability for bitter gourd farming from the view point of individual farmers, the following algebraic equation was followed, where TR and TC represent Total Return and Total Cost, respectively.

π= TR-TC

$\pi_1 = \Sigma Q_y P_y - \Sigma (X_i.P_{xi})$ - TFC

Where,

π_1= Net return from bitter gourd (Tk/ha)

Q_y= Total quantity of (bitter gourd) outputs (Kg/ha)

P_y= Per unit price of bitter gourd (Tk/Kg)

X_i= Quantity of the concerned i^{th} inputs

P_{xi}= Per unit price of the relevant i^{th} inputs

TFC= Total fixed cost involved in bitter gourd production

i= 1,2,3,…….., n (number of inputs)

3.9.1 Calculation of gross return

Per hectare gross return was calculated by multiplying the total amount of product by their respective per unit prices.

Gross Return (GR) or Total Return (TR) = Quantity of the product × Average price of the product

3.9.2 Calculation of gross margin

Gross margin is defined as the difference between gross return and variable costs. Generally, farmers want maximum return over variable cost of production. The argument for using the gross margin analysis is that the farmers are interested to get returns over variable cost. Gross margin was calculated on TVC basis. Per hectare gross margin was obtained by subtracting variable costs from gross return. That is,

Gross Margin (GR) = Gross return – Variable cost

3.9.3 Calculation of net return

Net return or profit is calculated by deducting the total production cost from the total return or gross return. That is,

Net Return (NR) or Net Income (NI) = Total return – Total production cost.

3.9.4 Undiscounted benefit cost ratio (BCR)

Average return to each taka spent on production is an important criterion for measuring profitability. Undiscounted BCR was estimated as the ratio of total return to total cost per hectare.

BCR (Full cost basis) = Total Return/Total Cost (TR/TC)

BCR (Cash cost basis) = Total Return/Total Variable Cost (TR/TVC)

3.9.5 Independent sample t-test

For comparing profitability between IPM users and non-IPM users of bitter gourd an independent sample t test was done by using SPSS system software.

Independent sample t-test is a statistical technique that is used to analyze the mean comparison of two independent groups. When the two independent samples are assumed to be drawn from population with identical population variance, the test statistic t is computed as

$$t = \frac{\overline{x}_1 - \overline{x}_2}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where, $\overline{X}_1$ = Mean of IPM users yield

$\overline{X}_2$ = Mean of Non-IPM users yield

n_1 = Sample size of IPM users

n_2 = Sample size of non-IPM users

S_p = Pooled standard deviation which is as follows

$S_p = (S_1 + S_2) \div 2$

Effect size: while a p-value can tell us whether or not there is a statistically significant difference between two groups, an effect size can tell us how large this difference actually is. The effect size for a t-test for independent samples is usually calculated using Cohen's d. To calculate the effect size, the mean difference is standardized i.e. divided by the standard deviation.

Cohen's d = $(x_1 - x_2) / \sqrt{(S_1^2+S_2^2)/2}$

where:

- x_1, x_2: mean of sample 1 and sample 2, respectively
- s_1^2, s_2^2: variance of sample 1 and sample 2, respectively

According to Cohen (1992) the effect size is low if the value of d varies around o.1, medium if d varies around 0.3 and large if d varies more than 0.5.

3.10 Identification of Problems Through Problem Confrontation Index

There were various problems faced by IPM users and non-IPM users during adopting and practicing IPM technology in bitter gourd cultivation. The farmers were asked to give their opinion on eight (8) selected problems which were identified during data collection. A four-point rating scale was used for computing the problem score of a respondent. Each farmer was asked to indicate the extent of difficulty by each of the problem by checking any of the four responses such as 'high', 'medium', 'low' and 'not at all' and weights were assigned to these responses as 3, 2, 1 and 0 respectively.

For making rank order, Problem Confrontation Index (PCI) was computed as used by Hossein and Miah (2011). The PCI was computed by using the following formula:

$PCI = P_h \times 3 + P_m \times 2 + P_l \times 1 + P_n \times 0$

Where,

P_h = Total number of farmers faced high problem

P_m = Total number of farmers faced medium problem

P_l = Total number of farmers faced low problem

P_n = Total number of farmers faced no problem at all

Thus, PCI of any problem could range from 0 to 240 where 0 indicating ‘no’ problem confrontation and 240 indicating ‘high’ problem confrontation.

3.11 Measurement of Socio-Economic Variables

Any attribute that can take on various or varied values in different instances is referred to as a variable. The selection and measuring of variables are a key function in scientific research. The researcher conducted a literature review to gain a better knowledge of the natures and scopes of the variables that are relevant to this study. The researcher had selected many socio-economic variables in this study. The following were the methods and procedures for measuring these variables:

3.11.1 Age

The age of the respondents was calculated by using the time from birth to the time of the interview, and it was expressed in whole years based on their response (Rashid, 2014). For each year of age, a score of one (1) was assigned. This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.2: Age coding by SPSS

Variable Information	
Name	Age
Label	Age of the sample farmers
Measurement	Ordinal
Value	**Label**
1	Young aged (Up to 35 years)
2	Middle aged (35-50 years)
3	Old aged (above 50 years)

3.11.2 Gender

Gender is an indicator that shows whether the respondents are male or female. The researcher considered one (1) for identifying male and two (2) for identifying female. This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.3: Gender coding by SPSS

Variable Information	
Name	Gender
Label	Gender of sample farmers
Measurement	Nominal
Value	**Label**
1	Male
2	Female

3.11.3 Religion

Religion of the respondents was determined by using the most devoted religion practiced in the study area. The researcher considered one (1) for Islam, two (2) for Hindu, three (3) for Christian and four (4) for Buddhism. This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.4: Religion coding by SPSS

Variable Information	
Name	Religion
Label	Religion of the sample farmers
Measurement	Nominal
Value	**Label**
1	Islam
2	Hindu
3	Christian
4	Buddhism

3.11.4 Education

Education of a respondent was measured by the number of years of schooling completed in an educational institution. A score was given for each year of schooling completed. If the respondent was illiterate then the level of education score for his/her was considered as zero (0) and who can sign only was scored as one (1).

Table 3.5: Education coding by SPSS

Variable Information	
Name	Education
Label	Education of bitter gourd producing farmers
Measurement	Nominal
Value	**Label**
0	Illiterate
1	Can sign only
2	Up to primary
3	Up to SSC
4	HSC and above

Respondent who completed primary level of education his/her score was considered as two (2) as well as three (3) for completing up to SSC level of education. The respondent who completed HSC and above level of education was considered score four (4). This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown above Table 3.11.4.

3.11.5 Family size

The family size was measured by the total number of members in the family of a respondent. The family members included household head and other dependent members like husband/wife, children, brother and sister, parents etc. who lived and ate together. The total number of family members was considered as his/her family size score. This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.6: Family size coding by SPSS

Variable Information	
Name	Family size
Label	Family size of the selected bitter gourd growers
Measurement	Ordinal
Value	**Label**
1	Small family (1-4 members)
2	Medium family (4-8 members)
3	Large family (Above 8 members)

3.11.6 Occupation

Occupation was divided into two categories such as main occupation and subsidiary occupation. Other sector included day laborer, housewife, student etc. This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.7: Occupation coding by SPSS

Variable Information	
Name	Occupation
Label	Occupation of the sample farmers
Measurement	Nominal
Value	**Label**
0	Absent
1	Vegetable cultivation
2	Agriculture
3	Fish culture
4	Livestock rearing
5	Service
6	Business
7	Others

3.11.7 Farm size

Farm size of a farmer is referred to the total area of land owned by farmers. The farm size was measured in hectares for each farmer using the following formula:

$FS=A_1 +A_2 +1/2\ (A_3 +A_4) +A_5+A_6+A_7+A_8$

[Where FS= Farm size, A_1= Own cultivated land, A_2= Rented in, A_3= Rented out, A_4= Mortgage in, A_5=Mortgage out, A_6 = Homestead area, A_7=Pond, A_8= Orchard land]

Table 3.8: Farm size coding by SPSS

Variable Information	
Name	Farm size
Label	Farm size of the sample farmers
Measurement	Ordinal
Value	**Label**
1	Marginal size (0 to .5 ha) farm
2	Small size (.5 to 1 ha) farm
3	Medium size (1 to 2.5 ha) farm
4	Large size (Above 2.5 ha) farm

This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown in above Table 3.11.7.

3.11.8 Farming experience

Farming experience of a farmer was measured by the total number of years of his/her cultivation. A score of one (1) was assigned for each year of farming experience. This variable appears in the section-1 of the interview schedule as presented in Appendix-A.

3.11.9 Expenditure

Expenditure of the respondent was measured by calculating total money spent on food, health, education and other purposes. For measuring percentage spent on food, expenditure on food was divided by total expenditure and multiplied by 100. By this way expenditure on health, education and others was also measured. This variable appears in the section-1 of the interview schedule as presented in Appendix-A.

3.11.10 Annual family income

Annual income of a respondent was measured on the basis of total yearly earning from agriculture, service and business source by the respondent himself and other family members. Agricultural source included income from bitter gourd production, crop and vegetables, fisheries and livestock. This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.9: Annual family income coding by SPSS

Variable Information	
Name	Annual family income
Label	Annual family income of the selected farmers
Measurement	Ordinal
Value	**Label**
1	Low income (Up to Tk. 2,50,000)
2	Medium income (Tk 2,50,000-5,00,000)
3	High income (Above Tk. 5,00,000)

3.11.11 Training exposure

Training exposure of the respondent was measured by determining total number of trainings received by a farmer till the date of interview schedule. A score was assigned for completing each training successively.

Table 3.10: Training exposure coding by SPSS

Variable Information	
Name	Training exposure
Label	Training exposure of the sample farmers
Type	F8
Missing values	None
Measurement	Ordinal
Value	**Label**
0	No training (0)
1	Low training exposure (1-4)
2	Medium training exposure (5-8)
3	High training exposure (Above 8)

Respondent who received no training was assigned zero (0) score, one (1) was assigned for farmers who received one (1) to four (4) training, two (2) was assigned for farmers who attended four (4) to eight (8) training and three (3) was assigned for respondents who had completed more than eight (8) number of trainings. This variable appears in the section-1 of the interview schedule as presented in Appendix-A. SPSS coding is shown in above Table 3.10.

3.11.12 Organizational participation

Participants were those who was member of at least one organizations and non-participants were those who was not a member of any single organization. If the respondent was member of any organization, then score one (1) was assigned and if the respondent was not member of any organization, zero (0) was assigned. This variable appears in the section-1 of the interview schedule as presented in Appendix-A.

3.11.13 Credit facilities

Respondent who received credit from different sources was assigned score one (1) and who did not receive any credit was assigned score zero (0). This variable appears in the section-2 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.11: Credit facilities coding by SPSS

Variable Information	
Name	Credit facilities
Label	Credit facilities of the respondents
Measurement	Nominal
Value	**Label**
0	No
1	Yes

3.11.14 Women involvement in bitter gourd producing activities

If women were involved in various activities of bitter gourd cultivation, then it counted as "yes" and if women were not involved then it was counted as "no". It was measured by assigning one (1) for yes and zero (0) for no. This variable appears in the section-2 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.12: Women involvement in bitter gourd producing activities coding by SPSS

Variable Information	
Name	Credit facilities
Label	Credit facilities of the respondents
Measurement	Nominal
Value	**Label**
0	No
1	Yes

3.11.15 Selling place for produced bitter gourd

Selling place of the produced bitter gourd was local market, farmland, home, urban market and other places. This variable appears in the section-2 of the interview schedule as presented in Appendix-A. SPSS coding is shown below:

Table 3.13: Selling place for produced bitter gourd coding by SPSS

Variable Information	
Name	Selling place
Label	Selling place for produced bitter gourd of the sample farmers
Measurement	Nominal
Value	**Label**
1	Local market
2	Farmland
3	Home
4	Urban market
5	Other places

CHAPTER IV

COMPARING SOCIO-ECONOMIC STATUS OF IPM AND NON-IPM USING BITTER GOURD GROWERS

4.1 Introduction

This chapter deals with the socioeconomic characteristics of the sample farmers. Socioeconomic characteristics of the farmers are important in influencing production planning. People differ from one another in many respects. There are numerous interrelated and constituent attributes that characterize an individual and profoundly influence development of his/her behavior and personality. The socioeconomic aspects of the sample households were examined to the present study. These were age, gender, religion, education, family size, occupation, farm size, farming experience, expenditure, annual family income, training exposure, organizational participation, credit facilities, women involvement in bitter gourd producing activities and selling place. A brief discussion of these aspects is given below:

4.2 Age of the Sample Farmers

The age of the bitter gourd growers was found to be range from 25 to 59 years for IPM users and 33 to 64 years for non-IPM users. Considering the recorded age, the respondents were classified into three categories namely young aged, middle aged and old aged as shown in Table 4.1. Young aged category consisted with the farmers who was happened to be up to 35 years, Middle aged considered the farmers who was between 36 to 50 years and old aged considered the farmers above 50 years (Akter *at el.*, 2016).

Table 4.1: Distribution of respondent farmers according to their age

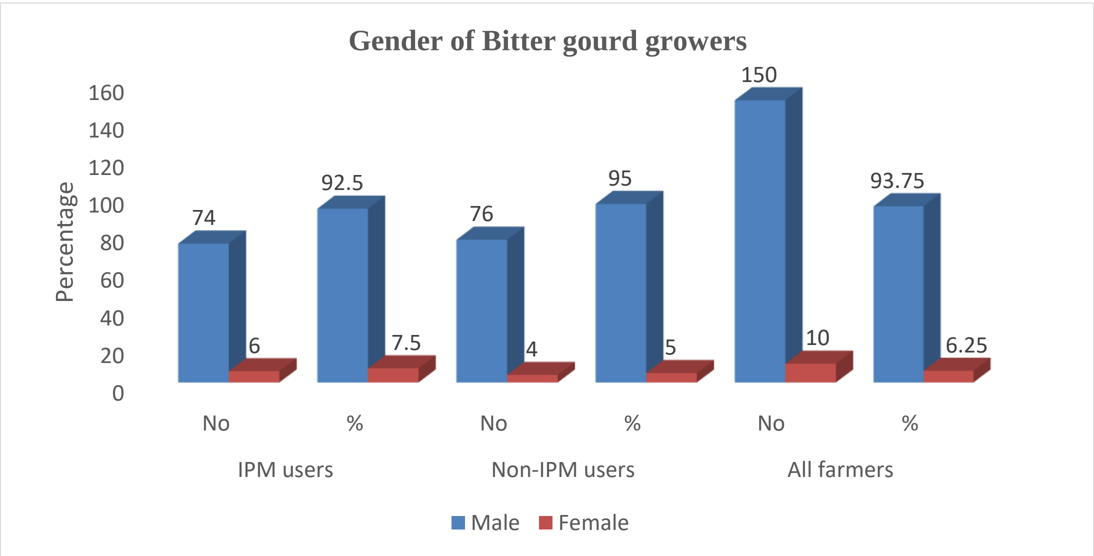
Category	IPM users		Non-IPM users		All farmers	
	No	%	No	%	No	%
Young (up to 35 years) aged	23	28.7	7	8.8	30	18.75
Middle (36-50 years) aged	37	46.3	41	51.2	78	48.75
Old (above 50 years) aged	20	25	32	40	52	32.5
Total	80	100	80	100	160	100
Average age (Years)	39.8		46.7		43.3	

Source: Field Survey 2020

Data presented in Table 4.1 indicates that highest proportion (46.3%) of the IPM users was in the 36-50 years category compared to 28.7% was in the young aged category and 25 % was in old aged category. On the other hand, majority (51.2%) of the non-IPM users belonged to middle aged category followed by 40% was in old aged category and 8.8% was in young aged category. The findings revealed that most of the IPM users were in young (28.7%) and middle (46.3%) age group while that of the non-IPM users were in middle (51.2%) and old (40%) aged group. Data presented in Table 4.1 indicated that average age of IPM users (39.8 years) were less than the average age of non-IPM users (46.7 years). Akter *et al*. (2016) and Kamal *et al*. (2018) also found almost similar findings. Elderly farmers seem to be somewhat less motivated to adopt IPM practices than younger and a middle-aged farmer in the study area. Young and middle-aged people generally show a more favorable attitude towards trying IPM practices.

4.3 Gender of Sample Farmers

Gender refers to biological identification of the respondents in the form of either male or female. In the study area, the level of gender of the respondents were divided into two categories such as male and female.



Source: Field survey, 2020

Figure 4.1: Distribution of bitter gourd growers according to gender

Figure 4.1 shows that the majority (92.5%) of the IPM users in the study area was male and rest (7.5%) of the respondents were female and for non-IPM users, highest proportion (95%) of the bitter gourd growers were male and only 5 percent bitter gourd growers were female. Therefore, most (93.75%) of the bitter gourd growers for both IPM users and non-IPM users were male.

4.4 Religion of the Sample Farmers

Religion is usually defined as a social-cultural system of designated behaviors and practices, morals, beliefs, worldviews, prophecies, ethics that generally relates humanity to supernatural, transcendental, and spiritual elements. Based on the socio-cultural system of Bangladesh, religion of the respondents was classified into four categories which is namely as Islam, Hindu, Christian and Buddhism.

Table 4.2: Distribution of Bitter gourd growers according to religion

Religion	IPM users		Non-IPM users		All farmers	
	No	%	No	%	No	%
Islam	73	91.3	71	88.7	144	90
Hindu	7	8.7	9	11.3	16	10
Christian	0	0	0	0	0	0
Buddhism	0	0	0	0	0	0
Total	80	100	80	100	160	100

Source: Field survey, 2020

Data presented in Table 4.2 indicates that Islam was the religion of the majority of IPM users (91.3%) and non-IPM users (88.7%) which is followed by Hindu religion and counted as 8.7 percent for IPM users and 11.3 percent for non-IPM users of Bitter gourd. Data also shows that there were no bitter gourd growers who belonged to other religion like Christian and Buddhism. Therefore, in the study area 90 percent of the Bitter gourd growers were Muslims which is little bit more than that of the national average 89.1 percent (BBS 2020).

4.5 Education of Bitter Gourd Producing Farmers

Education is the backbone of a nation and the root hidden qualitative causes for all kind of success. Education has its own merits and it contributes to economic and social development. Education also plays an important role in agricultural development. According to Akhi *at el*. (2020) the educational status of the Bitter gourd growers was classified into five categories which was illiterate, can sign only, up to primary (1-5 years), up to SSC (6-10 years), HSC and above which included 11 schooling years and above.

The educational status of the selected Bitter gourd growers is presented in Table 4.3.

The Table shows that highest proportion (33.8%) of IPM users had secondary level of education. In general, 31.3 percent IPM users had primary level of education, 3.8 percent IPM users were illiterate and remaining 5 percent had HSC and above level of education. The table also indicates that about 26.3 percent of the IPM users had no formal education and they only can sign their name.

Data demonstrated in Table 4.4 shows that for non-IPM users' majority (46.20%) had primary level of education followed by 31.25 percent belonged to a category who can sign only, 18.75 percent were illiterate and remaining 3.8 percent non-IPM users had SSC level of education. The table also indicates that there were no bitter gourd growers who had HSC and above level of education in the study areas in case of non-IPM users.

Table 4.3: Educational status of the Bitter gourd growers

Category	IPM users		Non-IPM users		All farmers	
	No.	%	No.	%	No.	%
Illiterate	3	3.8	15	18.75	18	11.25
Able to sign only	21	26.3	25	31.25	46	28.75
Up to primary	25	31.3	37	46.20	62	38.75
Up to SSC	27	33.8	3	3.8	30	18.75
HSC and above	4	5	0	0	4	2.5
Total	80	100	80	100	160	100

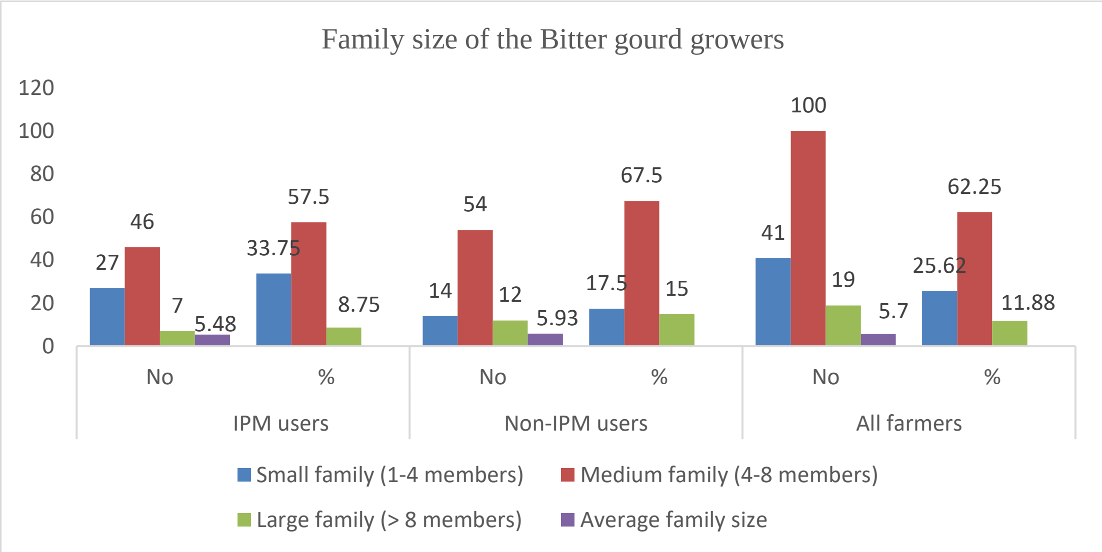
Source: Field Survey, 2020

The percentage of illiterate (18.75%) farmers was comparatively higher in non-IPM farmers and no non-IPM farmers completed higher secondary level of education which indicates that educated people are more innovative and more conscious about scientific agriculture by using IPM for crop pest management.

4.6 Family Size of the Selected Bitter Gourd Growers

The selected farmers size of family in the study area were divided into three categories such as small size, medium size and large size family. Small size family consists of up to 3 members, medium size family consists of 4-8 members and large size family has more than 8 members (Kamal 2018). From Figure 4.3 we can see that a large number of (57.5%) IPM farmers had a medium size family compared to 33.75 percent had small size family and only 8.75 percent had a large size family.

In the case of non-IPM users, highest proportion (67.5%) of Bitter gourd growers had a medium size family which is followed by 17.5 percent had small size family and remaining 15 percent had large size family.



Source: Field survey, 2020

Figure 4.2: Distribution of Bitter gourd growers according to family size

The average family size was found 5.48 for IPM users and 5.93 for non-IPM users of Bitter gourd in the study area which is more than that of national average 4.060 (HIES, 2016).

4.7 Occupation of the Sample Farmers

The farmers were mainly lived their livelihood from agriculture. Table 4.4 shows the occupational status of the sample farmers. Agriculture is the main occupation for most of the IPM users (50%). About 23.8 percent, 8.7 percent and 7.5 percent farmers had vegetable cultivation, fish culture and livestock rearing as main occupation respectively. In the study area, 31.3 percent IPM users were involved into vegetable cultivation indirectly as subsidiary occupation followed by agriculture (28.6%) and 27.6 percent IPM users were not involved with any subsidiary occupation.

In case of non-IPM users, majority (57.5%) of the farmers main occupation was agriculture which was followed by vegetable cultivation (18.8%), business (8.7%), livestock rearing (7.5%), fish culture (6.3%) and service (1.3%) respectively. About

36.3 percent non-IPM users had no subsidiary occupation whereas 25 percent were indirectly involved with vegetable cultivation and 20 percent had agriculture as subsidiary occupation.

Table 4.4: Distribution of respondents according to the occupational status

Occupation	IPM users		Non-IPM users		All farmers	
	No	%	No	%	No	%
Main occupation						
Vegetable cultivation	19	23.8	15	18.8	34	21.3
Agriculture	40	50	46	57.5	86	53.7
Fish culture	7	8.7	5	6.3	12	7.5
Livestock rearing	6	7.5	6	7.5	12	7.5
Business	5	6.3	7	8.7	12	7.5
Service	3	3.7	1	1.3	4	2.5
Others	0	0	0	0	0	0
Total	80	100	80	100	160	100
Subsidiary occupation						
Absent	22	27.6	29	36.3	51	31.9
Vegetable cultivation	25	31.3	20	25	45	28.1
Agriculture	23	28.7	16	20	39	24.3
Fish culture	4	5	5	6.3	9	5.7
Livestock rearing	3	3.7	4	5	7	4.3
Business	3	3.7	6	7.4	9	5.7
Service	0	0	0	0	0	0
Others	0	0	0	0	0	0
Total	80	100	80	100	160	100

Source: Field survey, 2020

Therefore, in the study area, agriculture was the main occupation for both IPM users and non-IPM users of Bitter gourd growers and vegetable cultivation was one of the major sectors of subsidiary occupation of the farmers.

4.8 Farm Size of the Sample Farmers

On the basis of the size, farm was divided into four categories which was marginal size farm, small size farm, medium size farm and large size farm (Akhi et al.). Marginal size farm contains .5 ha of land, small size farm ranges from .5 ha-1 ha land, medium size farm ranges from 1 ha-2.5 ha of land and large size farm contains above 2.5 ha land.

Data presented in Table 4.5 shows that highest proportion (46.2%) of IPM users had small size farm compared with 30 percent had marginal size farm ,23.8 percent had medium size farm and in the study area there were no respondents who had large size farm. On the other hand, majority (56.3%) of non-IPM users had marginal size farm followed by 28.7 percent had small size farm and 15 percent had medium size farm.

Table 4.5: Distribution of respondents according to their farm size

Farm category	IPM users		Non-IPM users		All farmers	
	No	%	No	%	No	%
Marginal size (0-0.5 ha) farm	24	30	45	56.3	69	43.1
Small size (0.5-1 ha) farm	37	46.2	23	28.7	60	37.5
Medium size (1-2.5 ha) farm	19	23.8	12	15	31	19.4
Large size (>2.5) farm	0	0	0	0	0	0
Total	80	100	80	100	160	100
Average farm size (ha)	0.63		0.51		0.57	

Source: Field survey 2020

The average farm size of IPM farmers (0.63 ha) was more than that of non-IPM farmers (0.51 ha) and average farm size was 0.57 ha for all the farmers which was less than national average (.82 ha) rural area farm size (BBS, 2018); this result match the findings of Akter *et al*. (2016) and Akhi *et al.* (2020).

4.9 Farming Experience of the Sample Farmers

For IPM users on an average farming experience was found 12.54 years and for non-IPM users it was 15.76 years (Table 4.5) in the study area. Non-IPM users were more experienced and they did not want to adopt new techniques rather continued conventional method years after years which they believed less risky than the IPM farmers.

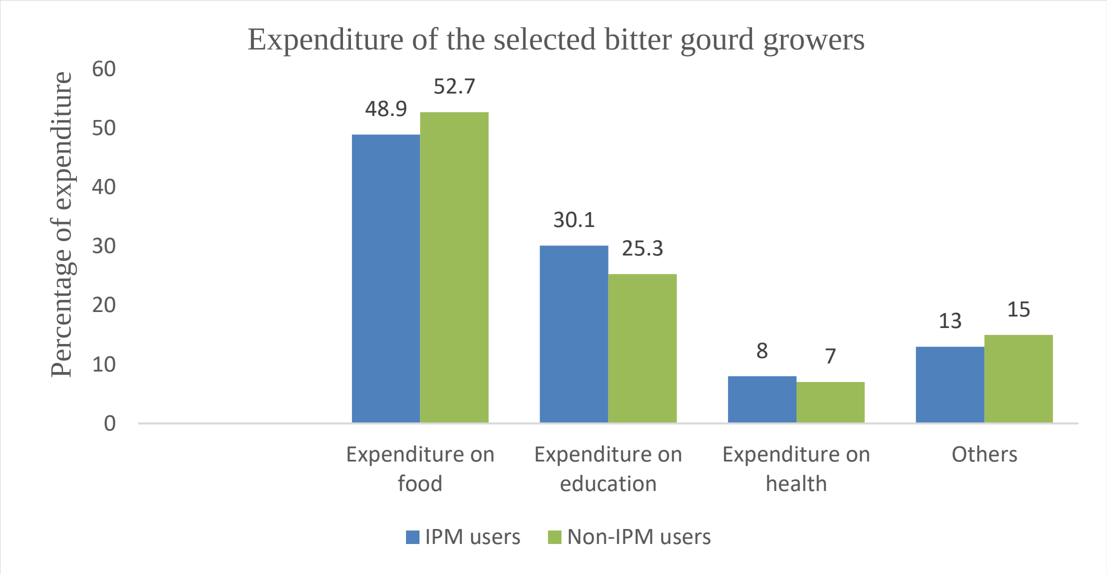
Table 4.6: Farming experience of the bitter gourd growers

Category	IPM users	Non-IPM users	All farmers
Average farming experience (Years)	12.54 years	15.76 years	14.15 years

Source: Field survey, 2020

4.10 Expenditure of the Sample Farmer

The monthly expenditure of Bitter gourd growers differs from one another. In the present study, the expenditure of the selected farmers was categorized as follows: expenditure on food, expenditure on education, expenditure on health and other expenditure.



Source: Field survey, 2020

Figure 4.3: Distribution of bitter gourd growers according to their expenditure

Figure 4.3 indicates that highest proportion (48.9%) of total expenditure was spent on food for IPM users where 30.1 percent on education, only 8 percent on health and 13 percent for other expenditure. For non-IPM users, expenditure on food (52.7%) was highest which is followed by expenditure on education (30.1%), expenditure on health (7%) and other expenditure (15%). Therefore, expenditure on food was the major expenditure for both IPM users and non-IPM users of Bitter gourd producing farmers.

4.11 Annual Family Income of the Selected Farmers

Annual income of a respondent was measured on the basis of total yearly earning from agriculture and other sources (service, business etc.) by the respondent himself and other family members. The value of all the agricultural products encompassing crops, livestock, fisheries, fruits, vegetables etc. were taken into consideration. On the basis of the annual income, the respondents were classified into three categories such as low income (up to Tk. 250000), medium income (Tk. 250000-5,00000) and high income (above Tk. 500000) (Das *et al.* 2016) which is shown in Table 4.6.

Table 4.7: Distribution of respondents according to their annual family income

Category	IPM users		Non-IPM users		All farmers	
	No	%	No	%	No	%
Low income (up to Tk.250000)	31	38.7	39	48.7	70	43.8
Medium income (Tk.250000-500000)	45	56.3	38	47.5	83	51.8
High income (> Tk.500000)	4	5	3	3.8	7	4.4
Total	80	100	80	100	160	100
Observed range (Tk.)	110000-680000		90000-560000		90000-680000	
Average annual family income (Tk.)	276431		255768		266099	

Source: Field survey, 2020

Annual income score of the respondents ranged from Tk. 90000 to 680000 with an average of Tk. 266099 (Table 4.6).

Data presented in Table 4.6 indicate that the highest proportion (56.3 percent) of the respondent had medium annual income, while (38.7 percent) had low income and (5 percent) had high income in case of IPM users of Bitter gourd. On the other hand, majority (48.7 %) of non-IPM users had low income compared with 47.5 percent had medium annual family income and only 3.8 percent non-IPM users of Bitter gourd had high family income annually (Table 4.6). As a result, the most (95.6 percent) of the respondents in the study area were low to medium income earners.

The average income (Tk. 266099) of the respondents in the study area was much higher than the average per capita income of the country i.e., 2227 U.S. dollar (BBS, 2020). This might be due to the fact that the respondents in the study area were not only engaged in agriculture but also earn from other sources, such as service, business etc. Higher annual income of the respondents allows them to invest more in Bitter gourd and other vegetables operations.

4.12 Training Exposure of the Sample Farmers

Training is necessary for the improvement of the skill and technical knowledge. On the basis of the number of trainings received by the respondent’s, training exposure was divided into four categories which was no training (0), low training (1-4), medium training (5-8) and high training (> 8) (Akhi *et al*. 2020).No training category included the farmers who did not receive any training, low training included the farmers who had received at least 1 to 4 training, medium training included the farmers who had received at least 5 to 8 training and high training exposure counted the farmers who had taken above 8 number of training which is shown in Table 4.7 as follows.

Table 4.8: Distribution of Bitter gourd growers according to training exposure

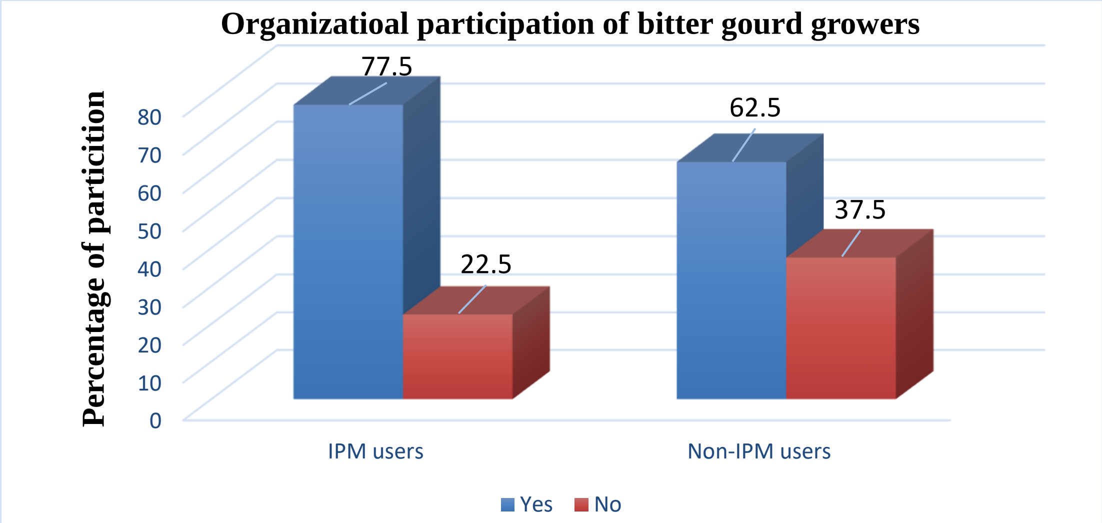
Category	IPM users		Non- IPM users		All farmers	
	No	%	No	%	No	%
No training (0)	25	31.2	36	45	61	38.1
Low training exposure (1-4)	30	37.5	26	32.5	56	35
Medium training exposure (5-8)	20	25	18	22.5	38	23.8
High training exposure (> 8)	5	6.3	0	0	5	3.1
Total	80	100	80	100	160	100
Average training (No.)	3.25		2.32		2.78	

Source: Field Survey, 2020

The majority of the Bitter gourd growers had low (37.5%) and medium (25%) training exposure and 31.2 percent had no training exposure while only a few (6.3%) had high training exposure in the case of IPM farmers. On the other hand, 45 percent of non-IPM users had no training experience and there was no farmer found who had high training experience in the study area. From Table 4.8 we can see that average number of trainings received by IPM users (3.25) was more than the raining received by non-IPM users (2.32) in the study area. Kamal *et al*. (2018) and Akhi *et al*. (2020) also found almost similar findings.

4.13 Organizational Participation of the Sample Farmers

In the study area Bitter gourd growers were members of many organizations which was namely as Common Interest Group (CIG), Oil Seed Production Farmer Group, Local Farmer Group, IPM Club and Pulse Production Farmer Group. Based on the organizational participation, Bitter gourd growers were classified into participants and non-participants which is shown in Figure 4.5. Participants were those who was member of at least one mentioned organizations and non-participants were those who was not a member of any single organization.



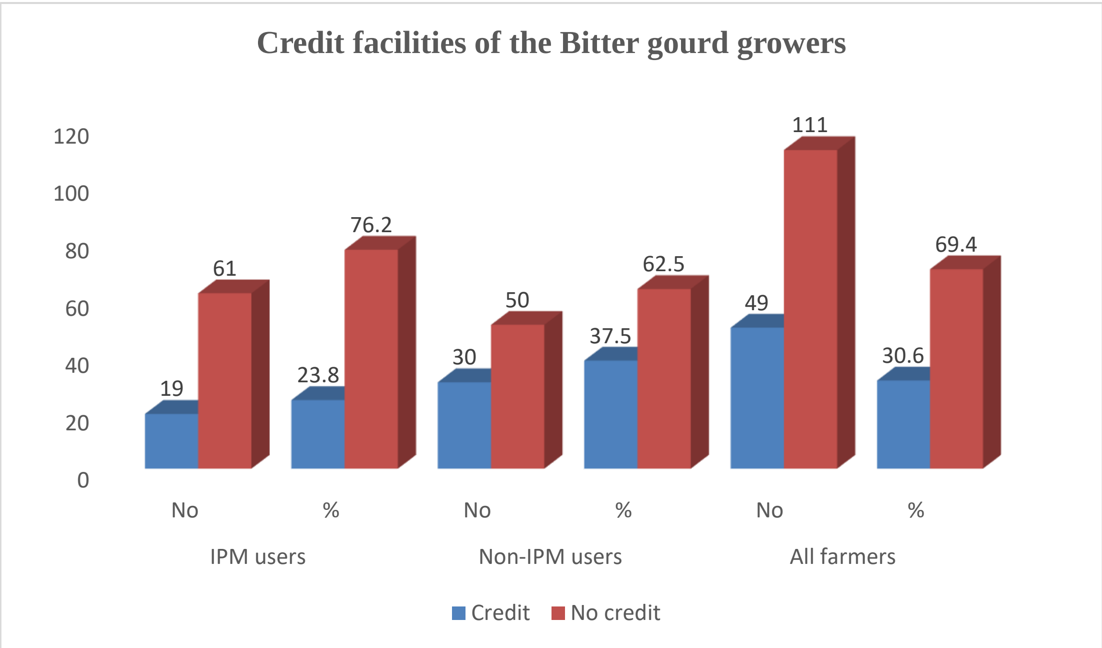
Source: Field survey, 2020

Figure 4.4: Distribution of the farmers according to organizational participation

Figure 4.4 shows that 77.5 percent and 62.5 percent IPM users and non-IPM users had organizational participation respectively and remaining 22.5 percent of IPM users and 37.5 percent non-IPM users had no organizational participation.

4.14 Credit Facilities of the Respondents

Available amount of funding is an important factor for any kind of farming. The sources of credit facilities for the Bitter gourd producing farmers include Banks, NGOs, Relatives, friends and also money lenders.



Source: Field Survey, 2020

Figure 4.5: Distribution of the respondents according to credit facilities

In case of IPM and non-IPM users, about 23.8 percent and 37.5 percent farmers were taken credit for their production and 76.2 percent and 62.5 percent farmers were not taken any credit facilities (Figure: 4.5). Therefore, majority (69.4 %) of the Bitter gourd growers in the study area used their own fundings and not took any credit which is higher than the percentage of national average (63.04%) agricultural credit for production (BBS, 2018).

Table 4.9: Distribution of selected farmers according to source of credit received

Category	IPM users		Non-IPM users		All farmers	
	No	%	No	%	No	%
Banks	5	26.3	8	26.7	13	26.6
NGOs	9	47.4	13	43.4	22	44.9
Friends & relatives	2	10.5	4	13.3	6	12.2
Neighbors	2	10.5	3	10	5	10.2
Money lender	1	5.3	2	6.6	3	6.1
Total	19	100	30	100	49	100

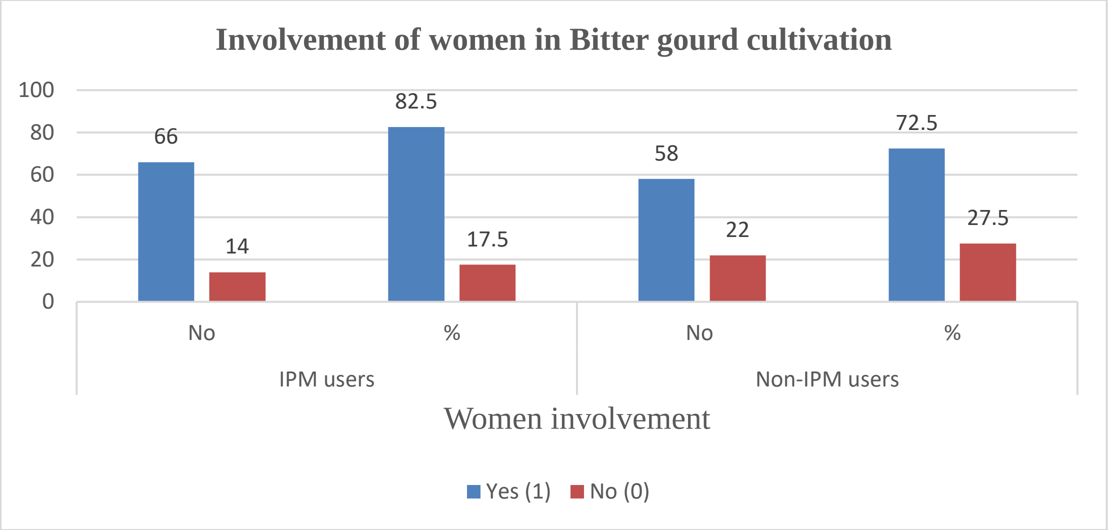
Source: Field survey, 2020

Agricultural credit provided to households by many sources which is presented in Table 4.8. Out of 160 households surveyed, 19 IPM users took loans (23.8%) and 30 (37.5%) non-IPM users took credit from different sources. From Table 4.8 we can see that the major sources of loan provider to Bitter gourd growers were NGOs. About 47.4 percent of the IPM users took loan from NGOs followed by bank (26.3%), friends and relatives (10.5%), neighbors (10.5%) and money lender (5.3%). In the case of non-IPM users, major source of credit was NGOs (43.4%) and only 3 percent took credit from money lender (Table 4.8).

4.15 Women Involvement in Bitter Gourd Producing Activities

Women were actively involved in various activities like weeding, transplantation, IPM usage and harvesting of Bitter gourd during the cultivation period in the study area. Based on the women participation in Bitter gourd cultivation, respondents were asked whether or not women were involved in the cultivation process.

Data presented in Figure 4.6 shows that highest proportion (82.5%) of IPM users agreed that women were involved in their Bitter gourd cultivation process and only 17.5 percent said that women were not involved in their cultivation period.



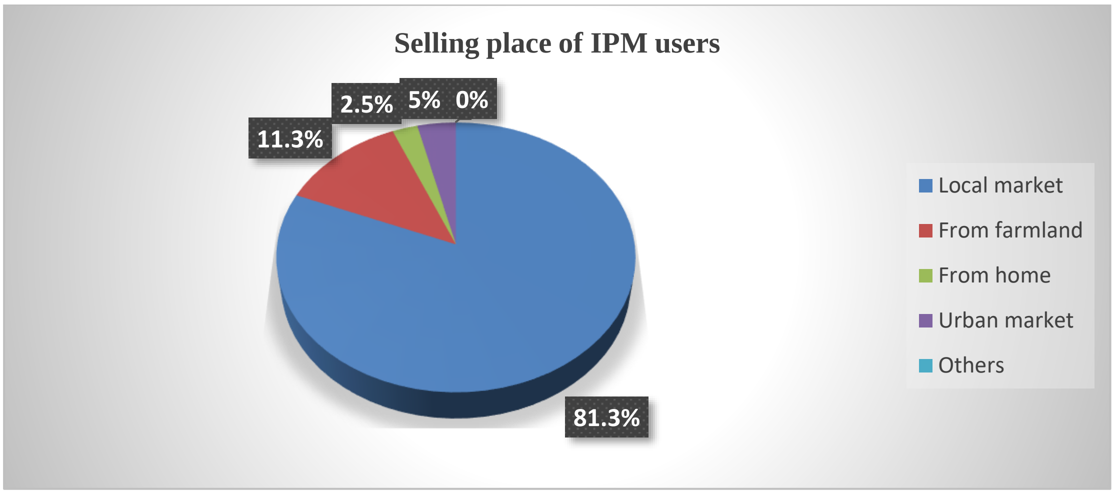
Source: Field survey, 2020

Figure 4.6: Distribution of respondents according to women involvement

In the case of non-IPM users, majority (72.5%) said that women were involved in various activities of Bitter gourd cultivation process and 27.5 percent farmer said that women were not involved in any other activities of cultivation. So, women were more involved in Bitter gourd cultivation of IPM users than non-IPM users.

4.16 Selling Place for Produced Bitter Gourd of the Sample Farmers

Bitter gourd growers in the study area sold their produced Bitter gourd in different places which was namely as local market, from farmland, from home urban markets and other places as shown in Figure 4.7.



Source: Field survey, 2020

Figure 4.7: Selling place of produced Bitter gourd for IPM users

Figure 4.7 shows that most (81.3%) of the IPM users sold their produced Bitter gourd in local market which was followed by 11.3 percent from farmland, 2.5 percent from home and remaining 5 percent in urban market.

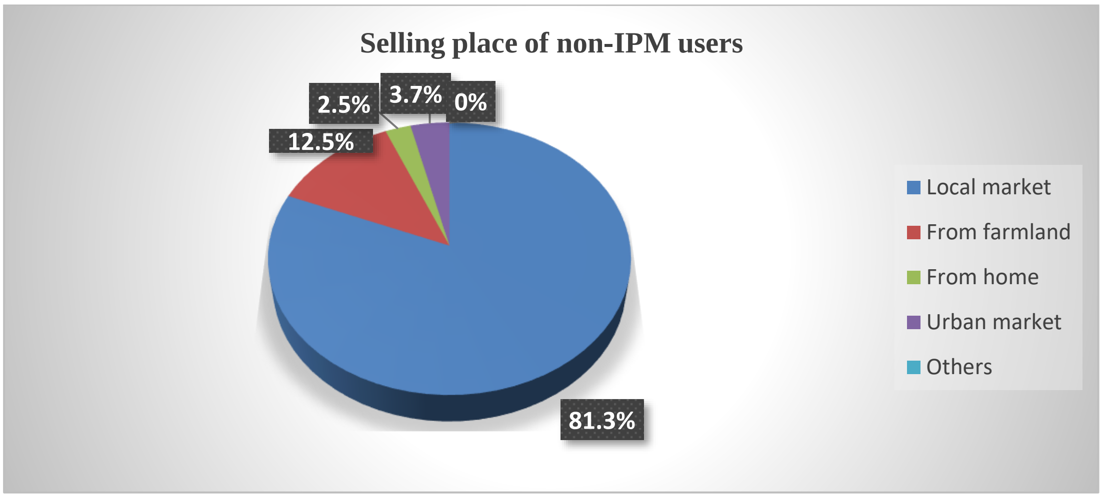


Figure 4.8: Selling place of produced Bitter gourd for non-IPM users

Figure 4.8 shows that most (81.3%) of the non-IPM users sold their produced Bitter gourd in local market which was followed by 12.5 percent from farmland, 2.5 percent from home and remaining 3.7 percent in urban market. Therefore, most (81.3%) of the Bitter gourd growers sold their produced Bitter gourd in local market which is more than national average (52.59%) who sell their agricultural produce in local market (BBS, 2018).

4.17 Concluding Remarks

Based on the descriptive evidence from this study, it was noticed that there were some variations in socioeconomic characteristics of IPM and non-IPM Bitter gourd growers. The results indicated that the IPM practicing farmers were in better-off condition than that of non-IPM farmers in most of the socioeconomic characteristics.

CHAPTER V

COMPARING PROFITABILITY OF BITTER GOURD CULTIVATION OF IPM AND NON-IPM FARMERS

5.1 Introduction

For every production process, cost plays a vital role for making right decision of the farmers. This chapter mainly deals with the estimation and analysis of costs of Bitter gourd production for both IPM users and non-IPM users. The costs were classified into variable costs and fixed costs. Most of the inputs were valued at the current market rate and sometimes governments' rates in the study area during the survey period or the prices at which farmers bought the inputs. But, for some unpaid inputs such as family labor, non-cash price was actually paid and pricing was very difficult in such cases. In these cases, the rule of opportunity cost was followed.

In this chapter, in terms of Bitter gourd cultivation per hectare yield, gross return, gross margin, net return and undiscounted benefit-cost ratio are discussed. Therefore, a financial return of producing Bitter gourd were calculated from the standpoint of IPM users and non-IPM users. All the returns were accounted for the study period. A brief account showing how the individual costs and returns were estimated in the present study is presented below. For analytical advantages, the cost items were classified under the following heads:

Table 5.1: Cost items of Bitter gourd cultivation

Cost item	
IPM users	**Non-IPM users**
Human labor cost	Human labor cost
Machinery cost	Machinery cost
Seed	Seed
Urea	Urea
TSP	TSP
MoP	MoP
Gypsum	Gypsum
Cow dung	Cow dung
Irrigation	Irrigation
Insecticides	Insecticides
IPM usage	Land use
Interest on operating capital and Land use cost	Interest on operating capital

5.2 Variable Costs of Bitter gourd

5.2.1 Cost of human labor

Human labor is one of the most important variable inputs in the production process. Human labor is required for various activities and management of the selected farms such as- land preparation, trellis making, sowing, weeding, sorting, applying fertilizes and insecticides, IPM usage, irrigation, harvesting and carrying etc. Human labor was classified into: (a) hired labor and (b) family labor. It is easy to calculate hired labor costs. To determine the cost of family labor, the opportunity cost concept was used. In this study, the opportunity cost of family labor was assumed to be as wage rate per man i.e., the wage rate, which the farmers actually paid to the hired labor for working a man-day. The labor of women and children was converted into man-equivalent day by presenting a ratio of 2 children day = 1.5 women days = 1-man equivalent day (Miah, 1987). In this study a man-day was considered to be 8 hours of work. For avoiding complexity, average rate has been taken into account. Labor wage rate varies with respect to different seasons. In the study area it varied from 500 to 700 Tk. Per man-days. Thus, the computed average rate was Tk. 600 per man-days for Bitter gourd cultivation. Use of human labor and its relevant cost incurred were shown in Table 5.2.

Hired human labor was the most essential and widely utilized input in generating both IPM and non-IPM bitter gourd agriculture. It accounted for a significant amount of the overall cost of bitter gourd growing for both IPM and non-IPM users. As shown in Table 5.2, the quantity of human labor required IPM users in Bitter gourd cultivation was 170 man-days per hectare. While this was 200 man-days per hectare for cultivation by non-IPM users (Table 5.3). The overall cost of human labor was calculated to be Tk. 102000.00 and Tk. 120000.00, representing 34.89 and 36.76 percent of the total cost of Bitter gourd cultivation, respectively, for IPM users and non-IPM users (Table 5.2 and Table 5.3).

Family labor was the most important and largely used input in producing both IPM user and Non IPM user Bitter gourd cultivation. It shared a large portion of total cost of IPM user and non-IPM user in Bitter gourd cultivation. It can be seen from Table 5.2 that the amount of human labor used for IPM user was 65 man-days per hectare. While this was 75 man-days per hectare for non-IPM user cultivation (Table 5.3). Total cost of human labor was estimated Tk. 39000.00 and Tk. 45000.00 covering 13.34 and 13.79

percent of total cost of IPM users and non-IPM users of Bitter gourd cultivation, respectively (Table 5.2 and Table 5.3).

5.2.2 Cost of machinery

The cost of machinery is divided into two components: land preparation and transportation. The most critical component of the agricultural process is land preparation. Plowing, laddering, and other operations were performed with the help of power tiller on the land to prepare it for Bitter Gourd production. Transportation costs included van, truck, rickshaw fee, and other transportation costs associated with transporting the bitter gourd at local marketplaces. Thus, the average machinery cost of bitter gourd cultivation was determined to be Tk. 11849.45 and 13988.97 per hectare, representing 4.05 and 4.29 percent of the total cost of bitter gourd cultivation, respectively, for IPM and non-IPM users (Table 5.2 and 5.3).

5.2.3 Cost of seed

The price of seed varied significantly according on its quality and availability. On average, farmers used 7.15 kg and 7.58 kg of seed, respectively, while using IPM and when not using IPM. Per kg seed cost ranged from TK.600-800 in the study area. The total cost of seed per hectare was calculated to be Tk. 5005.00 and Tk. 5284.72, representing 1.71 and 1.62 percent of the overall cost of Bitter gourd cultivation for IPM users and non-IPM users, respectively (Table 5.2 and 5.3).

5.2.4 Cost of urea

On an average, IPM users used 350.51 kg and non-IPM users used 350.81 kg of urea per hectare, respectively. The cost of urea per hectare was Tk. 5958.59 and Tk. 5963.84, which equals 2.04 and 1.83 percent of the total cost for IPM users and non-IPM users, respectively (Table 5.2 and 5.3).

5.2.5 Cost of TSP

On average, TSP is applied at a rate of 300.48 kg per hectare for IPM users and 290.11 kg per hectare for non-IPM users. The average cost of TSP was Tk. 10216.27 and Tk. 9863.73, respectively, representing 3.49 and 3.02 percent of the overall cost for IPM users and non-IPM users (Table 5.2 and Table 5.3).

Table 5.2: Per hectare cost of Bitter gourd cultivation for IPM users

Cost Items	Quantity	Price Per Unit (Tk.)	Costs (Tk./ha)	% of total
A. Variable Cost				
Machinery Cost (Land Preparation & Carrying Cost)			11849.45	4.05
Hired labor (man-days/ha)	170	600	102000.00	34.89
Family labor (man-days/ha)	65	600	39000.00	13.34
Seed cost (kg/ha)	7.15	700	5005.00	1.71
Urea (kg/ha)	350.51	17	5958.59	2.04
TSP (kg/ha)	300.48	34	10216.27	3.49
MOP (kg/ha)	200	15	3000.37	1.04
Gypsum (kg/ha)	99.94	17	1698.98	0.58
Cow dung (kg/ha)	19771.52	1.5	29657.29	10.14
Insecticides (Tk/ha)			10323.54	3.53
Irrigation (Tk/ha)			13009.07	4.45
Trellis Making cost (Tk/ha)			11892.46	4.07
IPM Cost (Tk/ha)			3814.40	1.30
Interest on operating capital			5567.06	2.54
Total Variable cost (TVC)			**252992.00**	**87.17**
B. Fixed Cost				
Land use cost			37500.00	12.83
C. Total costs (TC)			**290492.00**	**100.00**

Source: Field survey, 2020

5.2.6 Cost of MoP

MoP is applied at a rate of 200 kg per hectare on average for IPM users and 201.08 kg per hectare for non-IPM users. The average cost of MoP was Tk. 3000.37 and Tk. 3016.16, respectively, representing 1.03 and 0.92 percent of the total cost for IPM users and non-IPM users (Table 5.2 and 5.3).

5.2.7 Cost of gypsum

The average amount of gypsum applied per acre was 99.94 kg for IPM users and 101.35 kg for non-IPM users. The average cost of gypsum was Tk. 1698.98 and Tk. 1722.91, respectively, representing 0.58 and 0.36 percent of the total cost for IPM and non-IPM users (Table 5.2 and 5.3).

5.2.8 Cost of insecticides

Farmers utilized a variety of pesticides to keep their crops pest- and disease-free. The average cost of pesticides for IPM and non-IPM users was Tk. 10323.54 and Tk. 20003.15 per hectare of Bitter gourd cultivation, respectively (Table 5.2 and 5.3), which represented 3.53 and 6.13 percent of overall cost, respectively.

5.2.9 Cost of irrigation

The average cost of irrigation was determined to be Tk. 13009.07 for IPM users and Tk. 13497.70 for non-users per hectare of Bitter gourd production (Table 5.2 and 5.3), representing 4.45 and 4.13 percent of total cost, respectively.

5.2.10 Cost of trellis making

For trellis making farmers used bamboo and rope in the study area. The average cost of trellis construction was Tk. 11892.46 for IPM users and Tk. 12483.70 for non-IPM users per hectare of Bitter gourd production, respectively (Table 5.2 and 5.3), representing 4.07 and 3.82 percent of total cost, respectively.

5.2.11 Cost of IPM

IPM is an acronym for integrated pest management; it encompasses pheromone traps, yellow sticky traps, vermicompost, tricho compost, and soil amendments made from chicken waste, among other things. IPM costs averaged Tk. 3814.40 per hectare of Bitter gourd production (Table 5.2), accounting for 1.30 percent of overall costs.

5.2.12 Cost of cow dung

Farmers in the research region employed cow dung to produce their businesses. They purchased a substantial amount of cow excrement from milk producers. Cow dung or compost application rates for IPM users and non-IPM users were 19771.52 kg and 19780.64 kg per hectare, respectively, for Bitter gourd growing. And the cost of cow dung was Tk. 29657.29 for IPM users and Tk. 29670.95 for non-IPM users per hectare of Bitter gourd growing, respectively (Tables 5.2 and 5.3).

5.2.13 Interest on operating capital

Interest on operating capital was determined on the basis of opportunity cost principle. The operating capital actually represented the investment on different farm operation over the period because all the cost was not incurred at the beginning or at any single point of time. The cost was incurred throughout the whole production period; hence, at the rate of 9 percent per annum interest on operating capital for three months was computed for bitter gourd cultivation (Interest rate was taken according to the bank rate prevailing in the market during the study period). Interest on operating capital was calculated by using the following standard formula (Miah, 1992).

Interest on Operating Capital= Alit

Where,

Al= Average Investment (Total investment /4)

t = Total time period of a cycle

i= Interest rate which was 9 percent per year

It should be emphasized that interest on operational capital was computed by factoring in all operating expenditures incurred throughout the Bitter gourd growing season at 9% of the bank rate. The interest on operational capital for Bitter gourd cultivation was calculated to be Tk. 5567.06 per hectare for IPM users and Tk. 6311.16 per hectare for non-IPM users, respectively (Table 5.2 and Table 5.3).

5.2.14 Total variable cost

Thus, based on the aforementioned cost categories, the total variable cost of Bitter gourd cultivation was calculated to be Tk. 252922.00 and Tk. 286807.16 per hectare, representing 87.17 and 88.51 percent of the total cost, respectively, for IPM users and non-IPM users (Table 5.2 and Table 5.3).

5.3 Fixed Cost

5.3.1 Rental value of land

The rental value of land was determined using the opportunity cost of land usage per hectare during a three-month cropping cycle. The cash rental value of land was used to calculate the cost of land usage. According to statistics obtained from bitter gourd growers, the land usage cost per hectare is Tk. 37500. (Table 5.2 and 5.3).

Table 5.3: Per hectare cost of Bitter gourd cultivation for non-IPM users

Cost Items	Quantity	Price Per Unit (Tk.)	Costs (Tk./ha)	% of total
A. Variable Cost				
Machinery Cost (Land Preparation and Carrying cost)			13988.97	4.29
Hired labor (man-days/ha)	200	600	120000.00	36.76
Family Labor (man-days/ha)	75	600	45000.00	13.79
Seed (kg/ha)	7.58	700	5284.72	1.62
Urea (kg/ha)	350.81	17	5963.84	1.83
TSP (kg/ha)	290.11	34	9863.73	3.02
MOP (kg/ha)	201.08	15	3016.16	0.92
Gypsum (kg/ha)	101.35	17	1722.91	0.53
Cow dung (kg/ha)	19780.64	1.5	29670.95	9.09
Insecticides (Tk/ha)			20003.15	6.13
Irrigation (Tk/ha)			13497.70	4.14
Trellis Making Cost (Tk/ha)			12483.70	3.82
Interest on operating capital			6311.16	2.58
Total Variable cost (TVC)			**286807.16**	88.51
B. Fixed Cost				
Land use cost			37500.00	11.49
Total Fixed cost (TFC)			**37500.00**	11.49
C. Total costs (TC)			**324307.16**	100.00

Source: Field Survey, 2020

5.4 Total Cost (TC) of Bitter gourd Cultivation

To determine the overall cost per hectare, all resources used in IPM and non-IPM Bitter gourd cultivation were considered. As shown in Tables 5.2 and 5.3, the total cost of cultivation of Bitter gourd for IPM users and non-IPM users was Tk. 290492 and Tk. 324307.16 per hectare, respectively.

5.5 Return of Bitter gourd Cultivation

5.5.1 Gross return

The average output of Bitter gourd per hectare was calculated to be 22010.96 kg for IPM users and 21535.88 kg for non-IPM users, respectively (Table 5.4). Gross return on investment per hectare was determined by multiplying the total quantity of goods by the average farm price. According to Table 5.4, the gross return per hectare for IPM users and non-IPM users of Bitter gourd was Tk. 660329.00 and Tk. 646076.30, respectively.

Table 5.4: **Per hectare gross return of Bitter gourd cultivation**

Items	IPM users			Non-IPM users		
	Yield (kg/ha)	Price (TK./kg)	Return (TK./ha)	Yield (kg/ha)	Price (TK./kg)	Return (TK./ha)
Gross return	22010.9	30	660329	21535.8	30	646076.3

Source: Field survey, 2021.

5.5.2 Gross margin

Gross margin is the difference between the gross profit and variable costs. Farmers usually want to gain maximum return over variable cost of production. The probable reason is that estimation of fixed cost of production is difficult to determine. Thus, the gross margin analysis has been taken into account to calculate the relative profitability of bitter gourd cultivation. Gross margin can be calculated by subtracting total variable costs from gross return. The profit margin per hectare was calculated to be Tk. 407337.00 for IPM users and Tk.359269.14 for non-IPM users of Bitter gourd cultivation, respectively (Table 5.5).

5.5.3 Net return

In general net return is termed as entrepreneur's income. To evaluate the profitability of bitter gourd production, net return is an important aspect. Net return is the difference between gross return and total costs which is determined by deducting the whole expenditure from the total return. Bitter gourd's net return per hectare was Tk. 369837.00 for IPM users and Tk. 321769.14 for non-IPM users, respectively (Table 5.5).

Table 5.5: Difference between per hectare cost and return of Bitter gourd cultivation

Cost and Return Item	Cost/Returns (Tk/ha) IPM user	Cost/Returns (Tk/ha) non-IPM user
A. Gross Return	660329.00	646076.30
B. Total Variable Cost (TVC)	252992.00	286807.16
C. Total Fixed Cost (TFC)	37500.00	37500.00
D. Total costs (TC)	290492.00	324307.16
E. Gross Margin (A-B)	407337.00	359269.14
F. Net Return (A-D)	369837.00	321769.14
G. Undiscounted BCR (A/D)	2.27	1.99

Source: Field survey, 2020

5.6 Benefit Cost Ratio (Undiscounted)

Benefit cost ratio was calculated by dividing gross return by gross cost or total cost. It implies return per taka invested. It helps to analyze financial efficiency of the farm. The BCR of IPM and non-IPM users of Bitter gourd was computed in the research as the ratio of gross return to gross cost.

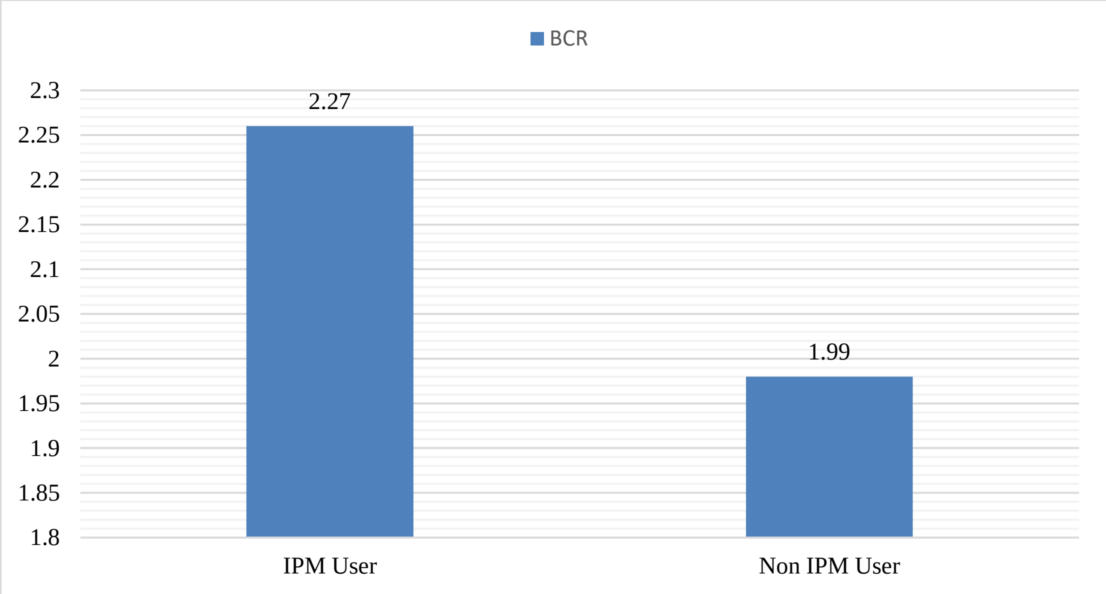


Figure 5.1: Comparative BCR of IPM user and non-IPM user of Bitter gourd

The undiscounted benefit cost ratios for IPM and non-IPM users for cultivating Bitter gourd per hectare were 2.27 and 1.99, respectively, implying that Tk. 2.27 would be earned by investing Tk. 1.00 for bitter gourd production in case of IPM users and Tk. 1.99 would be earned by investing Tk. 1.00 for non-IPM users of bitter gourd. So, bitter gourd cultivation for both IPM and non-IPM users was found highly profitable but IPM users was more profitable than non-IPM users (Table 5.5).

5.7 Independent Sample t-test to Compare Profitability Between IPM users and non-IPM users

Independent sample t-test is a statistical technique that is used to analyze the mean comparison of two independent groups.

5.7.1 Independent sample t-test for Yield

From Table 5.6, it was demonstrated that the estimated value of p (0.036) was less than significance level (0.05) which indicates the null hypotheses was rejected and there was statistically significant difference between mean yield of IPM users and non-IPM users. An independent sample t-test was used to compare the mean yield of IPM users (n=80) and non-IPM users (n=80) of bitter gourd growers. Neither Shapiro-Wik statistics was significant, indicating the assumption of normality was not violated. Levene's test was also non-significant, thus an equal variance can be assumed for both groups. Therefore, an independent sample t-test was run on the data with a 95% confidence interval (CI) for the mean difference. It was found that mean yield of IPM users (M=22010.9, SD=1417.10) was significantly higher (mean difference 475.11, 95% CI [32.14,918.1], than non-IPM users (M= 21535.79, SD= 1419.77), t (158) = 2.118, P = .036, two tailed. The calculated value of Cohen's d was 0.33 which concluded a medium size effect between the mean yield of IPM users and non-IPM users (Table 5.6).

Table 5.6: Estimated values of t statistic, p-value and effect size for IPM users and non-IPM users

Variables	Adapter	N	M	SD	t statistc	p value	df	Decision
Yield	IPM user	80	22010.9	1417.10	2.118	0.036	158	Reject H_0
	Non-IPM user	80	21535.79	1419.77				
Gross return	IPM user	80	660327.11	42513.02	2.118	0.036	158	Reject H_0
	Non-IPM user	80	646073.82	42593.35				
Net return	IPM user	80	369837	41793.9	7.275	0.000	158	Reject H_0
	Non-IPM user	80	321769.1	41776.5				

Variable	Levene's test	Mean difference	Cohen's d	Effect size
Yield	.224	475.1	0.33	Medium effect
Gross return	.224	14253.3	0.33	Medium effect
Net return	.242	48067.9	1.15	Large effect

Source: Field survey, 2020

5.7.2 Independent sample t-test for gross return

From Table 5.6, it was demonstrated that the estimated value of p (0.036) was less than significance level (0.05) which indicates the null hypotheses was rejected and there was statistically significant difference between means gross return of IPM users and non-IPM users.

An independent sample t-test was used to compare the mean gross return of IPM users (n=80) and non-IPM users (n=80) of bitter gourd growers. Neither Shapiro-Wik statistics was significant, indicating the assumption of normality was not violated. Levene's test was also non-significant, thus an equal variance can be assumed for both groups. Therefore, an independent sample t-test was run on the data with a 95% confidence interval (CI) for the mean difference. It was found that mean gross return of IPM users (M=660327.1, SD=42513.02) was significantly higher (mean difference 14253.29, 95% CI [964.8, 27542.2], than non-IPM users (M= 646073.8, SD= 42593.3), t (158) = 2.118, P = .036, two tailed. The calculated value of Cohen's d was 0.33 which concluded a medium size effect between the mean gross return of IPM users and non-IPM users (Table 5.6).

5.7.3 Independent sample t-test for Net return

From Table 5.6, it was demonstrated that the estimated value of p (0.000) was less than significance level (0.05) which indicates the null hypotheses was rejected and there was statistically significant difference between means net return of IPM users and non-IPM users of Bitter gourd. An independent sample t-test was used to compare the mean net return of IPM users (n=80) and non-IPM users (n=80) of bitter gourd growers. Neither Shapiro-Wik statistics was significant, indicating the assumption of normality was not violated. Levene's test was also non-significant, thus an equal variance can be assumed for both groups. Therefore, an independent sample t-test was run on the data with a 95% confidence interval (CI) for the mean difference. It was found that mean net return of IPM users (M=369837, SD=41793.9) was significantly higher (mean difference 48067.9, 95% CI [35018.8, 61116.9], than non-IPM users (M= 321769.1, SD= 41776.5), t (158) = 7.275, P = .000, two tailed. The calculated value of Cohen's d was 1.15 which concluded a large size effect between the mean net return of IPM users and non-IPM users (Table 5.6).

5.8 Concluding Remarks

The overall findings for IPM and non-IPM users of Bitter gourd were reported in Table 5.5. They included yield per hectare, gross return, gross margin, net return, and BCR. It is clear that both IPM-administered and non-IPM-administered Bitter gourd cultivation were lucrative. Additionally, IPM users who cultivate Bitter gourd get greater profits than non-IPM users who cultivate Bitter gourd (Table 5.5 and Figure 5.1). From Table 5.6, it was found that mean yield, mean gross return and net return of IPM users was significantly higher than non-IPM users of bitter gourd. This finding also matched the findings of Islam *et al*. (2017), Akter *et al*. (2016) Akhi *et al.* (2020), Islam *et al.* (2013), Das *et al.* (2016) and Jahan *et al.* (2016).

CHAPTER VI

FACTORS AFFECTING YIELDS OF BITTER GOURD CULTIVATION FOR IPM AND NON-IPM USERS

6.1 Introduction

An attempt has been made this chapter to identify and measure the effects of the major variables on Bitter gourd production for both IPM users and non-IPM users. Cobb-Douglas production function was chosen to estimate the contribution of key variables on the production process of Bitter gourd cultivation. The estimated values of the model are presented in Table 6.1.

6.2 Functional Analysis for Identifying the Factors Affecting in Production

Production function is a relation or a mathematical function specifying the maximum output that can be produced with given inputs. Keeping in mind the objectives of the study and considering the effect of explanatory variables on output of Bitter gourd cultivation, eleven explanatory variables for IPM users and ten explanatory variables for non-IPM users were chosen to estimate the quantitative effect of inputs on output. Management factor was not included in the model because specification and measurement of management factor is almost impossible particularly in the present study, where a farm operator is both a labor and manager. Other independent variables like water quality, soil condition, time etc., which might have affected production of farm enterprises, were excluded from the model on the basis of some preliminary estimation. A brief description is presented here about the explanatory variables included in the model.

6.3 Estimated Values of the Production Function Analysis

i. F-value was used to measure the goodness of fit for different types of inputs.

ii. The coefficient of multiple determinations (R^2) indicates the total variations of output explained by the independent variables included in the model.

iii. Coefficients having sufficient degrees of freedom were tested for significance level at 1 percent, 5 percent and 10 percent levels of significant.

iv. Stage of production was estimated by returns to scale which was the summation of all the production elasticity of various inputs.

The estimated coefficients and related statistics of the Cobb-Douglas production function for Bitter gourd production are shown in Table 6.1.

Table 6.1: Estimated values of coefficients and related statistics of Cob-Douglas production function

Explanatory variables	Coefficients	Standard error	P – value
Human labor (X_1)	-0.136*	0.119	0.063
Power tiller (X_2)	-0.258***	0.111	0 .000
Trellis making (X_3)	0.084	0.368	0.261
Seed (X_4)	0.095**	0.163	0.020
Urea (X_5)	0.376**	0.226	0.010
TSP (X_6)	0.232**	0.123	0.012
MoP (X_7)	-0.310***	0.217	0.008
Gypsum (X_8)	0.029	0.301	0.764
Cow dung (X_9)	0.358***	0.098	0.000
Irrigation (X_{10})	0.199*	0.114	0.087
Adoption (X_{11})	0.015	0.139	0.788
Constant	2.120	6.103	0.729
R^2	.528		
Adjusted R^2	.493		
F – value	15.05		
Observation	160		

Source: Field survey, 2020

Note: *** Significant at 1 percent level; * Significant at 10 percent;

** Significant at 5 percent level

NS: Not Significant

6.4 Interpretation of Results

Effect of human labor (X_1):

From Table 6.1, it can be seen that in case of Bitter gourd growers, the value of the coefficient of human labor (-0.136) was negative and significant at 10 percent level of significance which indicates that at 1 percent increase in the use of human labor keeping other factors constant yield of Bitter gourd would decrease 0.136 percent. In the study area most of the Bitter gourd farmers was unskilled and had very little knowledge about usage of IPM in Bitter gourd cultivation procedure. So, result showed that unskilled labor negatively affects the growth of Bitter gourd.

Effect of power tiller (X_2):

From the Table 6.1, it can be seen that the value of the coefficient of power tiller (-0.258) was negative and significant at 1 percent level of significance which indicates that at 1 percent increase in the cost of power tiller keeping other factors constant yield of Bitter gourd would decrease 0.258 percent in the study area.

Effect of seed (X_4):

From the Table 6.1, it was found that the value of coefficient of seed (0.095) was positive and significant at 5 percent level of significance for Bitter gourd which indicates that at 1 percent increase in quantity of seed keeping other factors constant would increase the yield of Bitter gourd by 0.095 percent.

Effect of urea (X_5):

It was observed from the regression that the value of coefficient of the use of urea (0.376) was positive and significant 5 percent level of significance which indicates that at 1 percent increase in the quantity of urea keeping other factors constant would increase the yield of Bitter gourd by 0.376 percent in the study area (Table 6.1).

Effect of TSP (X_6):

It was found from the Table 6.1 that the value of the coefficient of the use of TSP (0.232) was positive and significant at 5 percent level of significance which indicates that at 1 percent increase in the use of TSP remaining other factors constant would increase the yield of Bitter gourd by 0.232 percent.

Effect of MOP (X_7):

It was observed from the regression, that the value of coefficient of the use of MOP (-0.310) was negative but significant at 1 percent level of significance which indicates that at 1 percent increase in the use of MOP remaining other factors constant would decrease the yield of Bitter gourd by 0.310 percent (Table 6.1).

Effect of cow dung (X_9):

From the Table 6.1, it can be seen that the value of the coefficient of the use of cow dung (0.358) was positive and significant at 1 percent level of significance which indicates that at 1 percent increase in the use of cow dung keeping other factors constant would increase the yield of Bitter gourd by 0.358 percent.

Effect of irrigation (X_{10}):

It was observed from the regression analysis that the coefficient of the irrigation (0.199) was positive and significant at 10 % level of significance which indicates that at 1 percent increase the application of irrigation remaining other factors constant would increase the yield of Bitter gourd by 0.198 percent (Table 6.1).

6.5 Coefficient of Multiple Determinations (R^2)

The values of the coefficient of multiple determination of Bitter gourd production were found to be 0.528 which implied that about 52.8 percent of the total variation in the yield (Kg/ha) could be explained by the included explanatory variables of the model. So, we can say the goodness of fit of this regression model is better since R^2 indicates the goodness of fit of the regression model (Table 6.1).

6.6 Adjusted R^2

Here the term adjusted means adjusted for the degrees of freedom. The adjusted R^2 for Bitter gourd production was found to be 0.493 which indicated that about 49.3 percent of the variations of the output were explained by the explanatory variables included in the model (Table 6.1).

6.7 F- value

The F-statistic was computed to denote the overall goodness of fit of any fitted model. The F-value for the Bitter gourd production was estimated at 15.05 which were significant at 1 percent level. It means that the explanatory variables included in the model were important for explaining the variation in yield of Bitter gourd production (Table 6.1).

6.8 Concluding Remarks

It was evident from the Cobb-Douglas production function model that seed, urea, TSP, cow dung and irrigation which was included in the model for bitter gourd growers had significant and positive effect on Bitter gourd production. On the other hand, human labor, power tiller cost, MoP had significant but negative effect on Bitter gourd production except the insignificant effect of gypsum, trellis making and adoption. So, there was a positive effect of many key factors in the production process of year-round Bitter gourd cultivation. It is possible to increase the yield of Bitter gourd for both IPM users and non-IPM users by increasing the number of skilled labor and importing improved verity seed and seedlings.

CHAPTER VII

PROBLEMS IN ADOPTING AND PRACTICING IPM TECHNOLOGY

7.1 Introduction

Bitter gourd cultivation as a source of livelihood has been an age-old practice for thousands of vegetable farmers in Bangladesh. But the use of IPM in vegetable cultivation is not widely accepted for many of the vegetable farmers in Bangladesh. In the present study, an attempt had been made to identify and analyze the major problems faced by the farmers which act as main barriers in practicing, adopting and enhancing IPM technology in the cultivation of Bitter gourd.

7.2 Problems Faced by Bitter Gourd Growers in Adopting and Practicing IPM Technology

Various problems were faced by the IPM users and IPM non-users in adopting and practicing IPM technology in the study areas. Bitter gourd growers were asked to give their opinion on eight (8) selected problems which were identified during data collection. Eight selected problems were lack of proper training facility, lack of technological knowledge in using IPM technology, weak extension services, unavailability of pheromone trap, labor scarcity, lack of knowledge on harmful effects of insecticides, unavailability of skilled labor and lack of awareness. A four-point rating scale was used for computing the problem score of a respondent. The computed PCI of the eight (8) problems ranged from 50 to 204 (against a possible range from 0 to 240) for IPM users and 58 to 202 for non-IPM users (against a possible range from 0 to 240) which have been presented in Table 7.1.

7.2.1 Lack of proper training facilities

Majority of the IPM farmers pointed out that lack of proper training facilities was the main problem in the study areas in practicing and adopting IPM technology. It was also one of the major problems faced by the non-IPM farmers. Because of the biased selection, they did not get any training on practicing IPM technology and detailed information about this technology. Out of 80 IPM users, 54 (67.5%) farmers confronted this problem at high extent, 20 (25%) farmers confronted at medium extent, 2 (2.5%) farmers confronted at low extent 4 (5%) IPM users confronted it as no problem at all. (Table 7.1). In this case, the computed value of PCI was 204 against a possible range from 0 to 240 and standardized PCI was 85 which made it 1st ranked problem (Table 7.1) for IPM users. On the other hand, for non-IPM users, 45 (56.3%) farmers confronted this problem at high extent, 18 (22.5%) farmers confronted at medium extent, 17 (21.2%) farmers confronted at low extent (Table 7.2). In this case, the computed value of PCI was 188 against a possible range from 0 to 240 and standardized PCI was 78.3 which made it 2nd ranked problem (Table 7.2) for non-IPM users.

7.2.2 Lack of technological knowledge in using IPM technology

A good number of farmers point out that, lack of technological knowledge in using IPM technology was an important problem in the study areas. Basically, the reason behind this was the lack of training facilities in the study areas. Most of the farmers did not have clear ideas about IPM technology. On the other hand, many of them believed that pesticides were easy to apply and available in all the retailers and they did not want to take risk without pesticides. From Table 7.1, we can see that only 38 (47.5%) IPM users confronted this as high problem, 24 (30%) as medium problem, 18 (22.5%) as low problem. The calculated value of PCI was 180 against a possible range from 0 to 240 and standardized PCI was 75 for IPM users and was considered as the 2nd ranked problem (Table 7.1). In case of non-IPM users, 56 (70%) farmers mentioned this as high problem, 16 (20%) farmers as medium problem, 2(2.5%) mentioned it as low extent problem and only 6 (7.5%) mentioned it as no problem. The calculated value of PCI was 202 against a possible range from 0 to 240 and standardized PCI was 84.2 and was considered as the 1st ranked problem (Table 7.2) for non-IPM users.

7.2.3 Weak extension services

Weak extension services were a problem which was mentioned by 35 (43.8%) bitter gourd growers as high, 24 (30%) farmers as medium, 17 (21.3%) farmers as low and 4 (5%) farmers mentioned no problem which made it 3rd ranked problem in rank order for IPM users. In this case calculated value of PCI was 170 against a possible range from 0 to 240 and standardized PCI was 70.8 (Table 7.1). On the other hand, calculated value of PCI was 167 and standardized PCI was 69.6 for non-IPM users (Table 7.2). For non-IPM users, it was considered as 3rd ranked problem. This was due to lack of coordination between extension workers and farmers and not receiving the opportunity to get services by the extension workers in time of necessity. Sometimes extension workers selected same farmers for training over and over again because of their biasness which made other farmers deprived in receiving any lessons and they felt discourage. This situation indicated weak extension services in the study area.

7.2.4 Unavailability of pheromone trap

Comparatively fewer problem confronted by the farmers was unavailability of pheromone trap, that means it was not a serious problem by the farmers. This is due to because, it was available in the local market, was not costly and farmers in the study area might easily get it if they wish to use it in the farming system which made it the least problem mentioned by the farmers among other problems. PCI of this problem found to be 50 against a possible range from 0 to 240 and standardized PCI was 20.8 (Table 7.1) for IPM users. From Table 7.2 we can see that PCI of this problem for non-IPM users found to be 58 and standardized PCI was 24.2 which made it least mentioned problem by the farmers.

7.2.5 Labor scarcity

The shortage of agricultural laborer is nothing new. It became acute during the harvesting time of major food crops in the study area. Because it was also the time of sowing of Bitter gourd. Migration of farm laborers to urban areas and their switching over to better-paying occupations were largely responsible for the shortage. Data presented in Table 7.1 indicated that labor scarcity was a problem which was mentioned by 15 (18.8%) bitter gourd growers as high,18 (22.5%) farmers as medium, 8 (10%) farmers as low and 39 (48.8%) farmers as not at all due to unavailability of labor during the cropping season. PCI of these problem was 89 and standardized PCI was 37.1 which was ranked as 5th in rank order for IPM users (Table 7.1). On the other hand, data presented in Table 7.2 indicated that labor scarcity problem was mentioned by 37 (46.2%) bitter gourd growers as high,18 (22.5%) farmers as medium, 6 (7.5%) farmers as low and 19 (23.8%) farmers as no problem at all due to unavailability of labor during the cropping season. PCI of these problem was 153 and standardized PCI was 63.7 (Table 7.2) for non-IPM users which made it 4th ranked problem in rank order.

Table 7.1: Summary of IPM users problem confrontation along with rank order

Sl. No.	Problems	Extent of problem confrontation (N=80)				PCI	Standardized PCI = (PCI / H.P. PCI) × 100	Rank order
		High (3)	Medium (2)	Low (1)	Not at all (0)			
1	Lack of proper training facilities	54	20	2	4	204	85	1
2	Lack of technological knowledge in using IPM technology	38	24	18	0	180	75	2
3	Weak extension services	35	24	17	4	170	70.8	3
4	Unavailability of pheromone trap	0	15	20	45	50	20.8	8
5	Labor scarcity	15	18	8	39	89	37.1	5
6	Lack of knowledge on the harmful effect of insecticides	2	21	17	40	65	27.1	7
7	Unavailability of skilled labor	23	12	6	39	99	41.2	4
8	Lack of awareness	5	14	25	36	68	28.3	6

Source: Field survey, 2020

7.2.6 Lack of knowledge on the harmful effect of insecticides

Overuse and lack of safety precautions followed during pesticide application amongst vegetable growers in Bangladesh are serious threats to sustainable food security, food safety, farmers' health and the environment. In the study area. most of the time farmers did not follow the prescribed dose and only followed the instructions of the pesticide retailers which was more or less overly instructed the dose. Majority of the farmers in the study area believed that applying more pesticide would ensure more productivity of their vegetable produce and they unconsciously hindered his/her health and surroundings.

Table 7.2: Summary of non-IPM users' problem confrontation along with rank order

Sl. No..	Problems	Extent of problem confrontation (N=80)				PCI	Standardized PCI = (PCI / H.P. PCI) × 100	Rank order
		High (3)	Medium (2)	Low (1)	Not at all (0)			
1	Lack of proper training facilities	45	18	17	0	188	78.3	2
2	Lack of technological knowledge in using IPM technology	56	16	2	6	202	84.2	1
3	Weak extension services	31	29	16	4	167	69.6	3
4	Unavailability of pheromone trap	0	18	22	40	58	24.2	8
5	Labor scarcity	37	18	6	19	153	63.7	4
6	Lack of knowledge on the harmful effect of insecticides	8	20	19	33	83	34.6	7
7	Unavailability of skilled labor	31	15	7	27	130	54.2	5
8	Lack of awareness	9	19	34	18	99	41.2	6

Source: Field survey, 2020

Lack of knowledge on the harmful effects of insecticides was a problem which was mentioned by 2 (2.5%) farmers as high, 21 (26.2%) farmers as medium, 17 (21.3%) farmers as low and 40 (50%) farmers as no problem at all with a PCI score of 65 and standardized PCI was 27.1 which made it as 7th problem in rank order for IPM users (Table 7.1). Data presented in Table 7.2 indicated that PCI for non-IPM users was 83 and standardized PCI was 34.6 which made it 7th ranked problem in the rank order.

7.2.7 Unavailability of skilled labor

Due to lack of knowledge on IPM technology and how it works, researcher found that many agricultural laborers in the study area could not use IPM properly on their vegetables and questioned about the effectiveness of IPM. Although IPM in vegetable started in Bangladesh a long time ago, farmers in study area still not used it as frequently as pesticides. Therefore, it was not easy to find skilled labor for practicing IPM. It was a problem which was ranked as 4th in rank order with a PCI score of 99 and standardized PCI was 41.2 for IPM users (Table 7.1). Among 80 non-IPM users, 31 (38.8%) Bitter gourd indicated it as high problem, 15 (18.7%) farmers as medium problem, 7 (8.7%) farmers as low problem and remining 27 (33.8%) farmers indicated it as no problem at all in adopting and proacting IPM technology in the study area. It was a problem which was ranked as 5th in rank order with a PCI of 130 and standardized PCI of 54.2 for non-IPM users (Table 7.2).

7.2.8 Lack of awareness

Lack of awareness ranked as a problem which was mentioned by 5 (6.3%) farmers as high problem, 14 (17.5%) farmers as medium problem, 25 (31.2%) farmers as low and 36 (45%) farmers as no problem at all in adopting and practicing IPM technology in case of IPM users (Table 7.1). PCI score was recorded as 68 and was considered as 6th ranked problem in 6th rank order. Data presented in Table 7.2 indicated that PCI for non-IPM users was 99 and standardized PCI was 41.2 which made it 6th ranked problem in the rank order. This was due to many farmers unaware about the environmental and health hazard caused by overuse of pesticides and they were not confident enough of the effectiveness of IPM practices. Many farmers thought that use of IPM is troublesome and it was not available as frequent as pesticides in the study area. Therefore, the perception about the benefits of using IPM practices were largely lacking among the farmers and adequate motivational program were also lacking at the field level. As a result, the farmers could not acquire enough confidence on IPM technologies.

7.3 Concluding Remarks

Among various problems in adopting and practicing IPM technology in Bitter gourd, lack of proper training facilities especially in different aspects of IPM technology was ranked 1st in the study area which was followed by lack of technological knowledge on IPM and weak extension services for IPM users. In the study area, unavailability of pheromone trap was the least mentioned problem in adopting and practicing IPM technology for IPM users of bitter gourd. On the other hand, lack of technological knowledge on IPM was ranked 1st which was followed by lack of proper training facilities and weak extension services for non-IPM users and unavailability of pheromone trap was the least mentioned problem in the study area.

CHAPTER VIII

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

This Chapter summaries the thesis and provides conclusions according to the important findings of the study and suggests some recommendations for Bitter gourd production.

8.1 Summary

In Bangladesh vegetables are not equally produced throughout the year. vegetables are grown generally in summer and winter seasons. In summer the major vegetables grown are cucurbits and Bitter gourd is one of the major cucurbitaceous vegetables. But the production of bitter gourd is hindered due to several factors like insect, pests and disease. Integrated Pest Management (IPM) is an appropriate package of technology for pest management, which is most economical and less hazardous to the environment. Therefore, this study will add some valuable information to the existing body of knowledge regarding use of IPM technology in bitter gourd production particularly with respect to the area under study. Keeping this in view the study was undertaken with the following specific objectives.

- To compare the socio-economic status of the users and non-users of IPM;
- To compare the profitability of bitter gourd production between IPM users and non-IPM users in the study area;
- To identify the factors affecting the production of bitter gourd cultivation for IPM users and non-IPM users;
- To find out problems face by Bitter gourd growers in adopting and practicing IPM technology in the study area.

To achieve the objectives of the present study, a preliminary survey was conducted in four villages of Shibpur upazila under Narsingdi district. In the present study a total of 160 Bitter gourd farmers were selected randomly of which 80 farmers were IPM users and 80 of them were non-IPM users. The researcher herself collected necessary data from the respondents during the month of August-October, 2020 through personal interview. For data entry and data analysis, the Microsoft Excel programs, SPSS programs were used. Tabular technique was applied to classify data in order to derive meaningful findings by using simple statistical measures like means, percentage and ratios. A production function analysis was carried out to find the productivity and contribution of the individual inputs.

According to socio-economic profile of the respondents, most of the IPM users were in young (28.7%) and middle (46.3%) age group while that of the non-IPM users were in middle (51.2%) and old (40%) aged group. On the basis of gender, majority (93.75%) of the bitter gourd growers for both IPM users and non-IPM users were male and Islam was the religion of the majority of IPM users (91.3%) and non-IPM users (88.7%) which is followed by Hindu religion and counted as 8.7 percent for IPM users and 11.3 percent for non-IPM users of Bitter gourd. The educational status of the bitter gourd growers indicated that highest proportion (33.8%) of IPM users had secondary level of education, 31.3 percent IPM users had primary level of education and 26.3 percent of the IPM users had no formal education and they only can sign their name. On the other hand, for non-IPM users' majority (46.20%) had primary level of education followed by 31.25 percent belonged to a category who can sign only, 18.75 percent were illiterate. Based on family size, a large number of (57.5%) IPM farmers and non-IPM users (67.5%) had a medium size family. In the study area, agriculture was the main occupation for both IPM users (50%) and non-IPM users (57.55) of Bitter gourd growers and vegetable cultivation was one of the major sectors of subsidiary occupation of the farmers. The average farm size of IPM farmers (0.63 ha) was more than that of non-IPM farmers (0.51 ha) in the study area and non-IPM users were more experienced (15.76 years) in farming than IPM users (12.54 years). The study also revealed that most (95.6 percent) of the respondents in the study area were low to medium income earners and expenditure on food was the highest proportion of expenditure for both IPM users and non-IPM users. The majority of the Bitter gourd growers had low (37.5%) and medium (25%) training exposure and 45 percent of non-IPM users had no training experience and there was no farmer found who had high training experience in the study area. The result also indicated that about 23.8 percent IPM users and 37.5 percent non-IPM users were taken credit for their production. In the case of IPM users (82.5%), women were more involved in cultivation activities than non-IPM users (72.5%) and most (81%) of the IPM users non-IPM users (82%) sold their produced Bitter gourd in local market.

To determine the profitability of Bitter gourd in the study area, the items of costs include fertilizer, seed, labor cost, land cost, irrigation cost, cow dung cost IPM cost and cost on operating capital @ 9 percent in 3 months. Human labor cost is the most important cost for any production process which was covered 48.43 percent cost of total cost for IPM users and 50.55 percent for non-IPM users. Cost and returns were worked out to estimate profitability of Bitter gourd production. Per hectare total cost, gross return, net return and gross margin were Tk. 290492, Tk. 660329, Tk. 369837 and Tk. 407337 respectively for IPM users of Bitter gourd and Tk. 324307.16, Tk. 646076.30, Tk. 321769.14 and Tk. 359269.14 respectively for non-IPM users. Undiscounted benefit cost ratio of were 2.27 for IPM users and 1.99 for non-IPM users. Therefore, IPM users received more profit than non-IPM users of Bitter gourd. Independent sample t-test was conducted to compare profitability between IPM users and non-IPM users. An independent sample t-test was run on the data with a 95% confidence interval (CI) for the mean difference. It was found that mean yield of IPM users (M=22010.9, SD=1417.10) was significantly higher (mean difference 475.11, 95% CI [32.14,918.1], than non-IPM users (M= 21535.79, SD= 1419.77), t (158) = 2.118, P = .036, two tailed. It was also found that mean gross return of IPM users (M=660327.1, SD=42513.02) was significantly higher (mean difference 14253.29, 95% CI [964.8, 27542.2], than non-IPM users (M= 646073.8, SD= 42593.3), t (158) = 2.118, P = .036, two tailed. At length, it was found that mean net return of IPM users (M=369837, SD=41793.9) was significantly higher (mean difference 48067.9, 95% CI [35018.8, 61116.9], than non-IPM users (M= 321769.1, SD= 41776.5), t (158) = 7.275, P = .000, two tailed.

In this study, Cobb-Douglas production function model was used to determine the effects of key variable inputs. The regression coefficients of urea were positive and significant at 1 percent levels which indicate that on an average 1% increase in use of urea other things keeping constant would increase the yield of Bitter gourd at 0.358 percent. Similarly, seed, use of TSP, irrigation, cow dung had positive and significant effect on the yield of Bitter gourd. On the other hand, the regression coefficients of human labor, power tiller and MoP indicated that they had negative and significant effect on the production of bitter gourd. In case of bitter gourd production, R^2 was found to be 0.529 which implied that about 52.9 percent of the total variation in the yield (Kg/ha) could be explained by the included explanatory variables of the model. The F-value for Bitter gourd production was 15.05 along with 1 percent significant level.

Among various selected problems in adopting and practicing IPM technology in Bitter gourd, lack of proper training facilities especially in different aspects of IPM technology was ranked 1st with a PCI score of 204 in the study area which was followed by lack of technological knowledge on IPM (PCI score 180) and weak extension services (170) for IPM users. Lack of technological knowledge on IPM (PCI was 202) was ranked 1st which was followed by lack of proper training facilities (PCI was 188) and weak extension services (PCI was 167) for non-PM users. In the study area, unavailability of pheromone trap was the least mentioned problem in adopting and practicing IPM technology for both IPM users and non-IPM users.

8.2 Conclusion and Policy Recommendations

Findings of the study and the logical interpretation of their meanings in the light of other relevant facts enabled the researcher to draw the following conclusions:

- Average age of IPM users (39.8 years) were less than the average age of non-IPM users (46.7 years). This implies that younger farmers are more interested in IPM.
- IPM users of Bitter gourd were more educated than non-IPM users. This implies that educated people are more innovative and more conscious about scientific agriculture by using IPM for crop pest management.
- The average family size for both IPM users and non-IPM users of Bitter gourd is more than that of national average.
- Agriculture is the main occupation for both IPM users and non-IPM users. But number of farmers involve in agriculture as main occupation is higher for non-IPM users.
- The average farm size of IPM users of Bitter gourd is more than that of non-IPM users but less than national average rural area farm size.
- Non-IPM farmers have more farming experienced than IPM farmer as number of old age farmer is higher in non-IPM.
- Annual family income was higher for IPM users compare to non-IPM users of Bitter gourd. This fact leads to the conclusion that IPM users are in better off condition than non-IPM users.
- IPM users of Bitter gourd has received more training than non-IPM users.
- Organizational participation is comparatively higher for IPM users than non-

IPM users.

- Cost of production of bitter gourd is higher for non-IPM users compared to IPM users due to high pesticide cost and requirements of more labor for applying insecticides.
- Bitter gourd production is profitable for both IPM and non-IPM users but IPM users are more profitable than non-IPM users as BCR is higher for them.
- Seed, urea, TSP, irrigation and cow dung has positive and significant role in the yield of bitter gourd while human labor, power tiller and MoP has negative and significant effect in the yield of Bitter gourd.
- Lack of proper training facilities, lack of technological knowledge on IPM and weak extension services are the main problem confronted by farmers in adopting and practicing IPM technology.

Recommendations based on the findings and conclusions of the study are presented below:

- Adequate training should be provided to the vegetable growers on different aspects of IPM technology like seed treatment, pheromone traps, sticky traps, neem oil, vermicompost, biopesticides, parasitoids etc. so that the rate of adoption could be gradually increased in the study area.
- Farmer's awareness and motivation could be accelerated through training, demonstration plot, group meeting of farmers, field day etc.
- Extension services should be improved because the present study observed lack of coordination between farmers and extension workers in the study areas.
- Community approach should be done to popularize IPM method. Educated, commercially oriented and lead farmers should be involved to introduce IPM technology at farmers' level for vegetable and crop production to increase farm income.
- More IPM clubs should be involved to introduce IPM technology at farmers' level.
- The reasonable price of the IPM-applied vegetables should be ensured through cooperative markets or growers' market so that the growers are motivated to use

IPM and grow vegetables and other crops that are safe and of superb quality.

IPM related publicity should be promoted through the mass media and awareness on dangers of pesticides, pesticide residues in food, health and environmental hazards of pesticides need to be created.

The following recommendations are made for future research on the basis of scope and limitations of present study.

- This research was carried out only at Baghaba and Masimpur union in Shibpur upazila under Narsingdi district. To justify the current study findings, it's important to make scope for more research in other regions.
- The study was based on IPM users and non-IPM users of bitter gourd. Further study may be conducted to other types of vegetables.
- In this study the investigations explored many selected socio-economic characteristics of the respondents with their profitability and factors affecting the production. Other factors may have influenced the production of bitter gourd and more research is needed to determine them.

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APPENDIX-A

INTERVIEW QUESTIONS

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An Interview Schedule for the Study Entitled

Comparative Study on Integrated Pest Management (IPM) Users and Non-users: Case of Bitter Gourd Growers in Narsingdi District of Bangladesh

1. Identification of the farmers:

Name of the farmer:

Village: …………...   Union: …………….

Upazila: …………….

District: ……………….

Section-1: Socio-economic Characteristics:

2. Family Size:

No. of the Family member**……………….**

1=   2=   3=

Code: 1=Male, 2= Female, 3=Children

3. Family details:

Sl. No.	Questions/ Query	Response/Answer	Code
1.	Age	_____ Years	
2.	Gender		1=Male, 2=Female
3.	Religion		1=Islam,2=Hinduism,3=Christianity, 4=Buddhism
4.	Educational level	__________ Schooling Years	Can sign only =1, Up to Primary=2, Up to SSC=3, Up to HSC=4, Illiterate=0

5.	Occupation	Main=	Absent=0, Vegetable cultivation=1, Agriculture=2, Fish Culture=3, Livestock Rearing=4, Business=5, Service=7, others=8
		Subsidiary=	
6.	Expenditure	1=Tk. 2=Tk. 3=Tk. 4=Tk.	1=Food, 2=Education, 3=Health, 4=Others

4. Annual Family Income (TK):

Income Source	**Sectors**	**Amount (Monthly)**	**No. of Month**	**Total Income (Tk.)**
Agriculture	Bitter gourd production			
	Crops and vegetables			
	Fisheries			
	Livestock			
Service				
Business				
Others				

5. Farm Size and Farm Category:

Tenure type	**Area (decimals or hectare)**	**Cost (Tk.)**	**Total size =(1+2+4+6+8+9-3-5-7)**	**Farm category**
1. Own cultivated land				
2. Rented in				
3. Rented out				
4. Mortgaged in				
5. Mortgaged out				
6.Homestead				
7. Pond(own)				
8. Orchard				

If total land size is 0 to 0.5 hectare=marginal size farm, 0.5 to 1 hectare= small size farm, 1 to 2.5 hectare =medium size farm and Above 2.5 hectare= large size farm

Farm category code- Marginal farm=1. Small farm= 2, medium farm=3, large farm= 4

6.Training Exposure:

i) Have you received any training program related to bitter gourd cultivation / IPM?

Yes: …………...   No: ………………

If yes then furnish the following information

Sl. No.	**Name of training course**	**Duration (days)**

7.Organizational Participation:

Are you a member of any organization?

i) Yes……………   No……………… (put tick mark) if yes then…………

ii) Name of the organization…………………...

Section-2: Profitability and Factor Analysis:

8. A) Input use in bitter gourd:

Please identify land area in local units as follows: A: Decimal, B: Bigha of………. decimal, C: Katha of ……. decimal, D: Pakhi of ………… decimal, E: Other ……………. Of …………… decimal.

i) Human labor Use:

Variety				
No. of plots				
Total area (in decimal)				
Activities		Man-days/ Unit area	Wage rate (Tk/day)	Total (Tk.)
1.Land Preparation	a. Family			
	b. Hired			
2.Trellis making	a. Family			
	b. Hired			
3.Seedling/ Transplantation (Hours)	a. Family			
	b. Hired			
4.Weeding	a. Family			
	b. Hired			
5.IPM Usage	a. Family			
	b. Hired			

6.Harvesting & Carrying	a. Family			
	b. Hired			
7.Applying fertilizer	a. Family			
	b. Hired			
8.Applying irrigation water	a. Family			
	b. Hired			
9.Applying insecticides/ Others(specify)	a. Family			
	b. Hired			

ii) Machinery Inputs:

Purpose of machinery use	Unit	Cost/Unit
1. Land Preparation (Power Tiller/ Tractor)		
2.Carrying (Tractor / Power Tiller / Van)		
Others (specify)		

iii) Material Inputs:

Items	Quantity/ Unit	Cost/ Unit
Trellis making (bamboo, rope)		
Seed/Seedling (KG)		

Cow dung (KG)		
Urea (KG)		
T.S.P (KG)		
MoP (KG)		
Gypsum (KG)		
Insecticide (Gram)		
Irrigation		
Others (Specify)		
Rental value of land		

iv)IPM usage information in survey land:

IPM tools	Number/Kg	Cost(tk.)
Pheromone trap		
Yellow sticky trap		
Soil amendment using poultry refuse		
Tricho compost		
Vermi compost		
Biopesticides		
Parasitoids		
Hand picking of Insect		

9.Amount of bitter gourd production

Total production	Unit price (tk./kg)	Total

a) Involvement of bitter gourd cultivation in terms of year?

(Age of farm)…………………

b) Involvement of women in bitter gourd cultivation:

Yes…………… No……………

c)Where do you sell produced bitter gourd? Local market/From farmland/From home/Urban market/Others……………

10.Credit availability

a) Had you taken any credit this year?

Yes: …………... No: …………… (put tick mark)

if yes, please mention your amount of credit……………. Thousand Taka

Sources	**Amount (Tk.)**	**Monthly Installment**	**Interest Rate**	**Installment Period**
Banks				
NGOs				
Friends & relatives				
Neighbor				
Money lender				

Section-3: Problems

11.Please identify the problems faced by you in adopting and practicing IPM technology in bitter gourd cultivation (put tick marks)

Sl. No	**Problems**	**Degree of problems**			
		High	Medium	Low	Not at All
1.	Lack of proper training facilities				
2.	Lack of technological knowledge in using IPM technology				
3.	Weak extension services				

4.	Unavailability of pheromone trap				
5.	Labor scarcity				
6.	Lack of knowledge on the harmful effect of insecticides				
7.	Unavailability of skilled labor				
8.	Lack of awareness				

12.What are your suggestions to overcome the above problems?

a)

b)

c)

d)

Thank you for kind co-operation

Date: Signature of the interviewer

APPENDIX-B

Field Visit and Interviewing During Survey Work

Plate: Interview and Field Visit