A SEMINAR PAPER

ON

STATUS AND PROSPECT OF IPM FOR MAJOR INSECT PESTS OF BITTER GOURD IN BANGLADESH

SUBMITTED TO

COURSE INSTRUCTORS	MAJOR PROFESSOR
Dr. Md. Mizanur Rahman Professor **Dr. A. K. M. Aminul Islam** Professor **Dr. Md. Rafiqul Islam** Professor **Dr. Dinesh Chandra Shaha** Assistant Professor **BSMRAU**	**Dr. Md. Ramiz Uddin Miah** Professor Department of **ENTOMOLOGY** **BSMRAU**

SUBMITTED BY

TASLIMA AKTER SIDDIQUA

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STATUS AND PROSPECT OF IPM FOR MAJOR INSECT PESTS OF BITTER GOURD IN BANGLADESH[1]

TASLIMA AKTER SIDDIQUA[2]

ABSTRACT

Under the broad policy of sustainable agricultural development, the government of Bangladesh with alliance of Food and Agricultural Organization (FAO) has been trying to implement Integrated Pest Management (IPM) farming since 1981. But the distribution of IPM farmers in various regions is not balanced. Conversely, though desired progress has not been achieved, but profitability of IPM over conventional farming in social, economic and environmental aspect, predict a fair probability to set up IPM farming in the future. In Bangladesh vegetable shortage is a chronic phenomenon. Most of the important vegetables are produced in winter and their production in summer is tremendously low. During this lag period cucurbitaceous vegetables play an important role to supplement this shortage. Bitter gourd is one of the most important cucurbitaceous crop. But insect pests play a vital role for the lower yield of bitter gourd. Management practices for major insect pests of bitter gourd were reviewed in Bangladesh perspective. IPM package involving monitoring, sanitation, use of sex pheromone trap, along with community approach significantly reduced the populations of major insect pests. Use of IPM tactics are economic, eco-friendly, time consuming, non-laborious. IPM practices have the potentiality for reducing various insect pest's infestation in bitter gourd by avoiding hazardous insecticide and their excess doses and save the environment as well as human life.

Keyword: IPM, cucurbits, pheromone, economic, ecofriendly.

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[1] A seminar paper presented at Bangabandhu Sheikh Mujibur Rahman Agricultural University for Graduate Seminar Course.

[2] MS Student Department of Entomology, BSMRAU, Gazipur-1706.

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CHAPTER 1

INTRODUCTION

Bangladesh is one of the most densely populated countries (964/sq.km) in the world with a remarkable growth rate of 1.29% (BBS, 2011). Although Bangladesh is on course for middle income country status by 2021, agriculture remains the largest employer in the country by far; and 45.1% (BBS, 2013) of the population is directly employed in agriculture. Millions of farmers in Bangladesh have long been using huge amount of chemical pesticide in their limited land to cultivate crops. To rely fully on chemical control, it is not feasible in social, economic and environmental aspect. For this reason, an alternative strategy is needed that can control pest in less expensive and environment friendly way. Although pesticides may provide temporary relief from pest problems, long-term dependency on pesticides is not desirable. It is now widely accepted that indiscriminate use of pesticides not only creates serious environmental and human health problems but also promotes development of pest resistance to insecticides, destroys beneficial insects, upsets the balance between the pests and their natural enemies leading to the increase in the population of the target pests and even the creation of new pest problem (Akter et al., 2016).

Agricultural research continues to combat farmer dependence on pesticides by developing strategies to manage pests by reducing the volume of chemical input needed to control them. Integrated Pest Management (IPM) is one such sustainable strategy for the management of pests. IPM is a broad ecological approach to pest control using various pest control tactics in a compatible manner. A broader definition was adopted by FAO Panel of experts (FAO, 1967) that, "A pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury". It is a holistic approach to crop production based on sound ecological understanding. Though generally there is a similarity about IPM technologies around the globe, in some extent these vary country to country as well as crop to crop. Over the years several IPM technologies have been developed in Bangladesh though all are not suitable for vegetables.

In Bangladesh, IPM activities first started in 1981 with the introduction of the first phase of FAO inter-country programme (ICP) on IPM in rice crop. However, it was only until 1987 that IPM activities began to expand and became a popular topic among people from all walks

of life. It is reported thatrom 1989 to 1995, the ICP played a strong catalytic role in promoting the IPM concept and approach among the government officials and donor community (Kabir et al., 2013). There is vast literature reporting focuses on the determinants of the implementation of such practices. While almost all studies are focused on farmers and farm characteristics, only a few have underlined the importance of technology, marketing and pesticides safety control. Moreover, only a few papers have studied IPM adoption in developing or emerging countries. In developing countries, studies related to IPM have not been as prevalent as in developed countries (Bonabana-Wabbi, 2002). Moreover, extent and level of IPM use in Bangladesh is still largely unknown. Many extensions led projects have been implemented by the Department of Agricultural Extension (DAE) and other NGOs to popularize IPM practices among the farmers throughout the country. Farmers' training, result demonstrations, method demonstrations etc. have been conducted to educated the farmers on IPM practices but there is hardly any study on how the farmers are implementing IPM practices in their farming.

In Bangladesh vegetables are not equally produced throughout the year. In summer the major vegetables grown are cucurbits. Bitter gourd is an important fast growing cucurbitaceous vegetable covering an area of 5,502 hectares with a total production of 20,470 tons in Bangladesh (Anon., 2004). It is considered one having medicinal properties and with a compound named 'Charantin' present in the bitter gourd is useful to reduce blood sugar for diabetic patients (Dhillon et al., 2005). It is also rich in vitamins and carbohydrates. The production of bitter gourd is hindered due to several factors like insect pests and disease. Many insects viz., cucurbit fruit fly, red pumpkin beetles, and epilachna beetle are the major constraints to the successful production of bitter gourd. 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 (Anon., 2004). 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. Therefore, it is desirable to

explore alternative methods of control, and develop a control strategy for effective, cheap and environment friendly management of bitter gourd insect pests. Unfortunately, no single method has so far been proved to be effective and reliable against cucurbit pests (Butani & Jotwani, 1984). Effective and environmentally safer control methods and IPM package are needed for the proper management of the insect pests of Bitter gourd. It demands to look for ecofriendly IPM package(s) because lot of pesticide is used for the control of bitter gourd insect pest which have adverse effect on the environment. Therefore, the effective control of insect pests of bitter gourd deserves some new approaches which is ecofriendly, economically and socially acceptable and might not have to rely only on chemicals. The approach might lead to develop an IPM approach against insect pests. Use of several IPM approaches as selected from the result of the previous workers may be used to develop a sound IPM packages against the insect pests of bitter gourd.

Objective of the study

The present study was carried out considering the following objectives:

1. To highlight the status and prospects of IPM in Bangladesh
2. To review the integrated efforts of controlling major insect pests of bitter gourd using various IPM techniques in Bangladesh

CHAPTER 2

MATERIALS AND METHODS

This seminar paper is completely a review paper. Therefore, all the information was collected from secondary sources with a view to prepare this paper. The key information was collected from various relevant books, journals and thesis paper which were available in the library of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). For collecting recent information internet browsing was also done. Good suggestions, valuable information and kind consideration from my honorable major professor, research supervisor, course instructors and other resources personnel from Bangabandhu Sheikh Mujibur Rahman Agricultural University were taken to enrich this paper. After collecting necessary information, it has compiled and arranged chronologically for better understanding and clarification.

CHAPTER 3

REVIEW OF FINDINGS

3.1 Current organizational involvement in IPM activities

From the beginning to present, besides government organization's several non-government organizations, development banks, bilateral and international agencies are involved for establishing IPM practices throughout the country (Table 1). Research organizations like Bangladesh Agricultural Research Institute (BARI) and Bangladesh Rice Research Institute (BRRI) is responsible for technology dissemination in a small scale; however, the major liable is for Department of Agricultural Extension (DAE) the largest public agro-based organization in Bangladesh. The plant protection wing of DAE directly deals IPM activities. There are some other semi-government organizations, such as Bangladesh Agricultural Development Corporation (BADC), and the Bangladesh Academy for Rural Development (BARD) that is engaged in transfer of IPM technologies to the farmers.

Table 1. Organizations involved with IPM activities in Bangladesh

Government organization	NGOs	Development Banks	International Agencies	Bilateral donor agencies
1.DAE 2.BARI 3.BRRI 4.BADC 5.BARD	1.MCC 2.GKSS 3.SABL 4.Ispahani Biotech 5.CARE 6.IPM CRSP	1.World Bank 2.Asian Development Bank	1.FAO 2.UNDP	1.USAID 2.DANIDA (Denmark)

(Source: Harris, 2011; Rickert-Gilbert, 2005)

3.2 Adoption and extent of IPM

Harris, (2011) and Rickert-Gilbert, (2005) conducted studies 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.

Dasgupta et al., (2007) conducted a survey in a large scale among the vegetable farmers of different regions of Bangladesh. It is found that a negligible rate of IPM farmer in comparison to the conventional farmers of Bangladesh (Table 2).

The findings represent the overall picture of the country regarding IPM adoption rate where there is a huge gap between the IPM and conventional farmers in terms of a number. Moreover, the picture not only reveals that still the adoption rate is low but also there is a huge variation in the intensity of IPM farmer from one district to another. (Table 2).

Table 2. Regional distribution of IPM farmers in some selected areas of Bangladesh

Division	District	Conventional farmer	IPM farmer
Dhaka	Munsigonj	25	0
	Narsingdi	82	0
	Kisorgonj	35	20
Rajshahi	Rajshahi	137	8
	Chapainawabgonj	3	0
Rangpur	Rangpur	68	26
Khulna	Jashore	111	54
Chittagong	Chittagong	56	0
	Kumilla	61	31

(Source: Dasgupta et al., 2007)

3.3 Socio-Economic Profile of the Farmers

Farmers are getting more aware and feeling interest towards IPM practices day by day, but their number are very few. In most cases it is happening to the large farmers who possess only 4% of the total farmers. Except this category, majority are the medium, small and marginal farmers who are 76 % in number and cover 73% of total operated areas (Figure 1). These farmers always try to the highest utilizes of their limited land, but uncertainty goes with every step of their life. Natural disaster and poverty is a common scenario to them. The poverty of these farmers is deep rooted, pervasive and multi-faceted, relating not just to the absence of reliable incomes and production, but also to sanitation, shelter, inequities and lack of power. Moreover, majority of them have no formal education which is a hinder to form a favorable perception, attitude and awareness on IPM. In addition, they are less well known about the technical skills that are required to use IPM practices. In this context, the GOs and NGOs should provide interest free agricultural loan to the farmers and also do monitor that this loan are properly utilizing or not for crop cultivation with IPM practices. Apart from socio-economic condition, psychological matter is another issue that hinders the farmers to adopt IPM technologies. Farmers feel confusion that if the IPM technologies are fail to gain desire yield or the demand of the product is low (Pokhrel et al., 2007).

In this context, DAE and NGOs worker should come forward to remove farmers' confusion regarding adoption of IPM practices.

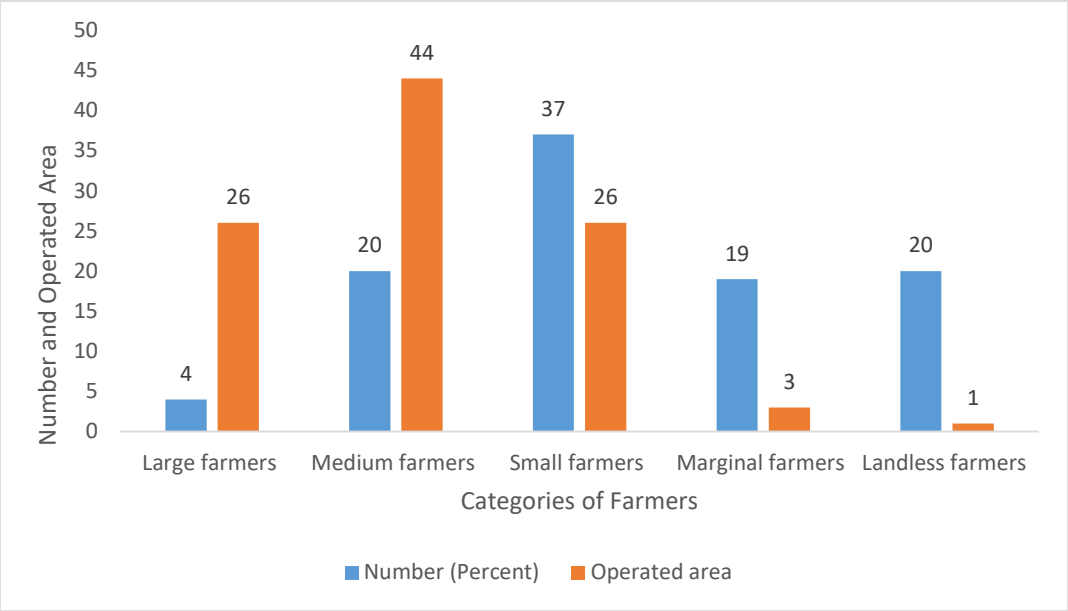

Figure 1. Categories of farmers with number and operated areas in Bangladesh.
(Source: Pretty et al., 2003)

3.4 Efficacy of IPM package for the control of fruit fly and borer complex

Cucurbits are infested by a number of insect pests, which are considered as the significant obstacles for its successful production. In cucurbit, bitter gourd is one of the popular vegetable crops in our country. It was severely infested with several insect pests and among them fruit fly is highly damaging. About 39-60% of the crop can be damaged by the attack of fruit fly. However, sex pheromone based management was proved as a very effective control technique against this pest. However, it is revealed from the last few year data that different types of borers became serious pests of bitter gourd. Three types of borers were reported to attack bitter gourd, two species of common cutworm (*Spodoptera litura* and *S. execua*) and pumpkin caterpillar. Due to the attack of this borer complex 40-60% bitter gourd crops can be damaged. So, it is very much important to develop a management package to control the fruit fly as well as borer complex of bitter gourd.

IPM package can significantly reduce the pest populations, fruit fly and borer complex in bitter gourd than farmer's practice (Table 3). The table 3 revealed that IPM package significantly reduces both the fruit fly infestation 0.96% & 1.40% in 2011 and 2012 respectively. Also the borer infestation 1.98% & 2.3% in 2011 and 2012 respectively.

In both the cases and years IPM significantly reduces the pest populations in bitter gourd than farmer's practice (Table 3).

Table 3. Efficacy of IPM package for the control of fruit fly and borer complex at Jashore during 2011 and 2012 bitter gourd cropping season

Treatments	2011 (Mean of 4 observations & 3 reps.)		2012 (Mean of 6 observations & 3 reps.)	
	% fruit fly infestation	% borer infestation	% fruit fly infestation	% borer infestation
IPM	0.96	1.98	1.40	2.3
Farmer's practice	18.32	29.48	21.12	32.24

(Source: BARI, 2012)

3.5 Effectiveness of IPM package for the yield and pest management cost of bitter gourd

Table 4 showed that the yield of IPM treated plots were 28.53 t/ha and 31.35 t/ha in 2011 and 2012 respectively which were much higher than non-IPM plots. Also pest management cost of IPM treated plots was 12,000 tk/ha/season in both the years of 2011 and 2012 which was much lower than non-IPM plots (Table 4).

Table 4. Yield and pest management cost of bitter gourd in the IPM and non-IPM plots at Jashore during 2011 and 2012 in bitter gourd

Treatments	2011		2012	
	Yield (t/ha)	Pest management cost/ha/season	Yield (t/ha)	Pest management cost/ha/season
IPM	28.53	12,000/00	31.35	12,000/00
Non-IPM (Sprayed plots)	17.64	32,000/00	24.54	34,000/00

(Source: BARI, 2012)

3.6 Effect of different IPM packages on bitter gourd yield

Begum (2013) performed a research to evaluate the yield over of fruit fly attacking bitter gourd. Effect of different IPM packages on bitter gourd yield was evaluated in terms of total healthy fruit yield obtained during the entire reproductive period of the crop. The result thus obtained including the percent increase of yield over control is presented in Table 5. The

result revealed that generally the infestation of fruits causes damage in terms of quality, quantity and market value (Table 5). The infestation of fruit flies on bitter gourd host invariably causes deformation and retardation of the fruit growth. As a result, the size and weight of infested fruits reduced in comparison to healthy ones. Severe infestation involving a number of punctures and larvae inside causes decomposition of fruits accompanied by liquefaction of pulp with foul odor. As a result, the fruit losses its marketable demand. Thus the yield of bitter gourd is reduced drastically. (Kabir et al., 1991; Mickinlay, 1992).

The treatment effect on marketable yield of bitter gourd and its increase over control was (89.26%) the highest in IPM packages 8 (Barrier crop + Pheromone + MSG + Handpicking) treated plot than the other IPM packages treated plots and followed by IPM packages 7, IPM packages 9 and IPM packages 2. The lowest marketable yield and increase over control was (41.48%) recorded in IPM packages 3 (Pheromone + MSG) and it was followed by IPM packages 5 (MSG + Barrier crop) (Table 5).

Table 5 showing that the effect of different IPM packages on the increase of yield over control of fruit fly attacking bitter gourd.

Table 5. Effect of different IPM management packages on the increase of yield over control of fruit fly attacking bitter gourd grown in 2013 at BSMRAU

IPM Packages	Marketable yield (kg/h)	Yield increase over control (%)
1. Mashed sweet gourd (MSG)	1375.00	54.84
2. MSG + Handpicking	1383.00	55.74
3. Pheromone + MSG	1256.38	41.48
4. Pheromone + MSG + Handpicking	1343.05	51.24
5. MSG + Barrier crop	1320.83	48.74
6. Barrier crop + Pheromone	1340.27	50.93
7. Barrier crop + Pheromone + MSG	1509.72	70.01
8. Barrier crop + Pheromone + MSG + Handpicking	1680.55	89.26
9. Insecticide spray at 7 days interval	1448.1	63.13
10. Control	888.00	_

(Source: Begum, 2013)

Another experiment is conducted determine the effect of different treatments on yield and yield increase over control for total reproductive stages of bitter gourd (Rahman, 2006).

Effect of treatments on yield at different reproductive stages including the total yield of bitter gourd is showed in figure 2. The figure showed that IPM component comprising hand

picking of infested fruits plus bait spray (T_5) effectively reduced the fruit infestation by number and weight and also provided higher yield increase over control (Figure 2).

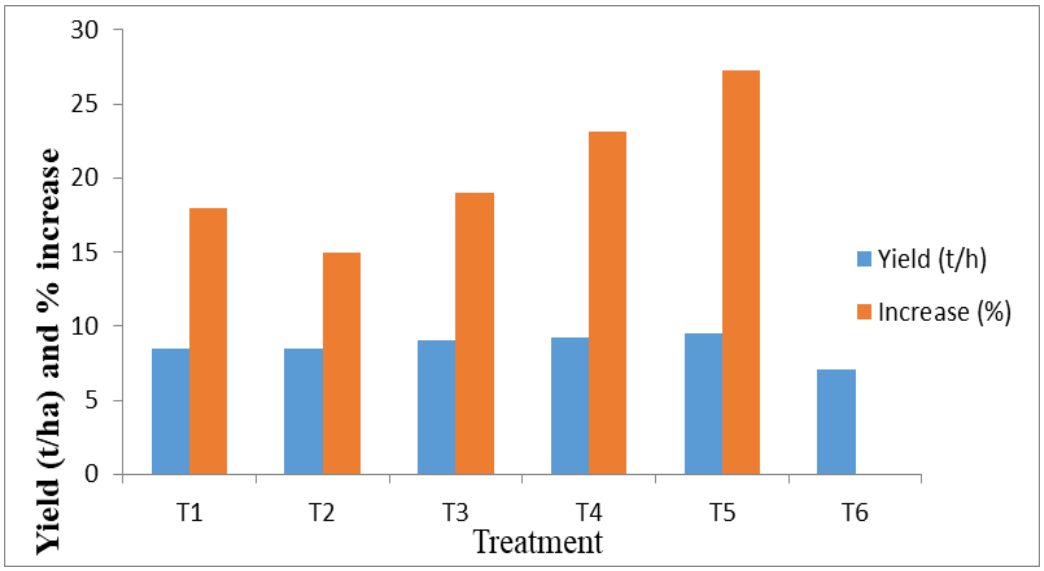

Figure 2. Effect of treatments on yield and yield increase over control for total reproductive stages of bitter gourd.

T_1= Handpicking+ bait trap, T_2= Red color reflecting ribbon, T_3= Nogos 100EC, T_4= Silver color reflecting ribbon, T_5= Handpicking+ bait spray, T_6= Control.

(Source: Rahman, 2006)

3.7 Effect of different IPM packages on the (%) of infested bitter gourd at different fruiting stages

The qualities of infested fruit directly depend on the intensity of infestation. Just a simple infestation might not affect the quality or quantity of fruits. The quantity of infested fruits in terms of percent edible portion of single fruits at early, mid and late fruiting stages is presented in Table 6.

The result revealed that significantly the highest edible portion (75.01%) was recorded with IPM packages 8 (Barrier crop + Pheromone + MSG + Handpicking) and the lowest edible portion (21.23%) of single infested fruit was found in untreated control plot which was observed with IPM packages 1 & 6 (Table 6). The reason for this might be the prevalence of hindrance free activities of the fly in untreated plots, as a result, the damage in majority of infested fruits incurred by larval activity inside, which might reach the extreme level leading to rotting of the fruits which made considerable portion of the fruit non edible. This finding was in conformity to those found by Uddin (1996).

Table 6. Effect of different IPM packages on the (%) of infested bitter gourd at early, mid and late fruiting stages grown in 2014 cropping season at BSMRAU

IPM Packages	Edible portion (%)		
	Early stage	Mid stage	Late stage
1. Mashed sweet gourd (MSG)	47.61	52.29	36.03
2. MSG + Handpicking	65.45	60.00	44.44
3. Pheromone + MSG	72.27	60.00	60.00
4. Pheromone + MSG + Handpicking	75.00	65.49	42.88
5. MSG + Barrier crop	57.14	62.22	45.04
6. Barrier crop + Pheromone	46.66	54.53	42.88
7. Barrier crop + Pheromone + MSG	78.61	60.00	60.00
8. Barrier crop + Pheromone + MSG + Handpicking	88.90	69.39	66.73
9. Insecticide spray at 7 days interval	43.36	60.24	61.57
10. Control	19.09	31.42	13.19

(Source: Begum, 2013)

3.8 Performance of poison bait trap in controlling fruit flies in bitter gourd

A field experiment is conducted at Shakhipur, Tangail to find out the effectiveness of poison bait trap for controlling fruit flies in bitter gourd (Chowdhury et al., 2007).

The percentage of fruit fly infestation in control plots ranged from 26.0 to 45.7 with an average of 37.9 while that with poison bait trap varied from 10.7 to 24.7 with an average of 16.8 (Table 7). The male to female ratio of the trapped insects was 1.43 which indicates that the poisoned bait trap was more efficient to trap female flies than the male flies. Farmers gave favorable opinions toward acceptance of the technology. However, jackals created some problems such as sometimes they ate the bait material and broke the earthen pots.

Further research may be conducted to determine the number of traps required per unit area for different cucurbits (Table 7).

Table 7. Performance of poison bait trap in controlling fruit flies in bitter gourd at Shakhipur, Tangail, Kharif I season, 2006

Observations	Fruits infested (%)		Fruit flies trapped (no/day/trap)		
	Control	Trap	Male	Female	Total
1	45.7	24.7	50.3	69.8	120.1
2	40.1	20	117.4	166	283.4
3	39.8	11.9	99.5	149.5	249
4	26	10.7	109.1	151.1	260.2
Mean	37.9	16.8	94.1	134.2	228.2

(Source: Chowdhury et al., 2007)

3.9 Effect of sex pheromone trap for controlling fruit fly

Cucurbit fruit fly is a major problem in bitter gourd. It is reported that if the proper control measures are not taken in proper time, 100% yield may be loss. The insect damages all cucurbits like bitter gourd, cucumber, sweet gourd, wax gourd, teasel gourd, squash, watermelon etc. But severe attack was found in bitter gourd, cucumber, sweet gourd etc. Fruit flies lay their eggs through long ovipositor within young and tender fruits. After hatching larvae feed on internal soft tissue and finally fruits are rotten. A recent survey report revealed that controlling this insect farmer sprayed 2-3 insecticides in a mixture at 2-3 days' interval in Bangladesh (Nasiruddin et al., 2007). But all efforts had little effect on the control of fruit fly. On the other hand, uncontrolled applications of huge amount of insecticides cause harmful effect on human health as well as environment. Considering, the above facts BARI has developed sex pheromone trap, which can effectively control fruit fly. For trapping insects with special wonderful capacity it is termed as "Magic box" by farmers. So, this study has undertaken to show its effectiveness to the new farmers in Rajshahi (Table 8).

The results revealed that the highest number of infested fruit was found in the treatment T3 (32.83%) followed by T2 (25.03%), whereas, the sex pheromone trap placed plots (T1) had the lowest infestation (2.73%) (Table 8). The highest number of edible fruit per plant was produced by T1 (4.78) where sex pheromone trap was placed followed by T2 (3.47) and T3 (2.83). Individual fruit weight was found higher in T1 (5.57kg) followed by T3 (4.78kg). The lowest individual fruit weight was found in T2 (4.2kg) where frequent insecticides were sprayed.

The sex pheromone placed treatment (T1) produced the highest yield (36.90 t/ha) followed by T2 (20.0 t/ha) and T3 (18.91 t/ha). (Table 8)

Table 8. Effect of sex pheromone of bitter gourd in Rajshahi during 2007-08

Treatment	% infested fruit	No. of fresh fruit/plant	Average fruit weight (kg)	Yield (t/ha)
T_1 (Sex pheromone)	2.73	4.78	5.57	36.90
T_2 (with insecticide)	25.03	3.47	4.20	20.0
T_3 (without insecticide)	32.83	2.83	4.78	18.91

(Source: BARI, 2009)

3.10 Fruit infestation and their reduction over control by number and weight

Effect of treatments on bitter gourd fruit infestation and their reduction over control by number and weight for total reproductive stage in the net house is presented in Table 9.

Table 9. Effect of treatments on bitter gourd fruit infestation and their reduction over control by number and weight for total reproductive stage in the net house (2004-2005 rabi season) at BSMRAU

Treatment	Fruit infestation and their reduction over control by number and weight			
	Number (%)	Reduction over control (%)	Weight (%)	Reduction over control (%)
T_1	34.71	31.89	26.06	29.49
T_2	33.42	34.42	20.82	43.67
T_3	28.50	44.07	22.86	38.15
T_4	27.67	45.70	20.49	44.56
T_5	20.68	59.42	20.17	45.43
T_6	50.96	-	32.96	-

T1= Yellow color ribbon; T2= Red color ribbon; T3= Indigo color ribbon; T4= Silver color ribbon; T5= Nogos 100EC @2ml/L of water; T6= Untreated control.

(Source: Rahman, 2006)

From the above table we can see that The results showed that higher percent reduction over control by number obtained from (T_5) Nogos treated plot. The lowest percent reduction over control by number was found in (T_1) fruits provided with yellow color ribbon. In fruit infestation reduction over control by weight showed more or less similar performance. This might be due to higher attraction of female towards (T_1) yellow color and consequently higher number of egg deposition was ensured. But in case of (T_5) Nogos treated fruits might elicit lower attraction for fruit fly and resulted poor egg deposition on bitter gourd (Table 9).

3.11 Percent fruit infestation by number at early, mid and late fruiting stage-

The percent infestation of fruits by number was higher in late stage than the mid and early growing stages (Figure 3). It was also found from Figure 3 that the rate of fruit infestation by number at early, mid and late growing stages was the highest in the untreated control plots and lowest in the plots having pheromone traps (Figure 3).

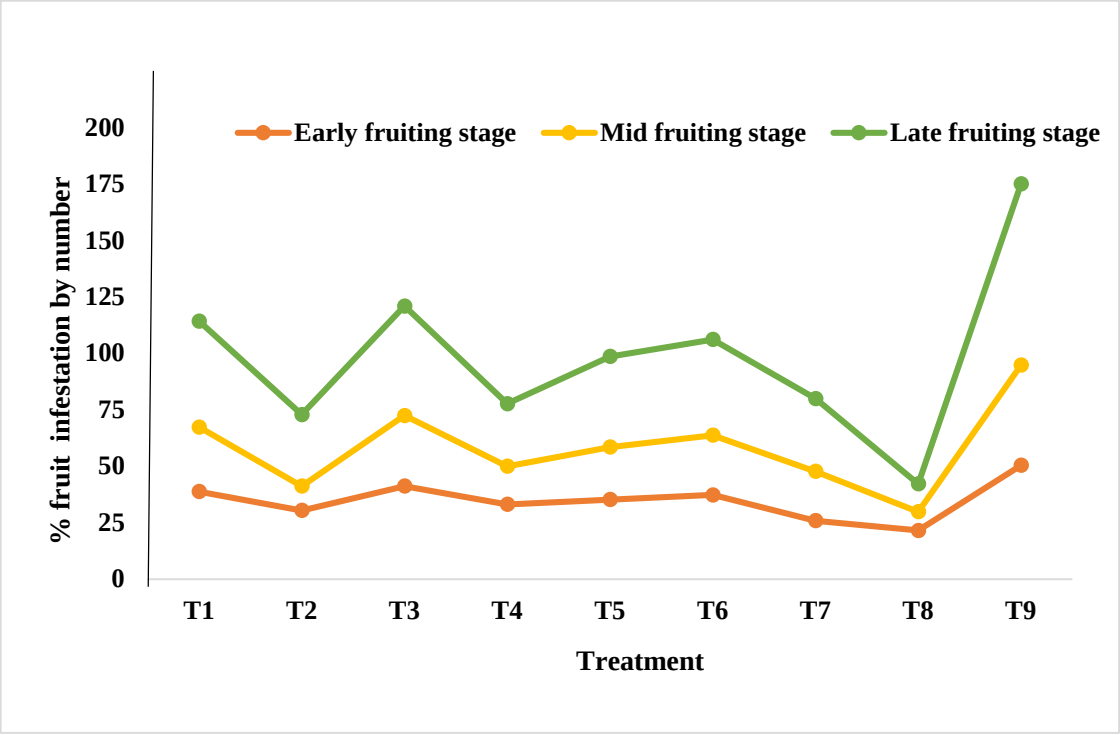

Figure 3. Percent fruit infestation by number at early, mid and late fruiting stage.

T_1= Ash gourd bait, T_2= Cu micronutrient, T_3= Cucumber bait, T_4= Zn micronutrient, T_5= Ripened MSG bait trap, T_6= Unripen MSG bait, T_7= B micronutrient, T_8= Pheromone trap, T_9= control.

(Source: Luma, 2017)

3.12 Comparative effectiveness of various IPM packages in reducing leaf infestation

Figure 4 revealed that the highest percent reduction (81.67%) of leaf infestation over control was observed in IPM package 2 treated plots (Forwatap applied @4g/plant in soil 2 times at 10 days interval+ use of mosquito net barrier) followed by IPM package 3 plots (handpicking of adult RPB+ spraying with Nitro 505EC @1ml/L of water 2 times at 7 days interval). On the other hand, the lowest percent reduction (71.25%) of leaf infestation over control was obtained from IPM package 6 treated plots (Forwatap applied @4g/plant in soil 2 times at 10 days interval+ handpicking of adult RPB). IPM package 1 treated plots (planting of muskmelon as trap crop + handpicking of adult RPB) was obtained (73.43%) reduction over control.

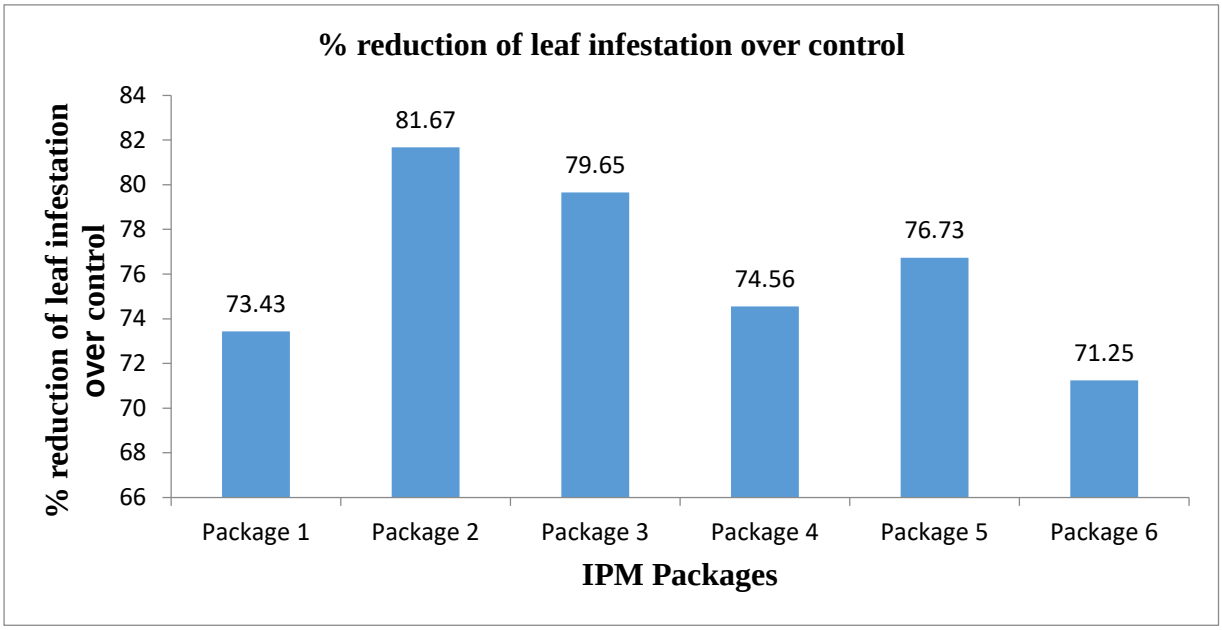

Figure 4. Effect of different IPM packages on the reduction of leaf infestation of red pumpkin beetle (RPB) over control.

IPM Package 1= planting of muskmelon as trap+ hand picking of adult RPB, IPM Package 2= Forwatap applied @4g/plant in soil 2 times at 10 days interval+ use of mosquito net barrier, IPM Package 3= handpicking of adult RPB+ spraying with Nitro 505EC @1ml/L of water 2 times at 7 days interval, IPM Package 4= use of mosquito net barrier+ hand picking of adult RPB, IPM Package 5=planting of muskmelon as trap+ use of mosquito net barrier, IPM Package 6= Forwatap applied @4g/plant in soil 2 times at 10 days interval+ handpicking of adult RPB.

(Source: Khan, 2009).

However, the IPM package 4 plots (use of mosquito net barrier+ handpicking of adult RPB) had provided (74.56%) of leaf infestation reduction over control (Figure 4).

3.13 Economic analysis of different treatments against insect pests in bitter gourd

The analysis was done in order to find out the most profitable management practices based on cost and benefit of various components. The results of economic analysis of bitter gourd showed that the highest net benefit of Tk. 247,600 ha-1 was obtained in T_6 treatment component followed by the second highest Tk. 237,000 ha-1 in T_4 (Table 10). The highest benefit cost ratio (9.44) was estimated for T6 treatment and the lowest (1.06) benefit cost ratio for T_3 treatment under the trial. The benefit cost ratio (BCR) calculated for each of the treatment component revealed that the BCR of the treatment T_4 was (7.32) and the in the treatment component T_5 (4.64) which was followed by the treatments T_2 (1.60) and treatment T_1 (1.25), respectively (Table 10). Highest BCR was found in the treatment T_6 may be due to the less management cost compared to the other treatment components and highest yield. Thus, it might be concluded that judicious use of insecticides in combination with micronutrients as well as hand picking of infested fruits would be best for bitter gourd cultivation at farmers' level.

Table 10. Benefit cost ratio of bitter gourd using various management practices

Treatments	Cost of pest Management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net Return (Tk.)	Adjusted net return (Tk.)	Benefit cost ratio
T_1	8000	10.92	218400	210400	10000	1.25
T_2	22000	12.88	257600	235600	35200	1.60
T_3	25500	12.65	253000	227500	27100	1.06
T_4	5000	12.10	242000	237000	36600	7.32
T_5	5000	11.43	228600	223600	23200	4.64
T_6	5000	12.63	252600	247600	47200	9.44
T_7	0	10.02	200400	200400	--	--

T_1: Hand picking of infested fruit of bitter gourd at 7 days' interval, T_2: Neem seed kernel @ 5gm/l of water at 5 days' interval + T_1, T_3: Shobicron 425 EC @ 2ml/l of water at 7 days' interval + T_1, T_4: Micronutrient-Zn @ 6.72kg/ha, T_5: Micronutrient-B @ 1.96kg/ha, T_6: Micronutrient Zn + B, T_7: Untreated control

(Source: Akram, 2010)

3.14 Profitability Analysis of bitter gourd for both IPM and Non IPM plot

Islam et al. (2015) performed a research on an economic study on practicing IPM technology for producing bitter gourd in selected areas of Kumilla district and the study revealed that IPM farmers gained more profit than non-IPM farmers on bitter gourd production (Table 11). The average per acre total cost of bitter gourd production was Tk. 77462.6 and Tk. 93159.5 for IPM and non-IPM farmers respectively in the study areas. In case of IPM farmers, net returns of Bitter gourd cultivation were Tk. 88967.9, while for non-IPM farmers, the respective figure was Tk. 72440.6 (Table 11). Net returns of IPM farmers was higher than that of non- IPM farmers which is also supportive to the fact that IPM farmers are more efficient than the non-IPM farmers. In case of IPM farmers, per acre benefit-cost ratios of bitter gourd was 2.2 respectively, while for non-IPM farmers, the respective ratio was 1.8. It indicates that though both of the groups are in profitable condition, IPM farmers are more profitable than non-IPM farmers.

Table 11. Profitability of Bitter gourd for both IPM and Non-IPM farmers

Items	Bitter gourd	
	IPM	Non-IPM
Yield (Kg/acre)	14514.3	13142.9
Price (Tk./kg)	11.5	12.6
Gross Return (Tk./acre)	166430.5	165600.0
Total variable cost (TVC)	21205.7	26393.6
Total Cost (Tk./acre)	77462.6	93159.5
Gross Margin (Tk./acre)	145224.9	139206.4
Net Return (Tk./acre)	88967.9	72440.6
Benefit Cost Ratio	2.2	1.8

(Source: Islam et al., 2015)

3.15 Interest in buying production of organic farming

Alam et al. (2012) performed a research relevant to the production of organic farming products and farmer's attitude, acceptance and interest in buying production of organic

farming. It is observed that 80% of the consumers are interest in buying production of organic farming due to the purity, tasty and aesthetic value of these products (Figure 5).

On the other hand, 20% consumers have no interest in buying production of organic farming due to the lack of knowledge and the high rate of organic product (Figure 5).

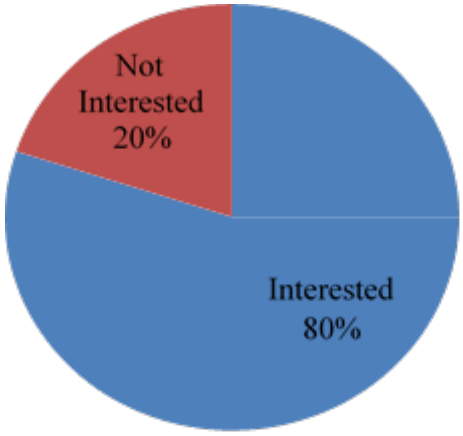

Figure 5. Interest in buying products produced by organic farming.

(Source: Alam et al., 2012)

3.16 Constraints of IPM practices

To identify the core problems for Integrated Pest Management, a problem analysis was conducted. All the problems mentioned by the farmers and consumers, as well as personal observations and summarized these in Figure 6. It has four core problems poor farmers, poor farmer knowledge of IPM practices and its benefits, insufficiency of inputs, and poor marketing of organic foods.

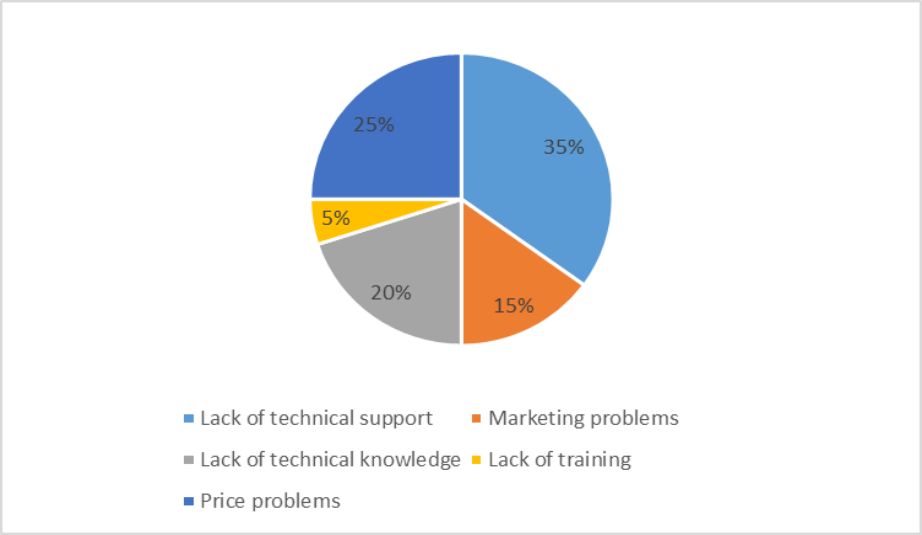

Figure 6. Problems of IPM practices faced by farmers.

(Source: Alam et al., 2012)

3.17 Overcoming the constrains of IPM practices

- Reducing certification and renewal fee of organic certification.
- Providing organic inputs at subsidized rates.
- Providing minimum support price for IPM practices.
- Providing periodical training on inputs preparation.
- Ensuring timely availability and adequate quantity of inputs.
- Creating awareness on IPM practices and its produces (Sivaraj, 2017).

CHAPTER 4

CONCLUSIONS

1. Despite efforts being made from different organizations for promotion of IPM, adoption and extent of this sustainable farming is increasing slowly. Moreover, not only the number of IPM farmers is less than conventional but also the distribution is not balanced throughout the country. Another significant issue is IPM farming is more profitable than conventional farming in social, economic and environmental aspect. Relative advantage is an important criterion of technology adoption. Since IPM farming is more profitable than conventional farming, the farmers will be interested to acknowledge this program. Sometimes farmers are reluctant to adopt any new technology if the production is low. In this context, the DAE and NGOs come forward to remove this confusion and make IPM financially attractive.
2. Integrated pest management practice comprising of different trap was the most effective one in controlling insect infestation of Bitter gourd. Both the percent fruit infestation by number and weight was lowest in the plots having different IPM practices plot in compared with control plots. Statistically identical yield was obtained from the IPM practices plot.

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