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Do Farmers Not Widely Adopt Environmentally Friendly Technologies? Lesson from Integrated Pest Management (IPM)

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Abstract

Integrated pest management (IPM) is such approach where pest are controlled by following a number of technologies that are environmentally sound. The study attempted to determine the adoption rate of IPM by the vegetable growers in Bangladesh for better understanding about what extent farmers adopt to IPM and find the current adoption rate also analyzed. Data were collected from 331 vegetable farmers of Narsingdi district, Bangladesh by following a structured questionnaire. To determine the adoption rate of IPM, the study applied one of the three global used methods which were better than others and suitable for the study area and crop type (vegetables). Less than one third (30%) farmers adopted IPM while others fully dependent on chemical method for controlling pest. Moreover, lack of knowledge about IPM, lack of training facilities and inadequacy of IPM equipments were the major reasons to keep far away the farmers to adopt IPM. Factor analysis showed that farmers faced by three types of barriers such as institutional, social and management. Discussion on these barriers focusing on ways to overcome is presented. The findings can play important role to increase adoption rate of this environment friendly farming approach.

Keywords: adoption rate, IPM, barriers, factors analysis

1. Introduction

Pests (insect, pathogen, weeds etc.) are one of the most important barriers to increase food production, a usual need for both develop and developing countries. To ensure desire production or to minimize crop loss due to pest infestation, there is a trend to use huge chemical pesticides across the countries. Research reports revealed albeit pesticide is efficient to protect crop loss from pests, its heavy use causes several negative impacts on environment like soil infertility, pollution of surface and ground water, destruction of natural enemies, emerges of new pests etc. (Kabir & Rainis, 2012; Kabir & Rainis, 2013a). These adverse effects were the base to develop integrated pest management (IPM), an approach where to control pest emphasize are given on non-chemical or organic ways and chemicals are only applied when pest infestation is severe. Due to having efficiency of IPM to maintain same level of production with a reduce rate of pesticide use, this approach was disseminating rapidly among various countries. In the part of that process, the government of Bangladesh like many developing countries, with the assistance of FAO introduced IPM technologies for vegetables in 1996.

Immediately after introduction of IPM technologies, Department of Agricultural Extension (DAE), the prime and largest agricultural organization in Bangladesh, with co-operation with various non-government organizations and international agencies started to disseminate information regarding these practices among the farmers (Kabir & Rainis, 2013b). More than one and half decades have been passed of IPM disseminating program, still there is no evaluation regarding adoption rate of these environment friendly technologies. An attempt to determine adoption rate of IPM is necessary not only to realize the current status of acceptance level of these practices by the farmers but also make future plan. In addition, if the adoption level is low then what are the reasons exist behind the result and how the rate can be increased is also need to analyze. Therefore, the objectives of this study are twofold; i) to determine the rate of IPM adoption by the vegetable growers and ii) to analyze reasons behind the current adoption rate of IPM.

The leftover of the study are designed as follows. The next section highlights the vegetable IPM technologies in Bangladesh. Section 3 and 4 describes methodology and results and discussion respectively. The final section contains conclusion.

2. Vegetable IPM Technologies in Bangladesh

IPM is an approach where pest are controlled by following a number of environment friendly practices or technologies. 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. The IPM practices that are suitable and use in vegetable cultivation are Pheromone trap, Biological control, Soil solarization, Soil amendments, Grafting, Botanicals and Manual cleaning. A brief description of these technologies is given below.

Pheromone trap

Pheromone trap is a technology where pheromone, a female sex hormone, is attached with soapy water inside a plastic trap. The purpose is to attract male insect and kill. Since insects are killed through using sex hormone thus the technology is also called Sex pheromone. The technology has proven to be highly effective for killing fruit fly and other insects (Nasiruddin et al., 2004). Various pheromones are used depending on the type of insects. Sometime other attractant like mashed sweet gourd is also used in the trap but this substance is not as effective as synthetic sex pheromone (Steed, 2010). The technology may applicable for all types of vegetables but more suitable for cucurbit and eggplant.

Biological control

Biological control means managing pests with natural enemies (Shelton, 2010). Natural enemies of insect pest are usually called bio-control agents or beneficial insects, and include predators, parasitoids and pathogen. According to Alam (2003) nearly every field crop insect pest have natural enemy. In some cases, one insect pest has several natural enemies. For example, eggplant fruit and shoot borer has about 20 natural enemies including one predator, 16 parasitoids and 3 pathogens. Trichogramma and Bracon are the most common beneficial insects used in controlling harmful insect from vegetables. Trichogramma is a small parasitic wasp that attacks over 200 species of moths (Islam, 2010). On the other hand, Bracon eat larvae of many harmful insects.

Soil solarization

Some scholars treated the technology as sun solarization. Soil solarizataion is an IPM practice that kills pathogen in the soil by using high temperature from the sun. The technique involves wet the seed bed to make mud and then cover it with a white polythene sheet and left alone for three weeks. The polythene sheet allow the sun radiant energy to be trapped in the soil and heating the top portion. During this period the top 6 inches of the soil will heat up to as high as 131 degree Fahrenheit, destroying a wide range of soil born pests, such as weeds, pathogens, nematodes and insects. In solarized soil, plant often grow faster and produce both higher and better quality yields (Elmore et al., 1997).

Soil amendments

Vegetable seedlings are very much sensitive to various soil born diseases like damping off, root knot nematode, root rot and stem blight. These diseases either destroy the seedlings or severely stunt their growth. Fortunately various soil amendments are available to combat these diseases. Application of poultry refuse, mustard oil cake and saw dust to the soil greatly reduce the damage caused by soil born diseases. Among these three soil amendments, use of saw dust is comparatively lower than two others. Poultry refuse and mustard oil cake release organic acid that kill soil inhabiting pathogen and improve soil fertility (Den Tex, 2004; Rahman et al., 2004).

Grafting

Grafting is used in eggplant and tomato to protect bacterial wilt and root-knot nematode, two soil born diseases which causes serious damage. The technology was first developed by the Asian Vegetable Research and Development Centre in Taiwan and later transferred throughout Asia. It is a process of removing roots from high yielding eggplant or tomato seedling and replaced by a wild rootstock which is resistant to these diseases. The new rootstock is taped into place and the seedling is housed in humid environment for 7 to 10 days before being transplanted in the main field (Harris, 2011).

Botanicals

Botanicals are pesticides derived from plant. It is processed into dust and powder made from dried leaves, seeds, roots and flowers. Botanicals generally act in two ways: as a contact poison when sprayed on the insect or as a stomach poison when eaten. It degrades within few hours or days but should use more frequently. Because of

availability, use of botanicals varies across the countries. Rotenone, Sabadilla, Ryania, Pyrethrin, Nicotin and Neem are the botanicals that used in different countries. In Bangladesh, the vegetable growers use Neem as botanicals to control pest. Neem is a mixture of leaves, bark and seed extracts from an evergreen tree, the *Azadirachta Indica.* It belongs to bitter test that deters insects from feeding. It can also be applicable to control plant diseases, such as powdery mildew, black spot, anthracnose and many others (Guleria & Tiku, 2009).

Manual cleaning

The term is also called manually catching. Manual cleaning means manually removal of pests from vegetables. It includes several activities such as removing weeds, clipping infected leaves and picking insects. These activities are done directly by the farmers' hand or other instrument but not by using any chemicals. Farmers can easily remove weeds by their hand or hoe. On the other hand, at primary stage, they can clip infected leaves and pick insects from the field. If they continue these activities then the vegetable field will remain clean and the probability of pests' infestation will be reduced. To do these, farmers need regular visit the field and observe the situation regarding pest infestation.

3. Methodology

3.1 Study Area, Sample Farmers and Data Collection

The study has been conducted in Narsigndi district which is one of the most important regions in Bangaldesh in the context of vegetable production, pesticide application and existence of IPM program. By following multistage random sampling technique, a total of 331 vegetable growers were selected as sample for the study. A face to face interview was conducted with these farmers followed by a structured questionnaire. The questionnaire consisted two parts which one covered a list of vegetable IPM technologies that were existed in the study area for long and another belonged to a list of barriers of IPM adoption with their level of importance.

3.2 Procedure to Determine Adoption Rate of IPM

The rate of adoption of a technology is usually measured by how many farmers of a community adopt that technology in a certain period of time. Habitually adoption rate is determined up to until or unless all members of a society do not accept an innovation. It is easy to determine adoption rate if there is an understanding about technology adopters and non-adopters. To determine the rate of IPM adoption, there is a need to categorize the growers into adopter and non-adopter. It is simple to make this categorization for single technology, just put a question that the growers adopt the technology or not. But IPM is not a single technology rather it is an approach that belongs to a set of technologies (Kabir & Rainis, 2013c). Hence the determination of IPM adoption rate is different from the others especially those who are single in nature like improve variety, pesticide, fertilizer etc. The previous scholars measured adoption rate of IPM in three different ways. A comparison analysis of those measurement techniques are presented in Table 1.

The table shows type-2 is better than others in aspect of ease of use, extent of use, way to calculate and applicable place. Therefore, the study applied this technique to determine adoption rate of IPM by the vegetable growers in Bangladesh. According to the technique, determination of IPM adoption rate is done in two stages. Firstly, a total of IPM practices that are suitable for a specific crop and location/country are list down. Secondly, the list is used as an indicator to divide the farmers into adopter and non-adopter group in a simple way like the farmers who use minimum one or more IPM practices are consider as adopter otherwise non-adopters. That means the non-adopter farmers use none of the practices while adopter farmers use any type or number of practices. Finally, adoption rate is considered by the number of farmers out of total who adopted IPM practice or practices.

Table 1. Comparative analysis of various IPM adoption rate measurement techniques

Topic/Issue	Type-1	Type-2	Type-3
Measuring issue	Nine selective IPM practices are considered as a base to determine IPM adopter/non-adopters	A set of IPM practices that are suitable for a specific crop and exist in a study area for long	Arrangement of all IPM practices under four key components like monitoring, identification, prevention and control

Way to calculate adoption rate	The percentage of farmers of a community adopt all these nine practices	The percentage of farmers of a community adopt minimum one or more IPM practices	The number of farmers of a community adopt IPM practices under all components but at a different rate
Proposers/Users	Puente et al., (2011)	Dasgupta *et al.,* (2007); Fernandez-Cornejo *et al*., (1994)	Li et al., (2011)
Location of study	U.S.A.	U.S.A and Bangladesh	England
Experimental crop	Cotton	Rice, Vegetables	Nursery crops
Ease of use	Ease	Ease	Complex
Extent of use	low	High	Low
Applicable	In the countries where the selective nine IPM practices are exist	All countries	More suitable for the develop countries

3.3 Procedure to Analyze Barriers of IPM Adoption

Whatever the rate of IPM adoption (low, medium or high), there must have a portion of the farmers who do not adopt IPM. Moreover, from experience of other developing countries as well as an earlier study in Bangladesh on rice, we assumed that the bigger portion of the vegetable farmers do not adopt IPM. Thus the study had an attempt to analyze the reasons of being non-adopters. To achieve this, at first, a list of ten barriers of IPM adoption was selected through a combination of review previous literature and conduct pilot survey. From the list, to investigate the most important barriers, a five point Likert-type scale (1 = very low, 2 = low, 3 = intermediate, 4 = high and 5 = very high) was used (Borkhani et al., 2010). The vegetable growers were asked to give marks against the barriers according to importance. By using SPSS statistical software, we calculated mean and standard deviation of all the items and made a rank order of the barriers on the basis of these values. Moreover, factor analysis was applied to identify what type of barriers of IPM adoption exists.

4. Results and Discussion

4.1 Adoption Rate of IPM among the Vegetable Growers

There are seven IPM practices namely; biological control, pheromone trap, grafting, soil solarization, soil amendments, botanicals and manual cleaning used by the vegetable growers throughout the country. Among these, except grafting, rest all was present in the study area. So, six IPM practices were considered as indicator to identify the farmers either adopters or non-adopters. The vegetable growers who used at least one or more IPM practices from the existing six practices were considered as adopters while non-adopters use none of the practices. Our survey revealed 100 vegetable growers out of 331 used IPM practices. Thus, adoption rate of IPM was 30%.

From the present adoption rate, it was observed that the progress rate of IPM practices use is slow that is 1.76% per annum (from the IPM introduction year, 1996 to survey year, 2013). If the trend remains same, then it will take too much time to cover majority of the farmers under this environment friendly approach. Alternatively it can be said that despite being passed 17 years of IPM introduction, still majority of the farmers (70%) are non-adopters of IPM. These farmers totally depended on chemical pesticides for controlling pest which is opposite with the mission of establishment of environment friendly agriculture. Therefore, it is necessary to increase the effectiveness of government IPM dissemination program. In this case, analyzing obstacles or barriers of IPM adoption may provide helpful information for better dissemination program. Reasonably, discussion about the barriers of IPM adoption is presented in the next objective.

4.2 Analyze Barriers of IPM Adoption

Farmers barriers of IPM adoption is analyzed and discussed in two ways; based on descriptive statistics (mean and standard deviation value) and based on inferential analysis (factor analysis).

Based on descriptive statistics

In the study, the vegetable growers were divided into two groups; adopters and non-adopters of IPM. Unfortunately the number of the non-adopters was much higher than that of adopters. The non-adopter farmers mention several reasons for not using IPM. However, all reasons or barriers were not similar importance to them. A rank order of the barriers based on the mean and standard deviation value are depicted in Table 2. From the

table it is observed that according to the level of importance, the barriers are lack of knowledge about IPM, lack of training facility, inadequacy of IPM materials or equipments, availability of pesticides, lack of co-ordination between farmers and extension agent, fear about IPM program, outcome from IPM practices is time being, no discrimination about price of vegetable with or not IPM, need more labor and influence of pesticide agents.

Table 2. Rank order of the barriers of IPM adoption

Barriers	Mean	Standard deviation	Rank order
Lack of knowledge about IPM	4.25	.708	1
Lack of training facility	4.13	.707	2
Inadequacy of IPM materials	3.96	.712	3
Availability of pesticides	3.43	.724	4
Lack of co-ordination between farmers and extension agent	3.12	.693	5
Fear about IPM program	2.74	.639	6
Outcome from IPM practices is time being	2.23	.700	7
No discrimination about price of IPM and non-IPM vegetable	2.19	.686	8
Need more labor	1.99	.622	9
Influence of pesticide agents	1.96	.610	10

Lack of knowledge about IPM was the most important barrier of IPM adoption. Study conducted by Borkhani *et al.,* (2010) identified lack of knowledge and information for using IPM technologies was the most important barrier for the paddy farmers in Iran. Some studies in case of other agricultural technologies found similar result (Nowak, 1991, Truong Thi, 2008). In the study, the farmers had lack of knowledge on various aspects. Firstly, most of them did not hear about all the IPM practices existed in their area. On average they heard about one to three practices. Secondly, they had not proper knowledge about using of the practices that they heard. Thirdly, they did not know that in case of IPM, pesticide can also use. A rigorous dissemination process can play important role to improve farmers' level of knowledge regarding IPM. In this context, DAE is the most responsible. The organization had already developed four dissemination techniques namely FFS training, extension contact, field day and IPM club to disseminate this approach. Besides, they used mass media for publicity. They should continue these approaches with more attention. In addition, some initiative like establishment of adult school or farmer organization in the rural level may be helpful to fill their knowledge gap of IPM.

The second most important barrier of IPM adoption was lack of training facility which was consistent with the study of Rahman (2012). In the study area, the name of training program provided to the farmers was farmer field school. The number of farmers covered by the training program in a season was limited. Most of them did not get opportunity to participate in the training. So, government organizations especially DAE and NGO's should create more training facilities for the farmers. At the time of farmer selection for providing training, there is a tendency to choose large farmers due to various reasons. This propensity is not consistent with the mission of IPM promotion. Generally the large farmers are innovative, and they have more risk bearing capability. They are always more interested than others to adopt a new approach. Thus, special consideration should be given to the medium and small farmers who operated 70 % of total area but have a low risk bearing capability. Another issue, though DAE is the major responsible for promotion of IPM farming, but the organization itself will never achieve success. Hence to increase the scope of DAE regarding training facilities, the international agencies and development bank that are working in the country should take project with larger scale and implement jointly with DAE (Kabir & Rainis 2013a**)**.

Inadequacy of IPM materials or equipments was the third most important reason for farmers being unable to adopt IPM. The barrier was observed as one of the three most important barriers by the study of Borkhani *et al.,* (2010), Muthuraman and Sain, (2002) and Rodriguez, (2005). Among various IPM techniques, sex pheromone was widely known to the farmers. But the equipments and material of this technique (pheromone and trap) was inadequate in comparison to demand. Except this, some others material or component like larvae of beneficial insect and poultry refuse were also not much available. In this aspect, Bangladesh Agricultural Research Institute (BARI), the most responsible organization to develop IPM techniques, should take initiative to develop and supply more IPM materials. Other research organizations, private sectors (NGO) and the agricultural universities can come forward to develop more vegetable IPM practices or equipments.

The other notable barriers that occupied the rank from 4 to 5 were availability of pesticides and lack of co-ordination between farmers and extension agent. Initiative like increasing awareness among the farmers about harmful effects of pesticides and reduce subsidy on this input may helpful to adjust the farmers with the fourth important barrier. To improve the co-ordination between farmers and extension agent, there is a need to recruit more Sub Assistant Agriculture officers (SAAO) who are treated as extension agent. Besides, incentives such as providing transport vehicle or allowance to the existing SAAO and an in-depth monitor on their activities by the upazila level officers are also useful for proper co-ordination between the extension agent and farmers.

Fear about IPM program and outcome from IPM practices is time being was the sixth and seventh important barrier. Now it is evident through several researches that IPM farming where pesticides are use when needed and also in judicious rate is more profitable than conventional farming in social, economic and environmental aspect. The extension agents, NGO's personnel and mass media should more highlight this issue that helps the farmers to avoid their fear about IPM program. On the other hand, arranging more practical training and demonstration program may assist the farmers about effective use of IPM technologies that can save their time. Additionally, through participation on these events, they may realize that as IPM give emphasize on non-chemical ways for controlling pest, then it is normal to take little more time than conventional practice that is use of chemical pesticides.

Similar price of IPM and non-IPM vegetable, need more labor and influence of pesticide agents were least important barriers. Some activities like i) a well design and effective marketing policy where IPM product will get more favor should be implemented by the government ii) initiative to develop less laborious IPM techniques and iii) educate the farmers about advantages of IPM and disadvantages of pesticide use; may help to overcome these barriers.

Based on inferential analysis (factor analysis)

In order to better understand about the importance of barriers, factor analysis was conducted. The Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy and Bartlett's Test of Sphericity (BTS) were applied to check the appropriateness of data and measure the homogeneity of variables entered to the model. KMO value was 0.733 and BTS was 540.012 ($p<.01$) indicating the data were appropriate for factor analysis. Principle component analysis was used as extraction method. Results of the analysis are presented in Table 3 and 4 respectively.

Table 3. Eigen values, Variance percentage and Cumulative variance percentage of extracted determinants

Factors	Eigen value	% of variance	Cumulative %
1	3.296	32.962	32.962
2	1.508	15.080	48.042
3	1.096	10.960	59.002

Table 4. Items loaded in the factor using principal component analysis

Factors	**Variables**	**Factor loading**
Institutional	No discrimination about price of IPM and non-IPM vegetable	0.671
	Lack of co-ordination between farmers and extension agent	0.665
	Availability of pesticides	0.655
	Inadequacy of IPM materials	0.557
	Lack of training facility	0.524
Social	Influence of pesticide agents	0.630
	Fear about IPM program	0.597
	Lack of knowledge about IPM	0.389
Management	Outcome from IPM practices is time being	0.593
	Need more labor	0.363

From both tables, it is noticed that three types of factors exist in the study area namely institutional barriers, social barriers and management barriers. Institutional barriers were the most important accounted 32.962% of total variance followed by social (15.080%) and management (10.960%) barriers. The variables under institutional barriers were similar price of IPM and non-IPM vegetables, lack of co-ordination between farmers and extension agent, availability of pesticides, inadequacy of IPM materials and lack of training facility. On the other hand, influence of pesticide agent, fear about IPM program and lack of knowledge about IPM under social

barriers. Remain two were under management barriers. As institutional barriers were most important, more attention should pay to minimize these barriers.

5. Conclusion

This study assessed what extent the vegetable growers adopt IPM technologies as well as analyzed barriers of adoption of these environment friendly technologies by considering the issue of non-adopters. The findings revealed less than one third farmers (30%) adopted IPM practices. The results also revealed that the rest farmers did not adopt IPM because of several barriers among which lack of knowledge about IPM, lack of training facility and inadequacy of IPM materials were the three most important. Besides, factors analysis revealed farmers faced by three types of barriers namely; social, institutional and management while institutional barriers were the most important to them.

Regarding first issue that is to determine adoption rate, the study applied one of the three previous methods which is more appropriate, easy and acceptable. The method is also applicable to measure adoption rate of other multiple agricultural technologies like integrated crop management, conservation farming and so on. Regarding second issue, the study analyzed farmers' barriers to adopt IPM based on descriptive and statistical analysis. Both cases most important barriers were highlighted and discussed. The information is helpful to increase adoption rate of environment friendly farming practices which is a mission of present government in Bangladesh.

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