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REVIEW ARTICLE

FACTORS CONTRIBUTING TO ADOPTION OF AGRICULTURAL TECHNOLOGIES: A CASE OF INTEGRATED PEST MANAGEMENT (IPM) IN KHULNA DISTRICT OF BANGLADESH

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ABSTRACT

This study tries to find the contributing factors of the Integrated Pest Management (IPM) adoption behavior of Bangladeshi farmers. For analysis, the necessary information was collected from 345 farmers residing in Phultala Upazila of Khulna division, Bangladesh with structured questionnaires. A simple random sampling technique was applied for data collection. In the bivariate setup, the association between the adoption status of IPM and possible contributing factors was examined by performing a chi-square test. A multivariable logistic regression was applied in a multivariate setup. The estimates of the model provide evidence that farmers' education level, farm size, training status on IPM, membership status of IPM club and farmer's field school have significant effects on farmers' adoption behavior of IPM. The findings call for greater attention on the part of the government for increasing farmers' education level, facilitating more training programs and arranging several motivational seminars on IPM at the primary level.

KEYWORDS

Adoption, IPM farming, Multivariable Logistic Regression, Significant factors, Bangladesh.

1. INTRODUCTION

Proper use of chemical pesticides to control pests has become one of the major tasks for the farmers in Bangladesh, a densely (964/sq.km) populated country having a rising growth rate of 1.34% (BBS, 2011). Every year Bangladesh loses a significant amount of production due to the serious damage caused by miscellaneous pests. Previous studies provide evidence that on average 16% of rice, 30-40% of vegetables, 25% of pulses, 11% of wheat were annually lost because of the serious attack of various pests (MOA, 2002). To reduce the attack of pests, a greater portion of the farmers of Bangladesh still uses chemical pesticide in their cultivated land inappropriately. Farmers' good health is essential for production efficiency, but improper use of pesticides have caused adverse consequences on farmers' wellbeing (Antle and Pingali, 1994; Ulimwengu, 2009; Bhattacharjee et al., 2013; Chitra et al., 2006; Dasgupta et al., 2005). Therefore, we have to search for a suite of approaches that can reduce the serious attack of pests as well as ensure good health for the farmers and ensure a wholesome environment. A unified approach such as Integrated Pest Management (IPM) plays a significant role that has less impact on human health and ecology (Henning et al., 1991; Kilcher, 2006; Lynch et al., 1996).

IPM is a philosophy that considers the scouting of pests, action thresholds, and multiple control strategies. It is not a philosophy that tries to eliminate pesticide use but supports the judicious use of pesticides in a safe manner for the applicator and the environment. However, IPM has no exact definition; several scholars characterized this integrated approach differently. A study analyzed several definitions of IPM and concluded that environmental safety is the main focus of all the definitions (Lynch et al., 1996). In general, IPM is an approach that manages pests by integrating biological, mechanical, cultural, physical and chemical tools in such a way that reduces health, economic and environmental risk. According to the Food and Agriculture Organization (FAO) Integrated Pest Management is:

"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."

Colloquial extension of sustainable agriculture is one of the most challenging tasks in a developing country like Bangladesh. To meet this challenge, one needs to understand the major determinants of sustainable agriculture. A few scholars identified that integrated nutrient management, maintaining agro-ecological health, biodiversity and landscape quality are the key factors for sustainable agriculture (Edwards and Grove, 1991; Clemetsem et al., 2000). In contrast, minimum use of chemical inputs and increasing productivity are considered as the key requirements of agricultural sustainability by others (De Jager et al., 2001; Ouedraogo et al., 2001; Tisdell, 1996; Webster, 1997). In this context, it is obvious that sustainable agriculture remains incomplete without adopting IPM farming. Generally, the adoption of a new technology relies on several socio-economic, demographic and physiological factors that may influence human mentality at any moment. Hence, IPM adoption is no exception from this setting. In this study, the objective is to find out the contributing factors for IPM adoption behavior of Bangladeshi farmers by fitting a multivariable logistic regression model.

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2. Materials and Methods

2.1 Data Source and Data Collection

This research was conducted in Phultala Upazila of Khulna division in Bangladesh. The survey data were collected from June to July 2022 with a structured questionnaire from 345 farmers (for detailed calculation of sample size determination, see Appendix) selected by a simple random sampling technique. The detailed procedure of the simple random sampling technique is described below:

Step 1: First, a list of rice farmers (n=8932) were collected from the district agriculture office.

Step 2: Sequential numbers were assigned separately to each rice farmer (1, 2, 3…n). This was the sampling frame (the list from which we drew our simple random sample).

Step 3: Determined the sample size (for a detailed calculation of sample size determination, see Appendix). In this study, the desired sample size was 345.

Step 4: A random number generator was considered to select samples from the sampling frame defined in Step 2. For example, since our sample size was 345 and our population is 8932, we generated 345 random numbers between 1 and 8932. Finally, among 345 rice farmers, we were able to find out 197 conventional farmers (those who reported that they did not adopt IPM) and 148 IPM farmers (those who reported that they adopt IPM) for further analysis.

Note that, the questionnaire was made as simple as possible and only relevant questions were included. Best efforts were made to obtain unbiased answers from the respondents.

2.2 Variable Selection

The main variable of interest, the adoption status of IPM was divided into two categories. They are:

$$Adoption\ Status\ of\ IPM = \begin{cases} Yes, & if\ the\ farmers\ reported\ that\ they\ adopt\ IPM \\ No, & if\ the\ farmers\ reported\ that\ they\ did\ not\ adopt\ IPM \end{cases}$$

Besides the main variable, we also considered respondents' sex (male, female), education level (no, primary education, secondary/ higher), farming experience (less than 10 years of farming experience, 10-20 years of farming experience, more than 20 years of farming experience), farm size (categorized into three groups based on existing size of the cultivated land), ownership of the farm (yes, no), training on IPM (yes, no), membership on IPM club (yes, no), attending in farmer field school (FFS) (yes, no) as possible influencing factors of IPM adoption. These variables were found significant in previous studies (Amir et al., 2012; Chaves and Riley, 2001; Fernandez-Cornejo and Jans, 1996; Ofuoku et al., 2008; Dasgupta et al., 2007; Bonabana-Wabbi, 2002; Hristovska, 2009; Talukder et al., 2017; Kabir et al., 2017).

2.3 Statistical Analysis

The association between selected covariates and the status of IPM adoption was examined by carrying out both bivariate and multivariate analyses. Note that the response variable "Adoption of IPM status" is categorical. In the bivariate setup, to measure the association between response and covariates, a chi-square test of significance was used. The chi-square has the form

$$\sum \frac{(O_{ij}-E_{ij})^2}{E_{ij}}, \quad (1)$$

Where O_{ij} and E_{ij} represents the observed and expected frequency of i^{th} row and j^{th} column respectively.

In a multivariate setup, multivariable logistic regression was considered to examine the adjusted effects of explanatory variables on the adoption status of IPM. Let $Y_i = (y_{i1}, \dots, y_{ic})'$ represents the binary response for subject i, and $x_i = (x_{i1}, \dots, x_{ip})'$ denote explanatory variable values for i. Let $\beta = (\beta_1, \dots, \beta_p)'$ denote parameters for the model. Then multivariable logit regression model is defined as

$$\log\left[\frac{\pi_i}{1-\pi_i}\right] = \alpha_j + \beta' x_i, \quad i = 1,2, \dots n. \quad (2)$$

Where π_i represents the probability of category i is expressed as $P(Y_i = 1)$.

3. Results and Discussion

3.1 Bivariate Analysis

Results obtained from bivariate analyses are displayed in Table 1. From this table, it is observed that about 56% of the illiterate farmers have never adopted IPM, while approximately 44% of the secondary or higher educated farmers have adopted IPM. It is apparent from the study that farmers' adoption behavior on IPM farming increased if the years of farming experience increases. The availability of farm size sharply influences the farmer's IPM adoption status. It is observed that the IPM adoption rate is higher for the farmers having their cultivated land (90%), having formal training on IPM (83%), being a member of the IPM club (81%) and Farmer's field school (69%). All these selected covariates are found to be statistically significant ($P < 0.05$). However, the covariate gender has an insignificant effect on farmers' IPM adoption behavior.

Table 1: Assessing Association Between Adoption Status of IPM and Possible Contributing Factors with P Values Obtained from Chi-Square Test.

Covariates	Adoption Status of IPM		P value
	Yes n (%)	No n (%)	
Gender			
Female	37 (39.37)	57 (60.63)	0.601
Male	111 (44.23)	140 (55.77)	
Education Level			
No Education	38 (43.68)	49 (56.32)	<0.05
Primary	65 (41.49)	90 (58.06)	
Secondary or Above	45 (43.69)	58 (56.31)	
Farming Experience (years)			
<10	27 (30.34)	62 (69.66)	<0.001
10-20	51 (38.94)	80 (61.06)	
20+	70 (56.00)	55 (44.00)	
Farm Size (acre)			
<1	33 (32.68)	68 (67.32)	<0.05
1-1.5	51 (39.54)	78 (60.46)	
1.5+	64 (55.66)	51 (44.34)	
Farm Ownership Status			
No	90 (31.81)	193 (68.19)	<0.001
Yes	56 (90.33)	06 (9.67)	
Training on IPM			
No	31 (15.2)	173 (84.80)	<0.001
Yes	117 (82.98)	24 (17.02)	
Member of IPM Club			
No	34(16.75)	169 (83.25)	<0.001
Yes	114 (80.29)	28 (19.71)	
Member of Farmer's Field School			
No	51 (24.88)	154 (75.12)	<0.001
Yes	97 (69.29)	43 (30.71)	

3.2 Regression Analysis

The adjusted odds ratio (AOR) of selected covariates obtained from the multivariable logistic regression model is displayed in Table 2. It was observed that the likelihood of adopting IPM was higher among educated farmers. To be precise, the secondary or higher educated farmers were $(1.41 - 1) \times 100 = 41\%$ more likely to adopt IPM compared to uneducated farmers. The likelihood of adopting IPM is also higher for the farmers who have more than 1.5 acres of cultivable land [AOR=1.35, 95% CI (1.10, 1.66)] compared to their counterparts. Moreover, the likelihood of adopting IPM was higher for the farmers receiving training on IPM [AOR=1.33, 95% CI (1.13, 1.42)], member of the local IPM club [AOR=1.26, 95% CI (1.11, 1.64)] and member of the FFS [AOR=1.87, 95% CI (1.05, 1.55)].

Table 2: Adjusted Odds Ratios (AOR) With 95% Confidence Interval of Selected Covariates for The Adoption of IPM Obtained from Multivariable Logistic Regression Model

Characteristics	Category	AOR (P-value)	95% Confidence Interval	
			Lower Bound	Upper Bound
Intercept (α)	–	0.31 (0.21)	0.58	1.35
Gender	Male (ref)	-	-	-
	Female	2.21 (0.25)	0.85	2.22
Education Level	No education(ref)	–	–	–
	Primary	1.34 (0.12)	1.25	1.75
	Secondary or above	1.41 (<0.01)	1.61	2.21
Farming Experience (year)	<10 (ref)	-	-	-
	10-20	2.45 (0.53)	0.98	2.20
	20+	1.45 (0.25)	0.85	1.45
Farm Size (acre)	<1 (ref)	–	–	–
	1-1.5	1.13 (0.1)	0.91	1.25
	1.5+	1.35 (<0.01)	1.10	1.66
Farm Ownership Status	No (ref)	–	–	–
	Yes	0.98 (0.1)	0.732	1.319
Training on IPM	No (ref)	–	–	–
	Yes	1.33 (<0.01)	1.13	1.42
Member of IPM Club	No (ref)	–	–	–
	Yes	1.26 (<0.01)	1.11	1.64
Member of Farmer's Field School	No (ref)	–	–	–
	Yes	1.87 (<0.05)	1.05	1.55

Ref=Reference Category

The main aim of this study was to explore the contributing factors of farmers' behavior on IPM adoption in Bangladesh. To fulfill our objective, we first performed a chi-square test as a bivariate analysis to assess the association between response and selected covariates. In the bivariate analysis, we observed that farmer's education level, farming experience, farm size, farm ownership status, training status on IPM, membership status of IPM club and farmer's field school were the significant factors for IPM adoption in the study area. However, gender did not play a significant role in determining the level of IPM adoption. Furthermore, we estimate the adjusted effects of the selected factors by fitting a multivariable logistic regression model.

Based on the multivariable logistic regression model, higher educated farmers had a higher likelihood of adopting IPM. This finding coincides with other previous studies (Chaves and Riley, 2001; Talukder et al., 2017; Samie et al., 2009; Kabir and Rainis, 2013). An educated farmer possesses a better understanding of the adverse effects of chemical pesticides on human health as well as the environment. He has a greater opportunity of learning about the integrated techniques which were helpful for human health and the environment. This finding calls for greater attention on the part of the government for framing policies to facilitate education at an institutional level keeping farmers at the center.

This study reveals that the membership status of IPM club and farmer's field school (FFS) had a significant contribution to the farmers' IPM adoption behavior. The farmers who were the members of the local IPM club and FFS had a greater likelihood to adopt IPM. This result is consistent with the existing literature (Talukder et al., 2017; Samiee et al., 2009). This probably happened because there were gatherings of farmers in the clubs where everyone can share their opinions and experiences on IPM practices, which may influence other farmers to adopt this environment-friendly technique. By considering this fact, we suggest the concerned authority to organize several motivational seminars on IPM by establishing IPM club and FFS in village level.

Moreover, the amount of cultivated land and training status on IPM has a significant effect on farmers' IPM adoption behavior. This finding also corresponds with similar previous works (Talukder et al., 2017; Kabir and Rainis, 2013). It is expected that a trained farmer will be more interested in applying a newly introduced technique in his cultivable land. Based on these findings, we strongly suggest the policymakers take initiatives for facilitating more training programs on IPM at the base level. However, why the amount of cultivated land increases the likelihood of IPM adoption demands further investigation.

This study has several limitations. There are a lot of socio-economic and demographic factors for farmers' adoption behavior in IPM practice. Because of limitations with time and money, we considered only selected factors for our analysis. Moreover, for policy development, it is important to consider all significant factors that can contribute to farmers' IPM adoption behavior. Existing literature provides evidence that farming experience has a significant effect on IPM adoption (Talukder et al., 2017). However, we did not get any evidence of the significance of the farming experience. This may have happened due to the data pattern that was used for our analysis.

4. Conclusions

In Bangladesh, a very few has known about the factors that have a significant influence on the adoption behavior of integrated pest management (IPM). Farmers' education level, farm size, training status on IPM, membership status of IPM club and farmer's field school (FFS) have significant impacts on farmers' adoption behavior of IPM in Bangladesh. This study, calls for greater attention on the part of the government for increasing farmers' education level, facilitating more training programs on IPM and arranging several motivational seminars on IPM at the primary level. Moreover, several research is required considering more factors that can contribute to this environment-friendly farming technique.

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We would like to thank district agricultural office of Khulna for providing us the list of the farmers.

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APPENDIX

Calculation of Required Sample Size:

We used the following formula for estimating our sample size which is obtained by solving the maximum error of the estimate formula for the population proportion for n

$$n = \frac{n_0}{1 + \frac{n_{0-1}}{N}},$$

Where

n_0= Initial sample

N= Population size

Again,

$$n_0 = \frac{z^2_{\propto/2}pq}{d^2},$$

Where

$z^2_{\propto/2}$= Standard normal deviate.

p = Assumed population in the target population estimated to have a particular characteristic.

d = Allowable maximum error in estimating population proportion.

Here we consider for 95% confidence interval for which the value of z is 1.96, thus we get the initial sample as

$$n_0 = \frac{(1.96)^2 \times 0.5 \times 0.5}{(.0517)^2} = 359$$

Where, p= 0.5

q= 0.5

d= 0.0517

From the Phultala upazila office of Khulna, we were able to know the sampling frame of our target population=8932.

Finally, our required sample is, $n = \frac{359}{1 + \frac{359-1}{8932}} = 345$.

Tables:

Table 1: Assessing Association Between Adoption Status of IPM and Possible Contributing Factors with P Values Obtained from Chi-Square Test.

Covariates	Adoption status of IPM		P value
	Yes n (%)	No n (%)	
Gender			
Female	37 (39.37)	57 (60.63)	0.601
Male	111 (44.23)	140 (55.77)	
Education level			
No education	38 (43.68)	49 (56.32)	<0.05
Primary	65 (41.49)	90 (58.06)	
Secondary or above	45 (43.69)	58 (56.31)	
Farming experience (years)			
<10	27 (30.34)	62 (69.66)	<0.001
10-20	51 (38.94)	80 (61.06)	
20+	70 (56.00)	55 (44.00)	
Farm size (acre)			
<1	33 (32.68)	68 (67.32)	<0.05
1-1.5	51 (39.54)	78 (60.46)	
1.5+	64 (55.66)	51 (44.34)	
Farm ownership status			
No	90 (31.81)	193 (68.19)	<0.001
Yes	56 (90.33)	06 (9.67)	
Training on IPM			
No	31 (15.2)	173 (84.80)	<0.001
Yes	117 (82.98)	24 (17.02)	
Member of IPM club			
No	34(16.75)	169 (83.25)	<0.001
Yes	114 (80.29)	28 (19.71)	
Member of farmer's field school			
No	51 (24.88)	154 (75.12)	<0.001
Yes	97 (69.29)	43 (30.71)	

Table 2: Adjusted Odds Ratios (AOR) with 95% Confidence Interval of Selected Covariates for the Adoption of IPM Obtained from Multivariable Logistic Regression Model

Characteristics	Category	AOR (P-value)	95% Confidence Interval	
			Lower Bound	**Upper Bound**
Intercept (α)	_	0.31 (0.21)	0.58	1.35
Gender	Male (ref)	-	-	-
	Female	2.21 (0.25)	0.85	2.22
Education level	No education(ref)	_	_	_
	Primary	1.34 (0.12)	1.25	1.75
	Secondary or above	1.41 (<0.01)	1.61	2.21
Farming experience (year)	<10 (ref)	-	-	-
	10-20	2.45 (0.53)	0.98	2.20
	20+	1.45 (0.25)	0.85	1.45
Farm size (acre)	<1 (ref)	_	_	_
	1-1.5	1.13 (0.1)	0.91	1.25
	1.5+	1.35 (<0.01)	1.10	1.66
Farm ownership status	No (ref)	_	_	_
	Yes	0.98 (0.1)	0.732	1.319
Training on IPM	No (ref)	_	_	_
	Yes	1.33 (<0.01)	1.13	1.42
Member of IPM club	No (ref)	_	_	_
	Yes	1.26 (<0.01)	1.11	1.64
Member of farmer's field school	No (ref)	_	_	_
	Yes	1.87 (<0.05)	1.05	1.55

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