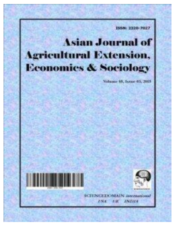

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Financial Analysis of IPM and Non-IPM Technology Used on Brinjal Production in Some Selected Areas of Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author AA designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors MAT and FH wrote the protocol and managed the analyses of the study. Author FH managed the literature searches. Author XG supervised the study. All authors read and approved the final manuscript.

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ABSTRACT

The study was undertaken to determine the production of Brinjal and to compare the financial profitability between IPM and Non-IPM Brinjal growers in the study areas. The study areas covered two intensive vegetables growing districts namely Comilla and Narsinghdi. The sample was 100 farmers taking 50 from each district. Among the farmers, 50% considered as pesticide users and 50% IPM users. Apart from descriptive statistics, Probit regression model and Cobb-Douglas production function was used in order to analyze the data. The findings of the study suggested that cost of brinjal production was higher for Non IPM farmers compared to IPM farmers. The average yield for the IPM and non-IPM farmers was found 38.7 ton per hectare and 45.9 ton per hectare

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respectively. Findings also suggested that IPM farmers had cost advantage compared to Non IPM farmers in the study areas. Among the explanatory variables of probit regression, coefficient of experience was found positive and significant while coefficient of distance to market and family size were negative and significant. Cobb-Douglas production function analysis suggested that the coefficient of human labour and cowdung had positive and significant effect on the yield of Brinjal. On the other hand irrigation and fertilizer had negative effect on the yield. This may be due to the fact that farmers may over using the irrigation and fertilizer in the Brinjal field. Lack of technical knowledge and effectiveness of pheromone trap for all insects was the major drawback for IPM adoption. The study recommends undertaking more training and research activities to overcome the problems of IPM technology for Brinjal.

Keywords: Adoption; IPM technology; Brinjal; financial profitability.

1. INTRODUCTION

1.1 General Background

Agriculture is the main source of livelihood for the people of Bangladesh. Agriculture occupies the key position in the economic growth of Bangladesh. The economic development is intertwined with the performance of this sector. About 47.33 percent of total population of this country earns their livelihood directly or indirectly from the agriculture [1]. The direct contribution of agriculture to the Gross Domestic Product (GDP) is 16.33 percent [2]. The most important issue in Bangladesh agriculture is to enhance and sustain growth in crops production. Crop production structure, changing production trends of different agricultural products and the effects of technological change on agriculture are prerequisites for a better understanding of agricultural growth as well as the economic development in Bangladesh.

1.2 Importance of Brinjal

Eggplant, *Solanum melongena*, commonly called brinjal in South Asia, is the most popular and economically important vegetable in Bangladesh. This versatile vegetable is especially important during the hot, humid monsoon season, when other vegetables are in short supply. Bangladesh's third most important vegetable in terms of both yield and area cultivated. It is only surpassed by potatoes and onions. At present, Brinjal covers about 41608 acres of the cultivated land in Bangladesh which is almost 7.8 % of total land and is dedicated to growing about 126992 metric tons of brinjal per annum [3]. Narshinghdi is one of the brinjal growing pocket area in Bangladesh nearside the Dhaka city. Belabo upazila under Narshinghdi district covering an area of 117.66 square kilometer [4]. In Belabo upazila brinjal is cultivated popularly in both winter and summer season. Comilla is another district included in this study. Comilla is also another brinjal growing pocket area in Bangladesh. The total area of brinjal cultivation in Adarsha Sadar and Brahmanpara upazila is 100 and 87 acre respectively. In this both upazila production of brinjal is 600 and 1120 metric ton per annum [5].

1.3 IPM Technology Used in Brinjal

Integrated Pest Management (IPM) is a broad ecological approach to pest control using various pest control tactics in a compatible manner. In the contemporary usage, IPM is not limited to dealing with pesticides and pest management, in fact, IPM has holistic approaches to crop production based on sound ecological understanding [6]. 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. Most commonly used IPM technology for Brinjal productions in Bangladesh are:

- Sex pheromone trap to control fruit fly, white fly, fruit borer etc.
- Grafting technique to control bacterial wilt and root-knot diseases and to get healthy and good quality crop.
- Organic soil amendment practices for the control of soil borne diseases through the use of mustard oilcake and poultry refuse.
- Bio-pesticide (Biotin-10) to control white fly during the stage of flowering.
- Light trap
- Glue trap etc.

1.4 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 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.

To reduce the negative impact of pesticides and increase the productivity, the government has begun to emphasize integrated pest management (IPM) technologies in the country. 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. But very little is known about the factors affecting the adoption of IPM technologies for brinjal cultivation [7]. McCarthy et al. [8] evaluates the effectiveness and impacts of USAID's IPM IL vegetable technology transfer subproject in Bangladesh. Islam [9] performed a research on an economic study on practicing IPM technology for producing bitter gourd in selected areas of Comilla district and the study revealed that IPM farmers gained more profit than non-IPM farmers on bitter gourd production. 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 Brinjal on pesticide cost and return. These factors can be compared at the farm level for IPM adopters and non-adopters to provide feedback to scientists, policy makers and Government for further improvement in the technologies.

1.5 Objectives of the Study

The present study was undertaken with the following specific objectives:

1) To determine the factors affecting the adoption of Brinjal IPM technology.
2) To compare the financial profitability of brinjal production between IPM and Non-IPM farmers in the study areas; and
3) To identify the factors affecting the production of Brinjal cultivation in the study area.

2. METHODOLOGY

2.1 Survey Methods and Techniques

2.1.1 Study areas

The study areas covered two intensive vegetables growing districts namely Comilla and Narsingdi. From each district two *upazilas* were selected randomly to collect field level data.

2.1.2 Sample size

A total numbers of 100 Brinjal cultivating farmers taking 50 from each district were interviewed for collecting field level data. Among the farmers, 50% considered as pesticide users and 50% IPM users.

2.1.3 Method of data collection

Primary data were collected from the selected respondents through face to face interview by the researcher herself.

2.1.4 Analytical technique

Collected farm level data were edited, summarized, tabulated and analyzed to fulfill the objectives of the study. In most cases, descriptive statistics were used to present the results of the study.

2.1.5 Factors affecting the adoption of IPM practices

To assess the adoption of IPM practices at farm level and to find out the factors affecting their adoptions, Probit regression model was used. In this study the farmers who are using IPM technologies such as sex pheromone trap, hand picking of insects, organic fertilizer and maximum 5 applications of pesticides were considered as IPM farmers.

Probit model: In order to ascertain the relationship between the adoption of IPM technology and socio-economic factors, the following empirical Probit model (equation 1) was carried out. The dependent variable of this model was adoption of IPM technology. Since the dependent variable is dichotomous, OLS cannot be used.

$$Y_i^* = \alpha + \beta_i X_i + \ldots\ldots. + U_i, \quad \text{where } U_i \sim N(0,1),\ i = 1, \qquad (1)$$

$Y = 1_{\{Y^*>0\}} = 1$ if $Y^* > 0$
0 Otherwise

Where,

Yi = Adoption of IPM technologies (if adopter = 1; otherwise = 0)

α = Intercept

Xi = Explanatory variables (socioeconomic characteristics)

β_i = Coefficients of respective factors

Ui = Error term

The empirical probit model is as follows;

$$\text{Adoption of IPM} = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + u_i$$

Where,

X_1 = Education (Score)
X_2 = Farm size (hectare)
X_3 = Distance to local market (km)
X_4 = Family size (person/family)
X_5 = Experience (Years)
X_6 = Extension contact (Score)

2.1.6 Independent variables used in the probit model and their measurement

Education (X_1): Education of the respondent was measured on the basis of total level of education.

Farm size (X_2): Farm size is an indicator of social status of the respondents. It was calculated on per hectare basis for each respondent.

Distance to local market (X_3): It was measured in Kilometers. It was used as a proxy for market accessibility to see whether better market accessibility influence the adoption decision or not.

Family size (X_4): It was measured on the basis of number of members in the family.

Experience (X_5): It was measured on basis of total number of years that the farmers were engaged in brinjal cultivation.

Extension contact (X_6): In this study farmers were given score (0-4) based on their frequency of contact with the SAAO. Higher score indicates higher linkage with extension services.

2.1.7 Calculation of profitability

Cost and return analysis is the most common method of determining and comparing the profitability of different farm enterprises. In estimating the level of profitability in crop production the following formula was used:

$$\pi = P1Q1 - \sum_{i=1}^{n} PiXi - TFC$$

Where,

∏ = Profit per hectare for producing the Brinjal;

P_1 = per unit price of the Brinjal;

Q_1 = Quantity of output obtained (per hectare);

P_i = per unit price of the i^{th} input used for producing Brinjal;

X_i = Quantity of the i^{th} input used for producing Brinjal; and

TFC = Total fixed cost.

2.1.8 Interest on operating capital

Interest on operating capital was calculated for all cash expenses on inputs such as land preparation, human labor, Seedlings, Urea, TSP, MoP, Cowdung, Irrigation, Pesticides , sex pheromone trap etc. In this study interest on operating was charged at the rate of 8% per annum and was estimated for the period the operating capital was used. Interest on operating capital was calculated by using following formula [10].

Interest on operating capital = Operating capital/2 × Rate of interest × Time considered.

2.1.9 Factors affecting the productions of Brinjal

Cob-Douglas production function analysis was used to determine the factors affecting the Brinjal cultivation. To determine the contribution of the most important variables in the production process, the following specification of the model was applied:

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}e^{ui}$$

Or $\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + U_i$

Y= per hectare yield of brinjal (Kg/ha);
a= Intercept of the value
X_1 = Number of human labour (Man days/ha)
X_2 = Seedling cost (Tk/ha)
X_3 = Cost of cowdung (kg/ha)
X_4 = Cost of pesticides (Tk/ha);
X_5 = Cost of Irrigation (tk/ha);
X_6 = Cost of fertilizer (Tk/ha);
b_1…..b_6 = Coefficient of the respective variable;
Ui= Error Term;

3. RESULTS AND DISCUSSION

3.1 Determinants of Adoption of IPM Technology

Among the explanatory variables, experience was found positive and significant while distance to market and family size were negative and significant. The coefficient of Education is also found negative but not significant (Table 1).

The findings suggested that distance is negatively related with the adoption (P=0.00). The probability of adoption was decrease by 0.91% for every increase in distance from the market. This could be explained as distance increases, the possibility of adoption decrease.

Family size is negatively related with the adoption (P=0.00). The probability of adoption was decrease by 0.33% for every increase in family size by one member. This could be explained as family size increases, the maintenance costs of family member is increased resulted the shortage of money to purchase inputs of production.

Experience is positively related with the adoption of IPM technologies (P<0.1). The marginal effect of a unit change in experience, on the probability of adoption is 0.04. This means that the probability of adoption increases by about 0.037% for a one year of experience is increased.

Education is negatively related with the adoption of IPM technologies but insignificant. Similarly farm size is also negatively related but insignificant.

Extension contact was positively related with IPM adoption but found insignificant.

Table 1. Maximum likelihood estimates of variable determining adoption of IPM practices among respondent farmers

Explanatory variable	Coefficient	Standard error	z-statistic	Probability
Constant	6.621***	1.49	4.42	0.000
Education	-0.062	0.201	-0.30	0.761
Farm size	-4.94	6.89	-0.72	4.474
Distance	-2.282***	0.513	-4.45	0.000
Family size	-0.832***	0.2003	-4.15	0.000
Experience	0.094*	0.037	2.53	0.011
Extension contact	0.323	0.21	1.54	0.124

Note: Dependent variable = Adoption of IPM (Adopter = 1, Non-adopter = 0)
No. of observation = 100; LR chi-square (6) = 93.19;
Log likelihood = -22.719672; Pseudo R^2= 0.6722
*'***' '**' '*' represent significant at 1%, 5% and 10% level respectively*

Table 2. Marginal probability of factors that determine the adoption of IPM practices

Explanatory variable	Marginal effect (dy/dx)	Standard error	z-statistic	Probability
Education	-0.243	0.08	-0.30	0.760
Farm size	-1.96	2.738	-0.72	0.473
Distance	-0.91***	0.199	-4.55	0.000
Family size	-0.331***	0.081	-4.09	0.000
Experience	0.04*	0.015	2.49	0.013
Extension contact	0.13	0.084	1.53	0.126

*Note: '***' '**' & '*' represent significant at 1%, 5% and 10% level respectively*

3.2 Cost and Return

The aim of analyzing costs and returns is to determine the amount of profit a producer is making from a particular commodity production within the given technology and investment. The profitability of a commodity production crucially depends on its prices, cost of production, and availability of technology. It is worthwhile to know the existing technology in terms of agronomic practices and input use in the area. A brief description about the cost items of the Brinjal in the selected areas is presented in Table 4.

3.3 Financial Profitability of Brinjal Cultivation

Financial profitability is based on calculation of market prices of inputs and outputs that farmers actually pay or receive for producing a crop, along with the quantities used of each. It is evident from the Table 5 that the average yield of brinjal for Non-IPM farmers (45.9 t/ha) was higher than the IPM farmers (39.7 t/ha). On the other hand, net return and BCR was higher for the IPM farmers than the Non IPM farmers. The BCR for brinjal was 3.61 under IPM practices and 3.11 under Non IPM practices which indicated that, the cultivation of brinjal through the IPM method is more profitable than the Non-IPM method in the study areas. The Table also indicates that IPM farmers have cost advantage compared to non-IPM farmers.

3.4 Comparative Cost and Return of IPM & Non-IPM Farmers

It is evident from the Table 6 that the pesticide cost is 186% higher for non-IPM farmers compare to the IPM farmers. Similarly to some extent IPM farmers received higher gross return, gross margin and net return compare to the non-IPM farmers. On the other hand non-IPM farmers received higher yield. This Table clearly indicates that Non-IPM farmers had yield advantage but the IPM farmers had cost advantage.

Table 3. Level of input use per hectare of Brinjal

	Comilla		Narsinghdi		All	
	IPM	**Non-IPM**	**IPM**	**Non-IPM**	**IPM**	**Non-IPM**
Total Human labour (man/day)	322	206	274	319	298	263
Family	134	86	151	124	143	105
Hired	190	120	123	195	156	270
Seedlings (no./ha)	8443	12966	9442	12760	8943	15129
Urea (Kg/ha)	435	480	190	585	313	533
TSP (Kg/ha)	398	330	162	262	280	296
MoP (Kg/ha)	309	304	168	435	239	370
Cowdung (Kg/ha)	8938	8995	6063	8121	7501	8558

Table 4. Per hectare cost (Tk/ha) of Brinjal

	Comilla		Narsinghdi		All	
	IPM	**Non-IPM**	**IPM**	**Non-IPM**	**IPM**	**Non-IPM**
Variable cost						
Cost of land preparation	5641	6525	4752	6254	5197	6390
Total human labor cost	112700	72100	95900	111650	104300	91875
Seedlings	16886	12967	8727	17229	12806	15098
Urea	6954	7678	3034	9359	4994	8519
TSP	9968	8230	4062	6561	7976	26142
MoP	4635	4560	2516	6529	3576	5545
Cowdung	4469	8995	6063	8121	5266	8558
Irrigation	2531	2246	2246	1917	2389	2082
Cost of pheromone	1739	0	9225	0	4702	0
Pesticides	20811	92723	22667	31683	21739	62203
Sub-total	186334	216024	159192	199303	182128	207663
Interest on operating capital	3727	4320	3184	3986	3643	4153
Total variable cost	**190061**	**220344**	**162376**	**203289**	**185771**	**211818**
Fixed cost						
Land use cost	3107	10740	11560	8873	7334	9807
Total cost	**193168**	**231084**	**173936**	**212162**	**193105**	**221625**

Table 5. Per hectare return (Tk/ha) of Brinjal

	Comilla		Narsinghdi		All	
	IPM	Non-IPM	IPM	Non-IPM	IPM	Non-IPM
Yield (ton)	35.4	44.3	41.9	47.4	38.7	45.9
Gross Return	773776	688514	620802	686254	697289	687384
Total variable cost	**190061**	**220344**	**162376**	**203289**	**185771**	**211818**
Total fixed cost	3107	10740	11560	8873	7334	9807
Total cost (TC)	**193168**	**231084**	**173936**	**212162**	**193105**	**221625**
Gross Margin	583715	468170	458426	482965	511518	475566
Net Profit	580608	457430	446866	474092	504184	465759
BCR over total cost	**4.01**	**2.98**	**3.57**	**3.23**	**3.61**	**3.11**

Table 6. Comparative cost and return of IPM & NON-IPM farmers

Items	Comilla			Narsinghdi			Average			
	IPM	Non-IPM	% high/ low	IPM	Non-IPM	% high/ low	IPM	Non-IPM	Mean difference	% high/ low
Pesticide cost	20811	92723	346%	22667	31683	40%	21739	62203	40464	186%
Yield	35.4	44.3	25%	41.9	47.4	13%	38.7	45.9	7.2	19%
Gross Return	773776	688514	-11%	620802	686254	11%	697289	687384	-9905	-1.4%
Gross Margin	583715	468170	-20%	458426	482965	6%	511518	475566	-35952	-7.03%
Net Return	580608	457430	-21%	446866	474092	6.1%	504184	465759	-38425	-7.62%

3.5 Hindrance of IPM Technology

IPM technique is environmental friendly and enhanced production at farm level but it has some hindrance which should not be ignored. Among the hindrance, lack of technical know-how was the major barrier and about 44 % farmers' responses regarding this problem. Besides, 64 % farmers opine that pheromone trap is not effective for all insects. In addition, availability of sex pheromone trap in time (22%) and lack of training facilities (20%) are another concern for the farmers (Table 7).

3.6 Factors Affecting Brinjal Yield

For producing Brinjal different kinds of inputs, such as human Labor, seedling, cowdung, pesticide, irrigation, fertilizer, etc. were employed which were considered as a priori explanatory variables responsible for variation in the yield of Brinjal. Some others factors which also might affect production were management, farm size, land quality, soil condition, time of sowing, period of harvesting etc. The use of these inputs was not made because of data limitation. Cobb-Douglas type production function was employed to understand the possible relationships between the yield of brinjal and the inputs used.

3.7 Interpretation of the Estimated Coefficient

The estimated values of the coefficient and related statistics of the Cob-Douglas production function of IPM and Non-IPM Brinjal farmers have been shown in Table 8.

3.8 IPM Farmer

Human Labour (X_1): The co-efficient for human labour (X_1) was 0.98 and significant at 1 percent level. This indicated that on an average 1 percent increase in the human labour keeping other factor constant, would increase the yield by 0.98 percent.

Seed (X_2): The co-efficient of seed (X_2) was found negative (-0.12) and insignificant.

Cowdung (X_3): The co-efficient of cowdung (X_3) was found 0.60 and significant at 1 percent level. This indicated that on an average 1 percent increase in the use of cowdung keeping other factor constant would result in an increase of yield by 0.60 percent.

Pesticides (X_4): The co-efficient of pesticides (X_4) was found negative (-0.02) and insignificant.

Irrigation (X_5): The co-efficient of irrigation (X_5) was found 0.17 and insignificant.

Fertilizer (X_6): The co-efficient of fertilizer (X_6) was negative (-0.64) and was significant at 1 percent level. This indicated that on an average 1 percent increase in cost of fertilizer keeping other factor constant would result in a decrease of yield by 0.64 percent.

Model diagnostic: The co-efficient of multiple determination, R^2 was 0.78 for IPM farmers which indicated that about 78 percent of the total variation in yield of brinjal is explained by the variables included in the model. In other word the excluded variables accounted for only 22 percent of the total variation in yield of brinjal. The F-value was found highly significant which implies that the included variables are important for explaining the variation in yield.

3.9 Non- IPM Farmer

Human Labour (X_1): The co-efficient for human labour (X_1) was found negative (-0.07) and insignificant.

Seed (X_2): The co-efficient of seedling (X_2) was found 0.37 which was significant at 1 percent level. This indicated that on an average 1 percent increase in cost of this input keeping other factor constant would result in an increase of yield by 0.37 percent.

Cowdung (X_3): The co-efficient of cowdung (X_3) was found 0.13 and insignificant.

Pesticides (X_4): The co-efficient of pesticides (X_4) was found 0.06 and insignificant.

Irrigation (X_5): The co-efficient of irrigation (X_5) was found negative (-1.18) and was significant at 10 percent level. This indicated that on an average 1 percent increase in cost of irrigation keeping other factor constant would result in a decrease of yield by 1.18 percent.

Table 7. Hindrance of IPM technology

Particulars	% of respondents		
	Comilla (N = 25)	Narsinghdi (N = 25)	All (N = 50)
Lack of technical know how	40	48	44
Pheromone trap is not effective for all insects especially during flowering stage	56	72	64
Poor quality of sex pheromone trap	20	24	22
Lack of training facilities	16	24	20
Not available of sex pheromone trap in time	40	32	36

Table 8. Estimated values of coefficient and related statistic

Explanatory variable	IPM farmers		Non-IPM farmers		Both	
	Estimated coefficient	t-values	Estimated coefficient	t-values	Estimated coefficient	t-values
Intercept	3.91	1.14	14.79***	3.17	12.30***	6.51
Human Labor	0.98***	6.78	-0.07	-0.28	0.33***	3.31
Seedling cost	-0.12	-0.87	0.37***	3.56	-0.14	-1.61
Cowdung	0.60***	6.82	0.13	0.91	0.63***	7.22
Pesticide cost	-0.02	-1.39	0.06	1.88	0.03	1.52
Irrigation cost	0.17	0.34	-1.18*	-2.01	-0.90***	-3.66
Fertilizer cost	-0.64***	-3.97	0.01	0.05	-0.19*	-2.23
Adjusted R^2	0.781		0.459		0.481	
F-Value	30.19***		7.93***		16.29***	

*Note: *** significant at 1 percent level*
*** Significant at 5 percent level*
** Significant at 10 percent level*

Fertilizer (X_6): The co-efficient of fertilizer (X_6) was found 0.01 and insignificant.

Model diagnostic: The value of adjusted R^2 was found 0.459 for non-IPM farmers which indicated that about 46 percent of the total variation in yield of brinjal is explained by the variables included in the model. In other word the excluded variables accounted for only 54 percent of the total variation in yield of brinjal. The F-value was highly significant and it implied that the included variables are important for explaining the variation in yield.

3.10 Both Categories of Farmers

Human Labour (X_1): The co-efficient for human labour (X_1) was found 0.33 which was significant at 1 percent level. This indicated that on an average 1 percent increase in human labour keeping other factor constant would result in an increase of yield by 0.33 percent.

Seed (X_2): The co-efficient of seedling (X_2) was found negative (-0.14) and insignificant.

Cowdung (X_3): The co-efficient of cowdung (X_3) was found 0.63 which was significant at 1 percent level. This indicated that on an average 1 percent increase in cost of this input keeping other factor constant would result in an increase of yield by 0.63 percent.

Pesticides (X_4): The co-efficient of pesticides (X_4) was found 0.03 and insignificant.

Irrigation (X_5): The co-efficient of irrigation (X_5) was found negative (-0.90) and significant at 1 percent level. This indicated that on an average 1 percent increase in cost of irrigation keeping other factor constant would result in a decrease of yield by 0.90 percent.

Fertilizer (X_6): The co-efficient of fertilizer (X_6) was found negative (-0.19) and insignificant.

Model diagnostic: The co-efficient of multiple determination, R^2 was found to be 0.481 for both category of farmers together which indicated that about 48 percent of the total variation in yield of brinjal is explained by the variables included in the model. The F-value was found to be 16.29 which was highly significant and it's implies that the included variables are important for explaining the variation in yield.

4. CONCLUSION

The findings of the study suggested that there is no doubt that the cultivation of Brinjal through IPM technologies produced higher income and required less cost of production over the Non IPM farmers. Cost of production of brinjal was higher for Non IPM farmers compared to IPM farmers in all the areas due to high pesticide cost. The result clearly indicates that IPM farmers have cost advantage and Non IPM farmers have yield advantage. Due to this lower cost net return was found higher for IPM farmers in the study areas. Different factors like experience distance to market and family size plays a significant role for adoption of IPM technologies in the study areas. According to production function analysis in general factors like human labour and Cowdung are plays a significant role in increasing the yield of brinjal both IPM and non-IPM farmers.

5. RECOMMENDATIONS FOR POLICY IMPLICATION

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

- An increased rate and extent of adoption of commonly used integrated pest management practices in brinjal cultivation are vital both for increasing the yield of brinjal. But, only a considerable proportion of the farmers had adopted few IPM practices in brinjal cultivation. It is, therefore, recommended that, the DAE should take effective steps for strengthening extension services in order to change adoption percentage of the brinjal growers regarding IPM practices.
- Lack of technical knowledge is the major drawbacks that hinder IPM adoption decision. So it is recommended that along with DAE local NGO's should conduct more training programs on commonly used IPM practices that would make the farmers more skilled to adopt integrated pest management in brinjal cultivation.
- Chemical pesticides are harmful for health and environment. Therefore, it may be recommended that, DAE and other agricultural agencies should campaign more about the harmful effects of chemical pesticide on human health and adjacent environment to change the attitude of the brinjal farmers.

- The Department of Agricultural Extension (DAE) needs to pay more attention to ensure the adoption of integrated pest management (IPM) practices through building confidence among the farmers about commonly used IPM practices in brinjal cultivation by showing clear difference between traditional and recommended practices.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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