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POTENTIAL ECONOMIC BENEFIT AND PRODUCERS' WILLINGNESS TO ADOPT BT-BRINJAL IN BANGLADESH: AN EX-ANTE ANALYSIS

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ABSTRACT

Introduction of genetic engineering in agriculture is a recent idea of native scientists. Scientists from Bangladesh Agriculture Research Institute (BARI) are working on developing an FSB resistant brinjal variety namely Bt-brinjal in collaboration with Cornel University, USA. In addition, this study was attempted to find out the potential economic benefit and producers' willingness to adopt Bt-brinjal. A total of 80 respondents were randomly selected from Gazipur and Jamalpur districts. Descriptive statistics and Logistic regression analysis were used to analyze data. Yield gain and reduction in insecticide use data give the result as Bt-brinjal will increase yield by 65.76 percent and 44.87 percent and reduce pesticide cost by 71 percent and 70.36 percent compared to local OPV and Hybrid brinjal respectively. 98 percent of farmers will produce Bt-brinjal if they reduce insecticide use but 65 percent will not produce it if there are any health-related issues. Mass advertisement is also a significant factor of adoption (63.75 percent). It was found that the marketing channel for Bt and non-Bt brinjal is same. For this producers' adoption of Bt-brinjal is related to the potential benefit and harmlessness of the technology. Results also showed that adoption is significantly influenced by education, own land size, no. of spray per season, season of growing brinjal ($p<.01$) and household size, type of growing brinjal ($p<.05$) respectively. Though voice against GM crops was also very loud but the Bangladesh government is very much eager to introduce this technology to the market and give the benefits to its consumers.

Contribution/Originality: This study is one of the very few studies which have investigated potential economic benefit and producer willingness to adopt of Bt-brinjal in Bangladesh. This study was an ex-ante analysis related to Bt-brinjal adoption in Bangladesh. Hence; this is an original contribution in this field.

1. INTRODUCTION

Bangladesh is feeding its 165 million people mostly with its own local level production. About 13.41 percent (World Bank, 2017) of the country's gross domestic product has come from the agriculture sector. Not only that but also two-thirds of the country's total labor force is engaged with agriculture (Runge and Ryan, 2004). Bangladesh has rice, wheat, jute, sugarcane, tobacco, oilseeds, pulses and potatoes as the main crop along with some other crops. In addition, vegetables play a supreme role in the diet of almost every family in Bangladesh especially in rural areas (Weinberger and Genova, 2004). The major vegetables those are cultivated mainly include potato, brinjal, sweet

guard, bitter guard, bottle guard, ladies finger, wax guard, snake guard, pumpkin, pointed guard, cucumber, bean, long bean and so on. Vegetables can be categorized as summer/rainy vegetables, winter vegetables, and all-season vegetable. Actually, vegetable production in Bangladesh has increased with an average annual growth rate of more than two percent. Most of this growth can be attributed to area expansion and only a small share to yield increases.

Vegetables are globally accepted as healthy thus always recommended to include in everyday diet. It also provides energy, vitamins, minerals and fibre and there is growing evidence of additional health benefits from a range of phytonutrients. Besides, brinjal is equally important for both farmers and consumers as it contains almost 95 percent of water and is rich in fiber, folic acid, manganese, thiamin, and Vitamin B6, magnesium and potassium contents compared to other vegetables. Furthermore, brinjal is one of the commonly consumed as well as highly produced vegetables in Bangladesh as well as in the world. In 2007, China and India was the main contributor to brinjal's global production. In addition, Brinjal is a strong source of cash income for marginal and small farmers and full of nutrient. In 2007, Bangladesh produced 340,000 m. tons of brinjal (Meherunnahar, 2009). In 2016-17, over 125860 acres of total cultivable land was devoted to brinjal cultivation which was produced 507,432 metric tons (BBS, 2018). The growth and production of brinjal is alarmingly lowered due to a dozen of insect pest. Moreover, brinjal is attacked by 17 species of insects and six types of different diseases in Bangladesh (Roy, 1997). According to an estimate, an annual loss of yield due to insect pest alone is 25 percent for vegetables (NIPMP, 2002). Among insect pests brinjal shoot and fruit borer (*Leucinodes orbonalis*), Epilachna beetle (*Epilacna 28 punctata and 12 punctata*), brinjal leaf roller (*Eublemma olivacea*), Jassid (*Amrasca biguttula*) and among diseases Anthracnose (*Colletotrichum Melongena*), bacterial wilt (*Pseudomonas Solanacearum*), little leaf of brinjal (*Mycoplasma*) are common, most serious and destructive (Roy, 1997). The pests can attack either sporadically or in out breaks every year throughout the country.The main problem with growing brinjal is that the yield of brinjal is decimated mainly by brinjal shoot and fruit borer (FSB) (Mall *et al*., 1992; Abrol and Singh, 2003; Ghosh *et al*., 2003). FSB is a small larva that makes holes inside shoots, potholes and midribs of leaves, causing shoot tops to wilt. Consequently, Brinjal farmers are affected by significant yield losses, more than half, due to the Eggplant FSB every year. Ninety-eight percent of the farmers relied solely on pesticide applications to control this pest and more than 60 percent of the farmers sprayed their brinjal crop more than 140 times or more in a cropping season of 6-7 months (Karim, 2004). For this reason, farmers suffer numerous health problems (including skin and eye irritation, nausea, and faintness), resulting from direct exposure to pesticide during handling and spraying (Rahman, 2000; Wilson and Tisdell, 2001). In Bangladesh, almost all farmers experienced sickness related to pesticide application (e.g. physical weakness or eye infection or dizziness) and 3 percent were hospitalized due to complications related to pesticide use (Alam *et al*., 2003). Due to climatic conditions and vulnerable to diseases, Bangladesh has the lowest productivity of brinjal in the world. Researchers are always trying to improve the productivity by using modern technology and genetically modified crops play a vital role in order to increase income and nutrition as well as production by reducing loss (Choudhary and Gaur; Adesina and Zinnah, 1993; Von, 1995; James, 2006). Experiments showed that the productivity of brinjal could be more than tripled by growing genetically modified brinjal (Bt-brinjal). In essence, results also showed that Bt technology can play a significant role to increase producers' welfare through insecticide reductions and increases in marketable yield. Some socioeconomic studies (Crawford *et al*., 2003) indicated the potential of Bt-brinjal to increase producers' welfare through insecticide reductions and an increase in marketable yields of brinjal fruits.

Basically, Bt (*Bacillus thuringiensis)* is a common soil bacterium with a gene that can yield a protein detrimental to FSB. Researchers have embodied this gene to Brinjal to make it insect resistance. Bt-brinjal is provided with Bt gene. Based on improvement in different countries, some Asian countries, including Bangladesh, have recently launched a set of programs on GM food crops. Its popularity is growing day by day. In 1996 the land under GM crops was only 1.7 million hectares which increased up to 170.3 million hectare in 2012. Diversification into vegetable crops and increasing commercialization can support the development of the agricultural sector in several

ways. Using genetically modified crops has been characterized by households moving from subsistence systems into semi commercialize and commercializes systems (Pingali and Rosegrant, 1995). As Bt-brinjal has the potential to combat FSB, so scientists are very much hopeful for its effectiveness and mass cultivation. Several studies (Kolady and Lesser, 2005; Krishna and Qaim, 2007; Krishna and Qaim, 2008; Qaim, 2010; Kumar *et al*., 2011) have been conducted in abroad based on economics benefit and adoption of Bt-egplant as well as biotechnology aspect. However, in Bangladesh no study has been investigated about producer economic benefit and willingness to adopt Bt-brinjal as an ex-ante aspect. One important information is that during investigation time, Bt-brinjal variety was at BARI (Bangladesh Agricultural Research Institute) experimental field trial. Given this above backdrop, it is necessary to find how much the producers of Bangladesh will be willing to adopt Bt-brinjal. This research was an attempt to contribute to this extent. Thus, the main objective of this study was to find out the producers' willingness to adopt Bt-brinjal. However, the specific objectives of this study were: (i) to estimate the potential benefits of Bt brinjal in terms of yield gain and reduction in insecticide use (ii) to identify producers' willingness to adopt Bt brinjal in Bangladesh and (iii) to identify the factors affecting adoption of Bt brinjal in Bangladesh.

2. METHODOLOGY

The study was conducted in two districts of Bangladesh namely Gazipur and Jamalpur. A total of 80 respondents (10 adopters of field trials and 70 non-adopter of Bt-Brinjal) were selected from Gazipur and Jamalpur districts by using simple random sampling method. Data were collected during June and August, 2015 by interview through structured questionnaire. STATA software was used for statistical analysis. In addition to the field surveys with the brinjal producers, the study conducted expert interviews, and media contents surveys to identify the different controversies such as health, environmental, social and consumers' attitudes related to Bt-brinjal and finally major marketing channel in the study areas.

2.1. Logistic Regression Analysis

Logistic regression measures the relationship between a dependent variable and one or more independent variables, which are usually continuous. Binary logistic regression deals with such situations where the observed outcome for a dependent variable can be of two possible types. That is, the dependent variable can take the value 1 with a probability of success θ, or the value 0 with probability of failure 1-θ. Frequently "logistic regression" is used in the situation of binary variables i.e., the number of available categories is two.

A form of the logistic regression equation is:

$$\text{logit } [\theta(x)] = \log \left[\frac{\theta(x)}{1-\theta(x)}\right] = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_i X_i$$

The Logit model was estimated by using binary dependent variable where the value 1 was assigned for the producers willing to adopt Bt-brinjal and 0 otherwise. The Logit model has been specified as follows:

$$\text{Logit } Yi = \text{Loge}\left(\frac{Yi}{1-Yi}\right) = B_0 + B_1X_{1i} + B_2X_{2i} + B_3X_{3i} + B_4X_{4i} + B_5X_{5i} + B_6X_{6i} + B_7X_{7i} + B_8X_{8i} + U_i$$

$$\text{Loge}\left(\frac{Yi}{1-Yi}\right) = B_0 + B_1X_{1i} + B_2X_{2i} + B_3X_{3i} + B_4X_{4i} + B_5X_{5i} + B_6X_{6i} + B_7X_{7i} + B_8X_{8i} + U_i$$

$$L = B_0 + B_1X_{1i} + B_2X_{2i} + B_3X_{3i} + B_4X_{4i} + B_5X_{5i} + B_6X_{6i} + B_7X_{7i} + B_8X_{8i} + U_i \quad (1)$$

Here,

Yi=It is a binary dependent variable having 1 for the producers willing to adopt Bt-brinjal and 0 otherwise;

X_1=Age

X_2=Education level

X_3=Own land Size

X_4=Number of spray per season

X_5=Household size

X_6=Main occupation

X_7=Season of growing brinjal

X_8=Type of brinjal producing

B_1 to B_8= Co-efficient to be estimated

L, the log of the odd ratio; is not linear in X but also linear in parameters. L is called the Logit, hence the name Logit model for models like (1). The features of the Logit model are as followed:

a. As Yi goes from 0 to 1, the Logit L goes from - ∞ to + ∞. That is, although the probabilities (of necessary) lie between 0 and 1, the Logit are not so bounded.
b. Although L is linear in Xi, the probabilities themselves are not. This property is in contrast with the linear probability model where the probabilities increase linearly.
c. The interpretation of the Logit model is as followed: Bi, the slope measures the change in L for a unit change in Xi. Like most interpretations of intercepts, this interpretation may not have any physical meaning.
d. Whereas the LPM assumes that Yi is linearly related to Xi, the Logit model assumes that the log of odds ratio is linearly related to Xi.

3. RESULTS AND DISCUSSIONS

In-order to fulfill the first objective tabular analysis was done with the help of field survey data, secondary data, and various research findings related to Bt-brinjal.

3.1. Yield Gain and Reduction in Insecticide Use

Bt-brinjal is still in development stage. So it was not possible to collect data on yield gain and reduction in insecticide use of Bt-brinjal directly from producers. In the research area there were 10 Bt-brinjal producers who were provided with initial Bt-brinjal saplings for field trials. They produce it from the direct supervision of BARI officials. So, several rounds of discussions were made with them. BARI claimed that the average yield of Bt-brinjal will be 40 ton/ha (bari.gov.bd). Again based on experimental data, Bt-brinjal can increase yield by at least 30 percent and reduce the number and cost of insecticide applications by 71-90 percent (ISAAA, 2015). Results showed that average yield of local OPV was found 24.13 ton/ha. This yield is for four months. This can vary if the producers keep his plant for fruiting for more times. Average yield for hybrid was found 27.61 ton/ha. So Bt-brinjal will increase yield by 65.76 percent in case of local OPV. In case of hybrid brinjal the yield will increased by 44.87 percent Table 1.

Table-1. Increase of yield by Bt-brinjal.

Particulars	Ton/ha.	Percentage increase
Average yield of OPV	24.13	65.76
Average yield of Hybrid	27.61	44.87
Average yield of Bt-OPV	40.00	

Source: Authors estimation, 2015.

Average pesticide cost for local OPV is 43185.48 Tk/ha and for hybrid is 42256.76 Tk/ha. Average pesticide cost for Bt-brinjal is 12523.78 Tk/ha. So the cost of pesticide will decrease by 71 percent for local OPV and 70.36 percent for hybrid brinjal Table 2.

Table-2. Decrease of pesticide cost by Bt-brinjal

Particulars	Tk/ha.	Percentage decrease
Average pesticide cost for OPV	43185.48	71.00
Average pesticide cost for Hybrid	42256.76	70.36
Average pesticide cost for Bt-OPV	12523.78	

Source: Authors estimation, 2015.

Brinjal producers suffer significant yield losses at 51-73 percent (ISAAA, 2015) or 60-70 percent (Kumar *et al.*, 2011). Average marketable yield for OPV, hybrids and Bt OPV are 15.83 ton/ha, 19.93 ton/ha and 38.00 ton/ha, respectively. So yield will increase by 140.05 and 90.66 percent respectively Table 3.

Table-3. Increase of marketable yield by Bt-brinjal.

Particulars	Ton/ha.	Percentage increase
Average FRESH marketable yield of OPV	15.83	140.05
Average FRESH marketable yield of Hybrid	19.93	90.66
Average FRESH marketable yield of Bt-OPV	38.00	

Source: Authors estimation, 2015.

BARI is not still prepared for mass cultivation of Bt-brinjal. They are carrying out more open field trials covering more districts. They are supervising the brinjal fields, give information, technology and input to producers. There is still heterogeneity problem in fruits. BARI claimed some more trials will reduce this problem and they will get homogenous fruit. BARI scientists stated that after successful field trials they will go to the next step i.e. producing seeds. They targeted to produce 10 kilograms of seed. They will disseminate 5 kg from their stations and 5 kg from Bangladesh Agriculture Development Corporation (BADC). They also claimed, as it is an open pollinated type of seed the producers can keep their seeds for future use from healthy fruits they produce with the seeds supplied by BARI and BADC.

3.2. Marketing Channel of Bt-Brinjal

Marketing channel is very important for effective marketing of a product. Producers produce reach consumers through marketing channel. Thus an effective and established marketing channel benefits both producers and consumers. But there is no established marketing channel for brinjal in the study areas. Most of the producers directly sell their brinjal to consumers in local market. Sometimes they go to weekly market known as *Hat*. They also sell brinjal to hawker. It happens when there are marketable fruits but the farmer is not present to take them to market. Sometimes they sell brinjal to *Paiker* cum *Aratdars* who then sell them to distant markets. The researcher found the following marketing channel for brinjal in the study area.

Channel-1: Farmer-Consumer

Channel-2: Farmer-*Hawker*-Consumer

Channel-3: Farmer-*Paiker*-Consumer

Channel-4: Farmer-*Paiker* cum *Aratdar* (local market)-Consumer

Channel-5: Farmer-*Paiker* cum *Aratdar* (local market)-Retailer-Consumer

Channel-6: Farmer-*Paiker* cum *Aratdar* (local market)-*Aratdar* (distant market)-Retailer-Consumer

Source: Authors estimation, 2015

FSB (Shoot and foot borer) is a common fear for all the brinjal producers of Bangladesh. To save these producers Bangladesh government introduce Bt-brinjal technology for mass adoption. Producers are very much willing to adopt Bt-brinjal if they reduce insecticide use and increase marketable yield. BARI (Bangladesh Agricultural Research Institute) officials claimed that Bt-brinjal can be sold along with other brinjal and vegetables in the market. Producers who grow Bt-brinjal for field trials were found selling their small produce directly to local market informing the consumer about its attribute. They claimed people of different walks like school teachers,

village doctors and general consumers are frequently buying Bt-brinjal. As labeling is not well practiced for vegetables and the super shop type market is not available everywhere, BARI officials claimed that producers will able to sell Bt-brinjal along with other brinjal and vegetables in same manner. So the marketing channel for Bt-brinjal will be same with non Bt-brinjal.

3.3. Role of Advertising in Adoption of Bt-Brinjal

Advertising is controlled communication about a product. The communication happens through symbols and language to convey the message about its utility. A good advertising program can convince consumers about a product or service's benefit compared to similar products on the market. If consumers are convinced, they will buy the products. At the present world advertising play an important role to disseminate a new technology quickly. People now have access to radio, TV, internet. They participate in debate in different print and electronic media, as well as in different social networking sites. Any new information goes viral within a minute in these sites. Different social changes are happening quickly through media. People can easily gather different types of knowledge from the post, writing and lecture of respective experts. However, advertising is playing a vital role in new technology dissemination in the field of agriculture. Different types of agricultural tools and gadgets are now well known to the producers. Producers now know about different weeding practices, cultivation and irrigation practices, storing and transporting of different vegetables through media. But most of this awareness generating advertisement is aired by different governmental organizations such as MoA (Ministry of Agriculture), Agricultural Extension Department, MoST (Ministry of Science and Technology) etc. As Bt-brinjal is a new product with advantages and controversy, media especially advertising can play a vital role for the producers, ally and opponents. So respondents were asked about this factor which is very much influential for adoption of Bt-brinjal. Though it's not stated in the three objectives of this research but it was not least. The respondent producers are also consumers of brinjal. Though they produce brinjal for commercial purpose, they sell rest of the product after retain some portion for home consumption. They are also conscious about what they eat. So they were asked to answer the questions related to advertisement from both producer and consumer point of view.

Table-4. Role of advertisement in adoption of Bt-brinjal.

Questions	Alternatives	Outcomes	Percentage
Media play a vital role in adoption of Bt-brinjal	Yes	68	85
	No	12	15
Mass advertisement on Bt-brinjal will influence you to adopt	Yes	51	63.75
	No	29	36.25
More influential media	Personal communication	31	38.75
	Print media	4	5
	TV/radio	10	12.5
	Field day	35	43.75
Information in the advertisement	Very informative	59	73.75
	Basic information	18	22.5
	Less informative	3	3.75
Training on Bt-brinjal will increase its adoption	Yes	66	82.5
	No	14	17.5

Source: Authors estimation, 2015.

Table 4 shows that 85 percent respondents think that media will play a vital role for technology adoption. Radio, TV, is now available almost everywhere. Government extension workers and officer's from research organizations are frequently arranging different programs on different aspect of agriculture. For this, sixty four percent producers think that mass advertisement will increase adoption like field days (44 percent) or personal communication (39 percent). The respondents think that details information (74 percent) will be helpful for adoption of Bt-brinjal. Training is another influential medium of adoption (82.5 percent) as producers can

practically gather clear ideas about a new knowledge and they can discuss all of their queries. Consumers can also gather necessary information according to their demand.

3.4. Producers' Willingness to Adopt Bt-brinjal and its Associated Factors

Descriptive statistics and binary logistic regression were used to fulfill the second and third objectives.

3.4.1. Percentage Distribution of Different Factors Regarding Adoption

The percentage distribution of each question used in different section of the questionnaire is given below:

The entire farmer grows brinjal on their own land. Among them 46.25 percent grow hybrid brinjal but they started to do so not more than two years (86.25 percent) ago. Most of them get the information about hybrid from seed dealers (65 percent). They started to grow hybrid by considering low pest attack (41.25 percent) as main attribute but most of them (82.5 percent) claimed that the severity is same. Most of them purchase seed from same company (67.5 percent) for reasonable price (58.75 percent).These are presented below Table 5.

Table-5. Adoption and Ex-ante adoption of Bt-brinjal.

Questions	Alternatives	Outcomes	Percentage
Grow Brinjal on own land	Yes	80	100
	No	0	0
Growing hybrid brinjal	Yes	37	46.25
	No	43	53.75
Start growing hybrid brinjal	Less than 2 years	69	86.25
	More than 2 years	11	13.75
Initial source of information about hybrids	Dealers	52	65
	Friend/neighbor	28	35
Reasons for start growing hybrids	High yield	26	32.5
	As it's a new item	15	18.75
	Low pest attack	33	41.25
	Good fruit price	6	7.5
Attack of FSB on OPV and Hybrids is same	Yes	66	82.5
	No	14	17.5
FSB attack high on	OPV	63	78.75
	Hybrid	17	21.25
Purchase Hybrid seeds from different companies at different seasons	Yes	26	32.5
	No	54	67.5
Reason for purchasing Hybrid seeds from different companies at different seasons	For good price of seed	47	58.75
	For good quality of seed	33	41.25
Purchase OPV seeds from different companies at different seasons	Yes	18	22.5
	No	62	77.5
Reason for not purchasing OPV seeds from different companies at different seasons	Use own seed	46	57.5
	Collect from neighbor	34	42.5
Reason for purchasing OPV seeds from different sources at different seasons	Good quality seed	32	40
	High yield	48	60
Source of purchasing OPV seeds	Hat	32	40
	Village market	48	60

Source: Authors estimation, 2015.

Fifty five percent respondents think that chemical pesticides are effective in controlling FSB but they have negative impact (65 percent) on environment Table 6. Many of them (52.5 percent) experience health problems.

Table-6. Information about attitude to pesticide.

Questions	Alternatives	Outcomes	Percentage
Effectiveness of chemicals in controlling FSB	Yes	44	55
	No	36	45
Negative effect on environment	Yes	52	65
	No	28	35
Consume the heavily sprayed hybrids you grow on farm	Yes	56	70
	No	24	30
Experience any health problem	Yes	42	52.5
	No	38	47.5

Source: Authors estimation, 2015.

3.4.2. Perception of Respondents about Bt Brinjal

As Bt-brinjal is a new product, Table 7 shows only 31.25 percent respondents have heard about it among which 52.50 percent heard it from BARI officials and rest from friends or neighbors. In this 31 percent known respondents, 92.5 percent think Bt-brinjal will increase yield while 76.25 percent think that Bt-brinjal will increase their profit/income. Fifty two percent respondents think management involvements will remain same for both Bt-brinjal and its counterparts- non-Bt. Most respondents think that Bt-brinjal will reduce pesticide application and the percentage is 76.25 percent respondents think that Bt-brinjal will have good effect on human health while 72.5 percent do not know the effect on environments. However, producers still are not decided (62.5 percent) to adopt Bt-brinjal, but if they do, they will replace hybrid with Bt-brinjal for low pest attack and good quality fruit (42.5 percent both) and replace local OPV for low pest attack (61.25 percent).

Table-7. Knowledge and perception about Bt-brinjal

Questions	Alternatives	Outcomes	Percentage
Ever heard about Bt-Brinjal	Yes	25	31.25
	No	55	68.75
Source of information	BARI	42	52.50
	Friend/neighbor	38	47.50
Perception about the technology-yield/production	Increase	74	92.5
	Decrease	0	0
	No change	6	7.5
Perception about the technology-profit/income	Increase	61	76.25
	Decrease	6	7.5
	No change	13	16.25
Perception about the technology-Management involvement	Increase	19	23.75
	Decrease	19	23.75
	No change	42	52.5
Perception about the technology-pesticide application	Increase	6	7.5
	Decrease	61	76.25
	No change	13	16.25
Perception about the technology-effect on human health	Good	54	67.5
	Bad	10	12.5
	Not known	16	20
Perception about the technology-effect on environment	Good	19	23.75
	Bad	3	3.75
	Not known	58	72.5
Willingness to purchase Bt-Opv seeds	Yes/after 3yrs	30	37.5
	No/not decided	50	62.5
Producers willing to replace Hybrid with Bt because of-	Low pest attack	34	42.5
	Good quality	34	42.5
	High yield	12	15
Producers willing to replace OPV with Bt because of-	Low pest attack	49	61.25
	Good quality	31	38.75

Source: Authors estimation, 2015.

Table 8 shows that adoption depends on reduction in insecticide use (98.75 percent), increase in yield level (71.25 percent), increase in marketable yield (86.25 percent) but they will leave this technology if there is any possibility of health hazard (65 percent).

Table-8. Willingness to adopt Bt-brinjal.

Questions	Alternatives	Outcomes	Percentage
Produce Bt-Brinjal if they-reduce insecticide use	Yes	79	98.75
	No	1	1.25
Produce Bt-Brinjal if they-increase yield level	Yes	57	71.25
	No	23	28.75
Produce Bt-Brinjal if they-increase marketable fruit	Yes	69	86.25
	No	11	13.75
Produce Bt-Brinjal if they-provide easy production technique	Yes	77	96.25
	No	3	3.75
Produce Bt-Brinjal if they-have health problem	Yes	28	35
	No	52	65

Source: Authors estimation, 2015.

3.5. Producers' Willingness to Adopt Bt-Brinjal

The factors influencing the producers' willingness to adopt Bt-brinjal were estimated by logistic regression analysis.

Table 9 revealed that on an average this study comprises of middle aged producers with low level of education. The lowest educated farmer was illiterate and highest educated farmer was class five passed. Most of the respondents are medium producers as the researcher took the districts which are well-known for commercially produced brinjal. The household size is consistent with national average. No of spray per season are less than different findings because producers in this area are experienced and always keep touch with BARI officials and extension workers.

Table-9. Summary statistics for socioeconomic characteristics of sample producers.

Variables	Units	Total sample(N=80)	
		Mean	Std
Age	Years	40.01	11.60
Education level	Years	1.06	1.52
Own land size	Acre	1.51	1.13
Number of spray/season	Nos.	78.15	19.91
Household size	Nos.	4.82	1.29

Source: Authors estimation, 2015
Note: Std= Standard Deviation.

In this study dependent variable is Farmers willingness to adopt brinjal (*Bt*, local OPV and Hybrid). The researcher use 1 for willingness to adopt Bt-brinjal and 0 otherwise Table 10. Age, educational level, household size, own land size are continuous variable. Main occupation is a binary variable with 1 for agriculture and 0 otherwise. Season is also a binary variable with 1 for Robi season and 0 for Kharif season. Type of growing brinjal is a binary variable with 1 for OPV and 0 for Hybrid. At first binary variables were coded and then put in the excel sheet.

Table 11 indicated that producers' age negatively influences the probability of adoption of Bt-brinjal similar to the expected sign. In other words, young producers are more likely to adopt Bt-brinjal than old producers. The probability that a producer adopts Bt-brinjal decreases, *ceteris paribus*, by 0.114 units when farmer's age increases by one unit. This result is similar to the findings of Duram (1997); Marenya and Barrett (2007) who argued that young producers are more open to the adoption of new practices. In addition, similar to the expectation, the possibility that a farmer adopt Bt-brinjal tends to be, *ceteris paribus*, 1.756 units higher when the level of education increases a unit.

Table-10. Descriptions of logistic regression model variables.

Variables	Sub-factors	Description	Expected sign
Dependent variable	Bt-brinjal, Traditional brinjal (OPV &Hybrid)	1=willing to adopt Bt-brinjal, 0=not	
Age	Continuous variable	Years	-
Education level	Continuous variable	Level of education (1 years i.e. class 1 passed)	+
Household size	Continuous variable	The number of people in the household	+/-
Own land size	Continuous variable	Size of land in acre	+
No. of spray/season	Continuous variable	No. of spray in every season	+
Main Occupation	Binary Variable	1=Agriculture, 0=others	+/-
Season of growing brinjal	Binary Variable	1= Robi, 0= Kharif	+
Types of growing brinjal	Binary variable	1= OPV, 0=Hybrid	+/-

Source: Authors Estimation, 2015.

This means that highly educated producers are more likely to adopt Bt-brinjal than less educated producers. This result is in line with Burton *et al.* (2003). In this study, farmer's education ranges between class five passed and illiterate. But they were very experienced in vegetable production. So, producers who are illiterate have less willingness to adopt Bt-brinjal than producers with higher level of education i.e. class one passed. Education enhanced their experience. The regression coefficient of household size was estimated at 1.362, which is positive and significant. It means that keeping other factors constant probability to adopt Bt-brinjal of the families with higher member are more than the families with fewer members. This is because families with large number of members have huge expense. So they are eager to adopt such technology which can give them more income by reducing cost. Own land size has a positive and significant effect on willingness to adopt Bt-brinjal. The regression coefficient of own land size was 1.642. It is also found significant by Kolady and Lesser (2005). It means that producers growing brinjal in own land are significantly more likely to choose "Bt-brinjal". Producers growing brinjal in rented land are more profit oriented. So they are less adopter of a new technology. The regression coefficient of number of spray was estimated at 0.080, which means that the coefficient is positive and significant as similar to the expectation. It can be interpreted as the respondents with high number of spray per season have willingness to adopt Bt-brinjal. It means that keeping other factors constant the probability of adoption of Bt-brinjal will increase if the number of spray per season increases. Producers want to get rid of FSB. It is also found significant by Kolady and Lesser (2005). Main occupation has a negative and insignificant effect on adoption of Bt-brinjal. That means respondents with agriculture as main occupation or others have almost the same probability to adopt Bt-brinjal. In addition, Season of growing brinjal has a negative but significant effect on willingness to adopt Bt-brinjal. The regression coefficient is -5.199.It means that season has a negative relation with willingness to adopt. The main reason for this relationship can be explained by natural condition in seasons.

Table-11. Logistic Regression Results.

Variable	Regression Co-efficient	Standard Errors
Age	-0.114	-1.58
Education level	1.756***	2.87
Household size	1.362**	2.28
Own land size	1.642***	2.6
Number of spray/season	.080***	2.38
Main occupation	-0.858	-0.7
Season of growing brinjal	-5.199***	-3.16
Type of growing brinjal	3.247**	2.18

Author's estimation, 2015
***statistically significant at 1 percent level, ** at 5 percent level

During Robi season vegetable growing is easier with less pest attack. So producers who grow brinjal in Robi season are less willing to adopt this technology. But during dry season (Kharif) the pest can attack easily. So they

are very much willing to adopt Bt-brinjal. The regression coefficient of type of growing brinjal was 3.247, which indicated that the coefficient is positive and significant. It means OPV producers are more likely to adopt Bt-brinjal as they are easily attacked by pests.

4. CONCLUSION

Since Green revolution was accepted and producers enjoyed its benefit. As a result, the government Bangladesh is very much interested to introduce new technology in agricultural sector. Different government and non-government organizations are working in this regard. Introduction of GM crops is a recent idea of government. Bt-brinjal is introduced to the producers by limited field trials and GM Rice is in the pipe line. To combat the problem of FSB attack in brinjal, Bangladesh government give the permission for field trial of Bt-brinjal earlier this decade with following proper process and honoring national bio-safety rules. BARI is the main organization for research, field trials and technology dissemination of Bt-brinjal.The study revealed that the producers' willingness to adopt Bt-brinjal is significantly influenced by education, own land size, household size, number of spray per season, season of growing brinjal and type of growing brinjal. They also influenced by information provided through different media. This result is variable in respect to country's demographic condition. The insignificant variables may be found significant in other country situation. This type of research is not available in Bangladesh. So the researcher was not able to compare this result with others. Though voice against GM crops was also very loud but Bangladesh government is very much eager to introduce this technology to the market and give the benefits to its consumers. Again they are very much conscious about public health and environment. Protests from different stakeholders are also a great concern. Even Bangladesh may lose its export market access to the countries that are not willing to import from the countries producing GM crops. So, further study would be helpful to reach a firm conclusion.

5. RECOMMENDATIONS

Therefore, in order to improve overall economic condition by amusing both parties, in favor and against, the following recommendations can be taken into consideration: Frequent discussion on Bt-brinjal should be done with the participation of producers, experts and protestors. Making the people aware will be helpful for adoption, necessary trials should be done before mass cultivation, health related issues should be examined carefully, bio-safety laws should be strengthening to cover every aspect of Bt-brinjal as well as other GM crops, capacity building of existing experts and establishment of sound research, development and extension policies, and marketing channels should be given concern, Promotional activities for GM crops should be given attention.

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