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ADOPTION OF BARI MANGO VARIETIES IN SELECTED SITES OF CHITTAGONG DISTRICT

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Abstract

The study was carried out in 28 villages covering131 mango growers of three Upazilas in Chittagong District with view to examine the adoption status of BARI mango varieties at farmer's level. The adoption status of improved mango varieties was unknown to the region. Results revealed that out of 11 varieties of BARI mango, the highest 77% farmers adopted BARI Aam-3 followed by BARI Aam- 4 (22.1%) and BARI Aam-8 15.9%. But the rate of adoption of other varieties of BARI Aam was found to be lower irrespective of all locations due to unavailability of sapling and unknown to the variety. The rate of adoption of individual production technologies of BARI mango varieties was found unsatisfactory. Majority of the farmers did not adopt recommended practices as stated in BARI Krishi Projokti Hathboi such as pit size, planting distance, application of manure and fertilizers, plant growth regulator, insects and diseases management. Farmers maintained pit size for mango sapling (1.4 ft × 1.4 ft× 1.3 ft) compared to recommended size of (3ft×3ft×3ft). Similarly, planting distance was 12.0 x11.7ft as against the recommended distance of 25ft×30ft. About 67.7% farmers adopted the improved practice such as breaking inflorescence of mango trees and 65.0% of farmers used mulching. But majority (52%) of farmers did not receive training and practice pruning for mango trees. Probit regression analysis revealed that yield of mango variety, training, extension contact, risk taking behavior and willingness to take loan has indeed helped in contributing to adopt BARI mango varieties significantly. Therefore, promoting training on BARI mango production technologies; ensuring the availability of BARI mango saplings, and campaigning about the varieties in mass media could help to increase the rate of adoption of BARI mango varieties in the region.

Keywords: Adoption, BARI mango varieties, Technologies, Factors affecting, Chittagong region.

1. Introduction

Mango (*Mangifera indica L.)* is the most important commercially grown fruit crop of the country. The position of mango is 1st in terms of area and 2nd in

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production among the fruits grown in Bangladesh. Mango shares 31.22% of the area and 24.38% production fruit crops in Bangladesh (Hamjah, 2014). Mangoes are considered 'high volume' food, low on calorie but quite high in natural sugar. A single, small size mango can provide a quarter of the recommended daily dose of vitamin A, along with a generous amount of vitamin E and fiber. It is also considered a rich source of vitamin K, phosphorus, magnesium and iron (the dailysar.net). Mango production can play a vital role for Bangladesh economy. But it needs better adoption of improved varieties of mango at farm level. Bangladesh Agricultural Research Institute (BARI) has released 11 mango varieties so far. But the status of adoption of improved variety of mangos waslow in the Chittagong district.

On the other hand, agricultural development is accelerated through adoption[*] of improved agricultural technologies and formulating policies favouring appropriate institutional and infrastructural changes (Rajni *et al.,* 2009). Adoption of improved mango varieties is the key to higher production of fruits and higher incomes to farmers (Singh *et al.,* 2010). The technical knowledge of farmers appears to be the key link to higher level of adoption. While shifting focus has opened up greatly in the north site of the country, the opportunity waiting to be exploited in the horticulture sector in this region, but the ground realities present a grave picture of low yields of fruits, wide gaps in adoption of improved fruit cultivation practices, inadequate technical guidance and for value addition and enterprise development in the Chittagong region. Uddin *et al.* (2016) reported that the percentage change in area of mango is 7.15% over the period of 1993/94 to 2009/10, while annual growth rate in area of mango was estimated by 94.9%.

According to BBS 2016, the area and production of mango in Chittagong region are stated as: area under garden 284 acres, average yield per fruit bearing tree 52 kg, production of inside garden 967m.tons, production of outside garden 19143m.tons and total production of inside and outside garden was 20110 m. tones in 2013-14 which was 2.02% of the total production in Bangladesh. Out of 11 BARI mango varieties, four varieties such as BARI Aam-1, BARI Aam-2, BARI Aam-3 and BARI Aam-8 were further evaluated by Barua *et al.* (2013) as suitability judgment for the Chittagong region where BARI Aam-8 and BARI Aam-4 gave higher yield per plant. The name of BARI released mango varieties and their key features are shown in Appendix1.

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[*]Oladele (2005), Pannell *et al.* (2006), and Parminter (2011) stated that the term 'adoption' could be described as conscious decision to implement a new practice or apply a new technology on a continuous basis. It described the process of decision making and behavior change. They agreed that during this decision-making process the intended beneficiaries could reject a change and seek to re-establish the previous practice or technology. Williams *et al*., (1984) described the stages of adoption as:
Awareness $\rightarrow$ Interest $\rightarrow$ Evaluation $\rightarrow$ Trial $\rightarrow$ Adoption.

According to BBS report, the productivity of mango was found to be low in Chittagong region. This might be happened due to the absence of improved varieties. The district has traditional mango orchard with a great promise for productivity of fruits. Once farmers acquire knowledge, they begin to use and apply new techniques and improved practices in their orchards. Even among farmers, there is a great variation in their levels of knowledge, as well as their readiness to accept, try new methods and adopt improved production practices. The variation in rate and extent of adoption of improved practices in mango production and reasons thereof, need to be thoroughly understood. The specific following objectives of the study are:

i. To document socioeconomic and contextual information of the mango growers;

ii. To assess the actual status of adoption of BARI mango varieties at farmers level; and

iii. To know the farmers production technologies of mango growers, and

iv. To identify the factors responsible for adoption and non-adoption of BARI mango varieties.

Description of the area: The study was carried out in 28 villages under three Upazilas namely Hathazari, Fatikchari and Sitakundoin Chittagong District with view to examine the adoption status of BARI released mango varieties and their production technologies by mango growers in the locations. Multi-stage sampling techniques were followed to select the study area. Based on the availability of mango growers, specific locations were selected (Appendix-2) in consultation with Upazila Agriculture Officer (UAO) and Sub-Assistant Agriculture Officer (SAAO) in the respective Upazilas.

Selection of sampling technique adopted: The purposive and stratified random sampling technique was followed for selecting the sample in each Upazila. In total 131 mango growers were selected randomly as sample where in Hathazari (70), Fatikchari (30) and Sitakundo (31). But the sample number of each village varied due to the availability of mango growers.

Data collection procedure: Both primary and secondary data were used in the study. The primary data were collected by pre-tested semi-structured survey questionnaire. The secondary data were collected from published reports, internet and BBS sources. Face to face interview with mango growers was done by Scientific Assistants and Researcher himself. Moreover, the respective SAAO facilitated for selecting the respondents (mango growers) in all locations. In each Upazila, 3-5 SAAOs were engaged for collecting the necessary data.

Period of study: The data collection period was August 2016 to April 2017.

Analytical technique: In tabular technique, mean, percentages and mean comparison were used in the study. In statistical technique, the Probit regression analysis was used for estimating the contribution of factors responsible for adopting BARI mango varieties in the region. In that case, the independent variables were chosen as: age, education, occupation, family size, family type, land under mango orchards, risk taking behavior, innovativeness, economic aspiration, scientific orientation and credit orientation. Two communication variables are included in the study: extension contact and mass media exposure. Suitable scales were used to measure the variables. As an important indicator of adoption of BARI mango varieties, The collected data were analyzed using appropriate statistical techniques. One-way ANOVA was used for analyzing the mean difference of the selected variables in locations. The mathematical expression of the Probit model is given below:

Probit Model:

In order to ascertain the probability of adoption of improved mango varieties, the following empirical Probit model was employed. Since the dependent variable is dichotomous, Ordinary Least Square (OLS) method is not suitable. Therefore, MLE method was followed to run the Probit model using STATA software. The empirical probit model was as follows:

$$Ai = \alpha + \beta iXi + ……..+ Ui$$

Where,

Ai = Farmers adopting BARI mango variety (If adopted = 1; Otherwise= 0),

α = Intercept,

Xi = Explanatory variables,

βi = Coefficients of respective variables, and

Ui = Error term

The adoption of improved mango variety is likely to be influenced by different explanatory variables.

The variables are

X^1 = Ln Yield(t/ha)

X^2 = Ln Cultivable land(ha)

X^3 = Family size (no.)

X^4 = Family type (score)

X^5 = Training (score)

X^6 =Risk taking behavior (score)

X^7 = Innovativeness (score)

X^8 = Willingness to take loan (score)

X^9 = Having modern knowledge on mango production (score)

X^{10} = Economic aspiration (score)

X^{11} = Mass media exposure (score)

X^{12} = Research contact of the farmers (score)

X^{13} =Extension contact of the farmers (score).

The procedures of measuring qualitative variables included in the model are briefly discussed below.

3. Results and Discussion

3.1 Socioeconomic profile of the respondents

It can be shown in Table1 that average age of the respondents was found to be 44.8 years irrespective of locations implied that all the respondents were able to adopt new technologies for agricultural development due to belongs young age. The mean differences of the age of respondents varied insignificantly ($F=1.43$; $p \leq 0.243$) among the locations. In the case of education of the respondents, the average year of schooling was found to be 7.1 years in all locations which was varied significantly among the locations ($F=4.47$; $p \leq 0.013$). The major occupation of the respondents was agriculture (83.5%) irrespective of locations which was the highest in Hathazari (97.1%) followed by Sitakundo (93.5%). Occupation of the respondents may influence in adopting new technologies. The secondary occupation was reported to be business (37.1%) and private job (15.2%) in all locations. The average household size was 6.2 persons per family which was higher than that of national average of 5.0 (BBS, 2016). The mean difference of the household size was varied insignificantly among the locations ($F= 1.59$; $p \leq 0.206$). The family type may be influenced the decision making for adopting new technologies which was shown in the probit analysis. But in this study, more than 76%respondentsbelonged to single family and the rest with joint family. The difference of family structure was varied insignificantly ($F= 0.692$; $p \leq 0.503$).

3.2 Contextual information of mango growers

It can be seen from Table 2that 77.1% farmers owned mango orchard either in homestead areas or in other places irrespective of locations. Of them, the highest percentage was found in Sitakundo area followed by Fatikchari and Hathazari. The average area of mango orchard was reported to be 0.81 ha in all locations which was the highest in Sitakundo areas (1.40 ha) followed by Fatikchari (0.90 ha) and Hathazari (0.14 ha). The mean difference of the area of

mango orchard was found highly significant at 1% level of probability (F= 23.283; $p \leq 0.000$) among the locations. The year of 1st establishment of mango orchard was in 1985 at Fatikchari areas followed by Sitakundo (1993) and Hathazari (1994).

Table 1. Socioeconomic profile of the respondents by locations

Sl. No.	Particulars	Locations			
		Hathazari	Fatikchari	Sitakundo	All
1	Age of the respondent	47.52	43.2	43.8	44.8
2	Education: (average year of schooling)	7.02	8.7	5.7	7.1
3	Main occupation (%):				
	Agriculture	97.1	60.0	93.5	83.5
	Business	35.7	50.0	25.8	37.1
	Private job	22.8	6.7	16.1	15.2
4	Household size (Person/family):	6.4	6.5	5.9	6.2
	Male	3.4	3.6	3.2	3.4
	Female	3.0	2.9	2.7	2.8
5	Family types (%):				
	Single	80.0	70.0	80.6	76.8
	Joint	20.0	30.0	19.3	23.1

Source: Field survey, 2016

Irrespective of locations, the highest 29.5% mango orchard was established in the high land, 25.1% in medium high land and 22.7% in slope land. The highest 36.7% of the respondents reported that the soil type of mango orchard was sandy-loam. It was observed that on an average 8.1 to 13.3 mango trees were plantedin the homestead areas where the average area of homestead area was 0.08 ha to 0.1 ha. The average cultivable land was estimated to be 0.80 ha to 1.6 ha by locations. The mean differences of cultivable land was found to be significant at 5% level of probability ($F = 4.36$; $p \leq 0.015$). On the other hand, the average current fallow land per household was 0.08 ha irrespective of locations. This might be due to lack of capital. Table 3 shows that 74.2% farmers were found to be adopter of BARI Aam while 25.7 % were non-adopter. The respondent farmers were aware about the BARI mango from different sources such as BARI, DAE, Nursery, Media and NGOs. The highest percentages of the respondents gathered information about BARI variety from research station of BARI followed by DAE and nursery owner (Table 4).

Table 2. Contextual information of mango growers in the selected areas of Chittagong district

Sl. No.	Particulars	Locations			
		Hathazari	Fatikchari	Sitakundo	All
1	Having owned mango orchard (%)	41.42	90.0	100.0	77.1
2	Per household average area of mango orchard (ha)	0.14	0.90	1.40	0.81
3	Year of 1st establishment of mango orchard	1994	1985	1993	-
4	Types of land in mango orchard (%):				
	High land	17.1	23.3	48.3	29.5
	Medium high land	12.8	43.3	19.3	25.1
	Medium low land	5.71	3.3	9.6	6.2
	Slope land	12.8	23.3	32.2	22.7
5	Types of soil in mango orchard (%):				
	Loam	15.7	16.6	16.1	16.1
	Sandy-loam	11.4	40.0	58.8	36.7
	Clay-loam	18.5	30.0	38.7	29.0
6	Having mango tree (no.) in the homestead areas per household	12.4	13.3	8.1	11.2
7	Average area of homestead per household (ha)	0.09	0.1	0.05	0.08
8	Average cultivable land per household (ha)	0.45	1.6	0.80	0.90
9	Having current fallow land (ha) per household	0.05	0.1	0.1	0.08

Source: Field survey, 2016

Table 3. Respondents' awareness about BARI mango varieties

Sl. No.	Locations	Adopter (%)	Non-adopter (%)
1	Hathazari	88.5	11.5
2	Fatikchari	66.6	33.4
3	Sitakundo	67.7	32.3
	All	74.3	25.7

Source: Field survey, 2016

Table 4. Respondents' acquired the information about BARI mango varieties

Sl. No.	Locations	In % of respondents by source				
		BARI	DAE	NGO	Media	Nursery
1	Hathazari	72.8	22.8	-	-	4.28
2	Fatikchari	33.3	46.6	-	6.6	-
3	Sitakundo	19.3	58.8	3.2	3.2	9.6
	All	48.8	42.7	3.2	4.9	6.9

3.3 Extent of Adoption of BARI Mango Varieties: Out of 11 varieties of BARI Aam, the highest 77% farmers adopted BARI Aam-3 due to its sweetness, flavour and high market demand in Chittagong market followed by BARI Aam-4 (22.1%) due to late variety and higher market price and BARI Aam-8 15.9% due to its attractive colour and market demand (Table 5). But the rate of adoption of other varieties of BARI Aam was found to be lower irrespective of locations due to unavailability of sapling and unknown to the variety. The adoption of BARI Aam-3 was found as higher in Fatikchari areas (93.3%) might be due to receive more training and raised awareness about the variety followed by Sitakundo (80.6%) and Hathazari (57.1%).

Table 5. Rate of adoption of BARI Mango varieties in the Chittagong region, 2016

Sl. No.	BARI mango varieties	% of respondents (Rate of adoption)			
		Hathazari	Fatikchari	Sitakundo	All
1	BARI Aam-1 (Mohananda)	5.7	10.0	3.2	6.3
2	BARI Aam-2	3.0	-	3.2	3.1
3	BARI Aam-3	57.1	93.3	80.6	77.0
4	BARI Aam-4 (Hybrid)	28.5	21.6	16.3	22.1
5	BARI Aam-5	-	-	3.2	3.2
6	BARI Aam-6	1.4	-	3.2	2.3
7	BARI Aam-7	1.4	-	3.2	2.3
8	BARI Aam-8	12.0	16.6	19.3	15.9
9	BARI Aam-9 (Kachamitha)	-	2.0	2.5	2.4
10	BARI Aam-10	2.8	-	3.2	3.0
11	BARI Aam-11 (Baromasi)	-	10.0	6.4	8.2

Source: Field survey, 2016

Knowledge of modern technology for mango production: Table 6 shows that about 56.2 % of the mango farmers claimed that they had ideas on modern technologies of mango where the highest percentages 67.1% in Hathazari areas, 53.3% in Fatikchari and 48.3% in Sitakundo. The differences of the knowledge obtained by the farmers varied insignificant among the locations ($F = 1.891$; $p \leq 0.155$).

Training received: About 28.8% farmers received training on mango production in the last three years irrespective of locations. By location, the highest 57.1% farmers received training in Hathazari areas might be due to the activities of BARI and DAE offices. The differences of training received by the farmers was found to be highly significant at 1% level of probability ($F=15.174$; $p \leq 0.000$) among the locations (Table 6). *Source of sapling:* The highest 60.3% of the farmers collected BARI mango sapling from local nursery, 29.0% in research station and 16.9% in horticulture center. About 49.1 % of the farmers had owned

spray machine irrespective of all locations. More than 60% farmers consulted with DAE personnel for spraying insecticide in mango trees, 21.6% for owner of dealer shop and 20.7% for research personnel (Table 6).

Table 6. Some basic questions and responses regarding BARI mango production

Sl. No.	Particulars	In % of respondents who answered 'Yes'			
		Hathazari	Fatikchari	Sitakundo	All
1	Known to modern technology of mango cultivation	67.1	53.3	48.3	56.2
2	Received training on mango production	57.1	16.6	12.9	28.8
3	Source of sapling of BARI Aam:	15.7	10.0	-	12.8
	Owned	20.0	93.3	67.7	60.3
	Local nursery	51.4	6.6	-	29.0
	Research station	5.14	20.0	25.8	16.9
	Horticulture center	-	3.3	-	3.3
	BADC	14.2	13.3	3.2	10.2
	Local market	25.7	3.3	3.2	10.7
	Relatives				
4	Having spray machine	27.1	56.6	64.5	49.1
5	Consult for spraying in mango tree:	35.7	10.0	19.3	21.6
	Owner of dealer shop	34.2	83.3	64.5	60.6
	Extension personnel	55.7	3.3	3.2	20.7
	Research personnel	1.4	-	-	1.4
	NGO worker				

Source: Field survey, 2016

Rate of Adoption of Individual Production Technologies: The rate of adoption of individual mango production technologies varied significantly among the locations and farmers. None of the individual practices were adopted in fully. Most of them adopted partially or slightly might be due to unawareness or ignorance. The rate of adoption of individual production technologies is shown in Table 7. In case of *land preparation*12.3% farmers used tractor or power tiller in mango orchard irrespective of locations. The average ***pit size*** maintained by mango farmers was 1.4ft×1.4ft×1.3ft as against the recommended size of 3.2 ft×3.2 ft×3.2ft (*BARI Krishi Projokti Hathboi*, 2016). One hundred percent of farmers didn't use recommended doses of *manures and fertilizers*. On an average,manure was used 6.1 kg per pitas against the recommended dose of 20-30 kg/pit. In the case of *chemical fertilizer*, farmers used 262gTSP, 119gMoP and 27g Zypsum per pit. The amount of aforesaid fertilizers used in pit

preparation was found to be lower than that of recommended dose of 550 gm, 250gm, 215gm, respectively (*BARI Krishi Projokti Hathboi*, 2016). The average *planting distance*was12ftx11.7 ft which was lower than that of recommended distance of 24ft×30ft (BARI Krishi Projokti Hathboi, 2016). Majority of farmers 57.5% adopted the right *time of planting* (June-July) of sapling, while 57.7 % of farmer partially adopted the recommended *planting method* (square design) in mango orchard. More than 67.7% of farmers adopted the improved practice of *breaking the inflorescence of mango* trees in the study areas. Besides, 48.3% of farmers practiced *inter-cultural operation* in their mango orchard where leafy vegetables, ginger, banana and papaya were the intercrops into the mango orchard. *Fertilizer used per year per tree* is important for raising productivity. In the study area, cent percent farmers did not use the recommended dose of fertilizer per year per tree. A very negligible amount of fertilizer used in the mango tree per year (Table 7). *Irrigation in dry season* is also an important factor for higher yield of mango. More than 60% farmers provided irrigation into their mango orchard through pump or carrying bucket. But they did not know the exact time of irrigation for mango orchard.

Insect pest and disease management is inevitable for producing quality mango and for getting higher market price. Hoppers, fruit flies, mealy bugs, anthracnose, black spot on mango, and cracking of immature mango were the major problems reported by the respondents. More than 56% of farmers used pesticides in consultation with DAE people or pesticides dealer for controlling insect-pest and diseases. But they didn't follow the recommended dose for pest and disease management due to unawareness and lack of training in this regard. About 65% of farmers used *mulching in their mango orchards* as an alternative to irrigation in dry season. The mulching materials were dry leaves and dry grass. *Training and pruning* of a mango tree are also crucial for improved management mango orchard which could lead to enhance productivity of mango. Generally, training and pruning of a mango tree is done just after harvesting of mango. In the study area, no farmer was to adopt the improved practice like training in mango tree, but 48% of farmers did pruning in their mango orchard partially. *Use of plant growth regulators (Hormone)* are recommended for getting bigger fruits and uniform ripening of fruits. Only 12.2% of farmer used hormone in their mango orchards in this regard. *Method of harvesting* is an important issue for reducing postharvest loss of mango. BARI has developed a mango harvesting tool, namely BARI mango harvester. In the study areas, only 3.2 % of farmers used the harvester and rest of others harvested mango by hand, bamboo, stick and through shacking. Only12.7% of farmers took partial care in *packing* using bamboo basket and *handling* of mango and only 24.7% of farmers partially graded mango during marketing. There was no warehouse for storing mango. But they stored mango in a traditional way for a short time. In addition, it was not found to use any medicine or malpractice for artificial repining of mango in the study areas (Table 7).

Table 7. Extent of individual production technology adopted by the mango growers

Sl. No.	Individual technology	Study location			
		Hathazari	Fatikchari	Sitakundo	All
1	Land preparation through ploughing (In % of respondents)	21.42	3.3	-	12.3
2	Average size of pit (sq. feet)	1.3x1.3x1.2	1.8x1.8x1.6	1.3x1.2x1.2	1.4x1.4x1.3
3	Manure used per pit before planting (kg)	5.41	9.7	3.4	6.1
4	Fertilizer used (gm) per pit before planting	80.71	53	64.5	66
	Urea	289.28	277.3	220.9	262.4
	TSP	135.85	125	97.4	119.4
	MoP	20.14	51.6	10.3	27.3
	Zypsum				
5	Maintained plant distance (feet)				
	Plant to plant	9.74	13.4	13.0	12.0
	Line to line	7.43	14.3	13.4	11.7
6	Planting time (In % of respondents):				
	June	51.42	56.6	64.5	57.5
	July	27.14	10	25.8	21
	August	11.42	3.3	-	7.3
7	Orchard designed (In % of respondents):	80	43.3	48.3	57.2
	Square	1.4	-	9.6	5.5
	Triangular	2.8	20	32.2	18.3
	Rectangular	10	20	12.9	14.3
	Hapazard				
8	Breaking the mango inflorescence (%)	62.85	63.3	77.04	67.7
9	Cultivated intercrop in mango orchard	27.42	50	67.7	48.3
10	Average fertilizer applied (kg) per mango tree per year:				
	Urea	0.13	0.12	0.16	0.1
	TSP	0.16	0.12	0.2	0.1
	MoP	0.07	0.06	0.11	0.08
	Zypsum	0.0007	0.02	0.01	0.01
11	Irrigation in dry season (In % of respondents)	62.85	53.3	64.5	60.2
12	Pesticide use (In % of respondents)	42.85	43.3	83.8	56.6
13	Mulching in dry season (In % of respondents)	52.85	53.3	90.3	65.4
14	Pruning after mango harvest (In % of respondents)	52.85	40	51.6	48.1

Sl. No.	Individual technology	Study location			
		Hathazari	Fatikchari	Sitakundo	All
15	Hormone used for quality mango(In % of respondents)	4.28	6.6	25.8	12.2
16	Followed appropriate harvesting time (% of respondents)	85.71	56.6	80.6	74.3
17	Harvesting methods(In % of respondents):	68.57	50	77.4	65.3
	By hand	42.85	13.3	6.4	20.8
	By bamboo	45.71	10	16.1	24
	By shaking	-	-	3.2	3.2
	By harvester				
18	Storing mango after harvest (In % of respondents)	10.0	10.0	12.9	10.9
19	Grading after harvest (In % of respondents)	17.14	40	29	24.7
20	Packaging of mango (In % of respondents)	15.71	3.3	19.3	12.7
21	Medicine used for ripening the mango (In % of respondents)	-	-	-	-

Source: Field survey, 2016.

Causes of non-adoption of BARI mango varieties: The highest 83.6% farmers claimed that the sapling of BARI mango variety was not available in the local nursery. Even 77% farmers reported that they did not get sufficient sapling of BARI mango varieties from the research center situated in the region. The other causes for non-adoption of BARI mango varieties are mentioned in the Table 8.

Table 8. Causes of non-adoption of BARI mango varieties in the selected locations

Sl. No.	Causes	In % of respondents			
		Hathazari n=70	Fatikchari n=30	Sitakundo n=31	All n=171
1	Unavailability of sapling of BARI Aam	75.7	70.0	67.7	72.5
2	Not met the demand by the research center	87.4	60.0	83.8	80.3
3	BARI mango variety was not confirm in the local nursery	87.4	80.0	83.8	83.6
4	Unknown to the right planting method	42.5	70.0	67.7	60.1
5	Unknown to the of pest and diseases management	67.4	76.6	67.7	70.4
6	Unknown to the right harvesting time	78.7	63.3	64.5	68.7

Source: Field survey, 2016

Farmer's responses to the support need from BARI and DAE*:* The highest 67.9% of the respondents demanded for high quality sapling of BARI mango

varieties. The other need of the farmers was training on modern technology of specific BARI mango varieties. Providing power spray machine, proper treatment of the pest and diseases particularly of BARI Aam, judicious use of fertilizer in different BARI mango varieties and credit facilities were the important need of the respondent farmers (Table 9).

Table 9. Farmers responses to the support need from BARI and DAE

Sl. No.	Problem/Constraints	In % of farmers			
		Hathazari n=70	Fatikchari n=30	Sitakundo n=31	All n=171
1	Supply of high quality sapling	82.8	53.3	67.7	56.96
2	Training on modern technology	72.8	46.6	64.5	64.84
3	Provide power spray machine	-	20.0	64.5	42.25
4	Proper treatment for pest and disease	40.0	30.0	48.3	26.10
5	Judicious use of fertilizer & pesticide	54.2	23.3	45.1	40.86
6	Provide credit facilities	12.8	10.0	32.2	18.3

Source: Field survey, 2016

Farmer's reaction for expansion of BARI mango varieties at farm level

Ensure quality sapling, conducting farmer meeting at village level, broadcasting in mass media, providing modern training and monitoring the mango orchard could help to extent of adoption of BARI mango varieties at farm level as reported by the respondent farmers in the study areas (Table 10).

Table 10. Farmer's reaction to expand of BARI mango varieties at farm level

Sl. No.	Farmers reactions	In % of farmers			
		Hathazari n=70	Fatikchari n=30	Sitakundo n=31	All n=171
1	Ensure quality saplingsat farm level	72.8	30.0	67.7	61.79
2	Conduct farmer meeting at village level	11.4	26.6	54.8	30.93
3	Broadcast BARI Aam in mass media	7.14	53.3	16.1	25.51
4	Provide modern training on BARI Aam	57.4	53.3	25.8	45.50
5	Need regular orchard visit & monitoring	-	13.3	16.1	14.70

Source: Field survey, 2016

Factors Influencing BARI mango varieties adoption: In order to assess the contribution of various factors to the variation in the extent of adoption of BARI mango varieties at farm level. A regression equation was fitted with the dependent variable (0 and 1) of the extent of adoption of BARI mango varieties and fourteen independent variables such as yield, cultivable land, age of respondents, family size, family type, training, risk taking behaviour, innovativeness, willingness to take loan, having modern knowledge on mango production, economic aspiration, mass media exposure, research and extension contact. The results of the analysis are presented in Table 12 and Table 13.

The yield of BARI mango variety is a significant determinant of decision to grow BARI mango. Per household the highest yield was recorded from BARI Aam-3 followed by BARI Aam-4 and BARI Aam-8 (Table 11). The marginal effect of the relevant variable of training, extension contact and risk taking behavior are estimated at 0.29, 0.38 and 0.17 implying that a one per cent increase in the training, extension contact and risk taking behavour will increase the adoption of BARI mango variety significantly by 0.29, 0.38 and 0.17% respectively. On the other hand, the marginal effect of the variable willingness to take loan is estimated at - 0.14 implying that a one per cent increases in the loan will decrease the adoption of BARI mango variety. This might be due to the use the loan in other purposes (Table 13).

The results of regression analysis revealed that the yield of mango variety, training, extension contact, risk taking behavior and willingness to take loan has indeed helped in contributing to adopt BARI mango varieties at farm level. Out of these, family size, family type, innovativeness and mass media exposure can be seen as insignificant but positive indicator for formulating for adopting the BARI mango varieties in the region.

Table 11. Yield of BARI mango varieties per household in locations, 2016

Sl. No.	BARI mango varieties	Average yield (kg/hh)			
		Hathazari	Fatikchari	Sitakundo	All
1	BARI Aam-1 (Mohananda)	30.0	600.0	-	315.0
2	BARI Aam-2	20.3	-	-	20.3
3	BARI Aam-3	84.3	291.5	1221.9	532.5
4	BARI Aam-4 (Hybrid)	85.0	100.0	1000.0	395.o
5	BARI Aam-5	-	-	-	-
6	BARI Aam-6	-	-	-	-
7	BARI Aam-7	-	-	-	-
8	BARI Aam-8	40.0	-	845.0	442.5
9	BARI Aam-9 (Kachamitha)	-	310.0	442.0	376.0
10	BARI Aam-10	-	-	-	-
11	BARI Aam-11 (Baromasi)	-	-	-	-

Table 12. Probit regression coefficient of extent of adoption of BARI mango varieties

Independent variables	Probit Coefficient	Std. Err.	Z	P-value
Constant	-1.2444	1.2604	-0.99	0.323
Ln Yield	0.2372***	0.0680	3.49	0.000
Ln Cultivable land	-0.0414ns	0.0628	-0.66	0.509
Age	-0.0270ns	0.0378	-0.72	0.475
Family size	0.0246ns	0.0379	0.65	0.515
Family type	0.1070ns	0.3757	0.28	0.776
Training	1.1823***	0.4184	2.83	0.005
Risk taking behaviour	0.6126**	0.2625	2.33	0.020
Innovativeness	0.1620ns	0.2481	0.65	0.514
Willingness to take loan	-0.5041**	0.2236	-2.25	0.024
Having modern knowledge on mango production	-0.3319ns	0.2738	-1.21	0.225
Economic aspiration	-0.1748ns	0.2992	-0.58	0.559
Mass media exposure	0.2158ns	0.2447	0.88	0.378
Research contact	-0.2294ns	0.3386	-0.68	0.498
Extension contact	1.1788***	0.3352	3.52	0.000
Model diagnosis:				
Log likelihood	-50.2441	-	-	-
Pseudo R^2	0.3767	-	-	-
LR chi-squared	60.73***	-	-	0.000
Accuracy of prediction (%)	79.0%			
Number of observations	131			

Note: The variable of education dropped because of multi colinearity problem

*** Significant at 1% level (P≤ 0.01); ** Significant at 5% level ((P≤ 0.05); * Significant at 10% level (P≤ 0.10).

Table13. Marginal effects after probit analysis

Independent variables	dy/dx	Std. Err.	z	P-value	X
Ln Yield	0.0682***	0.0179	3.80	0.000	2.513
Ln Cultivable land	-0.0119	0.0180	-0.66	0.510	3.269
Age	-0.0077	0.0108	-0.72	0.472	45.671
Family size	0.0070	0.0108	0.65	0.513	52.786
Family type	0.0307	0.1078	0.29	0.775	1.778
Training	0.2960***	0.0902	3.28	0.001	0.374
Risk taking behaviour	0.1761**	0.0742	2.37	0.018	1.923
Innovativeness	0.0465	0.0715	0.65	0.515	2.618
Willingness to take loan	-0.1449**	0.06431	-2.25	0.024	1.786
Having modern knowledge on mango production	-0.0954	0.0777	-1.23	0.219	1.801
Economic aspiration	-0.0502	0.0863	-0.58	0.561	2.664
Mass media exposure	0.0620	0.0699	0.89	0.375	2.564
Research contact	-0.0662	0.0986	0..67	0.502	0.473
Extension contact	0.3808***	0.1122	3.39	0.001	0.687

Marginal effect after probit **y** = 0.7909 (*) dy/dx is for discrete change of dummy variable from 0 to 1

Note: The marginal effect is the average change probability when x increases by one unit. Since a probit is a non-linear model, that effect will differ from individual to individual.

4. Summery, Conclusion and Recommendations

Adoption of BARI mango varieties is an important for raising farm income in the region. But the rate of adoption was found to be low except BARI Aam-3. Unavailability of the saplings of BARI mango varieties and lack of its campaign were the major bottlenecks for wider adoption of BARI mango varieties in the region. The yield of BARI mango variety, training, extension contact, risk taking behavior and willingness to take loan influence farmers to adopt BARI mango varieties to a greater extent. In the case of individual production technologies, most of the farmers' respondent adopted partially or slightly might be due to unawareness or ignorance. However, the following recommendations have been made based on the findings of the study:

- Proper and necessary actions should be taken for ensuring the availability of BARI mango varieties at local nursery, research and horticulture center in the region by the concerned departments such as BARI and DAE.
- Provide hand-on training by BARI and DAE on BARI mango varieties and its individual production technologies to the farmers and private nursery owner at field level;

- BARI (OFRD) and DAE could be motivate the private nursery owners for planting mother tree of BARI mango varieties in their nursery for supplying quality sapling;
- Formulating policy for campaign about the BARI mango varieties in both electronic and print media and responsibility can be taken by the AIS under the Department of Agriculture Extension and ICT section of BARI.
- Build a strong monitoring committee for evaluating the adoption of BARI mango varieties at field level in the region in collaborating with BARI and DAE. The committee will encourage to establish BARI mango orchard in each Upazilla and monitoring these orchards at least twice in a year.

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Appendix-1.The major characteristics of BARI mango varieties

Sl. No.	Name of Variety	Year of released	Production Season	Yield (Ton/ ha)	Major Features
1.	BARI Aam-1 (Mohananda)	1996	May	15	Regular bearing, average fruit wt. 190-210gm, TSS-19%, early variety
2.	BARI Aam-2	1996	June	20-22	Regular bearing, average fruit wt. 240-260gm, TSS-17.5%,
3.	BARI Aam-3	1996	June-July	18-20	Regular bearing, average fruit wt. 210-220gm, TSS-23.4%
4.	BARI Aam-4 (Hybrid)	2002	July-Aug.	18-20	Regular bearing, average fruit wt. 600gm, TSS-24%, late variety
5.	BARI Aam-5	2009	May	15-20	Regular bearing, average fruit wt. 230gm, TSS-19%.
6.	BARI Aam-6	2009	June	15-16	Regular bearing, average fruit wt. 280 gm, TSS-18%
7.	BARI Aam-7	2009	June	20-25	Regular bearing, average fruit wt. 285 gm, TSS-18%
8.	BARI Aam-8	2009	July	20-25	Regular bearing, average fruit wt. 270gm, TSS-22%
9.	BARI Aam-9 (Kachamitha)	2011	May	1.35 (7 yrs tree)	Regular bearing, average fruit wt. 166gm, TSS-11%, early variety
10.	BARI Aam-10	2012	June	15-20	Regular bearing, average fruit wt. 200gm, TSS- 20%
11.	BARI Aam-11 (Baromasi)	2015	Rabi &Kharif	2.2 (6 yrs tree)	Three times bearing per year (November, February & May) average fruit wt. 317gm, TSS-18.5%.

Source: *Krishi Projokti Hathboi, 2016.*

Appendix-2. The name of study areas (villages) under three selected Upazilas in Chittagong district

Sl. No.	Name of Upazila	No. of villages	Name of villages where the survey was conducted
1	Hathazari	8	Charia, Fakirkil, Dakkin Pahartali, Tandachari, Fateyabad, Dewan Nagor, Alipur and Alampur
2	Fatikchari	13	Nanopur, Kepayetnagor, Gamaritola, Jushkhula, Purbo Hasnabad Bhuiyapara, Purbo Hasnabad Ajolapara, Gopalghata, Maijvandar, Masterpara, Barmaniya para, Pacchim Soabil, Dakkin Rangamatia and Dakkin Baghmara
3	Sitakundo	7	Khadempara, Kesobpur, Vatiari, Jahanabad, Samobetorpara, Dakkin Bashbariya and KadomRasul