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Socioeconomic determinants of BARI mustard-14 adoption at farm level in selected areas of Bangladesh

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ABSTRACT

BARI mustard-14 variety is a prominent mustard variety that is gradually accepted by the farmers of Bangladesh and generating higher income through farming. The focus of this study was to assess socioeconomic factors determining farmers' decisions to adopt BARI mustard-14. Primary data were collected through multistage random sampling technique from 76 BARI mustard adopters and 74 non-adopters from selected areas. Mean, percentage, standard deviation and Probit model was used. It was found that the rate of adoption of BARI mustard-14 was 38.95% at farm level but adoption rate was higher in Tangail compared to Cumilla and Rajshahi districts. Bangladesh Agricultural Research Institute (BARI) recommended practices showed that the adoption of different management techniques is low. Probit model showed that education of the farmer, farm size, availability of seed and influence of Sub Assistant Agriculture Officer (SAAO) enhanced the adoption of BARI mustard-14 variety. Profitability analysis showed that the yield of BARI mustard-14 variety is much higher compared to BARI old variety (Tori-7). The average net return of BARI mustard-14 variety was Tk. 14,450 per ha which was also significantly higher (20.77%) than BARI old mustard variety. The BCR of improved variety (1.23) was significantly higher (85.58%) compared to that of old variety. The policy should be targeted to ensure availability of seed and established linkage between extension agent and farmers to get information regarding BARI mustard-14 production and its technology.

Introduction

Agriculture has played a pivotal role to the sustainable growth and development of the Bangladesh economy. Although, the agriculture sector contributed only 13.82% (at current price) of GDP in 2017-18, its importance in the Bangladesh's socioeconomic development goes well beyond this indicator as 40.6% of the total workforce is employed in agriculture, which includes 59.15% cultivators and 29.85% agricultural labourers (BBS, 2018).

Bangladesh agriculture has made tremendous progress, particularly in respect of food grains production (achieved a record production of 38141 thousand tonnes) however performance has not been so good in case of other crops, particularly oilseeds, pulses and coarse cereals (BBS, 2018). Therefore, after achieving self-sufficiency in food grains the government is now focusing attention on these crops especially oilseed crops. There are eight oilseeds crops i.e Till, Rape and Mustard, Groundnut, Soyabean, Line seeds, Castor and Coconut. Total area under oilseed crops is around 484.21 thousand ha (which is 2.37% of the total area under cultivation) of land and producing about 975 thousand tones (BBS, 2018). Mustard is one of the most dominant crops in Bangladesh occupying 69.94% of the total area under oilseed crops. Total area under rape and mustard is around 336.44 thousand ha and producing 363 thousand tones. The country is producing about 0.36 million tons of edible oil from oilseed crops per year as against the total requirement of 1.4 million tons (Mallik, 2013). Internal production can meet only about 29% of total consumption (8 g/day /head). As a consequence, Bangladesh remains as a net importer of oils and the demand for oil will increase substantially in the future in response to increase in population and changes in dietary habits and nutritional awareness. Mustard is a predominantly winter crop and is sown

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during mid-October to November and harvested during late January to end of February. Given the future scenario of climate warming, it is recognized that the winter crops, such as mustard, other oilseeds and vegetables, are likely to be relatively more vulnerable to rising temperatures, which will add further pressure on increased demand for oils.

Adoption of improving agricultural technologies is crucial to increase productivity, which will further increase higher farm incomes. Due to complexity in different improve technology sometimes farmers find it hard to understand or remember all the operations. As a result farmer lags behind in adoption of recommended package of practices. It has been seen that a large number of techniques and practices do not reach the farmer's field or those carried to the farmers get considerably distorted or are often adopted partially with the result that the farmers do not get optimum results. The yield of mustard depends upon the adoption of scientifically recommended practices. Relevant agro-climatic specific production and protection technologies for the cultivation of mustard have been developed Bangladesh Agricultural Research Institute (BARI). However, the varying adoption of recommendations leads to a large difference between the potential yield and the actual yield. But there is no detailed empirical study available to access the status of knowledge and adoption of these practices by the mustard farmers in Bangladesh. The production of mustard can be achieved only, if the scientific agricultural technology is efficiently adopted at the proper time and stage by the farmers, at their farm level.

A few studies were available on mustard in Bangladesh mainly focusing profitability, socioeconomic and farmer perceptions. Rahman and Kazal (2016) studied profitability, input demand and output supply of mustard, Miah *et al*. (2015) investigated the adoption of BARI mustard technology and Hossain *et al*. (2013) examined farmers' perception on cultivating mustard. But none of the touch the socioeconomic determinants and adoption of BARI mustard-14 at farm level. Given this backdrop, the present study focuses the socioeconomic determinant of BARI mustard-14 adoption in farmers' field and estimates the level of adoption of BARI mustard-14 variety at farm level, profitability and determines the factors affecting its adoption.

Materials and Methods

Research design, selection of the study area and sampling technique

Non-experimental research design was employed for the study. This study was conducted in the three districts namely Tangail, Cumilla and Rajshahi in Bangladesh. Multi stage random sampling techniques were used to collect farm level data. At the first stage, Tangail, Cumilla and Rajshahi districts were randomly selected based on BARI mustard-14 production concentration and presence of BARI mustard-14 technology interventions. At the second stage, two Upazilas were randomly selected from each district and accordingly two villages were randomly selected from each Upazila. Finally, a total of 76 households for BARI mustard-14 and 74 for local varieties were selected for interview to collect primary data. Thus, the total number of samples was 150.

Extent of adoption of BARI mustard-14 cultivation practices

Extent of adoption is a measure of selected BARI mustard-14 production technologies recommended by BARI and was measured in terms of the percentage of farmers adopting a particular BARI mustard-14 production technology.

$$Extent\ of\ adoption = \frac{Number\ of\ respondents\ adopting\ a\ practice}{Total\ number\ of\ respondents} \times 100$$

Level of adoption of BARI mustard-14 cultivation practices

It is with respect to adoption of those recommended practices which will be divisible and measurable in terms of deviations from the recommended quantities of inputs namely; doses, seed rate, etc. The level of adoption was also measured in terms of deviation from the recommendations of BARI with respect to date, time and period of application of different practices. A farmer was defined as an adopter if he or she was found to be growing any BARI mustard-14. Thus, a farmer could be classified as an adopter, if he/she allotted his/her land for growing BARI mustard-14 variety. For assessing the level of adoption of crop management technologies, respondent farmers were grouped into three categories such as high, medium, and low adopter based on the percent of farmers followed recommended practice with respect to each technology. A higher percentage scored by a particular technology indicates a higher level of adoption, while a lower percentage indicates its lower level of adoption. Adoption level was categorized as high (scored 70-100%), medium (50-69%), and low (<50%). Such categorization of adoption levels was used in different studies (Hossain *et al*., 1997; Miah *et al*., 2004; Akter *et al*. 2010; Islam *et al*, 2013).

Analytical technique

In order to yield the relevant information in consistent with the objectives of the study, the data were analyzed with the help of suitable statistical measures as frequencies, percentages, mean and standard deviation. Descriptive statistics were used to analyze and compare the socioeconomic characteristics and institutional variables between adopters and non-adopters. Profitability or cost benefit analysis (CBA) was used, which includes detailed financial cost of production and returns from BARI mustard 14 and local variety on a per

hectare basis. The total cost is composed of total variable costs (TVC) and total fixed costs (TFC) (Begum *et al.,* 2011). TVC includes costs of human labour (both family and hired labour, wherein the cost of family labour is estimated by imputing market wage rate), mechanical power, seed, manure, fertilizers, and pesticides. TFC includes land rent (if owned land is used then the imputed value of market rate of land rent is applied) and interest on operating capital. The gross return (GR) is computed as total mustard output multiplied by the market price of mustard. Profits or gross margin (GM) is defined as GR-TVC, whereas the net return (NR) is defined as GR-TC. Finally, the Benefit Cost Ratio (BCR) is computed as GR/TC (Begum *et al.,* 2019).

Besides, Probit regression model was used to find out the factors of adoption of improved BARI mustard-14 variety. Probit model is based on a cumulative normal distribution function which is symmetric around zero with variance equal to 5. The Probit model is:

$$Log\ P = \alpha + \beta_i X_i \text{ ---------- (1)}$$

Where, P = Adoption (1 for adoption, 0 for non-adoption), Xi = Explanatory variables (i = 1, 2, 3.....n); α = Constant term; and βi = Coefficients (i = 1, 2, 3.....n). Relative change in P with a constant increase in Xi can be measured by the above model.

When P approaches 1, a relative change in P can be obtained with a constant increase in Xi by equation (1); here 1-P is used.

$$Log\ 1 - P = \alpha + \beta_i X_i \text{ ---------- (2)}$$

When equations (1) and (2) are combined, we get equation (3) that can be transformed into equation (4).

$$Log\ P - Log\ (1 - P) = \alpha + \beta_i X_i \text{ --------- (3)}$$
$$Log\ \{P/(1 - P)\} = \alpha + \beta_i X_i \text{ ---------- (4)}$$

The ratio of P/(1-P) is called the odd ratio and log {P/(1-P)} is called the log odds or Probit. Equation (4) can be rearranged and solved for P;

$$P = [1/(1 + e^{-(\alpha+\beta_i X_i)})] \text{ ---------- (5)}$$

The probability function used in Equation (5) calls the logistic distribution function and ensures that the predicted value (P) of the relative frequency of the independent variable is always between 0 and 1. The equation (5) was used to analyze the determinants of farmer adoption of an intervention.

Empirical probit model

In order to determine the relationship between the adoption of improved BARI mustard-14 variety and socioeconomic factors, the following empirical Probit model (equation 6) was carried out. The dependent variable of this model was the adoption of improved BARI mustard-14 variety. Since the dependent variable is dichotomous, OLS cannot be used. The model was as follows:

$$A_i = \alpha + \beta_i X_i + \cdots \ldots + U_i \text{ ---------- (6)}$$

Where, Ai = Farmers adopting improved BARI mustard-14 variety (If adopt = 1; Otherwise = 0), α = Intercept, Xi = Explanatory variables (socioeconomic characteristics), βi = Coefficients of respective factors and Ui = Error term. The adoption of improved BARI mustard-14 variety is likely to be influenced by the explanatory variables; i.e., X_1 = Age of the respondent (year); X_2 = Education (Year of schooling); X_3 = Farm size (decimal); X_4 = Family labour (No./ha); X_5 = Training received on mustard (No.); X_6 = Availability of HYV seed (wt. score); X_7 = Influence of neighboring farmers (wt. score); X_8 = Influence of SAAO (wt. score); and X_9 = Extension contact (wt. score). The aforementioned model was estimated using R software version 3.5.0.

Model diagnostics with multicollinearity test

Before going to apply the model, the data were checked for multicollinearity. The tests include variance inflation factors (VIF) were done for model diagnostics. The test supported that there is no major problem of multicollinearity of the data.

Results and Discussion

Socioeconomic profiles of BARI mustard-14 farmers

The socioeconomic conditions of the households of BARI mustard-14 farmers are of much important in planning of development activities because the nature and extent of them are influenced largely by such issues.

Age structure

The age of farmers has a key influence on the adoption of new farming practices (Singh *et al.,* 2010). Farmers' age also plays a vital role in the farming activities and management. The age of the BARI mustard-14 farmers were examined by classifying the farmers into six groups: 20-30, 31-40, 41-50, 51-60, 61-70 and above 70 years (Table 1). Majority of the adopter and non-adopter farmers belonged to the age group of 41-50 years. This information implies that the majority of the farmers was in middle age and was in a position to put more physical effort for mustard production. The higher percentage of adopter farmers were found in the age group of 31-40 (relatively younger in age) than non-adopter farmers and were in supposed to have enormous vigor and risk bearing ability to adopt new technology more rapidly than the older counterparts.

Table 1. Distribution of BARI mustard-14 adopter and non-adopter according to age group (percentage)

Age group (year)	Adopter *(n=76)*	Non-adopter *(n=74)*
20-30	11.84	14.86
31-40	26.32	25.68
41-50	27.63	36.49
51-60	22.37	16.22
61-70	11.84	4.05
Above 71	--	2.70
Total	100	100

Table 2. Distribution of BARI mustard-14 adopted and non-adopter by literacy levels (percentage)

Literacy level	Adopter *(n=76)*	Non-adopter *(n=74)*
Illiterate (0)	10.53	14.86
Primary (1-5)	39.47	48.65
Secondary (6-10)	43.42	25.68
Higher secondary (11-12)	3.95	8.11
Degree & above (13 & above)	2.63	2.70
Total	100	100

Table 3. BARI mustard-14 adopter and non-adopter involved with different social organizations (percentage)

Type of organization	Adopter *(n=76)*	Non-adopter *(n=74)*
1. Farmer`s coop society	13.16	4.05
2. Youth coop society	1.32	1.35
3. School committee	3.95	-
4. IPM/ICM club	1.35	6.58
5. Mosque committee	11.84	6.76
6. Market committee	1.35	3.95
7. Union council	9.21	6.76

Table 4. Level of influence by different persons in adopting BARI mustard-14 variety

Persons	Level of influence (%)				
	Very high	High	Medium	Low	No influence
Family member	6.58	13.16	26.32	6.58	14.47
Neighbor	25.00	21.05	34.21	1.32	18.42
SAAO	46.05	10.53	18.42	2.63	22.37
Agril. Officer	2.63	21.05	22.37	11.84	22.37
IPM/ICM club	-	-	-	2.63	48.68

Table 5. BARI mustard-14 adopter and non-adopter adopting innovative activities (percentage)

Innovative activity	Adopter *(n=76)*	Non-adopter *(n=74)*
Use of green manure	2.63	4.05
Use of compost	5.26	2.70
Crop cultivation on *ail*	1.32	1.35
Use of IPM technology	5.26	2.70
Artificial insemination	25.00	9.46
Bee keeping	2.63	1.35

Literacy and education

Veerina *et al.* (1999) stated that factors such as literacy have a role in influencing yields through production decisions. Education is likely to influence the farmers to adopt the modern technology and it makes them more capable to manage scarce resources efficiently so that they can earn higher profit. On the basis of education level, the literacy status of the respondent farmers has been grouped into five categories. The categories are (1) illiterate, (2) primary, (3) secondary, (4) higher secondary and (5) degree and above. It is observed that the average education level of adopter and non-adopter was 6.49 (secondary level) and 4.81 (primary level) respectively. Table 2 also shows that 10.53% of adopter farmers and 14.86 % of non-adopter farmers respectively did not have formal education. Of the educated respondents, 39.47% and 43.42% adopter, and 48.65% and 25.68% non-adopter had primary and secondary levels of education. A few number of adopters (2.63%) and non-adopter (2.70%) adopter farmers had a degree and above level of education.

Factors affecting BARI mustard-14 adoption

Status of societal membership

Social participation allows farmers to be in touch with their committee members. This allows them not only to exchange with committee members on new technologies, but also to have access to agricultural inputs. These committees/societies and the meetings they organize are channels for the dissemination of innovations. So belonging to a societal membership committee is expected to have a positive influence on the adoption of BARI mustard-14. There are some social organizations in study areas, such as Farmer's Cooperative Society, Youth Cooperative Society, School Committee, Integrated Pest Management (IPM) /Integrated Crop Management (ICM) Clubs, Mosque Committee, Bazaar Committee, and Union Council. Membership of these social organizations was considered as a measure for social participation. Table 3 reveals that most of the BARI mustard-14 farmers had no involvement with any social organization. About 13% of the adopter farmers were reported to be the member of the farmer`s cooperative society followed by 11.84% mosque committee, 9.21% union council, and 1.35% market committee. About 6.76% of the non-adopter BARI mustard-14 farmers belonged to the local mosque committee and union council (Table 3). However, the involvement of adopting farmers with different social organizations was much higher compared to non-adopting farmers in the case of farmer`s cooperative society, school committee, mosque committee and union council. However, the respondent BARI mustard-14 farmers who belonged to any social organization were involved mostly as a general member.

Influencing persons in adoption

At the initial stage of adopting BARI mustard-14 variety, the respondent adopters in the study areas were influenced by different persons at different levels. The influencing persons were reported to be family member, a neighboring farmer, Sub-Assistant Agricultural Officer (SAAO), Agriculture Officer (AO), and the members of an IPM/ICM club. Table 4 depicts that SAAO influenced to a greater extent in adopting BARI mustard-14 variety than the influences of other persons. Again, after SAAO major influences came from neighboring farmers and family members in BARI mustard-14 cultivation.

Innovative activities

Adopter farmers are likely to be tending more on various innovative activities since adopter farmers are more dynamic than that of non-adopters. Table 5 reveals that the highest percentage of both adopting (25%) and non-adopting farmers (9.46%) used artificial insemination (AI) followed by the use of composed fertilizer and use of IPM technology to control insect-pests infestation. However, the overall innovative activities used by adopting farmers were more compared to non-adopters in the study areas.

Contact with extension agents

Extension agents are sources of information on new agricultural technologies. Thus, it is expected that farmers who have contact with extension agents will be more likely to adopt BARI mustard-14 variety. The Government of Bangladesh has a very large extension network under the Department of Agricultural Extension (DAE) for the dissemination agricultural technologies from research institutes to farmers. The SAAO of DAE is the key person to make contact with the farmers for any kind of technology dissemination and crop related issues. However, farmers can get up-to-date knowledge on modern varieties, improved production practices, intercultural operations, insect-pest control, and many other related issues of crop production from different extension medias, such as agriculture fair, booklets, leaflets, field day, demonstration plots, research institutes, and mass media.

Table 6 revealed that the respondent adopters of BARI mustard-14 variety had frequent contact with extension personnel and neighboring farmers, which was more than the contact made by non-adopting farmers in the study areas. None of the adopter and non-adopter farmers visited agricultural research institutes frequently. Frequent contact with mass media (i.e.TV, newspaper) was also higher for adopting farmers compared to non-adopters. However, the levels of contact with different extension agents were found to be higher for adopters compared to non-adopters in the study areas.

Determinants of adoption

The results of the Probit Model (Table 7) revealed that four factors were significant in influencing the farmers' decision to adopt improved BARI mustard-14 variety. Education of the farmer, farm size, availability of seed and influence of SAAO in mustard fields were important variables that had an effect on the likelihood of farmers to adopt. The effect of education level of farmers on improved varieties was significantly positive. This implies that the level of education of a farmer increases the likelihood of improved BARI mustard-14 varieties adoption. This confirms to the results obtained by Dey *et al.* (2000). The effect of farm size had a significant positive effect on adoption of improved BARI mustard-14 variety. Suggesting that the increase in farm size increases the likelihood of farm household's choice of improved BARI mustard-14 variety. It was also observed that the availability of seed positively affected the decision of adopting improved BARI mustard-14 variety. The result confirms that households who have more availability of seed were more likely to adopt improved BARI mustard-14 variety. The influence of SAAO affected the decision of improved BARI mustard-14 variety positively. This means the influence of SAAO increases the more likely farmers to adopt improved BARI mustard-14 variety. Therefore, farmers have to opt for new improved BARI mustard-14 variety which allows more production.

Table 6. Level of extension contact of BARI mustard-14 adopter and non-adopter with different extension medias

Extension media	Farmers' responses (%)				
	Frequent	Often	Sometimes	Rare	None
Adopter *(n=76)*					
Extension personnel	25.00	35.53	30.26	7.89	1.32
Neighbour (farmer)	52.63	31.58	9.21	--	6.58
Local leader	3.95	17.11	27.63	1.32	50.00
Agriculture fair	2.63	5.26	25.00	22.37	44.74
Demonstration plot	1.32	9.21	26.32	9.21	53.95
Agril. book/booklets	--	1.32	1.32	6.58	90.79
Attend in the field day	--	3.95	19.74	14.47	61.84
Research institute visit	--	1.32	10.53	9.21	78.95
Radio	--	2.63	9.21	1.32	86.84
Television	9.21	14.47	42.11	18.42	15.79
Newspaper	3.95	--	2.63	2.63	90.79
Non-adopter *(n=74)*					
Extension personnel	9.46	25.68	47.30	10.81	6.76
Neighbour (farmer)	47.30	35.14	12.16	--	5.41
Local leader	5.41	17.57	18.92	2.70	55.41
Agriculture fair	1.35	--	17.57	17.57	63.51
Demonstration plot	1.35	--	12.16	17.57	71.62
Agril. book/booklets	--	--	2.70	1.35	95.95
Attend in the field day	1.35	--	5.41	4.05	89.19
Research institute visit	--	--	1.35	6.76	91.89
Radio	1.35	--	--	1.35	97.30
Television	5.41	10.81	44.59	18.92	20.27
Newspaper	--	--	1.35	1.35	97.30

Table 7. Maximum likelihood estimates of BARI mustard-14 variety among respondent farmers

Coefficients	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-5.055	1.352	-3.74	0.000
Age (year)	0.023	0.019	1.18	0.239
Education (Year of schooling)	0.137	0.068	2.01	0.044**
Farm size (Decimal)	0.007	0.002	2.85	0.004***
Availability of seed	0.962	0.188	5.12	0.000***
Influence of neighbor (Score) (Scale,0-4; 0= no influence, 4= high influence)	0.024	0.154	0.16	0.876
Influence of SAAO (Score) (Scale,0-4; 0= no influence, 4= high influence)	0.024	0.156	3.12	0.002***
Training on BARI-mustard-14 (No./life time)	0.059	0.240	0.25	0.805

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '5' 0.1 ' 1'; Dependent variable = BARI mustard-14 variety adoption (Adopter = 1, Non-adopter = 0) ; No. of observation = 150; Null deviance: 207.917 on 149 degrees of freedom, Residual deviance: 57.326 ; on 140 degrees of freedom, AIC: 77.326, Number of Fisher Scoring iterations: 9

Adoption of farming practices

The Table 8 reveals that land preparation had low levels of adoption. Only 20% BARI mustard-14 farmers provided a recommended number of ploughing (4-5 times). Most of them (78%) ploughed their lands 2-3 times, which was below the recommendation. The recommended period of seed sowing is October to November. It is surprising that 100% BARI mustard-14 farmers had sown seeds within recommended period. It is due to the fact that farmers have to sow the main *boro* crop after harvesting BARI mustard-14 as well as farmers found it convenient to sow it during the available range of time. Two types of sowing method were followed for BARI mustard-14 production. The recommended seed rate for BARI mustard-14 is 6-7 kg/ha. About 53.95% respondent farmers used higher amount of seed than its recommendation (Table 8). Two times irrigation, one is over 20-25 days of seed emergence (before flowering stage) and the other one is 50-55 days during fruits coming, is recommended for achieving higher productivity of BARI mustard-14. Most of the sampled farmers (72.8%) in Rajshahi district were found to irrigate their crops. About 96.30% farmers of Tangail district did not irrigate their crops because of rainfall that occurred in the early stage of production as well as the nature of the low land and loamy soil. The majority of BARI mustard-14 farmers (89.47%) did not perform weeding in their crop field because of very low weed infestation. About 67.11% farmers used pesticides to control insects like aphids and cutworm. The highest number of sampled farmers (100%) in Rajshahi district applied pesticides to control insects (Table 8).

Table 8. Adoption of crop management technologies used in BARI mustard-14 cultivation (percentage)

Technology	Tangail *(n=27)*	Cumilla *(n=23)*	Rajshahi *(n=26)*	All area *(n=76)*	Adoption level
Ploughing and laddering (No.)					
Recommended no. (4-5)	22.22 (6)	30.43 (7)	7.69 (2)	19.74 (15)	Low
Below recommendation (2-3)	74.07 (20)	65.22 (15)	92.31 (24)	77.63 (59)	
Above recommendation (>5)	3.70 (1)	4.35(1)	--	2.63 (2)	
Seed sowing period					
*(October- November)	100 (27)	100 (23)	100 (26)	100 (76)	High
Non-recommended period	--	--	--	--	
Seed sowing method					
Broadcasting	100 (27)	100 (23)	100 (26)	100 (76)	High
Line sowing	--	--	--	--	
Seed rate (kg/ha)					
Recommended rate (6-7)	25.93 (7)	21.74 (5)	80.77 (21)	43.42 (33)	Low
Below recommendation(1-5.4)	3.70 (1)	--	3.85 (1)	2.63 (2)	
Above recommendation (>7)	70.37 (19)	78.26 (18)	15.38 (4)	53.95 (41)	
No. of irrigation					
Recommended (2 times)	3.70 (1)	4.35 (1)	19.23 (5)	9.21 (7)	Low
Below recommendation	--	34.78 (8)	80.77 (21)	38.16 (29)	
Above recommendation	--	--	--	--	
Provide no irrigation	96.30 (26)	60.87 (14)	--	52.63 (40)	
No. of weeding					
Recommended (2 times)	3.70 (1)	21.74 (5)	7.69 (2)	10.53 (8)	Low
Below recommendation	--	--	--	--	
Above recommendation	--	--	--	--	
Provide no weeding	96.30 (26)	78.26 (18)	92.31 (24)	89.47 (68)	
Insect-pest control					
Used pesticides	22.22 (6)	82.61 (19)	100.00 (26)	67.11 (51)	-
Do not use pesticides	77.78 (21)	17.39 (4)	--	32.89 (25)	

-- indicates nil; Figures in the parentheses indicate no. of farmers responded

*Indicate recommended period; Adoption level: 70-100% as high; 50-69% as medium; & <50% as low (Miah et al, 2015).

Table 9. Percent of adopters used manure and fertilizer in BARI mustard-14 cultivation

Particular	Tangail *(n=27)*	Cumilla *(n=23)*	Rajshahi *(n=26)*	All area *(n=76)*	Adoption level
Cowdung (ton/ha)					
*8-10 ton/ha	--	--	7.69 (2)	2.63 (2)	Low
Below recommendation	--	73.91 (17)	69.23 (18)	46.05 (35)	
Above recommendation	--	--	3.85 (1)	1.32 (1)	
Non-users	100.00 (27)	26.09 (6)	19.23 (5)	50.00 (38)	
Urea (kg/ha)					
*200-250 kg/ha	77.78 (21)	26.09 (6)	19.23 (5)	42.11 (32)	Low
Below recommendation	3.70 (1)	43.48 (10)	69.23 (18)	38.16 (29)	
Above recommendation	18.52 (5)	30.43 (7)	11.54 (3)	19.74 (15)	
		TSP (kg/ha)			
*150-170 kg/ha	7.41 (2)	39.13 (9)	61.54 (16)	35.53 (27)	Low
Below recommendation	11.11(3)	8.70 (2)	15.38 (4)	11.84 (9)	
Above recommendation	70.37 (19)	52.17 (12)	11.54 (3)	44.74 (34)	
Non-users	11.11(3)	--	11.54 (3)	7.89 (6)	
MoP (kg/ha)					
*70-85 kg/ha	18.52 (5)	26.09 (6)	42.31 (11)	28.95 (22)	Low
Below recommendation	7.41 (2)	4.35 (1)	3.85 (1)	5.26 (4)	
Above recommendation	74.07 (20)	47.83(11)	53.85 (14)	59.21 (45)	
Non-users	--	21.74 (5)	--	6.58 (5)	
Gypsum (kg/ha)					
*120-150 kg/ha	7.41 (2)	--	19.23 (5)	9.21 (7)	Low
Below recommendation	66.67 (18)	13.04 (3)	69.23 (18)	51.32 (39)	
Above recommendation	3.70 (1)	--	3.85 (1)	2.63 (2)	
Non-users	22.22 (6)	86.96 (20)	7.69 (2)	36.84 (28)	
Zinc (kg/ha)					
*4-5 kg/ha	11.11 (3)	--	3.85 (1)	5.26 (4)	Low
Below recommendation	3.70 (1)	--	--	1.32 (1)	
Above recommendation	33.33 (9)	--	80.77 (21)	39.47 (30)	
Non-users	51.85 (14)	100.00 (23)	15.38 (4)	53.95 (41)	
Boron (kg/ha)					
*10 kg/ha	--	--	--	--	Low
Below recommendation	33.33 (9)	--	57.69 (15)	31.58 (24)	
Above recommendation	3.70 (1)	--	30.77 (8)	11.84 (9)	
Non-users	62.96 (17)	100.00 (23)	11.54 (3)	56.58 (43)	

-- indicates nil, Figures in the parentheses indicate no. of farmers responded

*Recommended dose; Adoption level: 70-100% as high; 50-69% as medium; and <50% as low (Miah et al, 2015).

Table 10. Cost of mustard cultivation in the study areas

Particular	BARI Sarisha-14		Local (Tori 7)	
	Tk/ha	%	Tk/ha	%
A. Total Variable cost (Tk)	39,282.66	62.39	36,068.07	62.77
Land preparation	5,942.80	9.44	6,125.46	10.66
Labour	15,013.68	23.85	13,916.87	24.22
Family labour	9,099.20	14.45	8,628.46	15.02
Hired labor	5,914.48	9.39	5,288.41	9.20
Seed	685.66	1.09	727.89	1.27
Fertilizers	13,054.24	20.73	11,869.81	20.66
Manure	2,058.52	3.27	1,216.27	2.12
Pesticide	1,360.72	2.16	1,125.74	1.96
Irrigation	1,167.03	1.85	1,086.03	1.89
B. Total Fixed cost (Tk)	23,680.18	37.61	21,388.18	37.23
Land use	22,960.00	36.47	20,668.00	35.97
Interest on operating capital	720.18	1.14	661.25	1.15
C. Total cost (A+B)	62,962.84	100.00	57,456.25	100.00

Table 11. Profitability of mustard cultivation (Tk/ha)

Particular	BARI mustard-14 *(n=76)*	Local *(n=74)*
1. Seed yield (kg/ha)	1457.16	1261.99
2. Price (Tk/kg)	48.61	44.73
3. Gross return (Tk/ha)	77412.72	60457.32
Main product	70830.2	56452.95
By-product	6582.52	4004.37
4. Total variable cost (Tk/ha)	39,282.66	36,068.07
5. Total cost (Tk/ha)	62,962.84	57,456.25
6. Gross margin (Tk/ha) (3-4)	38,130.06	24,389.25
7. Net return (Tk/ha) (3-5)	14,450	3,001
9. Rate of return:		
Over variable cost (3÷4)	1.97	1.68
Over total cost (3÷5)	1.23	1.05

The recommended fertilizer doses vary from location to location. The Table 9 reveals that BARI mustard-14 farmers often do not follow the recommendations for applying fertilizers. They tended to either use fertilizers in excess or in very small quantities. None of the farmers in Tangail district applied cowdung. Almost all the respondent farmers applied urea in three districts. The highest percentage (77.78%) of farmers was found to be using the recommended dose of urea in Tangail district. In Cumilla district, none of the farmers applied zinc and boron because farmers' had no good idea about the effectiveness of zinc and boron. In the case of MoP application, more than 59% farmers used higher amounts compared to the recommendation. Most of the BARI mustard-14 farmers applied gypsum in lower quantity compared to their recommended doses.

Adoption at household level

The highest percentage of the respondent farmers in Tangail district were found to be very much enthusiastic towards BARI mustard-14 variety due to their short duration (80-85 days) and high yielding characteristics. Another reason for this might be because of the low land, after the cultivation of BARI mustard-14 seeds farmers cultivate Boro rice (BARI mustard 14-*Boro*-Fallow-*T-aman)*. But the rate of adoption of this variety was not satisfactory in the Rajshahi district mainly because of dry land farmers cultivate other crops instead of Boro rice (Data not shown). However, the adoption rates of BARI mustard-14 may be higher in study areas compared to other mustard growing areas.

Profitability of mustard cultivation

The average cost of cultivation of BARI mustard-14 was estimated to be Tk. 62962.84/ha which was 9.13% higher than the cost of producing BARI old mustard variety (Tori-7). This increased cost was for using the higher amount of labour, fertilizers, pesticides, and irrigation. Around 37.61% and 37.23% cost was spent for fixed inputs for BARI mustard-14 and Tori variety, which includes land use and interest on operating capital for both the varieties. The cost of land preparation and labour were higher for local variety cultivation which were not much difference between them. The share of total cost was found to be the highest for land use (37.61-37.23%) followed by family labour (14.45-15.02%) and fertilizers

(20.73-20.66%) among the cost items (Table 10). The yield of BARI mustard-14 variety is much higher compared to BARI old variety (Tori-7). The average yield of BARI mustard-14 was 1.46 t/ha which was significantly higher (13.39%) than the yield of old mustard variety (1.26 t/ha) (Table 11). The average net return of BARI mustard-14 variety was Tk. 14,450 which was also significantly higher (20.77%) than BARI old mustard variety. This higher return was due to higher yield and high price of the produce. The Benefit Cost Ratio (BCR) over total cost was higher than unity, implying that the productions of both improved and BARI mustard-14 were profitable at farm level. The BCR of improved variety (1.23) is significantly higher (85.58%) compared to that of old variety. The result is consistent with Dey *et al*. (2013) estimated average net return and BCR of mustard production were Tk. 14,649 per hectare and 1.36 respectively.

Conclusions and policy recommendations

The higher percentage of adopter farmers were found in the age group of 31-40 (relatively younger in age) than non-adopter farmers and were supposed to have enormous vigor and risk bearing ability to adopt new technology more rapidly than the older counterparts. About 39.47% and 43.42% adopter, and 48.65% and 25.68% non-adopter had primary and secondary levels of education which is encouraging and spread up technology adoption. SAAO influenced to a greater extent in adopting BARI mustard-14 variety than the influences of other persons in the study areas. The respondent adopters of BARI mustard-14 variety had frequent contact with extension personnel and neighboring farmers, which was more than the contact made by non-adopting farmers in the study areas. Education of the farmer, farm size, availability of seed and influence of SAAO in mustard fields were important variables that had an effect on the likelihood of farmers to adopt. The effect of education level of farmers on improved varieties was significantly positive. Only 20% BARI mustard-14 farmers provided a recommended number of ploughing (4-5 times). Most of them (78%) ploughed their lands 2-3 times, which was below the recommendation. The recommended seed rate for BARI mustard-14 is 6-7 kg/ha. About 53.95% respondent farmers used higher amount of seed than its recommendation. BARI mustard-14 farmers often do not follow the recommendations for applying fertilizers. They tended to either use fertilizers in excess or in very small quantities. The highest percentage of the respondent farmers in Tangail district were found to be very much enthusiastic towards BARI mustard-14 variety due to their short duration (80-85 days) and high yielding characteristics. The BCR of improved variety (1.23) is significantly higher (85.58%) compared to that of old variety.

The policy should be focused to establish linkage between SAAO/extension agent and farmers to influence farmers for getting up-to-date knowledge and information regarding BARI mustard-14 production and its technology. The policy should also be focused on smooth operation of the hired labour which will in turn enable the landless labourers to reap the benefits of increase mustard production through wages. This is because labour is the major input in mustard production.

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