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Socio-Economic Impacts on Adoption of Quality Protein Maize (QPM) Using Organic Mulches in Riverine *Chars* of Bangladesh

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Abstract:

*The vast areas of the **riverine** formed land (locally known as char) are often subjected to forceful flood and erosion making traditional cultivation difficult. The farmers of the char people are thus poor and malnourished. The aim of this study was to identify the socio-economic impacts that influence farmers' decision to adopt QPMin the riverine chars of Brahmaputra and Jamuna basins of Bangladesh by using the farm household survey data collected from 60 maize farmers during 2013-14. This paper presents the results of an empirical application of maximum likelihood estimate of Binary Logistic Model. The results indicated that the mean probability of i) QPM adoption varied based on: years of agricultural experience (X2) (P<0.036), years of schooling (X3) (p<0.089), contact with extension personnel (X6) (p<0.035) and training (X7) (P<0.078)while ii) theorganic mulch adoption varied due to thefarmers age (X1)*

(P<0.055), years of agricultural experience (X2) (P<0.029),farm size(X5) (P<0.047) and contact with extension personnel (X6) (p<0.056). However, age, household size, farm size for QPM adoption and years of schooling, household size and training on QPM for mulch adoption had no significant influence. The farmers of the study area identified inadequate fund, seed quality with price and fertilizer cost as the main constraints for the production of QPM.

Key words: adoption, organic mulch, QPM, socio-economic factors, binary logistic model

Introduction

In Bangladesh, agriculture is one of the intended leading sectors of the economy, in which cereal crops contribute a large share of the output of the agricultural sector. Contribution of agriculture to the growth in gross domestic product (GDP) is gradually declining i.e. contribution of agriculture to the GDP growth was 18.36 percent in 2009-10 financial year and it fell to 16.33 percent in the 2013-14 FY. Interestingly, maize production in Bangladesh is in continually increasing starting from 2001 to 2013 (WBdata 2014). It is gaining popularity day by day for its unique nature like- it can be used as for food, feed and fodder, it grows within temperature range of 10-40^{0}C, the optimum temperature being around 30^{0}C, its yield is high compared to other cereals. Researchers through plant breeding have tried to improve the quality and characteristics of maize to suit the various consumers. The common cereals are mostly deficient in essential amino acids (lysine, tryptophan, etc.) and vitamin. CIMMYT has developed nutritionally improved maize which is rich in the aforesaid limiting amino acids along with a vitamin, niacin, and called it as quality protein maize (QPM). Due to the presence of the limiting amino acids and high

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biological value of QPM compared to other normal maize, the QPM accessions/cultivars can supplement dietary deficiency of the undernourished people of Bangladesh especially in *char* lands.

Any new technology or management practices or new developed ideas that are superior in performances but not yet in use among majority of the farmers can be considered as innovation. Mulching is such an innovation which regulates farm environment and thereby enhances crop production through regulating soil temperature (Khan, 2001), by reducing leaching and evapotranspiration (Liu *et al*., 2000), by increasing the content of soil organic matter (Roldan *et al*., 2003) and by reducing nutrient loss due to run off (Smart and Bradford, 1999).The efficacy of water hyacinth, and rice straw, mulches on QPM under the agro-climatic conditions of Bangladesh are also well documented (Rahman and Khan, 2002; Khan, 2001).

An addition to innovation or new technology being a superior on its merit itself, individuals' decision to adopt particular technology also requires a compatible of the innovation with various underlying factors such as technology specific factors, farmers (adopter) specific socio-economic factors, agro ecology specific factors, and broader institutional and public policy factors (Doss 2006; Langyintuo and Mekuria, 2005). Several of the past studies have illustrated that farmer wealth status, education, farm size, and frequency of contacts with extension staff are significant factors affecting the farmers' decision to adopt or not in a particular development (Doss, 2006; Feder *et al*., 1985). Some studies have also clearly demonstrated that the factors affecting adoption improved agricultural technology and management recommendations by poor farmers are not the same as for richer farmers to adopt, thus farmers' wealth level is a key aspect of the technology adoption process in the developing countries.

Farmers learn about new technologies from various organizations, programs, and projects dedicated to research, extension, or rural development. These organizations develop and promote new varieties, inputs, and management practices. It is essential that such organizations be able to follow the results of their efforts and understand how the technologies they promote fit into the complex pattern of agricultural change in which all farmers participate. To assess different aspect of adoption a follow-up on acceptability with farmers who have participated in experiments (individual or group interviews) usually 1-2 years after experimental program can be made with a sample size of 10-20 to see if farmers keep using technology and identify whether there are problems with its continued use(CIMMYT Economics Program, 1993).

Therefore, the objective of this study was to assess the socio economic factors influencing the adoption of QPM and organic mulch technology in the study areas with a view to assess the impact of the field experimental work previously done by the authors, in the same study areas on the performance of quality protein maize under conservation tillage and indigenous mulches in the year 2011-12 and 2012-13.

Materials and Methods

This study was conducted in three districts (Mymensingh, Tangail, and Jamalpur) of Bangladesh during 2013-2014. Six locations (previous field experimental sites) were selected for the detailed farm household survey. Primary data were collected at farm household level. Household level information was collected using one-to-one interview with structured questionnaires. Definition and measurement of key variable affecting farmers' decision to adopt particular QPM production using organic mulch technologies, as used in the adoption analyses in this paper, are in Table 1.

Table 1. Definition, measurement and statistics of selected variables

variables	Definition	Measure	Mean	St. Dev.
Dependent variables				
QPM grower	Farmers who were growing QPM	1=yes;0= no		
Organic mulch user	Farmers who were applying organic mulching to cover maize field	1=yes;0= no		
Explanatory variables				
Age of house hold head	Age of household head	year	48.53	11.854
Experience in agricultural farming	Time spent for agricultural farming	year	19.60	10.237
Year of schooling of household head	Time (year) spent for formal education	year	4.25	3.789
Household size	Number of family members in a household	Number	4.35	1.400
Farm size	Own cultivable land	Decimal	247.85	170.976
Contact with extension personnel	Whether farmers had contact with extension personnel	1=yes;0= no		
Training received on QPM	Whether farmers received training on QPM	1=yes;0= no		

Source: Authors' survey in 2013-2014. Total maize growers = 10 x 6 locations =60.

Descriptive statistics like- frequency, percentage, mean and standard deviationetc. were used for analyzing the socio-economic variables. Reasons for growing QPM/using organic mulches in the study area and the constraints associated with these technology were estimated as $\bar{R}$=Weighted rank value for each reason. The under lying principle is - Higher the rank value≈the more important the factor. The weighted average rank is formulated as $\bar{R} = \frac{\sum n*S}{N}$, where n is number of farmers responding to each category, N is total responded who adopted QPM and S is score, which is higher score is more important.

Dichotomous (binary) logistic regression model were used to achieve this objective which is to evaluate the factors influencing the adoption of QPM and organic mulch. Binary logistic regression is a type of regression model where the dependent variable is converted into dichotomous/binary variables coded 0 and 1. Particularly the value 1 was indicated as farmers adopting QPM production or organic mulch use technology, while 0 indicates farmers not adopting QPM production or organic mulch use technology. The model uses Maximum Likelihood Estimation (MLE) procedure. The advantage of this model is that the probabilities are bound

between 0 and 1. The adoption or non-adoption of QPM and organic mulches were addressed as a decision involving binary/dichotomous response variable. The socio-economic factors influencing farmer's adoption or non-adoption of QPM and organic mulches includes the following: Age of the household head; Number of years of experience in agricultural farming; Years of formal education of household head; House hold size; Farm size; Contact with extension personnel and lastly Training received on QPM.

The effect of a set of explanatory variables on adoption of QPM/organic mulches is specified using the following expression:

Adoption = f (X1 X2 X3 X4 …X 7)

Y= ß 0 + ß 1X1 + ß 2 X2 + ß 3 X3 +……ß7X7+ □□….. (1)

Where,

Y = A dichotomous response variable such that; Y= 1 If farmers adopt QPM/ mulch and 0 if farmers do not.

X1= Age of the household head (year)

X2 = Number of years of experience in farming

X3 = Years of formal education

X4 = Household size

X5 = Farm size

X6 = Visits by extension agents

X7 = Training on QPM

□□= Disturbance term or error term which normally indicated as zero mean and variance

ß1, ß 2 …ß 7 were the coefficients of the independent variables.

The coefficient of the regression model was estimated using a software; SPSS.

Results and Discussions

Socio-Economic Characteristics

Age:

Age is an important determinant of social – economic status of a population because age of farmers plays an important role in the crop production and better management of the farming activities. According to The World Bank (WBdata2014), total population between the ages 15 to 64 is the number of people

who could potentially be economically active. The economically active population of Bangladesh was 65.2% of the total population and that of 4.8% was 65 years and above. Farmers between the ages of 25-64 years old (93.3%) were involved in maize production in the study area. The average age of the respondents is approximately 48.5where the minimum age was 25 and maximum age was 70. Based on World Health Organization (WHO, 2014) average life expectancy chart 2013life expectancy at birth for Bangladesh was 71, it can be inferred that among the maize farmers in the study area 93.3 % were in economically active age and 100% of them are within the life expectancy period (Table 2).

Household size:

The result indicates that farmers have varying household size. About 63.3% of the respondents have household size ranging from 2-4 persons, while 35% have household size of 5-7 persons. The average household size is 4.35 with a standard deviation 1.40 which is almost equal to national rural household size of 4.36 (BBS, 2012).Like small farmers, large farmers also have small to medium family and medium farmers have small to large family. This indicates that there is no correlation between farm size and household size. This may be due to the success of birth control program in the country. Although large family size can sometimes be an asset to the farmers in terms of available work force/labour, often time a farmer is faced with the challenges of providing social and welfare facilities such as feeding, education, sheltering, health care and other living expenses for a large number of dependents. These expenses account for low saving at the end of every harvest season aside the fact that most farm produce are consumed by the large household members.

Literacy level:

Illiteracy is one of the factors militating against agricultural development in any developing country like Bangladesh. The study shows that 41.6% of the farmers had no formal education. This suggests extension workers should do more by sensitizing farmers on the importance of formal education. While about 58.4% farmers have one form of formal education or the other. Their educational status as it is however is enough to provide them with the ability to read and write, handle and interpret messages relating to their farm operation in the instruction manuals on input and machinery uses, and also enable them to appreciate extension services. Sullumbe, 2004 opined that Education is a major determinant of the Nation's economy. He further argues that the level of formal education attained by an individual goes a long way in shaping his personality, attitude to life and adoption of new and improved practice. Education has also been regarded as an investment in human capital, which is capable of raising the skill and quality of the man, narrow his information gaps and increase his locative efficiency thereby leading to more productive performance (Patel, 1985). Therefore, it can be said with certainly that introduction of new ideas and adoption of new innovations and technology in the study area will be easy. This will in turn increase yield, income and agricultural production in general.

Farming experience:

Farm experience is an important factor to ensure farm productivity. Farmers who have more experience in farm operations generally attain higher level of technical efficiency. Technical inefficiencies of the production of farmers are significantly related to farming experience of the farmers (Ajibefun *et al*. 2002). The average agricultural farming experiences of the respondents were 19.6 years with a standard deviation of 10.24. The minimum experience was 3 years and the maximum was 40 years. 75% of the respondent had

experience greater than 10 years. This means that most farmers in the study area have adequate farming experience. Since experience is gained with age and farming being the major occupation of most of the respondents, the number of years of experience in farming can be linked with the age of the farmer.

Farm size:

Land is the most important asset for the farmers because farm families depend mainly on land. In areas, such asrural area of Bangladesh, where farming activities dominate as an economic activity, those who have secure access to land have social, economic and political power. This can be highlighted in the following manner: *Control over land = money = economic empowerment = wealth = improved status = improved welfare of the family. Land is therefore power* (Duncan B. A. and Brants C., 2004). The average farm size of the study area was 247.85 decimal. The minimum farm size was 40 and maximum was 750 decimal. According to farm size farmers were categorized in to three groups i) small farmer (<1 ha) - 60%; ii) medium farmer (1-2 hectare) -25 % and iii) large farmer(>2 hectare)-15%.

Extension contact:

Extension personnel play an important role in technology transfer and better crop production. They can make a bridge between researchers and farmers for new technology. 86.7% of the respondents were in contact with extension personnel. Among the farm size groups, the extension contact of small farmer was found the highest (53.8%) and it was followed by medium (28.8%) and large (17.4%).

Training received on QPM:

Training is the most important tool for acquiring knowledge about any technology. It can increase farmers' skill regarding production practices and related aspects. Popularization of

QPM …. Project arranged training for farmers on production technology and uses of QPM. It was found that 48.3% of the respondent received training from QPM project or other sources.

Table 2: Socio-economic characteristics of the maize farmers

Variable	Description	Frequency	Percentage
Age group (year)	Young (20-35 years)	12	20.0
	Mid (36-50 years)	22	36.7
	Mature (51-64 years)	22	36.7
	Old (65 years and above)	4	6.7
	Total	60	100
Household size	Small family (2-4 members)	38	63.3
	Medium family (5-7 members)	21	35.0
	Large family (>7 members)	1	1.7
	Total	60	100.0
Literacy level	Illiterate	11	18.3
	Sign only	14	23.3
	primary	21	35.0
	Secondary	7	11.7
	SSC	4	6.7
	HSC	2	3.3
	Graduate/Post graduate	1	1.7
	Total	60	100.0
Farming experience (Year)	Up to 10 years	15	25.0
	11-20 years	18	30.0
	21-30 years	17	28.3
	>30 years	10	16.7
	Total	60	100
Farm size	Small	36	60.0
	Medium	15	25.0
	Large	9	15.0
	Total	60	100.0
Extension contact	Yes	52	86.7
	NO	8	13.3
	Total	60	100
Training received on QPM	Yes	29	48.3
	NO	31	51.7
	Total	60	100

Motivation of farmers cultivating QPM varieties and using organic mulches:

Farmers reported that maize farming is a profitable enterprise. Table3 shows that economic motives were the main drivers affecting the farmers' decision to grow QPM. Other reasons for growing QPM were satisfactory yield and suitable for food use.

Other reasons, such as nutritionally important, seeds of BARI hybrid maize 5 (QPM) is available at cheap rate, ensure food security and good fit with cropping pattern, were less important in influencing farmers' decision to grow QPM. Organic mulches have multidimensional good effect on soil, plant, micro environment and ultimately on crop production. Table 4 shows the reasons for using organic mulches by the farmers in the study area. The organic mulch user respondent rated "increases maize yield" as highest rank, then "retain soil moisture" and "control weed effectively" as second and third rank respectively as the factors that dominate their decisions of using organic mulch for maize production. The other less ranked issues were "add organic matter to soil", "retain soil fertility" and "water hyacinth is available at nearby pond, cannel or river".

Table 3: Reasons for growing QPM in the study area, 2013-14

Reason	Indicators			
	Weighted rank ($\bar{R}$)	Respondents (n)	% of response	Rank
Profitable than other crop	6.33	39	100	1
Yield is satisfactory	5.15	35	89.7	2
Suitable for food use	4.31	34	87.2	3
Nutritionally important	2.82	28	71.8	4
Seed is available at cheap rate	1.92	20	51.3	6
Ensure food security	1.95	19	48.7	5
Good fit with cropping pattern	0.41	10	25.6	7

Table 4: Reasons for using mulching in the study area, 2013-14

Reason	Indicators			
	Weighted rank ($\bar{R}$)	Respondents (n)	% of response	Rank
Increases maize yield	5.50	38	95	1
Retain soil moisture	4.63	37	92.5	2
Control weed effectively	3.95	38	95	3

Add organic matter to soil	2.63	37	92.5	4
Retain soil fertility	1.70	29	72.5	5
Water hyacinth is available at nearby pond, cannel or river	0.28	11	27.5	6

Factors influencing adoption of QPM and organic mulch technologies

The results of the Binary Logistic Regression model estimating factors influencing participation in QPM and organic mulch technology were presented in table5. For QPM grower the Hosmer and Lemeshow Goodness-of-Fit test was done. The value of the test statistic was 3.596 ≅ 3.60 and the p-value (given by SPSS) was 0.892 which was greater than 0.05. So, we did not reject the null hypothesis that there was no difference between the observed and predicted values, i.e. the model appeared to fit the data reasonably well. The accuracy of the prediction was 90% by this model; so, the model was good because, the higher the overall percentage of correct predictions the better the model. The Nagelkerke R^2= 0.675 which means that the model explained about 68% of the variation in the data. These results showed that the specified explanatory variables were able to explain participation in QPM production in the study area. In case of organic mulch user, the Hosmer and Lemeshow Goodness-of-Fit test was also done. The value of the test statistic was 10.92 and the p-value (given by SPSS) was 0.206 which was greater than 0.05, i.e. the model appeared to fit the data reasonably well. The accuracy of the prediction was about 82% by this model. The Nagelkerke R^2= 0.465 which means that the model explained about 47% of the variation in the data. These results showed that the specified explanatory variables were able to explain participation in organic mulch use in the study area.

With the exception of years of agricultural experience, all other variables in the model for QPM production had positive influences as anticipated. The decisions by households to participate in QPM production were significantly influenced by the following household socio-economic variables; years of schooling (X3) (P<0.089), extension contact (X6) (p<0.035) and training on QPM (X7) (p<0.078). On the contrary, Age, household size and farm size had no significant influence on participation in QPM production. In case of organic mulch use, years of agricultural experience had negative but significant influence(X2) (P<0.029),years of schooling, household size and training on QPMhad no significant influence. On the other hand, age (X1) (P<0.055), farm size (X5) (P<0.047) and extension contact (X6) (p<0.056) had positive influence.

The study reveals that the greater the experience in agricultural production, the lesser the probability of partaking in QPM production and organic mulch use. The practical effect may possibly be ascribed to the statement that experienced farmers may presume to be on familiar terms with non QPM or no mulch use as a preventative measure and as a result do not see the need to adopt QPM production or organic mulch use technologies. Similar findings were reported by many researchers that coefficient of years of experience was negatively and significantly influenced by farmers decision to adopt improved technology in different areas of the world (Abebaw and Abelay, 2001; Ebojei *et al*., 2012; Kuntariningsih and Mariyono, 2013 and Ugwuja*et al*. 2011).

Farm size had no significant relation with QPM production but it had positive and significant relation with organic mulch use technology, which indicates its positive influence on participation organic mulch use technology adoption. This may be because the farm size is a surrogate for a large number of factors such as size of wealth, access to credit, capacity to bear risk, access to information and other factors (Feder *et al*. 1985).

There is a high inclination for farmers who are educated to partake in hybrid maize production technologies compared to those that were illiterates. The odds ratio [Exp (B)] for this variable was 1.43 which implied that farmers who were educated are 1.4 times more liable to take part actively in QPM production technologies than those who were illiterates. This outcome was likely because those who can read and write are at a lead in perception and deduction of recommended packages. Therefore, the likelihood of participation in QPM production increases with increase in years of schooling, as risk aversion decreases. The study also suggests that QPM production was less labour intensive than organic mulch use. So, farmers having higher years of schooling influenced to adopt QPM than organic mulch use. Training on QPM had positive influence on QPM production which had no effect on organic mulch use. So, it could be concluded that arranging of special training along with method/ result demonstration on organic mulch use can be fruitful for its adoption by the farmers.

The results also suggested that participation in QPM production or organic mulch use could be motivated by frequent contacts with extension agents. Extension agents popularizes innovation by making farms exchange idea, experiences, and makes it cheaper to source information, knowledge and skills in order to enable farmers to improve their livelihood. Farmers who have frequent contacts with extension agents had a higher probability of participation in the innovation. This was presumed; as farmers were privileged with materials and managerial support, followed by cheap and timely availability of knowledge and skills, which apparently helped them, apply new technology.

The nature and command of age on farmer's contribution to new technology was indecisive. Younger farmers are likely to take up new technology than older farmers being that they are of higher schooling and have more contact to innovations. On the other hand, it may be that older farmers

may have extra resource that makes it more likely for them to try new technologies.

Table 5: Regression result of socio-economic factors that influence QPM and mulch adoption in the study area

	QPM variety		Organic mulching	
Explanatory variables	Coefficient	Exp(B)	Coefficient	Exp(B)
Constant	-9.06	.000 [n]	-9.984	.000 [b]
Age of the farmers	.32	1.377 [n]	.272	1.312 [c]
Years of agricultural experience	-.603	.547 [b]	-.405	.667 [b]
Years of schooling	.359	1.432 [c]	-.085	.919 [n]
House hold size	.231	1.260 [n]	.236	1.266 [n]
Farm size	.000	1.000 [n]	.009	1.009 [b]
Contact with extension personnel	4.71	111.271[b]	3.027	20.628 [c]
Training received on QPM	2.59	13.297 [c]	.424	1.528 [n]
-2 log likelihood		25.84		50.77
Accuracy of prediction (%)		90		81.8
Nagelkerke R square		0.765		0.465
Hosmer and Lemeshow test: χ^2		3.60[n]		10.92[n]

Note: [a]) significant at 0.01, [b]) significant at 0.05, [c]) significant at 0.1 [n]) insignificant

Constraints to QPM production

Table 6 explained some problems pointed out by the farmers that were affecting QPM production in the study area. These includes but not limited to inadequate fund, lack of good quality seed and its high price, high cost of fertilizer due to higher recommended dose, high cost of labor, insect infestation, damage by fox, birds and children, poor pricing of maize grain, lack of drying and storage facility, and insufficient rainfall during the rabi season. The result revealed that 100% of the farmers identified inadequate fund, seed quality and fertilizer cost as the main Constraints. Since most respondents are small scale farmers, they have low capital base and therefore cannot afford the high cost of inputs. Also, the stringent conditions and bureaucratic tendencies of formal credit agencies shy farmers away from obtaining loans to finance their farm operation. The 4th ranked constraint was high cost of labor. Although family

labor was used, but hired labor was mostly use. Scarcity is usually characterized by high cost of input variables of production; therefore the high cost of labor could imply unavailability of labor. Hence the amount charged per man-day was high. This explains the reason behind the high cost of labor. Another problem identified by maize farmers in the study area is insect infestation, especially cutworm. Successful required number of maize plant population establishment depends mostly on the effective control of cutworms in the study areas, especially in the Mymensingh and Tangail districts.

This is seen from the fact that about 90% of respondents acknowledge that their crops were damaged by fox, birds and children. Poor pricing of maize is not peculiar to maize alone and 85% of the farmers pointed poor pricing of maize grain as a constraint. The study area had a characteristic that there is scanty of rainfall during the crop growing season but at the time of harvest or later on the rain starts. As a result the farmers faced two problems; one is maintaining of required moisture in the crop field become troublesome due to the insufficient rainfall during the rabi season and the second one is drying and storing of maize grain by keeping seed moisture at optimum level become harder.

Table 6: Constraints to produce QPM in the study area, 2013-14.

Constraints	Indicators			
	Weighted rank ($\bar{R}$)	Respondents (n)	% of response	Rank
Inadequate fund	8.48	60	100	1
Lack of good quality seed and its high price	7.08	60	100	2
High cost of fertilizer due to higher recommended dose	6.95	60	100	3
High cost of labour	5.60	58	97	4
Insect infestation	4.82	53	88	5
Damage by fox, birds and children	3.73	54	90	6

Poor pricing of maize grain	3.27	51	85	7
Lack of drying and storage facility	1.82	47	78	8
Insufficient rainfall during the rabi season	1.45	45	75	9

Conclusions

The findings of this study suggests that except household size some of the six socio-economic variables; age, years of agricultural experience, years of schooling, farm size, training on QPM and extension visits influenced farmer's participation in QPM production and organic mulch use technology in the study area. It may be concluded that there is a scope to bring more area under quality protein maize cultivation. Furthermore, there is a need for special training, seminars, field demonstrations and technical support to increase the use of organic mulch in the maize fields. Steps should be taken to make the Fund available from Govt. and private sector by providing easy and accessible agricultural credit facility for maize farmers. High quality hybrid QPM seed availability and judicious use of fertilizer may boost up the QPM cultivation in char land areas.

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