American Journal of Agricultural Science Engineering and Technology

ISSN: 2158-8104 (Online), 2164-0920 (Print)

Volume: 3, Issue: 1

Published by: e-Palli,
Florida, USA

The ***American Journal of Agricultural Science, Engineering and Technology (AJASET)*** is blind peer reviewed international journal publishing articles that emphasize research, development and application within the fields of agricultural engineering, science and technology. The AJASET covers all areas of Agricultural Science, Engineering and Technology, publishing original research articles. The AJASET reviews article within approximately two weeks of submission and publishes accepted articles online immediately upon receiving the final versions.

Published Media : Online and Print

ISSN : 2158-8104 (Online), 2164-0920 (Print)

Frequency **:** 4 issues per year (*January, April, July, October*)

Area of publication **:** Agricultural Science, Engineering and Technology. The subjects covered by the journal includes but not limited to:

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Agricultural Statistics	Geophysics
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TECHNOLOGIES INTERVENTION TO REDUCE RICE POST HARVEST LOSES IN BANGLADESH

Mashrat Jahan[1*], Atiar Rohman Molla[2], Jaba Rani Sarker[3]

Abstract

The use of technologies in the reduction of post-harvest losses of rice at farm level is advocated in this paper. The research discusses the conditions under which producers can benefit (e.g, minimizing the losses, ensuring quality, reducing gender inequality, time & labor saving etc) from technological innovations and to identify the gaps and opportunities to address the post-harvest based technology needs in the improvement of post-harvest loses and reducing the drudgery. In post-harvest activities the quality of the harvested crop, the degree of losses incurred and the efficiency of the operations and hence, overall costs are affected by factors related to the respondent's age, education, family size, occupation, cropping area, institutional access to credit, the way of handling by male & female and the technology used. Purposive sampling technique was used to obtain data from 270 Bangladeshi Rice farmers. To estimate the casual impact of technology adoption propensity score matching methods and probit model is utilized to assess the results robustness that estimate the true welfare effect of technology adoption by controlling for the role on production and adoption decisions. Results show that adoption of improved technology gives higher returns to the farmers (5.62%) than the traditional farmers, though the former is more capital intensive than the latter. Quantity of operated area and access to credit are the two most important factors that contribute to adoption. With increasing Dependency Ratio and Cost of mechanical power, farmers tend to adopt less. The overall result from this paper generally confirms the potential direct role of Post-Harvest technology adoption on improving rural household welfare, as higher production tends to higher incomes.

Keyword: Rice; Technologies adoption; Postharvest loss and Probitmodel.

[1]Department of Agricultural Economics, Faculty of Agricultural Economics and Rural Development, Bangabandhu Sheikh MujiburRahman Agricultural University, Gazipur, Bangladesh..
Email: mjahan.aec@bsmrau.edu.bd; [2]Departments of Agricultural Economics, Faculty of Agricultural Economics and Rural Sociology, Bangladesh Agricultural University, Mymensingh, Bangladesh.
[3]Department of Agricultural Economics, Faculty of Agricultural Economics and Rural Development, BangabandhuSheikh MujiburRahman Agricultural University, Gazipur, Bangladesh.

*Corresponding author: Mashrat Jahan; email: mjahan.aec@bsmrau.edu.bd

Introduction

Agricultural products and commodities that produced on the farm levels have to undergo a series of operations such as harvesting, threshing, winnowing, drying, bagging, transportation, storage, processing, marketing and exchange before they reach the final consumer, and there are considerable losses in crop output at all these stages.

A recent estimate by the Bangladesh Agricultural Research Institute (BARI) showed that the total preventable post-harvest losses of food grains at 12-15 percent of the total production or about 4.15-5.19 million metric tons (MMt). In a country where 26 percent of the population is undernourished, post-harvest losses of 4-5 MMt annually is a substantial avoidable waste. According to a FAO and APO study (2006), post-harvest losses of food grains in Bangladesh are 15 percent of the total production. For the system as a whole, such losses have been worked out to be 5.19 MMt of food grains annually, which included 0.32 MMt of wheat and 4.87 MMt of rice. With an average per capita consumption of about 453 gm/day of food grains, these losses would be enough to feed about 31.72 million people, i.e. about 20 percent of the entire population of Bangladesh for about one year. Thus, the post-harvest losses have impact at both the micro and macro levels of the economy.

Introduction of modern and scientific power operated post-harvest equipment from harvesting to storage will minimize the enormous post-harvest losses and will ensure quality of the product. The technologies were also helping to create an opportunity for the rural people and to utilize their women recourses into diversified purposes during this stipulated working period. It also reduces women working period and increases the opportunities to involve themselves into other income generating activities. By using these technologies they also released fromheavy working pressure.

There are some studies previously undertaken about adoption of improved technologies in case of rice production or selection of crop. Rahman (2008) found that along with availability of irrigation facilities, several other factors like farmers' education, farming experience, farm asset ownership, infrastructure and non-agricultural income influence Bangladeshi farmers' choices about a crop. For promoting crop diversification, the literature argued for importance of investing in farmers' education and rural infrastructure development including irrigation. It also emphasized necessities of land reform policies and tenurial reforms. Mottaleb, Mohanty and Nelson (2014) found that in Bangladesh land characteristics, credit facilities and physical infrastructure (such as roads, irrigation facilities) and the availability of government-approved seed dealers, significantly influence the adoption of hybrid and modern rice varieties and land allocation to these varieties. Joshi and Pandy (2006) found that Nepali farmers' perceptions about varietal characteristics such as pest resistance, drought tolerance and suitability for making special products play a key role in explaining their adoption behaviour. They also found that the farm and farmer specific variables such as education, experience, and availability of extension services have significant effects on improved variety adoption. Results from other studies do not differ much from these but they use different farm-specific socio-economic and community level factors to explain differences in adoption under the same macroeconomic structure (Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Nkamleu and Adesina, 2000; Shiyani*et al.*, 2002).

Keeping inmind the scarcity of research on this area, this study aims to determine the factors that influence the improved technology adoption. Increased farm level adoptionwill increase farm production and hence profit. Ultimately farmers enjoy better incomeand livelihood status. At the macro level, the impact will be less post-harvest loss.

Therefore, the following objectives may arise.

1) To evaluate the post-harvest losses of farm productivity and
2) To identify the factors affecting the adoption of post-harvest technologies on technology receiver and technology non- receiver farmer's.

Hypothesis of the Study

In order to fulfill the research objectives of the study, the following null hypotheses would be tested.

a. There are no options and means for increasing farm productivity and also reducing losses; and,

b. There is no impact of post-harvest technologies on technology receiver and non-receiver farmers.

Methodology

The post-harvest technological impact were observed at farm level in Aman rice by using survey data, collected randomly from 270 rice growing households for the year 2013 covering five districts 1) Rangpur, 2) Nilphamari, 3) Khulna, 4) Jessore& 5) Satkhira. A participatory methodology was followed, to elicit information about post-harvest processes followed in the research locations. Two methods named Key Informants Interview (KII) and Focus Group Discussion (FGD) were followed for the survey of post-harvest technologies and constraints faced by women. There were two dimensions of data available for analysis: (i) farmer's who have received post-harvest related technologies, i.e., technology receiver and (ii) farmer's who didn't receive any post-harvest related technologies, i.e., technology non-receiver. Purposive sampling procedure was followedto select the respondents of the research locations.Sampling design and distribution of sampled respondents in the study sites are presented in the following Table.

Table1: Sampling frame of the study area

Region	Districts	Upazilla	Villages	Technology receiver		Technology Non receiver		Total
				Male	Female	Male	Female	
Rangpur	Nilphamari	Joldhaka	Uttar Beruband	8	7	8	7	30
		NilphamariSadar	Laxmichap	8	7	8	7	30
	Rangpur	RangpurSadar	Muktarpara	8	7	8	7	30
Khulna	Satkhira	Satkhirasadar	Perkukrali	8	7	8	7	30
	Khulna	Botiagattha	Titukhali	8	7	8	7	30
		Dhumaria	Baratia	8	7	8	7	30
Jessore	Jessore	Monirampur	Chandipur	8	7	8	7	30
		Bagherpara	Bakri	8	7	8	7	30
		Jessoresadar	Abdulpur	8	7	8	7	30
All				72	63	72	63	270

Analytical technique

Averages and percentages were used to compute the post-harvest losses. Information about post-harvest losses was obtained from the farmers during following operations: (i) harvesting, (ii) threshing, (iii) parboiling, (iv) drying and (v) storage.

Functional analysis was carried out to examine the factors affecting for the adoption of post-harvest technologies at farm level.

Post-harvest loss: Crop production undergoes a series of operations such as harvesting, threshing, drying, transportation, storage before reaching the consumer, and there are sizable losses in crop output at all these stages. The data collected from the farmers included general information about the cultivation of food crops, methods of harvesting, threshing, parboiling, drying and storage system and losses during post-harvest operations.

Post-harvest loss is the loss of dry matter during post-harvest operations. The post-harvest loss for any operation computed as:

$$\text{Post harvest loss} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}}$$

Propensity score matching (PSM) methods: The propensity score matching method is one of the non-parametric estimation techniques helps in comparing the observed outcomes of technology adopters with the outcomes of counterfactual non-adopters (Heckman *et al*., 1998). The following function was specified in the present study:

$$\tau=E[E(Y1i/Gi=1,P(X))-E(Y2i/Gi=0,P(X))]$$

Here,$G_i$denotes a dummy variable such that$G_i=1$ if the *i*th individual adopt improved technology and $G_i=0$ otherwise. Similarly let Y_{1i} *and* Y_{2i} denote potential observed welfare outcomes for adopter and non-adopter units respectively.

The propensity score is a continuous variable and there is no way to get adopter with the same score as its counterfactual(s). Thus, estimation of the propensity score is not sufficient to compute the average treatment effect given by equation. We need to search for counterfactual(s) that matches with each adopter depending on its propensity score. We use the nearest-neighbor matching method to pick comparison groups. This method could use a single nearest-neighbor or multiple nearest-neighbors with the closest propensity score to the corresponding adopter unit. The method could also be applied with or without replacement where the former allows a given non-adopter to match with more than one adopter (Becker and Ichino, 2002; Dehejia and Wahba, 2002). To check the robustness of our result, the impact estimate calculated using the nearest neighbor matching method is compared to the estimates of Kernel matching method. The observed outcome variables, used as a proxy for the welfare of smallholder farmers, in this paper, are crop income and household consumption expenditure per adult equivalent.

Probitregression model: The probit regression model can be used to compare the expected rice production of the farm households that adopted (a) with respect to the farm households that did not adopt (b), and to investigate the expected rice production in the counterfactual hypothetical cases (c) that the adopted farm households did not adopt, and (d) that the non-adopters farm households adopted. The conditional expectations for the outcome variables in the four cases are presented in the following table and defined as follows.

Table 2:Conditional expectations, treatment and heterogeneity effects

Sub-samples	Decisions stage		Treatment Effect
	To adopt	Not to adopt	
Log net production			
Farm households who adopted	(a)E(Y_{1i}/G_i=1)	(c)E(Y_{2i}/G_i=1)	TT
Farm households who did not adopted	(d)E(Y_{1i}/G_i=0)	(b)E(Y_{1i}/G_i=0)	TU
Heterogeneity effects	BH1	BH2	TH

Notes: (a) and (b) represent observed expected rice production; (c) and (d) represent counterfactual expected rice production.

Where,

Ai = 1 if farm households adopted improved agricultural technologies: Ai = 0 if farm households did not adopt:

Y1i = rice production if the farm households adopted

Y2i = rice production if the farm households did not adopt

TT = the effect of the treatment (i.e. improved technologies) on the treated (i.e., farm households that adopted);

TU = the effect of the treatment (i.e. improved technologies) on the untreated (i.e., farm households that did not
adopt);

BH = the effect of base heterogeneity for farm households that adopted (i = 1), and did not adopt (i = 2);

TH = (TT-TU), i.e., transitional heterogeneity

Results and discussion

In Bangladesh rice post-harvest losses are a function of complex interactions between men and women farmers on one side and the technologies they employ, on the other. In this regard, it may be concluded that the only missing link in rice post–harvest loss reduction in all phases in Bangladesh is the availability and non-accessibility of appropriate technologies. The post-harvest losses of different food items especially rice, is a great concern to us as rice is our main food. Post-harvest losses due to inadequate facilities of harvesting to storage must be given due importance to ensure the highest production for our growing population both at macro and micro levels.

Post-harvest loss

Table 3shows post-harvest losses at different regions occurred at Aman season. The results shows that at Jessore& Khulna loss incurred by technology user are lower than the non-user which mean technology have a positive impact on reducing post-harvest losses. But the picture at Rangpur shows different. Here technology user losses more than non-user. So it can be concluded that technology failed to provide positive impact at Rangpur as the farmers of Rangpur adopt technologies only at the time of storage. The outcome of the research study shows that the highest loss occurred during harvesting among all post-harvest handling, which is highest at Rangpur (4.29%), followed by Khulna (2.63%) and Jessore (2.37%). At the time of manual harvesting rice grain losses is higher because of shedding of grains. Only technology can be a great solution to this problem.

Technology like riper is the first choice for the smallholders in the study areas for its easily handling, & less time consuming to harvest characteristics. If more training or demonstration on different harvester can be placed, females along with males will feel interest to apply it.

Table 3: Amount loss of different PH activities

	Post harvest loss in kg per ha of Aman rice								
	Jesssore			Khulna			Rangpur		
Activities	**Technology receiver**	**Technology non receiver**	**All**	**Technology receiver**	**Technology non receiver**	**All**	**Technology receiver**	**Technology non receiver**	**All**
Harvesting	17.90 (2.05)	23.37 (2.69)	20.64 (2.37)	18.73 (2.38)	28.71 (2.89)	23.72 (2.63)	85.02 (4.18)	38.61 (4.40)	61.82 (4.29)
Threshing	5.22 (0.98)	8.10 (1.01)	6.66 (0.99)	9.94 (1.29)	7.92 (1.15)	8.93 (1.22)	58.36 (2.68)	28.06 (3.33)	43.21 (3.00)
Parboiling	2.92 (1.09)	3.33 (1.15)	3.12 (1.12)	4.48 (2.12)	1.44 (0.94)	2.96 (1.55)	3.37 (1.91)	1.63 (2.19)	2.50 (2.05)
Drying	5.36 (1.68)	5.68 (1.69)	5.52 (1.69)	8.11 (1.56)	6.87 (1.76)	7.49 (1.66)	105.62 (4.85)	41.39 (4.69)	73.50 (4.77)
Storage	8.44 (4.44)	8.39 (4.97)	8.42 (4.71)	12.22 (6.29)	16.05 (6.76)	14.13 (6.53)	49.02 (8.18)	20.82 (8.76)	34.92 (8.47)
All	39.84 (10.24)	48.87 (11.51)	44.35 (10.88)	53.48 (13.66)	60.99 (13.49)	57.23 (13.60)	301.39 (21.80)	130.51 (23.36)	215.95 (22.58)

Source: Field survey 2013

Note: Figure in the parenthesis indicate percentage of loss

But threshing at Rangpur where manual threshing is still practicing, losses are higher (3.00%) then the south region, because of no repeat threshing was done at the time of hand threshing there were a lot of wastage. There is an observation that some grains were lost during lifting and beating the panicles on the wooden bench or on some hard piece of wood. Some grains were eaten by birds and domestic fowls.

Parboiling loss is as usual at a minimum level. Drying loss is acute at Rangpur as compare to Jessore& Khulna. It is a very serious problem in the northern region of the country where the wet period is longer. Large quantities are further spoiled by fungal attack because immediately after parboiling because of unfavorable weather farmers keeps worried about proper drying, as irregular sun rising can creates full wastage of rice grain which in turn has no use to them.

According to the previous studies highest PH loss occurred at the time of storage but this study revealed only 19.15 kg (6.57%) storage loss among all the PH activities, as because of lots of PH training and technologies based on how to store rice seed & grain is provided to the farmers efficiently by extension agents. Rice post-harvest loss at Rangpur (215.95 kg/ha) is much higher than Jessore (44.35 kg/ha) indicating that loss reduction situation is improving at south region because of the awareness of the farmers about PH loss and because of being backward region north lag behind in reducing losses. So the situation is improving and to get ultimate results more effort should be given now to the mechanized harvesting and drying to reduce PH losses.

Comparison of PH technology adopter & non adopter

The research study dataset contains 270 farm households and of these, about 74% are adopters i.e. used at least one of the improved post-harvest technologies. Table 4 presents the t-test and chi-square comparison of means of selected variables by adoption status for the surveyed households. The analysis shows average age of sample household head is about 45.5 years and the difference is statistically significant. 5% household of adaptor and 1% from non-adaptor categories are female headed.

No significant difference is observed in the gender & education of the household head and also in the family size which suggests these variables might be uncorrelated with decision to adopt. The average DR is 16% having significances to adopt technologies. The adapter groups are also significantly distinguishable in terms of having earning member & average annual income. There are not so significant differences on the occupation of household head. The operated area significantly affects between adopters and non-adopters. The labor force distinguish by gender have no significant effect on the decision of adopting improve PH technologies. There are significant effects on the Cost of mechanical power expressing the tendency of adopters to expend more money on technologies than that of non-adopters. Access to credit and extension services have no significant effect on the decision of adopting technology but PH training to the household given has significances which is higher among adopter categories.

In the subsequent part at Table 7, a rigorous analytical model is estimated to verify whether these differences in mean net production per household equivalent remain unchanged after controlling for all confounding factors. To measure the impact of adoption, it is necessary to take into account the fact that individuals who adopt improved PH technologies might have achieved a higher level of rice production, even if they had not adopted.

Table 4: Descriptive summary of variables used in estimations

Variables	PH improved technology Adopters (n=199)	Non-adopters (n=71)	t-statistic (chi-square)
Dependent variable			
Net production in kg	3823	3428	-1.65*
Household characteristics variables			
Age of household head (years)	48	43	-2.48***
Sex of household head (1 = female)	0.05	0.01	1.43ns
Education of household head (years)	5.45	5.89	0.65ns
Family size (numbers)	4.64	4.59	-0.24ns
Dependency ratio (%)	12.61	19.35	3.37***
Household wealth variables and farm characteristics			
Earning members (person/household)	1.76	1.51	-2.06**
Annual income (Tk)	125,607	100,755	-2.06**
Occupation of household head (1 = agriculture)	0.95	0.90	2.07ns
Operated area (ha)	0.25	0.54	6.13***
Number of total male labor used (man-days)	32.73	29.99	-1.50 ns
Number of total female labor used (man-days)	65.16	59.66	-1.52ns
Cost of mechanical power (Tk)	6867	823	-5.06***
Institutional and access related variables			
Credit received (1=yes)	0.49	0.39	1.82ns
Training received (1 = yes)	0.55	0.38	5.87***
Extension services (1=yes)	0.50	0.55	0.56ns

Source: Authors calculation, 2013,Note: Statistical significance at the 99% (***), 95% (**) and 90% (*) confidence levels and, ns= not significant. T-test and chi-square are used for continuous and categorical variables,respectively.

Impact of Using Technology on households

The goal of evaluating the impact of the PH technology adoption is to measure differences in outcomes between the technology user and their counterfactual, a proxy for what outcomes would have been for this group had they not used the technology. The research study considers the effect of the PH technology adoption on the rice production of the sample farmers. The net production of rice is an important indicator of livelihood of being benefitted. The variables like income, occupation, operated area reduces the risks of vulnerability of households to disruptions in solvency because these variables are the part/ way of earning.

Table 5: Average marginal effects and odds ratio of probit regression

Variables	Marginal effects of Coefficient
Household characteristics variables	
Age of household head (years)	0.003^{***}
Sex of household head (1 =female)	0.220^{ns}
Education of household head (years)	0.003^{*}
Family size (numbers)	-0.010^{ns}
Dependency ratio (%)	-0.003^{**}
Household wealth variables and farm characteristics	
Earning members (person/household)	0.040^{ns}
Annual income (Tk)	0.001^{***}
Occupation of household head (1 = agriculture)	0.130^{*}
Operated area (ha)	0.200^{***}
Number of total male lab (man-days)	-0.040^{ns}
Number of total female lab (man-days)	0.020^{ns}
Cost of mechanical power (Tk)	-0.001^{***}
Institutional and access related variables	
Credit received (1=yes)	0.100^{**}
Training received (1=yes)	0.100^{**}
Extension services (1=yes)	0.010^{ns}
Constant	-3.50^{***}
Number of observations	270
LR Chi-squared	165.5^{***}
Pseudo Rsquared	0.530
Log likelihood	-72.810

Authors calculation, 2013

Lack of production is therefore both a cause and a consequence of occurring loss. The impact results suggest that adopting technology played a positive role of increasing rice production. Thus these findings lead to the rejection of hypothesis (b) which was stated as there is no impact of post-harvest technologies on beneficiaries and non-beneficiaries farmers. The table 5 shows the marginal effects and odds ratio of different variables. The age of household head is 0.3% more likely to adopt PH technologies than others. The DR and Cost of mechanical power of each of the family is 0.3% and 0.1% less likely to adopt PH technology. Annual Income, occupation of HH head and operated area is 0.1%, 13% & 20% respectively more likely to adopt technology.

The households are 10% more likely to have the interest to adopt new PH technologies in terms of access to credit and training exposure. The other particulars are not so significant to interpret.The average of predicted probabilities for adoption of PH technology is about 73% which is similar to the actual frequency for adoption of PH technology. The probit models correctly predict 90% of the values and the rest are misclassified.

Results of adopting improved post-harvest technologies

Once each treated household is matched with a control household, the difference between the outcome of the treated household and the outcome of the control household is calculated. The average effect of treatment on the treated (ATT) is then obtained by averaging these differences.

The impacts of the improved rice based post-harvest technologies are shown at the Table 6. The improved PH technology as a whole has a positive impact on the average rice production of the farmers. This positive impact means that those using improved PH technology produce rice, on an average, 5.62 per cent more than those who did not leading to the rejection of hypothesis (a) which was stated as there are no options and means for increasing farm productivity and also reducing losses.

Table 6: Propensity score matching (PSM) for technology adoption using nearest Neighbor matching method

Used of improved PH technology effects	Amount (kg)
Mean net production of matched treated	3822.93
Mean net production of matched controlled	3416.02
Impact of PH improved technology	406.91 (5.62%)
t-value	1.64
p-value	0.10

Source: Authors calculation, 2013

Note: *Total number of observations is 270; Beneficiaries and non-beneficiaries are 135 and 135, respectively. Matched treated and controls are 199 and 22, respectively.*

The impact of technology on production is very low as the farmers used technology only at the stage of threshing & storage. Although technology at all the stage of PH activities altogether can show higher production or better results, this study is limited in this fact.

Table 7 presents the treatment effects of adoption of improved rice based PH technologies. The result from the regression indicates that the mean value of net production equivalent of improved PH technology adoption is statistically higher than had they not been adopted. This is consistent with the result from propensity score matching.

Table 7: Average expected net production of Aman rice equivalent for post-harvest technology adopters and non-adopters in Bangladesh

Sub-samples	Decisions stage		Treatment Effect
	To adopt	Not to adopt	
Log net production			
Farm households who adopted	8.14	0.00	8.14
Farm households who did not adopted	8.12	8.04	-0.08
Heterogeneity effects	0.02	-8.04	8.22

Source: Authors calculation, 2013

Improved PH technology adoption increases the rice production by 814%. For non-adopters the mean net production of rice would have been increased by 8% had they adopted improved rice based PH technologies.

These results imply that adoption of improved PH technologies increased household welfare measured in terms of rice production; however, the transitional heterogeneity effect is positive 822% that is the effect is bigger for the farm household that did adopt with respect to those that did not adopt.

Conclusion

The study was aimed to identify the factors that affected adoption of improved technologies with a view to suggesting policies for reducing post harvest losses of rice in Bangladesh through enhancing farm level adoption of improved technologies. The north region, because of its draught nature incurs more losses (215.95 kg/ha) than south (50.8 kg/ha). According to the previous studies highest PH loss occurred at the time of storage but this study revealed only 19.15 kg (6.57%) storage loss per ha among all the PH activities, as because of lots of PH training and technologies based on how to store rice seed & grain is provided to the farmers efficiently by extension agents which in turn increases the seed Germination Rate by 92.67%. Educated and aged household head have the propensity of adopting improve technology as Because the older person realize the theme of heavy manual work pressure to their health than the younger and as working stress reduces only by using technology. Household size and dependency ratio has lowered the intensity to adopt technology because of their high family expenses. A unit increase in operated area will increase the possibility of adopting technology. As because of having large farm with large production; farmers try to find out a way to finish all the PH activities as soon as possible to reduce labor cost and also to avoid unexpected weather adversity, technologies is mostly expected by the large farmers followed by the medium and small farmers whereas a unit increase in the cost of mechanical power will lead to the reduction of adopting technology. Access to credit and training has a significant impact on adoption rate. Since farmers with access to credit are more capable in accumulating capital than their counterparts who do not have access, these farmers adopt more. The causal impact estimation of probit model suggests that improve technology adopters have significantly higher crop production than non-adopters by 5.62% even after controlling for all confounding factors. The results from this paper generally confirms the potential direct role of agricultural technology adoption on improving rural household welfare, as higher production tends to higher incomes from improved technology.

Since agricultural income is the main source to feed rural households, mechanism should be strength to increase the productivity through providing chronically insolvent farmers with modern PH technologies on subsidy base until they recover and finally, more intensive researches on the area should be undertaken specially in the areas of PH loss reduction, gender issues, improved PH technologies and similar issues that contributes for the rice productivity.

Acknowledgements

This research work provides authors numerous benefits and outstanding experience. It helps authors to bridge the gap between theoretical knowledge gained during Master's Program and practical environment of Agri-economics. The authors extend their whole hearted thanks to the Faculty of Agricultural Economics and Rural Sociology of Bangladesh Agricultural University for providing some facilities to do this research work.

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