

Adoption of hybrid rice cultivation: A case study of Joypurhat district, Bangladesh

Mamun Ahmed & S M Atiar Rahman

Abstract

This study aims to determine the factors of adopting hybrid rice cultivation in Bangladesh using Probit model. It is conducted through collecting data from the primary sources following random sampling technique. To identify the determinants hybrid rice adoption by applying Probit model, the proportion of hybrid rice area under all rice varieties is used as dependent variable, whereas some specific variables which may affect the hybrid rice cultivation are used as independent variables. The result of Probit model shows that age, education, agricultural extension department, BADC, NGO, and company are positively significant factors in encouraging hybrid rice adoption. In the opposite, farm size and the source of information are significant but negatively related to adoption of hybrid rice cultivation in Bangladesh. This study may provide great insights to the policy makers and agro-researchers to take the right initiatives for expanding hybrid rice cultivation, thus, contributing effectively to achieve the targets of sustainable development goals - like making hunger free country.



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1. Introduction

Though Bangladesh is considered as a mono-crop rice cultivated country, the hybrid rice cultivation is a technology that is practically a new to this areas people. Hybrid rice research started in 1996 in the public sector. Bangladesh Rice Research Institute (BRRI) initiated research on the hybrid rice in Bangladesh with the technical support of International Rice Research Institute (IRRI). Afterwards research work is burgeoning with the development of hybrid rice. BRRI has developed four varieties of hybrid rice from 2001 to 2010, out of which three hybrids are grown for Boro season and one for Aman season. In 1998, the private sector officially released and informed 4 exotic hybrid rice varieties for commercial cultivation in the boro season of 1999-2000. Meanwhile, farmers faced local seed crisis in 1998 because of flood. So, the government had given the permission to four private companies to import hybrid rice seed from China and India. The National Seed Board in its 40th meeting held on 9th September, 2009, evaluated the trial performances of hybrid rice and for the first time temporarily approved four exotic rice hybrids and allowed four private sector companies to import and marketing of 2200 tons of F1 hybrid seeds for commercial cultivation in Bangladesh (Table:1.1). In this way, GOB permitted the sale of four rice hybrids: Alok 6201, Sonar Bangla-1, Loknath 503 and Amarsree-1 during 1998-99 in boro season on the basis of the recommendation of the National Seed Board (NSB). And four seed companies Mallika Seed Company, Advance Chemical Industries, Ganges Development Corporation and MacDonald Bangladesh Private Ltd were allowed to import 2200 metric tons of hybrid rice seed from china and India. They imported four species of hybrid seeds, one from China and other three from India and sold them for 1998-99 Boro season. But only the China variety gave good harvest. The following years it was seen that the imported hybrid seed from India could not suit in our weather. As a result, seeds importer tended to import seeds from china. By 2014, the National Seed Board (NSB) had released and listed 117 different hybrid rice species for commercial cultivation in Bangladesh. Among them, BRRI produced four hybrids and private seed company released six hybrids. The rest of 107 hybrid varieties are exotic hybrid introduced from abroad. Eight rice hybrids are developed in Bangladesh of which four hybrids were developed by BRRI, two of them were developed by BRAC and two of them were developed by a private seed company. Most of these hybrids are sticky rice with amylase content less than 25 percent and most are also bold grain hybrids. The demand of hybrid cultivation among the farmers increases day by day for its high yielding capacity. For the boro season in 2012-13, the government has permitted 34 companies to import 7070 metric ton hybrid seed commercially (Source: seed wing, Ministry of Agriculture).

Table 1.1: First imported of hybrid rice seeds in Bangladesh (During 1998-99 in boro season)

Name of Company	Name of Hybrid Rice Variety	Name of Importing Country	Seed Companies/agencies in Bangladesh	Amount Imported
Advance Chemical Industries(ACI)	Alok-6201	India	BRAC	800 metric tonnes
Mac Donald Private Limited	Loknath-503	India	Kushtia Seed Company	100 metric tonnes
Ganges Development Corporation	Amorosri-1	India	Kushtia Seed Company	500 metric tonnes
Mollika Seed Company	Sonar Bangla-1 (C.N.G.C-1)	China	Mollika Seed Company	800 metric tonnes

Source: Seed wing, Ministry of Agriculture

To meet the seed demand from the farmers, BRAC also applied to the government for permission to import hybrid seeds in 2000 from China. To adjust the increased people's food demand government gave permission to produce and distribute hybrid seeds in our country. BRAC is the first institution that produced 26 metric ton F1 seed and distributed for 2001-02 Boro season. Following years, besides BRAC some others private companies contributed to produce, import, and distribute hybrid seeds in our country. Earlier, 150 tons of hybrid rice seed were imported which has increased to 8000 tones including local production and imported hybrid seed at present of 8000 tones, local production accounts for 7400 tones and import 600 tones. The import and local production of hybrid rice seed are presented in table-1.2. Here it is mentionable that local production is gradually increasing and imported amount is decreasing. The objective of the study is to examine the determinants of hybrid rice adoption in Bangladesh through collecting data from the field level farmers.

Table 1.2: Year-wise quantity of hybrid rice seeds import and local production in Bangladesh

Year	Hybrid rice seed imported and local production				
	Import (MT)	Local production(MT)	Total (MT)	% Import	% local production
2000-2001	406.25	27.00	433.25	94	6
2001-2002	244.33	106.00	350.33	70	30
2002-2003	458.42	262.89	721.31	64	36
2003-2004	674.42	212.40	886.82	76	24
2004-2005	797.83	490.80	1288.63	62	38
2005-2006	1489.05	681.14	2170.19	69	31
2006-2007	5336.18	2171.29	7507.47	71	29
2007-2008	7848.00	2500.00	10348.00	76	24
2008-2009	8148.00	2800.00	10948.00	74	26
2009-2010	3472.00	3200.00	6672.00	52	48
2010-2011	4000.00	3600.00	7600.00	53	47
2011-2012	3400.00	4800.00	8200.00	42	59
2012-2013	3500.00	6500.00	10000.00	35	65
2013-2014	600.00	7400.00	8000.00	7.5	92.5

Source: Seed Wing, Ministry of Agriculture.

2. Literature review:

At the initial stage, any technology can be perceived difficult. In addition, people become hesitant to receive new things spontaneously due to their previous thinking. In this context, if the technology is considered as helpful, people may accept it after some experiment. Similarly, hybrid rice is a newly introduced crop in Bangladesh and its seed production technique is also found complex. Therefore, whether people of country is adopting this new hybrid rice or not is a major concern for researchers and policy makers.

Adoption takes time, depending on the nature of the innovation, the farmer's level of comprehension, and the delivery system's competence. Between the development of any technology and its adoption, there is a time lag. The study of adoption behavior of the technology is expected to supply crucial information on the patterns of adoption and identifies who is by-passed by the innovation. Understanding who non-adopters are and reason for non-adoption can assist in repackaging the technology to meet the need of the producers as well as put in place other key services that would enable them to adopt. Rogers (1962) described adoption as the mental process that a person goes through from learning about an innovation to adopting it. Adoption is the decision to employ an innovation to its full potential as the optimal course of action (Rogers, 1983). According to Feder *et al*, (1985),

adoption of technological breakthroughs in agriculture has piqued the interest of development economists, and a clear quantitative definition is required for rigorous theoretical and empirical study. Adoption is influenced by a number of elements, according to empirical investigations (Rutton, 1977; Cimmyt, 1993). They are characterized as socioeconomic, cultural, personal, and situational elements by Lionberger (1968) and Maundu (1981). Farmers' demographic traits have an impact on the adoption of technology created by researchers (Basu, 1969; Aao, 1971; Nijindad and Njoki, 1985). According to Spielman et al. (2013), hybrid rice uptake in India is influenced by a number of factors. Farmers have been hesitant to embrace hybrids due to information gaps and ambiguity that limit their comprehension of varietal options, as well as concerns about low yields, poor seed quality, poorer profitability, and vulnerability to pests, diseases, and weeds. According to the survey done by Spielman et al (2013), the majority of hybrid rice adopters are relatively rich. According to their survey, over 75% of hybrid rice adopters have income above the poverty level, and more than half have per capita incomes in the upper middle or upper income quintiles. As family income rises, the percentage of households who consume hybrid rice rises as well. This association could simply reflect the fact that hybrid adoption raises earnings; wealth or income conditioning hybrid adoption has good theoretical underpinnings. Harun et al, (2011) noted that large scale adoption of hybrid rice has been hampered since 1998-99 by several constraints including unattractive physicochemical characteristics of the available hybrids, negative positions by some public sector agricultural extension workers, researchers and to some extent policy makers along with problems of seed quality, high seed cost, inconsistent yield performance, low grain quality, low grain price, less attention for adoption of hybrid rice and sometimes negative propaganda about hybrid rice and insufficient support from government. Even so, the adoption of hybrid rice along with the establishment of hybrid rice seed production in the country within a decade is very much encouraging. It was possible to achieve due to involvement of both the private sector and public sector, with active participation of motivated farmers.

In general, hybrid rice yields are 15–20 percent higher than conventionally developed kinds (Mottaleb et al, 2015). The findings of their study show that general land features, loan facilities, and general infrastructure, such as roads, irrigation, and the availability of government-approved seed merchants, all have a substantial impact on hybrid adoption. However, high cost of hybrid seed and inferior grain quality may work as great challenge to adopt hybrid rice (Abebrese et.al. 2019). Hybrid rice outperformed inbred rice in terms of higher yields, shorter plant life, more competitive harvesting, lower respiratory intensity, and higher assimilation translation, according to Hadi et al (2018). They found farmers perception about hybrid rice varieties and input price have significant impact on hybrid rice adoption. (Azad & Rahman, 2017) revealed that gross return per unit of land influences the producer's decision to grow hybrid rice, but that increases in relative labor and phosphate fertilizer prices had a negative impact. Pesticide and organic manure users are far more likely to adopt hybrid rice. Significant variables of hybrid rice productivity are land, irrigation, and mechanical power. A study conducted by (Shah et al 2016) confirmed that the information channel of hybrid rice were TV, dealer, neighboring farmers, and Agriculture extension office Their results suggest that farm size, promotional efforts available, perception of risk in hybrid rice cultivation, and attitude toward hybrid rice were all significant predictors of farmers' innovativeness.

Chester Ittner Bliss first proposed Probit analysis in Science in 1934. He worked as an entomologist for the Connecticut Agricultural Experiment Station, and his main focus was on developing an efficient insecticide to control insects that ate grape leaves (Greenberg 1980).

By charting the insects' responses to various pesticide concentrations, he was able to show that each pesticide had a different effect on the insects at varying doses, indicating that one was more successful than the other. However, he lacked a statistically solid way for comparing this disparity. Fitting a regression of the response versus concentration or dose and comparing the different pesticides would be the most reasonable method. However, the response to dosage relationship was sigmoid, and regression was only employed on linear data at the time. As a result, Bliss devised the method of converting the sigmoid dose-response curve to a straight line. Bliss' idea was taken up by David Finney, a professor of statistics at the University of Edinburgh, who authored a book called Probit Analysis in 1952. (Finny 1952). Probit analysis is still the most popular statistical tool for analyzing dose-response correlations today.

3. Research methodology:

To conduct the study, inductive research approach is taken with philosophical underpinning of positivism. Quantitative research method is applied in this study. For this primary as well as secondary data are used. Cross sectional primary data is collected from structural questionnaire survey in Joypurhat district of Bangladesh during 2019. The study applies random sampling techniques to collect the data from household level. Eight villages from Joypurhat district of Bangladesh have been randomly selected to collect the data. From each village 30 farm households are selected following random sampling method. So the sample size of this study is 240 farm sample households. Here three seasons are considered that include Kharip-1, Kharip-2, and Boro. In addition, the study emphasizes on getting information of hybrid rice cultivation along with HYV and Aman. The respondents are interviewed with a set of structured questionnaire covering age, education status, occupation, land use pattern, farm size, cropping pattern, about crops and its disease, knowledge of new agro-technology and so on related issues. The collected data are coded, edited, validated and analyzed using the SPSS program and econometric analysis i.e., probit model is used.

3.1 Econometric Methodology:

Several methods are used in the research of crop adoption. Two econometric models that usually use discrete choice variables are: the probit model and logit model. The functional link between the probability of adoption and the explanatory factors is specified by the probit and logit models (Feder et al, 1985). The logit model is based on cumulative or logistic distribution, whereas the probit model is based on conventional normal distribution. Probit and logit models may produce identical outcomes, according to Amemiya (1981). This study, however, employed the probit model to evaluate the variables of hybrid rice adoption because it is based on normal distribution. Probit model is good model for estimating ordinal number in that the responses cannot count as values and is frequently found in sociological surveys (Poirier, 1978; Winship, Mare, 1984). Probit analysis is a sort of regression that is used to examine binary response variables. It converts the sigmoid dose-response curve into a straight line that may be evaluated using regression using either the least squares or maximum likelihood approaches. One of three strategies can be used to do a probit analysis:

1. Estimating the probit using tables and fitting the relationship by sight
2. Compute the probit, regression coefficient, and confidence intervals by hand.
3. Using a statistical tool like SPSS to perform everything for you.

The answers analyze qualitative responses from different types of choices, which consists binary response and multivariate response. Random effects are consistent for the probit model, and the estimation for pooled data is consistent (Maddala, 1987). The probability of probit model remains in (0, 1) interval. A maximum likelihood method is used as the better

estimation (Winship; Mare 1984). Probit model analyzes variables that influence farmers for adoption in hybrid rice. The equation of Probit model is expressed as follows;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n$$

Where, Y= Dependent Variable whose value lies between 0 to 1

β_0 =Constant

$\beta_i \dots n$ = Coefficient of variables, $i=1 \dots n$

$X_i \dots n$ =Independent variables, $i=1 \dots n$

X_i is a vector of variables that capture farm and household characteristics, β is a vector of unknown coefficients, and ε is an error component that is supposed to be independently distributed with a mean of zero and a constant variance. The coefficients β represent each exogenous variable's marginal effect on adoption intensity.

3.2 Estimation of the Model:

For the analysis of probit model, dependent and independent variables are considered according to survey. The variables are age, education; farm size, agricultural extension department, BADC, NGO, Company, and source of agri-information. Measurements of variables are explained as follows:

Dependent variable:

In estimating the hybrid rice adoption behavior using the Probit model, here, Y indicates the dependent variable and Y_i is the proportion of hybrid rice area under all rice varieties and its value lies between 0 and 1.

Independent variables:

Age (X1) : Age of the farmers, measured in years.

Education (X2) : Farmers education levels are presented in different stages

Farm Size (X3) : Farm size represented by different types of farmer such as marginal, small, medium and large farmer and land measured in hectare.

Source of seeds : Source of seeds is divided into four parameters which are included in the probit model;

Agricultural Extension Department (X4) : How much hybrid seeds are provided for rice cultivation. It is measured by percentage.

BADC (X5) : How much hybrid seeds are provided by BADC for rice cultivation. It is measured by percentage.

NGO (X6) : How much hybrid seeds are provided by NGO for rice cultivation. It is measured by percentage.

Company(X7) : How much hybrid seeds are provided by company for rice cultivation. It is measured by percentage.

Source of agri-information(X8) : Farmers source of agri-information is 1, if farmers get information from govt, non-govt and paper and 0 for otherwise.

4.0 Results:

Adoption refers to the percentage of farmers who have embraced a new technology, which varies by technology and geography. Several studies have looked into the impact of various socioeconomic, cultural, and political aspects on farmers' readiness to adopt new technologies. A limited dependent variable econometric model is frequently used to model farmers' adoption of new technologies.

Table: 2- Estimated results for hybrid rice adoption model

Parameters	Estimate	Std. Error	Z	Sig.
Intercept	-6.145	0.748	-8.219	0.000
Age (X_1)	0.014	0.003	3.960	0.000
Education (X_2)	0.079	0.022	3.501	0.000
Farm size (X_3)	-0.125	0.056	-2.213	0.027
Agri.Ext.Dept (X_4)	0.36	0.008	4.704	0.000
BADC (X_5)	0.022	0.006	3.665	0.000
NGO (X_6)	0.028	0.007	3.883	0.000
Company (X_7)	0.028	0.007	3.824	0.000
Source of information (X_8)	-0.140	0.079	-1.759	0.079

Source: Authors' calculation

The most popular method is to use a binary dependent variable model like the probit or logit (Feder et al, 1985). The Probit Model is used in this study to estimate the parameters that influence hybrid rice production of survey area. According to the regression estimated by Probit Model as shown in table-2, the estimated result indicating the model had a Probit Pearson Goodness-of-Fit Test Chi-square value of 175.082 which is statistically significant implying that the variables (X) included in the model adequately explained the depended variable (Y). The results of the probit model show that age, education, agricultural extension department, BADC, NGO, and company are positively significant factors in encouraging hybrid rice adoption. In opposite, farm size and source of information are significant but negatively related to adoption of hybrid rice cultivation in the study area.

5.0 Discussion:

According to studies, the age of the farmers influences their decision to adopt. Depending on the individual farmer and technology involved, age (X_1) may have a favorable or negative impact on adoption. Older farmers, for example, may have greater expertise, resources, and authority, giving them more opportunities to experiment with new technology. In a study conducted by Baidu (1999), the results revealed that age had no major impact on adoption. Because of the old farmers' conservative viewpoint, this result contradicted the previously established negative influence of age (Cotlear, 1986). In Central Uganda, Mugisa-Mutetika et al. (1993) found that the proportion of adopters increased with age in the case of improved bean varieties. Sabiiti (1989) discovered a link between age and the usage of summethion insecticide among Ugandan coffee producers, with the majority of adopters being above the age of 50. Young farmers in India have been found to adopt new vegetable-growing innovations faster than their elder counterparts (Remmy, 1987). Age was found to be significantly related to adoption by Pession (1967), but not by Garvin (1980) or Dudhani et al. (1987). The computed maximum probability estimate value of age is 0.014 in table 1, which is positive and significant. This means that age has a beneficial impact on the adoption of hybrid rice.

Education (X_2) is substantially connected to adoption intensity, which is not surprising given that adopting a new technology necessitates the ability to absorb and interpret what is taught by either an extension worker or a fellow farmer before putting it into practice. As a result, education is anticipated to boost the likelihood of better hybrid rice crop adoption in the study area. It is expected that educated farmers will be better able to understand and apply adoption-related knowledge. According to (Nabbumba, 1994), there is a positive correlation

between technology adoption and education. According to the study, an increase in education level increases the likelihood of adoption by 0.079 percent. Because of the positive and significant nature of education, it is an important component that will encourage farmers in the study region to embrace hybrid rice. Education is expected to play a significant influence in the advantages derived from the interventions in those who are better educated.

Farm size and adoption were found to have a favorable association due to money, economic power, social prestige, and ties to local political leadership, as well as the availability of modern inputs and credit. Lack of funds for investment and access to land could stymie adoption (Yapa and Field 1978). Land scarcity is a result of population pressure in the research area, and the ability to use land productivity will be limited until farming intensity is enhanced. As a result, land availability boosts farmer adoption. Access to information and extension services may also be influenced by farm size (X3) (Leonard, 1977). Farm size was found to be substantially connected with the adoption of agricultural innovations by Pession (1967) and Garvin (1989), however Buyucolak (1978), who researched the adoption of improved wheat varieties in Turkey, found no correlation between farm size and adoption due to the limited land holdings. Farm size has a negative but substantial estimated likelihood value of -0.125 . According to Feeder et al (1985), the positive and substantial coefficient of farm size implies that it has a beneficial impact on technology adoption.

Sources of seed are crucial in agriculture and they are one of the most important determinants of productivity. Sources of seed are considered into four components which are estimated the probit model for adoption of hybrid rice. The components are Agricultural Extension Department (X4), BADC (X5), NGO (X6), and company (X7). And from these sources, seeds are used in the cropping season. The estimated maximum likelihood effects are presented in the table and estimates are positive and significant such as 0.36, .022, .028 and .028 respectively. These positive and significant sources of seed (four components) enhance farmers' adoption of hybrid rice in the study area. According to Brown (1981), the influence of information on adoption decisions varies depending on the source, content, motive, and frequency of use. The most important component in new technology adoption is the source of information (X8). Household access to information sources is likely to impact technology awareness; in most situations, rural households obtain information via extension agents, and as a result, agricultural extension plays a critical role in technology adoption. As a new variety of hybrid rice, it is so much important to know the farmers how to cultivate hybrid rice. Lack of information about hybrid rice technology such as seedlings or using pesticides might contribute to low adoption. The estimate is negative and significant (-0.140) indicating constraints to adoption of hybrid rice technology. If the information is not available, this result points to negative impacts on adoption. According to Maundu (1981), farm size, education, living standards, and agricultural information such as radio and extension are all positively connected to adoption. Our findings are consistent with Maundu's discovery (1981).

6.0 Conclusion:

The study tried to quantify the parameters that influence hybrid rice adoption in Bangladesh. Primary data was collected from field level survey and that was analyzed with the application Probit Model. Results of this study revealed that age, education, source of seed have positive impact of hybrid rice adoption. On the contrary, small farm size is convenient for adoption of hybrid rice but it is impossible for larger farm size. The result of information shows that most of the farmers do not have enough information and extension from government and non-government sectors. Our finding implies that developing and spreading hybrid rice

technology may be one of the most important initiatives for meeting Bangladesh's expanding need for basic foods. The findings of the study must be taken with great caution due its inherent limitation of the data used. Since majority of the farmers do not keep records of their farming activities, obtaining accurate and reliable information was one of the major difficulties of the study. They provided information from their memory. We tried to collect authentic information through face to face interview surveying. In addition, the study was conducted in two upozilla of Joypurhat District, Bangladesh, it may be better if we were able to include more sample areas in our study. The study was limited to determine the factors of hybrid rice adoption in Bangladesh using Probit model. However, anyone can use logit or tobit model to dig into the determinant of adoption of hybrid rice. In addition, further research and investigation may be done on soil degradation for using excessive chemicals and fertilizers or its impact on consumers' health condition.

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