Archives of Agriculture and Environmental Science 7(4): 595-600 (2022)
https://doi.org/10.26832/24566632.2022.0704018

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

Determinants of adoption and preferences for Aman rice mutant variety Binadhan-7 cultivation in Bangladesh

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ARTICLE HISTORY

Received: 15 October 2022
Revised received: 20 December 2022
Accepted: 21 December 2022

Keywords

Binadhan-7
Constraints
High yielding
Rice mutant
Short duration

ABSTRACT

This study was conducted in fourteen agricultural regions of Bangladesh namely-Mymensingh, Jashore, Cumilla, Bogura, Rajshahi, Sylhet, Dinajpur, Rangpur, Dhaka, Khulna, Chattagram, Rangamati, Barishal and Faridpur. The specific objectives of the present study were: i) to examine the determinants to adoption of rice mutant variety Binadhan-7; and ii) to identify the major preferences and constraints of rice mutant variety Binadhan-7 cultivation; A multi-stage stratified random sampling technique was used to collect the data. Marginal coefficients indicate that if male farmers increased by 100%, the probability of adopting Binadhan-7 variety would increase at 38 times more likely to adopt the variety. If the farm size of Binadhan-7 increased by 100%, the probability of adopting the variety would be increased by 0.07%. A farmer who has access to agricultural extension service is about 39 times more likely to adopt the variety. Again, if the yield increased by 100%, adopting the varieties would increase by 0.08%. The marginal coefficients of duration and soil fertility are negatively significant, indicating that if these two variables increased by 100%, the probability of adopting the varieties would decrease by 0.18% and 28%, respectively. Among the preferences, the highest preference was 88.93% for short duration followed by poverty reduction (88.57%), and lastly high yielding (81.43%). Among the constraints, the highest constraint was 80.71% for high labour price followed by lack of godown (69.64%), marketing problem (67.50%), destroy by bird (66.79%) and lack of quality seed (48.93%).

Citation of this article: Rahman, M. H., Sultana, R., Sarkar, M. M. A., Islam, S., & Sivasankar, S. (2022). Determinants of adoption and preferences for Aman rice mutant variety Binadhan-7 cultivation in Bangladesh. *Archives of Agriculture and Environmental Science*, 7(4), 595-600, https://dx.doi.org/10.26832/24566632.2022.0704018

INTRODUCTION

Rice is the most important staple food for more than half of the population in the world particularly in developing countries. Agriculture is a pillar of Bangladesh's economy, using more than 70% of land area and also provides nearly 40.60% of rural employment of the agricultural sector (BBS, 2018). As whole it contributes almost 13.48% to the GDP whereas crops and horticulture have a 7.13% share alone for the financial year 2019-20 (BBS, 2020). All over the world, farming is a means of food security but in Bangladesh it is a livelihood for a huge population as well as a means of reducing poverty (accounting for 90% of reduction in poverty between 2005 and 2010 (databd, 2019) and fostering sustainable economic development. Since the independence of the country, agriculture has been a significant source of employment, livelihood, and food security for the majority of rural people besides providing the raw materials to industry and also contributes to the country's exports (Rahman, 2017). Despite frequent natural disasters and population growth, Bangladesh has made admirable progress over the past 40 years in achieving food self-sufficiency, (food grain production, for example, tripled between 1972 and 2014, from 9.8 to 34.4 million tons). With one of the fastest rates of productivity growth in the world since 1995 (averaging 2.7 percent per year,

second only to China), Bangladesh's agricultural sector has benefited from a sound and consistent policy framework backed up by substantial public investments in technology, rural infrastructure and human capital (World Bank, 2016). Rice is one-third food requirement of the world population and a vital cereal crop in Bangladesh (Ahmad *et al*., 2015). The country is projected to advance from the status of a least developed country to a developing country in 2024 (Zhenmin, 2018). Bangladesh was the sixth most climate-vulnerable country in the world (Kreft *et al*., 2017). To combat with future challenge of food security Bangladesh Institute of Nuclear Agriculture & International Atomic Energy Agency developed a mutant rice variety Binadhan-7. It is a short duration and high yielding transplanted aman variety with good quality of rice released in 2007. Crop duration is 110-115 days from seed to seed (BINA, 2019). Aman is the country's second-biggest rice crop in terms of output volume, where as Boro is the greatest. As the variety of early maturing, facilitate rabi crop cultivation like potato, mustard, wheat etc. after harvesting the variety in aman season. It is more tolerant to sheath blight, leaf blight and stem rot. This variety is also more tolerant to major insect-pests especially to Brown Plant Hopper (BPH) and hispa. It produces grain yield is 5~5.5 t/ha. Paddy as well as the rice is long and fine. Rice is tasty and grains are bright color having higher market price. It can be transplanted little bit late as it is a short duration variety. It can also be cultivated in boro and aus seasons. Adopting improved agricultural technology and variety in drought-prone areas can be an essential alternative to eliminating food shortages and food insecurity by improving crop productivity and income. Further, promoting the adoption of improved crop varieties sustainably helps improve the welfare of households (Asfaw *et al*, 2012). After introducing short duration high yielding variety, production area of aman rice become more stable ranging 56.10-56.82 lac hectare. The study was performed to identify adoption, preferences and constraints of BINA developed aman rice mutant variety Binadhan-7 cultivation in the study areas. Previous study focusses on profitability and productivity (Zaman *et al*., 2022, Sultana *et al*., 2021, Moon *et al*., 2020) efficiency and impact of modern variety adoption on poverty and welfare (Bannor *et al*., 2020, Islam *et al*., 2019a, Islam *et al*., 2018b). Therefore, the present study was conducted to examine the determinants to adoption of rice mutant variety Binadhan-7, to identify the major preferences and constraints of rice mutant variety Binadhan-7 cultivation; and to suggest some policy guidelines.

MATERIALS AND METHODS

The study was conducted in fourteen agricultural regions of Bangladesh namely-Mymensingh, Jashore, Cumilla, Bogura, Rajshahi, Sylhet, Dinajpur, Rangpur, Dhaka, Khulna, Chattagram, Rangamati, Barishal and Faridpur. A multistage stratified random sampling technique was used to collect the data. Baseline data were collected from concern DD, DAE of 64 districts. A total of 280 farmers remaining 20 from each agricultural region were randomly selected to fulfill the objectives. A pre-designed interview schedule was used to collect the necessary data. Finally, data were classified into 14 agricultural regions to identify the adoption level, preferences and constraints of BINA developed aman rice mutant variety Binadhan-7. Tabular, descriptive statistics and probit models were used to analyze the collected data. Collected data were edited, summarized, tabulated and analyzed to fulfill the objectives of the study. Descriptive statistics used different statistical tools like averages, percentages and ratios to present the study results. Probit and Logit models have been used extensively by economists of agricultural production and farming systems to study and analyze farmers' adoption and diffusion of agricultural interventions. The probit model is a statistical probability model with two categories in the dependent variable (Liao). Probit analysis is based on the cumulative normal probability distribution. The binary dependent variable y takes on the values of zero and one. The outcomes of y are mutually exclusive and exhaustive. The dependent variable, y, depends on k observable variables xk, where k=1…K. While the values of zero and one were observed for the de- pendent variable in the probit model, there was a latent, unobserved continuous variable, y*.

$$y^* = \sum_{k=1}^{k} \beta^k x^k + \varepsilon \quad (1)$$

Where ε is IN (0, σ^2)

The dummy variable, y was observed and was determined by y* as follows.

y={1, if y* > 0}, 0 otherwise (2)

The point of interest relates to the probability that y equals one. From the above equations.

$$\text{Prob}(y=1) = Prob\sum_{k=1}^{k} \beta^k x^k + \varepsilon = Prob(\varepsilon > -\sum_{k=1}^{k} \beta^k x^k) = 1 - \Phi(-\sum_{k=1}^{k} \beta^k x^k) \quad (3)$$

Where, Φ was the cumulative distribution function of ε (Liao).

The specification of the probit model was as follows:

$$yi=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\beta_9X_9+\beta_{10}X_{10}+\beta_{11}X_{11}+\beta_{12}X_{12}+\beta_{13}X_{13}+U_i$$

Where, Yi=Farmers adopting Binadhan-7 variety (if adopted=1; Otherwise=0); α=Intercept, X_i=Explanatory variables, β_i=Coefficients of respective variables, and U_i=Error term.

The Maximum Likelihood Estimation (MLE) technique was used to estimate probit model parameters. MLE focused on choosing parameter estimates that gave the highest probability or likelihood of obtaining the observed sample y. Thus, the main principle of MLE was to choose as an estimate of β the set of K numbers that would maximize the likelihood of having observed this particular y.

The independent variables were captured as:

X_1=Age of the respondent (Year)
X_2=Gender
X_3= Education (Year of Schooling)
X_4= Farmer's experience in farming (years)
X_5= Family size
X_6=Annual income
X_7= Farm size (hectare)
X_8= Yield
X_9=Duration (days)
X_{10}=Extension contact
X_{11}=Soil fertility
X_{12}=Human labour
X_{13}= Locations

Measurement of dependent and explanatory variables was given as:

Variable	Type	Measurement
Dependent variable	Dummy	1 if farmer has adopted, otherwise 0
Explanatory Variable		
X_1=Age	Continuous	Age of the Household head (years)
X_2=Gender	Dummy	1 if the household respondent was male, otherwise 0
X_3= Education	Continuous	Formal education of the respondent (years of schooling)
X_4=experienceinfarming	Continuous	Farming experiences of the respondents (years)
X_5= Family size	Continuous	Number of active (aged 15–60 yrs.) members in the family (persons)
X_6=Annual income	Continuous	Amount of money earned by the family members in a year ('000BDT)
X_7= Farm size	Continuous	Amount of land under Binadhan-7 cultivation (ha)
X_8=Yield	Continuous	Yield obtained by farmers in kg
X_9=Duration (Days)	Continuous	No of days required for harvest
X_{10}=Ext. Contact	Dummy	If favorable=1; otherwise=0
X_{11}=Soil fertility	Continuous	High=1, Medium=2
X_{12}=Human labour	Continuous	No. of labour/ha
X_{13}=Location	Continuous	Score

RESULTS AND DISCUSSION

The demographic characteristics of the Binadhan-7 rice farmers were presented and discussed according to their age, sex, education, household size, years of farming experience and farm size. The distribution of the farmers by age showed that the mean age for Binadhan-7 cultivated farmers was 46 years. Among the farmer 92% was educated which was categories as primary, secondary, higher secondary and above. In the study areas, average experience of farmers was 22 years and income were Tk. 274486 per year. The average family size was 6, where 50% was male and 50% was female. This implies that the rice farming populations were still within their productive age and could still engage efficiently in short duration rice production. Rice farming is a labor-intensive occupation and exerts energy for land preparation, nursery, planting, weeding and harvesting.

Determination of factors affecting the adoption of the variety

The estimated log-likelihood value was highly significant, indicating that the model with predictors was to be preferred over a model without predictors. Education, farm size, yield and agricultural extension contact have a statistically positive effect on adopting the variety. The household characteristic related variables such as age, experience, annual income, human labour, duration of the variety have no statistically significant effect on the adoption of the variety. The soil fertility and agricultural regions are negatively significant for adopting the variety (Table 1). Marginal coefficients indicate that if male farmers increased by 100%, adopting the Binadhan-7 variety would increase at 35 times more likely to adopt the variety. If the farm size of the variety Binadhan-7 increased by 100 %, the probability of adopting the variety would increase by 0.07%. A farmer who has access to agricultural extension service is about 8 times more likely to adopt the variety. Again, if the yield increased by 100%, adopting the varieties would increase by 0.08%. The marginal coefficients of the duration and soil fertility are negatively significant. If these variables increase by 100%, the probability of adopting the varieties will decrease by 0.18% and 28%, respectively (Table 2). The overall area coverage of BINA developed rice mutant variety Binadhan-7 was 9.55% in aman season in Bangladesh, which was observed as the highest among the BINA developed varieties (Rahman *et al.*, 2020). The results presented in Table 3 depicted that the total area coverage of rice mutant variety Binadhan-7 was found 421080 hectare and among the 14 agricultural regions of Bangladesh the highest area coverage of rice mutant variety Binadhan-7 was found in the Jashore region (33.84%) and that was the lowest found 0.084% in Rangamati region.

Table 1. Maximum likelihood estimates of variable determining adoption of the variety Binadhan-7 among respondent farmers.

Variable	Co-efficient	Std. Err	Z statistic	Probability
X_1=Age	-0.00007371	0.00916866	-0.00800	0.8946
X_2=Gender	1.05648300	0.64296639	1.64314	0.0900
X_3= Education	0.08503218*	0.05590719	1.52095	0.1152
X_4= Experience in farming	0.00252927	0.00929277	0.27218	0.7065
X_5= Family size	-0.06475851	0.05432139	-1.19210	0.2097
X_6=Annual income	0.00000023	0.00000046	0.50988	0.5490
X_7= Farm size	0.00203337**	0.00070200	2.89654	0.0036
X_8=Yield	0.00347130**	0.00165330	2.09962	0.0324
X_9=Duration (Days)	0.00009729	0.01384479	0.00703	0.8946
X_{10}=Extension contact	0.34715592**	0.17644419	1.96751	0.0441
X_{11}=Soil fertility	-0.83823696***	0.22347954	-3.75080	0.0000
X_{12}=Human labour	-0.00142452	0.00490167	-0.29060	0.6939
X_{13}=Agricultural region	-0.00162153**	0.00083916	-1.93230	0.0477
Number of observations		179		
LR chi2 (12)		40.968		
Prob > chi2		0.00***		
Pseudo R2		0.1485		
Log-likelihood		-109.36475		

Notes: *, **, *** represent statistically significance at 10 %, 5 % and 1 % respectively.

Table 2. Marginal effect estimates of the probit model.

Variable	dy/dx	Std. Err	Z	Probability
X_1=Age	-0.0000243	0.003023	-0.00804	0.8946
X_2=Gender	0.34833276*	0.2075738	1.678116	0.0837
X_3= Education	0.02803599	0.0181356	1.545907	0.1098
X_4= Experience in farming	0.00083394	0.0030626	0.272297	0.7065
X_5= Family size	0.06475851	0.0543214	1.192136	0.2097
X_6=Annual income	7.659E-08	1.494E-07	0.512651	0.5481
X_7= Farm size	0.00067041**	0.0002197	3.051618	0.0018
X_8=Yield	0.0007695**	0.0005679	1.354992	0.0288
X_9=Duration (Days)	-0.001855**	.000745	-1.42236	0.045
X_{10}=Extension Contact	0.07650189**	0.0606942	1.260448	0.0252
X_{11}=Soil fertility	-0.276375***	0.0655522	-4.2161	0.0001
X_{12}=Human labour	4697.1	0.0016151	2908169	0.6939
X_{13}=Location (Agricultural region)	0.00053469	0.0002699	1.980994	0.0432

Notes: *, **, *** represent statistically significance at 10 %, 5 % and 1 % respectively.

Table 3. Region wise area coverage of rice mutant variety Binadhan-7 in 2020-21(in ha).

Variety	Cumilla	Mymensingh	Sylhet	Rangamati	Khulna	Barishal	Rajshahi	Rangpur	Dinajpur	Bogura	Dhaka	Chattagram	Jashore	Faridpur	All
Binadhan 7	9351	15764	22796	354	48484	9010	71506	13014	5154	21764	1426	2903	142504	57050	421080
(%)	2.22	3.74	5.41	0.084	11.51	2.13	16.98	3.09	1.22	5.17	0.34	0.69	33.84	13.55	100

Source: DAE data (2021).

Table 4. Distribution of respondents according to preferences and constraints of Binadhan-7 cultivation.

Study areas	Preferences					Constraints				
	Short duration	High yielding	Income increases	Create employment Opportunity	Reduce Poverty	Lack of quality Seed	Labour crisis & high price of labour	Marketing Problem	Lack of Godown	Destroy by bird
Mymensingh	20	17	19	19	20	7	10	5	12	12
Jashore	20	15	19	19	19	14	14	17	10	16
Cumilla	19	16	20	20	20	7	17	9	17	19
Rajshahi	17	14	17	17	16	13	16	7	10	17
Bogura	16	16	20	20	20	12	18	9	16	8
Sylhet	15	18	19	18	17	10	16	13	11	16
Dinajpur	14	17	19	18	20	7	15	10	14	13
Rangpur	19	15	20	19	20	8	16	12	15	14
Dhaka	18	18	15	17	19	11	18	18	19	11
Khulna	19	16	13	14	13	9	17	18	17	17
Chattagram	16	15	12	12	14	7	16	18	16	16
Rangamati	18	16	13	13	15	10	18	19	14	14
Barishal	19	17	18	20	18	12	17	15	10	10
Faridpur	19	18	16	18	17	10	18	19	14	4
%	88.93	81.43	85.71	87.14	88.57	48.93	80.71	67.50	69.64	66.79
Rank	I	V	IV	III	II	V	I	III	II	IV

Source: Field Survey (2021).

Farmers prefer this variety for various reasons such as short duration, high yielding, earliness, cropping intensity increase, four cropping patterns (Binadhan-7-potato/mustard/vegetables -boro-aus). They can include rabi crops like mustard, potato, wheat, different vegetables in their cropping pattern that leads to increase income as well as employment and reduce poverty. The results presented in figure 1 showed that among the preferences, the highest preference was 90% for short life, followed by reduce poverty 89%, employment opportunity increase 88%, increase cropping intensity 86% and the greater yield i.e., 81% and among the constraints, the highest constraint reported by the producer was high price of labour 81% followed by lack of storage capacity 69%, high cost of transportation 68%, destroy by bird & animals 67% and the lack of quality seed at proper time 50% in Binadhan-7 cultivation.

From the Table 5, we found that 82.86% respondents got information about this variety cultivation from research office and DAE. There were 62.14% growers who received training, 70% got suggestions from different Agricultural officers, and 29.64% receive seed support indicating 70.36 % of seed used from their previous harvest. Farmer harvested paddy within 110-115 days and 50% of that were used for family consumption and the rest were sold by them. The study found that, 74.29% paddy was sold by the growers in the market, 65% growers noticed about good taste to eat the rice, 52.14% cultivated other BINA developed variety rather than Binadhan-7 in aforsaid locations. On the other hand, the non-mutant growers are not growing mutant varieties like Binadhan-7 because of non-availability of quality seed, extension weakness, lack of training, reluctant to adopt new variety and farmers' willingness to the traditional variety cultivation for their own consumption.

Table 5. Major technical information to mutant rice variety Binadhan-7 Cultivation.

Type	Study areas														%	Rank
	My-mensingh	Jashore	Cumilla	Rajs hahi	Bogura	Sylhet	Dinaj-pur	Rangpur	Dhaka	Khulna	Chatt agram	Rang-amati	Barishal	Farid-pur		
Technical/ Other information																
Get information about this variety from DAE & Re-search station	18	17	17	16	16	17	14	18	19	19	14	8	19	20	82.86	I
Type of information/Support																
Training	17	10	16	14	12	14	13	15	8	15	12	16	4	8	62.14	V
Suggestions	19	14	17	15	15	16	15	17	12	5	8	18	13	12	70.00	III
Seed support	10	8	12	7	9	8	7	8	5	0	0	0	5	4	29.64	VIII
Rice used for family purpose	10	6	8	9	7	6	9	9	10	9	16	13	14	14	50.00	VII
Taste good to eat Binadhan-7	11	12	14	17	20	14	13	18	9	9	10	10	9	16	65.00	IV
Selling paddy at market	14	15	11	14	10	9	12	18	18	20	16	18	15	18	74.29	II
Cultivate other BINA's variety rather than Binadhan-7	12	11	16	14	13	10	11	13	6	0	9	5	18	8	52.14	VI

Source: Field Survey (2021)

Conclusion

Cultivation of rice mutant variety Binadhan-7 is highly profitable among the study areas and that increasing day by day. Farmers are happy to cultivate Binadhan-7 for the special characteristics of this variety such as-short duration, high yielding, early cutting and increasing the number of crops in their pattern i.e., Binasarisha (mustard), potato, Binarashun (garlic), Binamorich (Chili), Binatomato etc. Econometrics analysis showed that gender, farm size, yield and extension contact is statistically significant in adopting the variety. Now in a year, farmers can cultivate four crops so that they can earn more money which stabilizes their income and food security.

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