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Economics of BINA-6 rice production in some selected areas of Bangladesh

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Abstract

BINA-6 (Bangladesh Institute of Nuclear Agriculture-6) rice variety is a profitable enterprise irrespective of farm size. Its profitability increases with the increase in farm size. All the contributory variables in the production function have positive and significant impacts on the yield of BINA-6 rice. Among them impacts of animal labour and power tiller and irrigation are highly significant. Resource allocation efficiency analysis shows that production process of BINA-6 rice is going on in the rational zone of production (i.e., in stage-II) where resources are being used efficiently. Results of the sensitivity analysis reveals that BINA-6 rice is profitable compared to BR-28 and BR-29 (BRRI Dhan 28 and BRRI Dhan 29 respectively) and it was still potential in changed economic condition of rice production. Researchers are suggested to take initiate to reduce the maturity period of BINA-6 rice variety and extension workers and policy makers should take necessary steps to expand the cultivation of this rice all over the country.

Keywords: Profitability, Contributory variables, Returns to scale, Resource use efficiency and Potentiality

Introduction

Rice is the most important food crop in terms of area, production and its contribution to the national income and economic development in Bangladesh. About 80 percent of the cultivated area is devoted to rice production and millions of farmers have been growing rice in this country. Rice contributes 14.43 percent to the gross domestic product (GDP) of Bangladesh (BBS, 2001).

The availability of rice growing arable land is extremely limited in Bangladesh. To feed the growing population, therefore, high yielding rice variety is extremely needed. Despite the fact that rice is cultivated extensively in Bangladesh, per hectare yield is much lower in comparison with that of other rice growing countries of the world. Among the rice producing countries, Bangladesh ranks fourth next to China, India and Indonesia both in respect of area and production of rice (FAO, 1994). In order to meet this deficit, yield per unit area of rice should be increased. BINA-6 rice is a high yielding and good quality rice which is developed by BINA using nuclear technology. It was developed from the progeny lines BINA 4-5-17-19 and was generated through application of gamma rays on the F_2 seeds of a cross between the varieties IRATOM-24×Dular. More tillers give maximum grain yield of 9.0 tonnes per hectare with an average yield of 7.5 tonnes per hectare, which is higher than the hybrid rice. This variety is resistant to diseases, such as, leaf blight, sheath blight, green leafhopper, brown plant hopper, etc. but the maturity period of this variety is about 160-165 days. This variety closely competes with BR-28 and BR-29. So, it is of paramount importance to reduce the maturity period of BINA-6 variety to facilitate its cultivation throughout the country for enhancing rice production.

Economic study specific on BINA-6 rice production is insufficient. The present study is expected to provide useful data to the researchers and help them in identifying future research problem. It may also be helpful to the extension workers, policy makers and will aid them to learn the various problems of the farmers. An individual farmer may be able to see his performances and gain an insight into the question of how to improve his farming efficiency. Moreover, it may help him to choose appropriate variety among different rice varieties and the appropriate cropping pattern also. So a study on the profitability, potentiality and the contributory factors to the production process of BINA-6 rice is very important from both national as well as farmer's point of view. Considering these factors in mind, the present study was designed to achieve the following objectives:

i) to determine the profitability of BINA-6 rice production;
ii) to estimate the contribution of key variables to the production process of BINA-6 rice;
iii) to determine the resource allocation efficiency in BINA-6 rice production; and
iv) to assess the potentiality of BINA-6 rice variety.

Materials and Methods

Both primary and secondary data were used for this study. The primary data were obtained through field survey of 120 farmers from six districts, namely, Rangpur, Jamalpur, Barisal, Sylhet, Magura and Comilla. The respondents were classified into tree categories, i.e., small farm (up to 1.00 hectare of cultivale land), medium farm (having 1.01 to 2.00 hectares of cultivable land) and large farm (possessing above 2.00 hectares of cultivable land). Of a total 120 farmers, 51 small, 42 medium and 27 large farmers were selected purposively for the study. Structured and pre-tested interview schedules were used to collect primary data and the period of study was July to November, 2003.

Both tabular and functional analyses were done to attain the objectives of the study. Tabular analysis was performed to determine the cost, return and profitability of BINA-6 rice while functional analysis was done to determine the effects of key variables in the production function. Efficiency in resource allocation was also determined by value product-factor cost technique and sensitivity analysis was done to know the potentiality of BINA-6 rice cultivation. All the cost and return items were calculated at the prevailing market price. For human labour, the following conversion was used (Mian *et al*, 1998):

1 adult male = 1.5 adult female = 2 children
Depreciation of tools and equipment was calculated as:
$D = [(V_o-V_n)\times t] / L$
Where, V_o= present value, V_n= salvage value, L= remaining life and t= time considered (production period)
Interest on operating capital was calculated as:
IOC = (Oit) / 2
Where, IOC= interest on operating capital, O= operating capital, i= rate of interest and t= time considered.

For functional analysis, the following Cobb-Douglas production function was followed to determine the contributions of key variables in production process of BINA-6 rice:
$Y= aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}e^{Ui}$
Which took the linear for as: $\ln Y = \ln a+b_1\ln X_1+ b_2\ln X_2+b_3\ln X_3+b_4\ln X_4+b_5\ln X_5+b_6\ln X_6+U_i$

Where, Y= per hectare gross return, X_1, X_2, X_3, X_4, X_5, X_6 = per hectare cost of human labour, animal labour and power tiller, seedlings, fertilizer, irrigation and insecticides respectively, b_i= coefficient of ith variable, U_i= error term, ln= natural logarithm and i= 1,2, ..., 6.

Resource allocation efficiency was determined as: MVP/MFC = 1
Where, MVP= marginal value product (slope of the production function), MFC= marginal factor cost.

If the ratio is greater than 1, the resource is sub-optimally used and the gross return could be increased by using more of resources and if it is less than 1, the resource is over used and the excess use of resources should be decreased to minimize loss. So, the ratio equal to 1 is the criterion of efficient allocation of resources. Moreover, the most reliable, perhaps the most useful estimate of MVP is obtained by taking resources (X_i) as well as gross return (Y) at their geometric means (Dhawan and Bansal, 1977).

Results and Discussion

Cost of BINA-6 rice production

Per hectare cost of BINA-6 rice Production is shown in Table 1. The table shows that among the variable cost items human labour is the largest item as it occupies the largest share in total cost irrespective of farm size. The shares of human labour in total cost are 33.69, 35.35 and 34.58 percent for small, medium and large farms, respectively. The second largest variable cost item is irrigation and its respective shares are 14.77, 14.93 and 14.90 percent. Cowdung holds the third position in variable cost items and it constitutes 4.85 percent for small farms, 5.46 percent for medium farms and 5.75 percent for large farms in total cost of production. Among fertilizers triple super phosphate (TSP) comes to the next position and its respective shares are 4.46, 4.24, and 4.77 percent. Accordingly the fifth cost item power tiller's contributions are 4.25, 3.97 and 3.78 percent. Urea constitutes 3.53, 3.41 and 3.80 percent of total production cost of small, medium and large farms respectively and ranks the sixth. The respective figures for animal labour were found to be 2.59, 2.51 and 2.99 percent in the areas under study. The sequence of other variable cost items is muriate of potash (MP), seed, insecticides and gypsum which indicates gypsum is the smallest cost item for BINA-6 rice production in the study area.

Among the fixed cost items, land use cost is the largest item having 22.73, 21.22 and 20.20 percent shares in the total production cost of small, medium and large farms respectively. It was followed by interest on operating capital where the corresponding shares are 2.56, 2.63 and 2.67 percent. Cost of tools and equipment is the smallest fixed cost item having respective shares of 1.43, 0.97 and 0.80 percent for the frams under study.

Table 1 shows that all the cost items have almost same ranking in different farm size groups and the variable cost constitutes about 75 percent of total production cost. On an average per hectare cost of production of BINA-6 rice stood at Taka 32963.59 in the areas under study. The table also reveals that BINA-6 rice is a human labour and irrigation intensive technology as the shares of these two items are the largest among all variable cost items in total cost of production.

Return and profitability of BINA-6 rice production

Table 2 shows the return and profitability of BINA-6 rice production in the study area. The table reveals that per hectare yield of small, medium and large farms are 5829.20, 6224.60 and 6619.60 kg and the respective gross returns (including values of product and by-product) stood at Taka 42974.00, 45895.50 and 48835.20. Deducting total variable cost from gross return gross margin was determined and it was Taka 20299.72, 20985.71 and 22267.08 for the farms respectively. Accordingly the net return, which is the difference between gross return and gross cost, stood at Taka 12031.85, 12758.17 and 14024.32 in the study area. Thus undiscounted benefit-cost-ratios (BCRs) for small, medium and large farms were found to be 1.39, 1.39 and 1.40, respectively. The table also shows that the overall yield per hectare of BINA-6 rice was 6224.40 kg bearing a net return of Taka 12938.11 and BCR of 1.39 in the areas under study.

Table 1. Per hectare cost of BINA-6 rice production

Cost items	Small farm	Medium farm	Large farm	All farms (average)
Variable cost				
Human labour (Taka)	10424.00 (33.69)	11714.00 (33.35)	12038.00 (34.58)	11392.00 (34.56)
Animal labour (Taka)	800.10 (2.59)	831.60 (2.51)	1041.30 (2.99)	891.00 (2.70)
Power tiller (Taka)	1316.51 (4.25)	1316.51 (3.97)	1316.51 (3.78)	1316.51 (3.99)
Seedlings (Taka)	383.32 (1.24)	421.68 (1.27)	455.84 (1.31)	420.28 (1.27)
Urea (Taka)	1091.84 (3.53)	1129.86 (3.41)	1323.74 (3.80)	1181.81 (3.59)
TSP (Taka)	1378.56 (4.46)	1405.85 (4.24)	1659.57 (4.77)	1481.33 (4.49)
MP (Taka)	658.90 (2.13)	739.92 (2.23)	888.10 (2.55)	762.31 (2.31)
Gypsum (Taka)	50.99 (0.16)	53.49 (0.16)	116.08 (0.33)	73.52 (0.22)
Cow dung (Taka)	1500.56 (4.85)	1809.88 (5.46)	2000.98 (5.75)	1770.47 (5.37)
Insecticides (Taka)	500.00 (1.62)	541.00 (1.63)	541.00 (1.55)	527.33 (1.60)
Irrigation (Taka)	4569.50 (14.77)	4946.00 (14.93)	5187.00 (14.90)	4900.83 (14.87)
Total variable cost (Taka)	22674.28 (73.28)	24909.79 (75.17)	26568.12 (76.32)	24717.40 (74.98)
Fixed cost				
Land use cost (Taka)	7033.33 (22.73)	7033.33 (21.22)	7033.33 (20.20)	7033.33 (21.34)
Interest on operating capital (Taka)	793.60 (2.56)	871.84 (2.63)	929.88 (2.67)	865.11 (2.62)
Cost of tools and equipment (Taka)	441.34 (1.43)	322.37 (0.97)	279.55 (0.80)	347.75 (1.05)
Total fixed cost (Taka)	8268.27 (26.72)	8227.54 (24.83)	8242.76 (23.68)	8246.19 (25.02)
Total cost (Taka)	30942.55 (100)	33137.33 (100)	34810.88 (100)	32963.59 (100)

It is evident from Table 2 that like cost items, all the return items have positive relationship with farm size as they increase with the increase in farm size. It might be due to that BINA-6 rice variety is a modern technology and by nature it is capital intensive. As ability to input use per hectare increases (i.e., capital outlay) with the increase in farm size, the profitability also increases keeping a positive relationship with the size of farms under study.

Table 2. **Per hectare gross return, net return, gross margin and BCR of BINA-6 rice production**

Items		Small farm	Medium farm	Large farm	All farms (average)
Main product	Quantity (kg)	5829.20	6224.60	6619.60	6224.40
	Value (Taka)	40804.00	43571.00	46337.00	43571.00
By-product (Taka)		2170.00	2324.50	2498.00	2330.83
Gross return (Taka)		42974.00	45895.50	48835.20	45901.57
Total variable cost (Taka)		22674.28	24909.79	26568.12	24717.40
Gross margin (Taka)		20299.72	20985.71	22267.08	21184.17
Total fixed cost (Taka)		8268.27	8227.54	8242.76	8246.19
Total cost (Taka)		30942.55	33137.33	34810.88	32963.59
Net return (Taka)		12031.85	12758.17	14024.32	12938.11
BCR (undiscounted)		1.39	1.39	1.40	1.39

Factors affecting BINA-6 rice production

Contribution of key variables to the production process of BINA-6 rice variety is shown in Table 3. The table shows that all the independent variables have positive and significant impact on the per hectare yield of BINA-6 rice variety. Among them coefficients of animal labour and power tiller, seedlings and irrigation are highly significant (significant at 1 percent level), human labour and fertilizer are significant at 5 percent level and insecticides at 10 percent level. It implies that 1 percent increase in the cost of human labour, animal labour and power tiller, seedlings, fertilizer, irrigation and insecticide would be able to increase the per hectare yield of BINA-6 rice by 0.168, 0.142, 0.141, 0.033, 0.460 and 0.027 percent respectively. Value of R^2 (0.707) and F-value (45.341 and highly significant) indicate the good fitness of the production function.

Returns to scale was the sum of regression coefficients of all inputs. The sum of elasticities of all inputs was 0.971. This indicates that the production function exhibited decreasing returns to scale, i.e., if all the inputs specified in the production function were increased simultaneously by 1 per cent, the gross return would increase by 0.971 per cent on BINA-6 rice production.

Resource allocation efficiency

It is observed from the 4 that the ratios of MVP_{Xi} and MFC_{Xi} of animal labour and power tiller, seedlings, irrigation and insecticides in the BINA-6 rice production were positive and more than one which indicated that more profit could be obtained by increasing costs of animal and power tiller, seedlings, irrigation and insecticides. The ratio of MVP_{Xi} for human labour and fertilizer was positive but less than one indicating overuse of these resources. Hence it needs to be adjusted to bring it closer to unity.

Table 3. Estimated values of coefficients of BINA-6 rice and related statistics of Cobb-Douglas production function

Explanatory variables	Estimated values		
	Intercept and coefficient	Standard error	t-values
Constant/intercept	2.817		
Cost of human labour (X_1)	0.168**	0.065	2.570
Cost of animal labour and power tiller (X_2)	0.142*	0.039	3.624
Cost of Seedlings (X_3)	0.141*	0.034	4.136
Cost of fertilizer (X_4)	0.033**	0.014	2.409
Cost of irrigation (X_5)	0.460*	0.054	8.528
Cost of Insecticides (X_6)	0.027***	0.015	1.793
R^2	0.707	-	-
F- value	45.341	-	-
Returns to scale ($\sum b_i$)	0.971	-	-

* Significant at 1 % level
* * Significant at 5% level
* * * Significant at 10% level

Table 4. Marginal value of products (MVPs) and marginal factor costs (MFC_{Xi}) of different inputs included in production function

Variables	Geometric mean (Tk)	Coefficient	MFC	MVP_{Xi}/MFC_{Xi}
Gross return (Y)	45706.692			
Human labour (X_1)	11849.015	0.168	1.00	0.648
Cost of animal labour and power tiller (X_2)	1808.042	0.142	1.00	3.589
Cost of seedlings (X_3)	407.483	0.141	1.00	15.816
Cost of fertilizer (X_4)	3394.799	0.033	1.00	0.444
Cost of irrigation (X_5)	5377.614	0.460	1.00	3.909
Cost of Insecticides (X_6)	518.012	0.027	1.00	2.382

The returns to scale figure indicates the diminishing returns to scale and suggests that on the whole the BINA-6 rice growers are operating in rational zone (stage-II) of the production function where resources are being used efficiently.

Potentiality of BINA-6 rice production

Performance of BINA-6 rice was compared with two other most competing HYV rice varieties (BR-28 and BR-29) based on data obtained from previous studies.

Table 5. Per hectare cost and return of BINA-6 rice compared to BR-28 and BR-29 rice

Items	BR-28*	BR-29**	BINA-6
Yield (kg)	2340.00	5610.00	6224.40
A. Variable cost (Taka)	9015.15	29001.13	24717.40
B. Fixed cost (Taka)	3732.74	4616.27	8246.19
C. Total cost (A+B) (Taka)	12747.89	33617.40	32963.59
D. Gross return (Taka)	16381.00	42104.97	45901.57
E. Gross margin (D-A) (Taka)	7365.85	13103.84	21184.30
F. Net return (D-C) (Taka)	3633.11	8487.57	12938.11

*Sarwar 2003, **Rahman 2000

Table 5 shows that the per hectare gross returns from BR-28, BR-29 and BINA-6 rice were estimated at Taka 16381.00, 21534.57 and 45896.80 respectively. The corresponding net returns were Taka 3633.11, 8327.82 and 12933.21 respectively. So, it is evident from the table that BINA-6 rice growers earned both higher gross and net returns than BR-28 and BR-29 rice growers. Further, total costs for BR-28, BR-29 and BINA-6 rice were estimated at Taka 12747.89, 33617.40 and 32963.59 respectively. The implication is that compared to BR-28 and BR-29 rice, production of BINA-6 rice is highly profitable.

Table 6. Sensitivity analyses assuming 5 per cent rise in costs and returns of BR-28 and BR-29 keeping BINA-6 constant

Items	BR-28*	BR-29**	BINA-6
Yield (kg)	2460.00	5890.00	6224.40
A. Variable cost (Taka/ha)	9465.91	30451.19	24717.40
B, Fixed cost (Taka/ha)	3919.38	4847.08	8246.19
C. Total cost (Taka/ha) (A+B)	13385.29	35298.27	32963.59
D. Gross return (Taka/ha)	17200.05	44210.22	45901.57
E. Gross margin (Taka/ha) (D-A)	7734.14	13759.03	21184.30
F. Net return (Taka/ha) (D-C)	3814.76	8911.95	12983.11

If the costs and returns of BR-28 and BR-29 rice are increased by 5 per cent and the cost and return of BINA-6 rice held constant, then Table 6 shows that the net return of BINA-6 rice was higher than that of BR-28 and BR-29 rice. So, it can be sure from Table 6 that BINA-6 rice is potential in changing economic conditions of rice production.

Conclusion

Cultivation of BINA-6 rice is profitable irrespective of farm size groups of the country. Moreover, its profitability increases with the increase in farm size. All the factors of production are bearing positive and significant impact on the yield of this rice variety. Currently its production process is going on in the rational zone of action (stage-II) where resources are being used efficiently. It is more profitable than similar varieties like BR-28 and BR-29. The study, therefore, suggests taking adequate measures by the researchers, policy makers and extension agents to undertake necessary and sufficient measures in order to expand BINA-6 rice cultivation all over Bangladesh. Attention should be given to the following:

i. Without institutional credit support, it is difficult for the farmers to devote large area to the production of BINA-6 rice because costs of the whole production period are remarkably high. It is, therefore, necessary that credit on easy terms may be provided to the farmers for producing BINA-6 rice. Policy makers should pay an immediate attention to this matter.

ii. Fertilizers at subsidized rate should be supplied to BINA-6 rice growers. Regular supply of fertilizers and insecticides should be ensured. Some supply centers should be established to supply adequate amount of fertilizer at fair prices in right time.

iii. Scientific knowledge and modern technology should be imparted by extension workers for improving the efficiency in production.

iv. More irrigation facilities should be made available to the producers.

v. There is a price support programme for paddy in this country. It must be implemented effectively during the harvesting period.

vi. Scientists should explore how to shorten the production period of BINA-6 rice.

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