Comparative analysis of chickpea with boro rice in drought-prone areas of Bangladesh

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ABSTRACT

The study is conveyed to compare the profitability of chickpea and boro rice in Rajshahi district, which is one of the most drought-prone areas of Bangladesh. In this study, a total of 180 farmers (90 chickpea growers and 90 boro rice growers) are used as sample respondents, and data were collected by using a structured questionnaire in 2019. A probit regression model is used to find out the determinants that affect the cultivation of chickpea and boro rice. The important finding of this study is that the Benefit-Cost Ratio for chickpea and boro rice production is 1.88 and 1.05, respectively. The results indicate that chickpea cultivation is more profitable than boro rice cultivation. Besides, the study reveals that occupation, farm size, and seed have a positive impact while family size, human labor, and irrigation have negative effects on farmer's decision to cultivate chickpea cultivation rather than boro rice. It is, therefore, concluded that the farmers should be encouraged to grow more chickpea rather than boro rice as a means of increasing farm income through crop diversification program.

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Introduction

Agriculture in Bangladesh is primarily characterized by a rice monoculture, and boro rice is one of the major cereal food grains in Bangladesh (BBS, 2018). Boro rice contributed more than 55% of the total rice production where total pulse production was only 2.44% (BBS, 2018). However, boro rice is one of the most costly crops, the return from HYV Boro rice has declined because of low market price and high cost of production (Ahmed *et al.*, 2009). On the other hand, pulses fit well in the existing cropping systems of Bangladesh due to their short duration, low input, minimum care requirement, and drought-tolerant nature (Elias *et al.*, 1986). Among the pulses, chickpea is the third most important food legume crop worldwide (Ali, 2017) and it is one of the important cash crops for Bangladesh. In Bangladesh, The High Barind Tract of northwest covering larger parts of Rajshahi, Chapai Nawabganj, and Naogaon districts where rainfall is nearly low, considering the zone is semiarid and drought-prone. Because

of the low probability of the required amount of rainfall after mid-October, about 80% of the region remains fallow in the *rabi* season (Riches *et al.*, 2008). These circumstances make the area drought-prone, as well as no residual moisture is available for crop emergence but it can support short-duration crops such as chickpea. Because chickpea is a suitable crop for the farmers that can be grown on residual moisture without irrigation, following the harvest of transplanted main season (aman) rice.

As boro rice is an irrigated crop, a study showed that 78.7% of the lifted water was important for boro rice production which increases irrigation as well as production cost (Dey *et al.*, 2013). Also at the time of considering individual inputs, human labor was found as the largest contributor of expenses of HYV boro rice production in the Bhola district (Sujan *et al.*, 2017; Majumder *et al.*, 2009). However, in opposition, chickpea is a profitable crop, which has low water

requirements and it reduces labor requirements compare to boro rice (Kumar, 2007; Saha, 2002). The water requirement of pulses is about one-fifth of the requirement of cereals, thus effectively save available precious irrigation water (Reddy, 2009). In addition, its residue is used as animal feed and it improves the fertility of the soil (Shiferaw *et al.*, 2007). Since the production is not sufficient and consumption demand is so high, that Bangladesh needs to import a large amount of chickpeas from foreign countries. Bangladesh imported 1,86,000 tons of chickpea worth USD 127 million in 2013 (BBS, 2014) and this was a huge volume of import which shows the importance to enhance the scope of chickpea cultivation in Bangladesh. Hence, in drought-prone areas, the fallow land can be brought under chickpea cultivation due to its high yield on residual moisture as well as its low input requirements. So, it is better to create scope for crop diversification and therefore, chickpea can be a better start in these drought-prone areas to compete with the current situation.

In the context of Bangladesh, only a few studies were found about the economics of chickpea but on the other side, many kinds of research were done for boro rice. Rahman *et al.* (2018) found that the adoption of improved pulse productivity was significantly influenced by land, fertilizer, mechanical power, pesticides, and labor in Bangladesh. Saha (2002) found that chickpea was recognized as a low-cost, highly profitable crop that can be cultivated without irrigation in the High Barind Tract area of Bangladesh. He also found that chickpea was more important for small and medium level farmers. Sujan *et al.* (2017) stated that the boro rice cultivation was a profitable crop in Bogura district and the most important factors for boro rice cultivation was human labor, seed, urea, insecticide, and irrigation. Hoque and Haque (2014) studied the economic profitability of boro rice production by using the Cobb-Douglas production function and found that factors like cost of irrigation, insecticide, seed, and human labor showed a significant effect on profitability.

Keeping in mind the scarcity of research, this study will help to find out the benefit and costs of the two crops, which will assist the individual researchers in conducting further studies in this particular field. The study will also help to estimate the determinants that affect the chickpea and boro rice cultivation so that we can improve our understanding of decision-making in the production of chickpea as well as boro rice.

Materials and Methods

The study area

Based on the area, production, and yield, the present study was conducted in one of the highest chickpea and boro rice growing and drought-prone districts of Bangladesh. The data were collected from the Rajshahi district where rainfall is comparatively lower than any other region of Bangladesh. Geographically this region is situated in the Barind Tract and hence it has a dry climate and low fertile soil. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (Ali, 2000).

The data

Villages were purposively selected from Rajshahi district and then the farmers were selected randomly from the village levels. A complete list of chickpea and boro rice-growing farmers was prepared with the help of renowned village farmers and DAE personnel from the study areas. The primary data related to socio-economic characteristics of the farmers, input costs, and yield were collected from 180 farming households where 90 farmers grew chickpea and 90 farmers produced boro rice. The data were collected from March to June 2019. Secondary data on the area and production of chickpea and boro rice were also used to supplement the information.

The analytical framework

Financial profitability analysis for chickpea and boro rice cultivation

To estimate the financial profitability both for chickpea and boro rice cultivation, Benefit-Cost Ratio (BCR) were calculated as well as gross margin and net return analysis were done (Dillon and Hardaker, 1993). The undiscounted BCR was worked out using the following formula:

$$BCR = \frac{Total\ return}{Total\ cost}$$

The performance of chickpea and boro rice cultivation was also compared based on gross margin analysis, which was the difference between gross return (GR) and total variable cost (TVC).

$$GM = GR\text{-}TVC$$

Where, GM = Gross margin (BDT ha^{-1}), GR = Gross return (BDT ha^{-1}) and TVC = Total variable cost (BDT ha^{-1}).

Net return analysis was done by deducting both variable and fixed costs from the gross return. Return from by-product was also included with the net return. To calculate the net return for both the crops, the following formula was used in the study:

$$\pi = P_y Y + \sum_{i=0}^{n} P_{xi} X_i - TFC$$

Where, π = Net return (BDT ha^{-1}), P_y = per unit price of the product (BDT kg^{-1}), Y = Amount of product per hectare (kg), P_{xi} = per unit price of the ith inputs (BDT), X_i = Amount of the ith inputs

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per hectare (kg), *TFC* = Total Fixed Cost (BDT), *i* = 1, 2, 3... n (number of inputs).

Here, the gross return was calculated by the following algebraic formula, which was the sum of total return from the main product as well as from the by-product of the crops.

$$GR_i = \sum_{i=1}^{n} Q_{mi} p_{mi} + \sum_{i=1}^{n} Q_{bi} P_{bi}$$

Where, GR_i = Gross Return from the ith product (BDT ha^{-1}), Q_{mi} = Amount of the ith main product (kg ha^{-1}), p_{mi} = Average price of the ith main product (BDT kg^{-1}), Q_{bi} = Amount of the ith by-product (kg ha^{-1}), P_{bi} = Average price of the ith by-product (BDT kg^{-1}), i = 1, 2, 3... n (number of inputs).

Probit model for identifying the determinants of chickpea and boro rice cultivation

To identify the determinants, which were responsible for chickpea and boro rice, cultivation in the study area, the probit model was used because this model was the best-fit model due to its binary nature of the dependent variable. The probit model used in this study is similar to the models which were widely used for estimating technology adoption in earlier studies (Kehinde and Adeyemo, 2017; Alabi *et al.*, 2014; Uaiene *et al.*, 2009; Zavale *et al.*, 2005). The probit model assumes that while only the values of 0 and 1 for the dependent variable Yi are observed, there is a latent, unobserved continuous variable Yi* that determines the value of Yi (Sebopetji and Belete, 2009). So, the probit model which is also known as the normit model, determines the effect of X_i on the response probability,

$P_i = (Y = 1|X) = \Phi (\beta'x_i),$

where P_i indicates probability, Y indicates binary dependent variable where (1 for farmer's choice for chickpea cultivation and 0 for farmer's choice for boro rice cultivation), X indicates the independent variables, Φ is the cumulative distribution function (CDF) of the normal distribution and β is a vector of the unknown parameters.

So, the probit model of identifying the determinants for both the crops is obtained from an underlying latent variable model, which is expressed as:

$$Y_i^* = \beta_0 + \sum_{n=1}^{N} (\beta_n x_{ni} + u_i)$$

$$Y_i = \begin{cases} 1 \ if \ Y_i^* > 0 \\ 0 \ otherwise \end{cases}$$

Where, x_{ni} is a vector of regressors and u_i represents the error term and β is a vector of unknown parameters to be estimated.

The relationship between a specific variable and the outcome of the probability is interpreted through the marginal effect, which accounts for the partial change in the probability. The marginal effect associated with continuous explanatory variables x_{ni} on the probability $P (Yi = 1 | X)$, holding the other variables constant, can be derived as follows (Greene, 2011):

$$\frac{\partial P_i}{\partial x_{ni}} = \phi (x_i' \beta)\beta_k$$

So, the functional specification of the probit model in this study is given below:

$A_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + ...U_i$

Where, A_i = Farmers' selection of crops (if Chickpea = 1, Boro rice = 0), α = Intercept, X_1 = Family size (number of family members), X_2 = Age (year), X_3 = Education (year of schooling), X_4 = Experience (year), X_5 = Occupation (score), X_6 = Farm size (unit), X_7 = Human labour (score), X_8 = Seed (score), X_9 = Training (score), X_{10} = Irrigation (score).

Besides, it is important to note that since the socio-economic characteristics of farmers may vary from region to region, so the observational results across various land locales are liable to give a few variations.

Results and Discussion

Financial profitability analysis of chickpea and boro rice cultivation

Table 1 shows per hectare cost and return of chickpea and boro rice production where the gross return was higher for chickpea than boro rice. Table 1 also indicates that chickpea cultivars experienced lower costs than boro rice cultivars. Besides, chickpea cultivation needs comparatively lower labor and less irrigation cost than boro rice (Table 2). As boro rice is a labor-intensive crop, the most important factors for boro rice cultivation were human labor, seed, urea, insecticide, and irrigation (Sujan *et al.*, 2017; Nargis *et al.*, 2009). Ultimately, the cultivars of chickpea crop earned higher gross return, gross margin, and net return per hectare than the cultivars of boro rice crop. Therefore, the benefit-cost ratio of chickpea, which was 1.88, claimed higher than the benefit-cost ratio of boro rice, which was 1.05. Based on the above discussions in Table 1, it could be said that the cultivation of chickpea was estimated more profitable than that of boro rice. Consequently, the cultivation of chickpea other than boro rice would help growers to increase their income. So, chickpea has a head start in this agricultural race (Merga and Haji, 2019), and in the drought-prone area, chickpea cultivation is comparatively more profitable for the farmers.

Table 1. Per hectare cost and return from chickpea and boro rice production.

Items	Chickpea (BDT)	Boro rice (BDT)	t-value
Value of main product	84975(314.15)	80340(423.19)	-9.772
Value of bi product	1908(7.11)	5700(11.08)	-4.643
A. Gross Return	86883(320.48)	86040(431.38)	-9.703
Human labor cost	12051(46.23)	39552(227.26)	-13.548
Power tiller	4944(133.29)	4944(1456.49)	-3.416
Seed cost	5018.16(122.85)	2163(81.76)	5.056
Fertilizer cost	2088.84(35.82)	5722.68(218.95)	-13.964
Insecticide cost	1236(24.08)	1854(68.49)	-10.918
Herbicide cost	2472(33.26)	370.8(13.42)	-3.066
Irrigation cost	0(0)	8652(375.27)	-16.889
B. Total Variable Cost	27810(97.15)	63258.48(491.33)	-10.925
Land use cost	18000(78.14)	18000(77.80)	6.322
Interest on operating Capital	331.22(4.76)	672.12(34.40)	-6.365
C. Total Fixed Cost	18295.48(78.11)	18672.12(76.87)	4.100
D. Total Cost (B+C)	46105.48(125.44)	81930.6(494.19)	-9.724
E. Gross Margin (A-B)	59073(238.57)	22781.52(400.03)	0.607
F. Net Return (A-D)	40777.52(246.66)	4109.4(344.85)	-0.349
G. Undiscounted BCR (A/D)	1.88(0.06)	1.05(0.05)	3.656

Note. ( ) indicates standard error.

Summary statistics of independent variables used in the econometric model

This section aims to find out the summary statistics of explanatory variables used in the probit model for chickpea and boro rice are shown in Table 2. The table shows that the mean difference between chickpea and boro rice cultivation respecting occupation, farm size, human labor, seed, training, and irrigation were statistically significant. Chickpea growers had completed more years of schooling than boro rice growers. However, the farming experience was around 20 years for boro rice growers and family size consisted of around five members in one family. Besides, chickpea growers are involved with other occupations along with agriculture where maximum boro rice growers are only involved with agriculture. Following the estimation, boro rice cultivation required more labor and irrigation than chickpea cultivation in those drought-prone areas. As the proportion of labor and irrigation requirements are approximately 2 and 1.6 times higher than chickpea cultivation, respectively. The growers of chickpea received more high yielding variety of seeds from government organization where it is found low for boro rice farmers.

Table 2. Summary Statistics of explanatory variables for chickpea and boro rice farmers.

Variable	Chickpea (N=90)	Boro rice (N=90)	Mean Difference
Family size	4.26(0.202)	4.54(0.179)	0.29(0.270)
Age	44.30(1.354)	42.97(1.229)	1.33(1.821)
Education	7.14(0.435)	6.63(0.443)	0.51(0.621)
Experience	19.53(1.273)	19.59(1.293)	0.06(1.815)
Occupation	1.38(0.052)	1.11(0.037)	0.28(0.063) ***
Farm size	2.72(0.146)	3.93(0.228)	1.22(0.271) ***
Human labour	1.63(0.076)	3.16(0.101)	1.52(0.127) ***
Seed	0.87(0.036)	0.38(0.051)	0.49(0.063) ***
Training	0.80(0.042)	0.61(0.052)	0.19(0.067) **
Irrigation	1.54(0.063)	2.51(0.053)	0.97(0.083) ***

*Note. ( ) indicates standard error. *** Significant at the 1 percent level; **Significant at the 5 percent level; *Significant at the 10 percent level.*

Determinants of chickpea and boro rice cultivation

The cultivation of chickpea and boro rice is likely to be influenced by different socio-economic factors. Table 3 shows that family size, human labor, and irrigation have negative influences, whilst occupation, farm size, and seed have an affirmative impact.

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Table 3. Parameter estimates of variables determining chickpea and boro rice cultivation among respondent farmers.

Explanatory variables	Coefficients	z-statistic	Marginal effect
Family size	-0.36(0.148)***	-2.42	-0.022***
Age	0.09(0.062)	1.42	0.006
Education	-0.01(0.062)	-0.10	-0.0004
Experience	-0.01(0.057)	-0.13	-0.0005
Occupation	0.99(0.506)*	1.96	0.062*
Farm size	0.82(0.228)***	3.58	0.051***
Human labour	-3.29(0.839)***	-3.91	-0.205***
Seed	2.30(0.657)***	3.51	0.144***
Training	0.59(0.516)	1.15	0.037
Irrigation	-1.43(0.406)***	-3.54	-0.089***
Constant	2.50(2.011)	1.24	
LR chi-square (10) = 208.68			
Log likelihood = -20.43			
Pseudo R² = 0.84			

Note. *** Significant at p < 0.01; ** significant at p < 0.05; * significant at p < 0.10; ( ) indicates standard error.

According to Table 3, the adoption probability of chickpea cultivation is negatively affected by the variable of family size. If the family size increases, the farmers would be shifted to boro rice cultivation to meet up family consumption, as rice is the staple food of Bangladesh. It occupies nearly 90% of the total net-cropped area of the country and more than 99% of the people eat rice as their main food, which is 416 gm/person/day (Niaz *et al.*, 2013). So, family size is an important factor concerning the production of enough food grain for farm households. Those farmers, who are involved with other occupations such as business or different services accompanying agriculture, have the probability to adopt chickpea cultivation more than boro rice cultivation (Table 3). Because, getting higher scope to involve with off-farm activities, farmers provide less attention to rice production and ultimately it tends to be less efficient (Asadullah and Rahman, 2009; Rahman, 2003; Wang *et al.*, 1996; Ali and Flinn, 1989). Nonetheless, the farmers with off-farm income are indolent to adopt modern chickpea varieties due to their more priorities on non-agricultural activities (Sharna *et al.*, 2020a).

The variable of farm size has a positive and significant effect, which means that one unit increased the size of the farm increases the probability of chickpea cultivation by 5.1%. It indicates that small farmers normally used their land for rice cultivation both for earning income as well as to meet their household consumption demand. On the other hand, larger farmers attempt to use their additional land for chickpea cultivation for extra income. Some studies found that farm size influences adoption of agricultural technologies, as it is easy for large farmers to be acquired with agricultural inputs and other services (Mariano *et al.*, 2012; Chirwa, 2005; Isham, 2002; Zegeye *et al.*, 2001). However, these results are contrary to what Shiyani *et al.* (2002) found on the adoption of improved chickpea varieties in India. Another reason for that is, water logging is harmful to the chickpea field by decreasing productivity of grain yield (Palta *et al.*, 2010; Cowie *et al.*, 1996). Sometimes, water can be passed from the adjacent land so that the small and marginal farmers cannot ensure dry land for their chickpea field. Rather, it is easy for large farmers to monitor their chickpea fields properly.

The coefficient of human labor is negatively significant which indicates the probability of adopting boro rice over chickpea if enough human labor is available in the study area (Table 3). Because at every stage of land preparation as well as for harvesting period, boro rice requires more labor than chickpea cultivation and occurs higher labor cost than chickpea (Table 1). Additionally, several studies have shown the positive effect of human labor upon boro rice cultivation (Rahman and Nargis, 2015; Chowdhury, 2012).

The variable of seed has a positive effect on the probability of cultivating chickpea rather than boro rice. Since seed cost is higher for chickpea than boro rice (Table 1), chickpea farmers rely on government organization through which they get high yielding variety chickpea seeds with minimum or free of cost. Furthermore, Sharna *et al.* (2020b) found that governmental institutions in Bangladesh, for instance, the Department of Agricultural Extension (DAE) and Bangladesh Agricultural Development Corporation (BADC) subsidizes chickpea production by providing improved chickpea variety seeds with resistance characteristics, which are more profitable than traditional varieties. Meanwhile, more than 50% of the rice farmers in Bangladesh use seeds from the harvested products (Shelley *et al.*, 2016). A study showed that Bangladesh Agricultural Development Corporation (BADC), the main government organization in charge of producing and marketing quality seeds, contributes only about 25% of the rice seeds planted (Hossain,

2012). The coefficient of irrigation is negatively significant on the probability of chickpea cultivation (Table 3). If availability increases for irrigation supply, the growers in the study area would prefer to cultivate boro rice more than chickpea. Farmers, whose fields are located near the irrigation system, easily adopt boro rice cultivation. Because drought is one of the major abiotic constraints for rice grown under rainfed conditions in Bangladesh and causes a substantial reduction in yield (Shelley *et al.*, 2016). Hence, the growers who are not capable to manage irrigation facilities are eager to cultivate chickpea more than boro rice. So, irrigation variable is an important factor to influence the adoption decision of crops (Mottaleb *et al.*, 2014; Rahman, 2008).

Conclusion

The study has been undertaken to make financial profitability analysis and identify the determinants that affect the adoption decision between chickpea and boro rice cultivation. The study reveals that chickpea cultivation is more profitable crop, in comparison to boro rice in the drought-prone areas of Bangladesh. Cultivation of chickpea results higher gross return and ultimately provides a higher Benefit-Cost Ratio than boro rice.

Farmer's family size significantly affects the probability to adopt chickpea cultivation. The number of family members is an important factor to affect the farmer's decisions. Occupation plays an important role to adopt chickpea cultivation. Getting off-farm income along with farming helps to motivate the farmers to adopt less boro rice cultivation, considering its higher labor requirement. Farmer's adoption probability for chickpea cultivation enhances with farm size. Large farmers can fulfill the daily consumption requirement of rice easily and allot extra land for chickpea cultivation. On the other hand, small farmers may use their land only for boro rice cultivation to meet family consumption demand. Another crucial thing is wetland, which hampers chickpea yield very much. Those who have small lands cannot avoid their lands being damped through the water flowed down from neighboring lands. Hence, it is easier for large farmers to maintain the required dryness of their chickpea lands properly. Meanwhile, the availability of human labor would help the farmers to cultivate boro rice more than chickpea in the study area. The adoption probability for chickpea cultivation rises with the increasing probability of getting improved seeds. Acquiring a high yielding variety of seeds from government organizations assist the sample farmers to prefer chickpea cultivation. Another important determinant is irrigation, which negatively affects the probability of chickpea cultivation. Consequently, the availability of irrigation facilities convinces the farmer to adopt boro rice cultivation more than

chickpea cultivation in this drought-prone area. The paper suggests employing proper policies to increase the production of chickpea in drought-prone areas to reduce the demand for irrigation water and human labor. Thus, soil quality and groundwater level can be maintained through widening the cultivation of chickpea, as it requires less water and fertilizer than rice cultivation.

Acknowledgment

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Appendix

Table A.1. Description of explanatory variables used in the probit model.

Variables	Measurement Technique
Family size	Number of family members
Age	Farmer's age (year)
Education	Farmer's passing year(s) of schooling
Experience	Farmer's year(s) of experience
Occupation	Agriculture = 1; business along with agriculture =2; otherwise =3
Farm size	Farm size in hectares
Human labor	Labour required below 18 man-days/ha = 1; labour required between 18-21 man-days/ha = 2; labour required between 21-24 man-days/ha = 3; labour required above 24 man-days/ha = 4
Seed	Dummy, getting high yielding variety seeds from government organization = 1; otherwise = 0
Training	Dummy, received training = 1; otherwise = 0
Irrigation	Higher distance from irrigation facility = 1; moderate distance from irrigation facility = 2; Lower distance from irrigation facility = 3