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PROFITABILITY ANALYSIS AND COMPARATIVE ADVANTAGE OF LENTIL PRODUCTION IN BANGLADESH

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ABSTRACT

The study estimated the profitability and comparative advantage of lentil production in Bangladesh. It analyzed 360 household's data collected from 240 improved variety users and 120 non-users spread in the six lentil growing districts namely Faridpur, Magura, Kushtia, Jhenaidah, Manikganj, and Sirajganj. Along with descriptive statistics, different models were used for analyzing the data. The yield of improved variety (1.664 t/ha) was much higher than local cultivars (1.08 t/ha). The highest yield was found in medium-intensive growing areas due to the use of better variety and a higher level of inputs. Improved lentil cultivation was profitable from the financial point of view (Tk. 48,165/ha) and an economic perspective (Tk. 15,083/ha). The prices of pesticides, seed, cowdung, and DAP fertilizer were common factors that had a negative significant effect on the net return of both improved and local variety lentil production. The domestic production of improved lentils had a comparative advantage (DRC= 0.72). Some lentil farmers wanted to decrease lentil cultivation due to lack of suitable land, biotic and abiotic stresses, and lack of improved lentil seeds. Farmers should be encouraged to expand their lands for improved lentil cultivation to increase their benefit, improve soil fertility, and for a better comparative advantage of production.

Keywords: Lentil production, profitability, cost function, profit function, comparative advantage, Bangladesh

I. INTRODUCTION

Pulses are important food crops of Bangladesh as it supplies nutrition for human diet (Das *et al.*, 2016.), provides feed for the animal (Miah *et al.*, 2009), increase soil nutrient status by adding nitrogen, carbon and organic matter (Sharma and Jodha, 1982; Senanayake *et al.*, 1987; Zapata *et al.*, 1987; Sarker and Kumar, 2011), and improves farmers' livelihood through additional income. Because of the high protein content and low cost, pulses are called *poor man's meat* (Sumera and Ali, 2020;

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Bhatty, 1988). So, most of the low-income populations can use this nutritious crop as their staple food. The per capita consumption of pulse in our country is only 15.7 g/day (HIES, 2016) which is much lower than the desirable intake of 50 g/day (DDP, 2013).

Lentils (*Lens culinaris*) are protein-rich legumes that provide important micronutrients in a rice-based diet (ISPC, 2018). It is cultivated in different parts of the country covering an area of 0.141 million hectares with an annual production of 0.177 million metric tonnes, and the average yield is 1.26 t/ha. Among the pulse crops in Bangladesh (BBS, 2021), lentils placed the first position according to area coverage (40% of total pulse area) and production (45% of total pulse production). It is the most consumed pulse in the country and also ranks first among the pulses in terms of consumers' preferences (Miah and Rahman, 1991; Afzal *et al.*, 1999). The area and production of lentils were found fluctuating in nature, but the yield registered an increasing trend over the years. The area and production of lentils started decreasing from 2000-01 and continued up to 2008-09 that might be due to susceptible crop and less remunerative in production. The area, production, and yield of lentils further increased steadily from 2009-10 to 2019-20 due to the inclusion of improved varieties in the cropping patterns replacing local by improved varieties (Miah *et al.*, 2021). However, various businesses and importers say that the country's yearly requirement for lentils is around 6-7 lakh MT (The Daily Star, 4 July 2021) which is much higher than the current production. Therefore, the country has to import a huge amount of lentils every year to meet up the domestic demand.

Economic viability is one of the important criteria for assessing the suitability of a new crop technology. The improved lentil varieties so far developed and disseminated among farmers have been found suitable for the farmers in terms of productivity and profitability (Sarker *et al.*, 2020; Matin *et al.*, 2018; Tithi and Barmon, 2018; Hossain *et al.*, 2016; Islam *et al.*, 2015; Rahman *et al.*, 2012; Islam *et al.*, 2010). All the relevant aforesaid past studies estimated the profitability of lentils production without considering their varieties and did not measure its profitability from an economic point of view under the import parity level in Bangladesh. Again, most of the aforesaid studies were conducted on a limited sample size covering a narrow geographical location. However, the present study covered all these issues to a large extent. The estimation of comparative advantages of lentil production in Bangladesh has been received less attention. Tithi and Barmon (2018), Kazal *et al.* (2013), and Rashid and Hasan (2012) estimated comparative advantage of lentil production without considering its variety, whereas proper attention was given on this issue in the present study. Therefore, the present study estimated the financial and economic profitability, and comparative advantage of improved and local lentil production. The findings of the study are expected to provide valuable information and may be useful to the researchers of BARI as well as the policymakers of both GO and NGOs for formulating an appropriate policy for the widespread cultivation of lentils in Bangladesh.

II. MATERIALS AND METHODS

Sampling design

Based on the crop concentration index, the study was conducted in purposively selected six lentil growing districts of Bangladesh, taking Faridpur and Magura districts from highly-intensive growing areas, Kushtia and Jhenaidah districts from medium-intensive growing areas, and Manikganj and Sirajganj districts from low-intensive growing areas. Again, in each district two *Upazilas* (administrative unit) and from each *Upazila* one/two Agricultural Blocks (ABs) were purposively selected for collecting data and information from the sample farmers. The *Upazilas* and ABs were chosen in consultation with Agricultural Extension Officer, SAAO, and local BARI scientists. Finally, two lists of lentil growing farmers (improved lentil variety users and non-users) were prepared separately for each AB, and then a total of 30 farmers, taking 20 farmers from improved seed users and 10 from non-users were randomly selected from each *Upazila* for interview. Thus, the total numbers of users and non-users were 240 and 120 respectively (Table 1).

Table 1. Distribution of sample lentil growing farmers in the study areas

Study area		Improved	Local	All category
Highly-intensive growing area	Faridpur	40	20	60
(**CCI value = 5.54-11.31*)	Magura	40	20	60
Medium-intensive growing area	Kushtia	40	20	60
(*CCI value = 1.09-4.87*)	Jhenaidah	40	20	60
Low-intensive growing area	Manikganj	40	20	60
(*CCI value = 0.02-0.83*)	Sirajganj	40	20	60
All areas		240	120	360

$*Crop\ concentration\ index\ (CCI) = (Total\ area\ under\ lentils\ \div Totalcropped\ area) \times 100$

Data collection procedure

Data for the present study were collected by interviewing sample lentil growers with the aid of a pre-designed and pre-tested interview schedule during the period from March to April 2021. Both trained enumerator and researcher collected primary data. Concerning this study, secondary data on lentil area and production were also collected and used to supplement the study.

Analytical techniques

In most cases, a tabular method of analysis supported with appropriate statistical parameters was used to present the study results. The profitability of lentil cultivation was examined based on gross margin, net return, and benefit cost ratio (BCR) on production cost. The following different econometric models were also used in this study.

Profitability analysis

The profitability of lentil cultivation was calculated with the following formula (equation 1) proposed by Dillon and Hardker (1980).

$$\eta = (AP+SQ) - TC = (AP+SQ) - (TVC + TFC) \text{ ------------------------------ } (1)$$

Where, Ƞ = Net profit from lentil production (Tk/ha); A = Amount of lentil produced (kg/ha); P = Average price of lentil (Tk./kg); S = Amount of straw (kg/ha); Q = Average price of straw (Tk./kg); TC = Total cost of production (Tk./ha); TVC = Total variable cost (Tk./ha); TFC = Total fixed cost (Tk./ha)

Cost function model

A cost function is a mathematical relationship used to chart how production cost will change at different output levels. It estimates the total cost of production given a specific quantity produced. It also measures the minimum cost of production of a given level of output for some fixed factor prices. The form of a linear cost function (equation 2) is given below:

$$C = a + bx \text{ -- } (2)$$

Where, C is the total cost (TC); *a* is called the fixed cost (FC); coefficient *b* is called the marginal cost, and *x* is the number of factors.

A firm/farmer minimizes costs by adjusting the amount of inputs and output with a given input price vectors (W) and output (Y). Thus, the cost function can be expressed implicitly as C = f (Y, W; V, U). Where, V is random error and U is cost inefficiency effect. The specification of such type of cost function can be seen in the study of Pollak *et al.* (1984). However, the following empirical cost function model (equation 3) was used in this study to estimate the contribution of factors to the total cost of lentil production.

$$\ln C = \alpha + \beta_1 lnY_1 + b_1 lnX_1 + b_2 lnX_2 + b_3 lnX_3 + b_4 lnX_4 + b_5 lnX_5 + b_6 lnX_6 + b_7 lnX_7 + b_8 lnX_8 + b_9 lnX_9 + b_{10} lnX_{10} + b_{11} lnX_{11} + b_{12} lnX_{12} + b_{13} lnX_{13} + b_{14} lnX_{14} + Ui \text{ -------------------------------------- } (3)$$

Where, C = Total cost of production (Tk/ha); Y_1 = Amount of production (kg/ha); X_1 = Opportunity cost of land use (Tk/ha); X_2 = Cost of tillage (Tk/ha); X_3 = Cost of pesticides (Tk/ha); X_4 = Cost of irrigation (Tk/ha); X_5 = Price of human labour (Tk/man-day); X_6 = Price of seed (Tk/kg); X_7 = Price of cowdung (Tk/kg); X_8 = Price of Urea (Tk/kg); X_9 = Price of TSP (Tk/kg); X_{10} = Price of MoP (Tk/kg); X_{11} = Price of Boron (Tk/kg); X_{12} = Price of ZnSO4 (Tk/kg); X_{13} = Price of DAP (Tk/kg); Ui = Error term; β_1, b_1---- b_{13} = Respective coefficients (represents marginal cost of production)

Profit function model

A profit function is a mathematical relationship between a farm's total profit and output. Farm’s profit is maximum when its marginal revenue equals its marginal cost (MVP=MFC). It causes the average total cost to rise and the profit to fall. The profit function $P(\boldsymbol{x})$ is the difference between the revenue function R(x) and the total cost function $C(\boldsymbol{x})$. Thus, the profit function model (equation 4) is as follows:

$$P(\boldsymbol{x}) = R(\boldsymbol{x}) - C(\boldsymbol{x}) \text{ -- } (4)$$

The standard profit function assumes that markets for outputs and inputs are perfectly competitive. In that case, a firm/farmer maximizes profits by adjusting the amount of inputs and output with a given input (W) and output price vectors (P). Thus, the profit function can be expressed implicitly as Ƞ = f (P, W; V, U) and in logarithms terms: In (θ) = Inf (P, W) + (V-U). Where θ is a constant added to the profit of each firm for attaining positive values, enabling them to be treated logarithmically, V is random error and U is profit inefficiency effect. Basically, there are no perfectly competitive markets for outputs and inputs on the firms'/farmers side due to the exogenous nature of prices. If instead of taking price as given, the firms/farmers assume the possibility of imperfect competition, given only the output vector and not that of price. Thus, alternative profit function is defined as Ƞa = Ƞa(Y, W, V, U) in which the quantity of output (Y) produce replaces the price of output (P) in the standard profit function (Kolawole, 2006).

However, to estimate the contribution of factors to the net profit from lentil production, the following empirical profit function model (equation 5) was used in this study.

$$\text{Ln } Ƞ = \alpha + \beta_1 lnY_1 + b_1 lnX_1 + b_2 lnX_2 + b_3 lnX_3 + b_4 lnX_4 + b_5 lnX_5 + b_{6ln}X_6 + b_7 lnX_7 + b_8 lnX_8 + b_9 lnX_9 + b_{10} lnX_{10} + b_{11} lnX_{11} + b_{12} lnX_{12} + b_{13} lnX_{13} + Ui \text{ -- } (5)$$

Where, Ƞ = Net profit (Total revenue-Total cost), (Tk/ha); Y_1 = Amount of lentil; production (kg/ha); Y_2 = Amount of straw (kg/ha); X_1 = Opportunity cost of land use (Tk/ha); X_2 = Cost of land tillage (Tk/ha); X_3 = Cost of pesticides (Tk/ha); X_4 = Cost of irrigation (Tk/ha); X_5 = Price of labour (Tk/day); X_6 = Price of seed (Tk/kg); X_7 = Price of cowdung (Tk/kg); X_8 = Price of Urea (Tk/kg); X_9 = Price of TSP (Tk/kg); X_{10} = Price of MoP (Tk/kg); X_{11} = Price of Boron (Tk/kg); X_{12} = Price of ZnSO4 (Tk/kg); X_{13} = Price of DAP (Tk/kg); Ui = Error term; $\beta_1, \Phi_1, \Phi_2 b_1$---- b_{13}= Respective coefficients (represents marginal revenue of production)

Domestic resource cost (DRC)

The domestic resources cost (DRC) is widely used in developing countries for measuring comparative advantage, efficiency, and guiding policy reforms. The DRC, defined as the shadow value of non-tradable inputs used in an activity per unit of tradable value-added. In another way, it is the ratio of the shadow value of domestic resources and non-traded inputs to the net foreign exchange earned or saved by producing the good domestically (Morris, 1989; Masters and Winter-Nelson, 1995; Sadoulet and de Janvry, 1995; Anwar, 2004; Islam and Kirschke, 2010). The following formula (equation 6) was used in this study for calculating DRC (Miah and Rashid, 2015).

$$DRC = \frac{\sum D_{ij} V_i}{B_i - \sum T_{ik} V_k} \quad (j = 1\text{--------}m;\ k = 1\text{-------}n) \text{------------------------} (6)$$

Where, D_{ij} = Quantity of jth domestic resources & non-traded inputs for producing icrop per metric ton; V_i = Price (Tk/MT) of jth domestic resources and non-traded inputs; B_i = Boarder price (Tk/MT) of i crop; T_{ik} = Quantity of kth tradable inputs used for producing i crop per metric ton; V_k = Boarder price (Tk/MT) of kth tradable inputs

If DRC<1, the economy can save foreign exchange by producing the i^{th} crop domestically either for export or for imports substitution. In contrast, if DRC>1, domestic costs were more than foreign exchange or savings indicating that *i* crop should not be produced domestically and should be imported instead.

II. RESULTS AND DISCUSSION

Input use pattern

The total number of human labour used for cultivating improved and local lentils was 72 and 63 man-days/ha respectively. Improved lentil growing farmers used hired labour more than local lentil growers. The highest number of labour (82 & 74 man-days) was used in the medium-intensive growing areas. Respondent farmers used different BARI-developed improved varieties of seed namely BARI Masur-8, -7, -6, and -4. The seed rates were 46 kg and 44 kg per ha for improved and local variety lentils respectively. These rates were a bit higher than the recommended rate (35-40kg/ha). The applications of urea, TSP, and MoP for improved variety lentils in all study areas were a bit higher than the recommended dose. This was done might be due to their ignorance in applying fertilizers. However, the overall use of inputs was higher for cultivating improved varieties compared to local cultivars and this statement was true for different growing areas as well (Table 2).

Cost of production and its influencing factors

The average total costs of cultivation were Tk. 68,049 and Tk. 60,108 per hectare for improved and local variety lentils, respectively. The shares of variable cost and fixed cost were 55.1-53.3% and 44.9-46.7% respectively for improved and local variety. Human labour shared 35.2-36.2% of total cost, followed by land use (29.3-31.9%), land preparation (10.6-11.0%), manure & fertilizers (8.7-10.5%), and seed (6.9-7.3%). In earlier studies (Sarker *et al*., 2020; Matin *et al*., 2018; Tithi and Barmon, 2018; Rahman *et al*., 2012), the percent share of the cost of improved lentil production varied to a large extent for different inputs such as labour (27-41%), seed (5.4-8%), fertilizers (7-15%), and land use (17-36%). However, the average costs of improved and local variety lentils cultivation were found highest in the medium-intensive growing areas (Tk. 78,258 & Tk. 70,191/ha).

Table 2. Per hectare use of inputs in improved and local variety lentil cultivation

Input	High-growing area		Medium-growing area		Low-growing area		All area		Recomm. rate
	Impr.	Local	Impr.	Local	Impr.	Local	Impr.	Local	
Labour (m-day)	69	61	82	74	66	54	72	63	--
Hired labour	*41*	*38*	*46*	*39*	*42*	*36*	*43*	*38*	--
Family labour	*28*	*23*	*36*	*35*	*24*	*18*	*29*	*25*	--
Seed (kg)	48	47	49	47	42	39	46	44	35-40
Cow dung (kg)	1327	154	4772	4130	718	--	2272	1428	--
Urea (kg)	47	42	48	45	45	41	47	43	40-45
TSP (kg)	92	90	96	91	89	87	92	89	80-90
MoP (kg)	47	40	52	43	46	38	48	40	40-45
Boron (kg)	4.8	2.7	3.9	0.7	1.2	0.2	3.3	1.2	7-10
$ZnSO_4$ (kg)	3.9	2.1	3.8	0.7	0.8	0.6	2.9	1.1	--
DAP (kg)	10.7	8.6	19.0	2.5	7.9	6.8	12.5	6.0	--
Irrigation (Tk.)	2596	2649	1361	681	656	956	1538	1429	*once
Pesticides (Tk.)	1367	1282	1993	1236	770	95	1377	871	--

* Once within 30-40 days after germination

Table 3. Per hectare cost of improved and local variety lentil production in the study areas

Cost heading	High-growing area		Medium-growing area		Low-growing area		All area		% of TC	
	Impr.	Local	Impr.	Local	Impr.	Local	Impr.	Local	Impr.	Local
Variable cost	**38620**	**32813**	**41819**	**34515**	**31989**	**28773**	**37476**	**32022**	**55.1**	**53.3**
Land preparation	7101	6247	8259	7327	6793	6594	7384	6723	10.9	11.2
Hired labour	15294	13034	14857	12625	14598	13207	14916	12955	21.9	21.6
Seed	5124	4623	5157	4958	4025	3875	4769	4485	7.0	7.5
Manure/fertilizer	***6756***	***4653***	***9778***	***7347***	***4831***	***3761***	***7121***	***5242***	***10.5***	***8.7***
Cowdung	1204	124	3843	3231	555	0	1867	1118	2.7	1.9
Urea	780	707	806	745	750	688	779	720	1.1	1.2
TSP	2323	2265	2604	2344	2219	2197	2382	2260	3.5	3.8
MoP	759	641	848	692	740	602	782	636	1.1	1.1
Boron	813	385	626	141	215	23	551	183	0.8	0.3
$ZnSO_4$	611	281	595	127	147	76	451	161	0.7	0.3
DAP	266	250	456	67	205	175	309	164	0.5	0.3
Irrigation	2596	2649	1361	681	656	956	1538	1429	2.3	2.4
Pesticides	1367	1282	1993	1236	770	95	1377	871	2.0	1.4
Int. on OC	382	325	414	341	316	285	371	317	0.5	0.5
Fixed cost	**32107**	**27596**	**36439**	**35676**	**23174**	**20986**	**30573**	**28086**	**44.9**	**46.7**
Land use	21632	19710	24606	24482	14833	14409	20357	19534	29.9	32.5
Family labour	10475	7886	11833	11194	8341	6577	10216	8552	15.0	14.2
Total cost (TC)	**70727**	**60409**	**78258**	**70191**	**55163**	**49759**	**68049**	**60108**	**100**	**100**
Total cost (Tk./kg)	39.1	56.1	43.5	61.5	39.8	48.5	40.9	55.6		

Note: Tk means Bangladeshi currency Taka (BDT), 1 USD = 85 BDT

The total cost of production of lentils is likely to be influenced by different input prices, input costs, and the scale of production. The significant common factors of the total cost of production for improved and local variety were lease cost, TSP price, and DAP price (Table 4). The coefficient of total production is positive and highly significant meaning that 1% increases in the total production of improved lentils, keeping other factors remaining constant, would increase the total cost of production by 0.224%. Similarly, the coefficients of land-use cost are positive and significant indicating that 1% increases in the land-use cost of both improved and local lentils, keeping other factors remaining constant, would increase the total cost of production by 0.232% and 0.427% respectively. The price of TSP had a significant positive effect on increasing the total production of improved lentils, whereas this effect was significantly negative on the total cost of local lentils production. However, DAP price had a significant positive effect on the total cost of production of both types of lentils.

Table 4. Coefficients of the variables used in Cobb-Douglas type cost function

Variables	Improved variety			Local variety		
	Coefficient	Std. error	Sig. level	Coefficient	Std. error	Sig. level
Constant	***4.697	1.203	0.000	***7.218	2.048	0.001
LnProd	**0.224	0.098	0.023	0.115	0.090	0.205
LnLeasecost	***0.232	0.049	0.000	***0.427	0.065	0.000
Lntillagecost	***0.197	0.047	0.000	-0.012	0.063	0.846
LnPesticost	0.005	0.004	0.190	0.005	0.005	0.298
LnIrrigacost	0.003	0.003	0.346	0.005	0.004	0.182
LnLabPric	-0.090	0.116	0.438	-0.145	0.165	0.380
LnSeedPric	0.035	0.121	0.772	0.213	0.219	0.334
LnDungPric	-0.102	0.064	0.115	0.042	0.089	0.639
LnUreaPric	0.132	0.222	0.552	0.451	0.402	0.265
LnTSPPric	***0.389	0.107	0.000	***-0.593	0.162	0.000
LnMoPPric	-0.219	0.228	0.338	-0.237	0.349	0.500
LnBorPric	0.003	0.006	0.644	0.004	0.010	0.692
LnZnPric	-0.008	0.006	0.196	**0.023	0.011	0.043
LnDAPPric	*0.018	0.011	0.101	***0.047	0.017	0.006
F-value	16.746***			8.763***		
R^2	0.51			0.54		
N	240			120		

Note: ***, **, &* represent significant at 1%, 5% and 10% level respectively
Dependent Variable: Total cost of production (Tk./ha)

Profitability of lentil production and its influencing factors

The average return from lentil production in different locations is shown in Table 5. The average yield of improved lentil varieties (1.664 t/ha) was much higher (33.5%) than that of the local cultivar (1.081 t/ha). The yields of both improved and local varieties were higher at the medium-intensive growing areas compared to highly-intensive and low-intensive growing areas might be due to the use of higher amounts of inputs and improved variety (BAR Masur-8). The yield of a crop depends on many agro-socio-economic and environmental factors. It varies from variety to variety, location to location, and year to year. Rahman *et al.* (2012) recorded the higher yield (1.733 t/ha) of BARI Masur varieties (3, 4, 5, & 6) in Jhenaidah and Jashore districts during 2010-11. In the next year (2011-12), it was 1.479 t/ha in Jashore, Meherpur, and Natore districts (Matin *et al.*, 2018). Kazal *et al.* (2013) recorded much lower yield (1.160 t/ha) in Natore and Bogura districts during 2012.

The average total return from improved and local variety lentils production was estimated at Tk. 1,16,214 and Tk. 77,976 per hectare respectively. Again, the average net return from improved lentil production (Tk. 48,165) was much higher compared to local cultivars (Tk. 17,868). Even there were lower selling prices of grain (lentil) and straw, the improved lentil cultivating farmers obtained 32.9% higher gross and 62.9% higher net income compared to local cultivars users which was due to higher yield. The benefit-cost ratio (BCR) of improved variety production over variable cost and total cost were respectively 3.10 and 1.71, whereas it was 2.44 and 1.30 for local variety. The benefit-cost ratios over TC and VC were also 24.0% and 21.5% higher respectively for improved lentil cultivating farmers. However, the profitability indicators imply that the cultivations of both improved and local variety lentils at the farm level are profitable.

Table 5. Financial profitability of improved and local variety lentil production in the study areas

Particular	Highly-intensive growing area		Medium-intensive growing area		Low-intensive growing area		All area	
	Impr.	Local	Impr.	Local	Impr.	Local	Impr.	Local
1. Lentil yield (kg/ha)	1810	1077	1798	1142	1385	1025	1664	1081
2. Lentil price (Tk./kg)	68.0	68.5	69.0	71.5	66.5	67.5	67.8	69.2
3. Straw amount (kg/ha)	846	692	923	808	882	736	884	746
4. Straw price (Tk./kg)	3.50	4.26	4.06	4.25	3.96	4.25	3.84	4.25
5. Total return (Tk./ha)	126041	76722	127809	85087	95595	72316	116214	77976
6. Total variable cost (Tk/ha)	38620	32813	41819	34515	31989	28773	37476	32022
7. Total cost (Tk./ha)	**70727**	**60409**	**78258**	**70191**	**55163**	**49759**	**68049**	**60108**
8. Gross margin (5-6)	87421	43909	85990	50572	63606	43543	78738	45954
9. Net return (5-7)	55314	16313	49551	14896	40432	22557	48165	17868
10. BCR on VC (5/6)	3.26	2.34	3.06	2.47	2.99	2.51	3.10	2.44
11. BCR on TC (5/7)	1.78	1.27	1.63	1.21	1.73	1.45	1.71	1.30

Table 5 further reveals that the improved variety users of highly-intensive growing areas received the highest net return (Tk. 55,314/ha) followed by medium-intensive (Tk. 49,551) and low-intensive growing areas. But the local variety users of low-intensive growing areas received the highest net return (Tk. 22,557) and medium-intensive growing areas received the lowest net return (Tk. 14,896**)** only due to lower and higher production costs respectively. The estimated BCRs over total cost for improved and local lentil varieties are 1.71 and 1.30 respectively. Matin *et al.* (2018) and Hajong *et al.* (2020) estimated BCRs (1.81 & 1.75) of improved variety lentils higher than the present result (1.71), but Rahman *et al.* (2012) estimated a BCR of 1.53 which was lower than the present study.

The net profit of lentil production is mostly influenced by different input prices and output. The total production was a common factor (for local and improved varieties) that had a positive and significant effect on the net returns of lentil production. The coefficients of total production are positive and significant at the 1% level meaning that 1% increases in the total production of improved and local variety lentils, keeping other factors remaining constant, would increase the net return by 1.39% and 3.96% respectively. Again, the prices of pesticides, seed, cowdung, and DAP fertilizer were common factors that had a negative significant effect on the net return of lentil production. Tillage cost and TSP price had a negative and Boron price had a positive and significant effect on the net return of improved lentil production. Only the labour price had a positive and significant effect on the net return of local variety lentil production (Table 6).

Table 6. Coefficients of the variables used in Cobb-Douglas type profit function for lentil

Variables	Improved variety			Local variety		
	Coefficient	Std. error	Sig. level	Coefficient	Std. error	Sig. level
Constant	**3.154	1.563	0.045	***-17.441	6.126	0.005
LnProduction	***1.390	0.121	0.000	***3.955	0.305	0.000
LnStraw	0.010	0.053	0.846	-0.212	0.199	0.289
LnTillagecost	*-0.099	0.061	0.102	-0.238	0.210	0.259
LnPestcidescost	**-0.005	0.002	0.015	**-0.018	0.007	0.011
LnIrrigationcost	0.001	0.002	0.658	-0.009	0.006	0.139
LnLabourprice	0.101	0.149	0.498	*0.905	0.494	0.070
LnSeedprice	*-0.285	0.155	0.067	*-1.189	0.711	0.097
LnDungprice	***-0.019	0.003	0.000	***-0.075	0.015	0.000
LnUreaprice	-0.412	0.292	0.161	1.644	1.300	0.209
LnTSPprice	*-0.258	0.144	0.075	-0.041	0.521	0.938
LnMoPprice	0.239	0.299	0.424	-0.820	1.137	0.473
LnZincprice	0.002	0.003	0.424	-0.014	0.013	0.292
LnBoronPrice	**0.007	0.003	0.011	-0.011	0.011	0.348
LnDAPprice	***-0.016	0.004	0.000	*-0.024	0.013	0.101
F-value		30.279***			16.831***	
R^2		0.653			0.692	
N		240			120	

Note: ***, **, * represent significant at 1%, 5% and 10% level respectively
Dependent variable: Net profit (Tk./ha)

Economic profitability and comparative advantage of lentil production

Economic profitability: An attempt was made to assess the profitability of lentil cultivation from an economic point of view under the import parity level in Bangladesh. The average net returns were calculated for improved and local variety lentils at Tk. 15,083/MT and Tk. -306/MT respectively. The highest net return (Tk.

17,038/MT) was received by the improved lentils producers of highly-intensive growing areas mainly due to the lower cost of production followed by the producers of low-intensive growing areas (Tk. 15,872/MT). In medium-intensive growing areas, the net return was Tk. 12,505/MT for the producers of improved lentil variety mainly due to higher input cost of production. However, the net return of local lentils production was negative for high and medium growing areas mainly due to the lower yield. In the case of improved verities, the highest BCR (1.42) was found in the highly-intensive growing areas and the lowest (1.38) in the medium-intensive growing areas. Again, the average BCR of local lentils production was less than unity (0.99) implies that local lentil production is not profitable from an economic point of view under the import parity level in Bangladesh (Table 7).

Comparative Advantage: Comparative advantage is an economy's ability to produce a particular good or service at a lower opportunity cost than its trading partners. It implies that the country should produce more of those commodities which have lower opportunity costs, and be concerned about exporting those commodities, if possible. Again, the country should decrease the production of those commodities which have higher opportunity costs producing domestically rather than importing at a cheaper price from abroad. In this study, the farm gate price was used as domestic producer price, and the CIF (Cost, insurance, and freight, *is an international shipping agreement, which represents the charges paid by a seller to cover the costs, insurance, and freight of a buyer's order while the cargo is in transit*) import price was taken in terms of world price to measure the comparative advantage for lentil production in the country.

Comparative advantage in producing lentils in the country was evaluated through the calculation of their domestic resource costs (DRCs). DRC of greater than one implies that the country loses foreign exchange through domestic production (in the sense that it uses more domestic resources than it generates net value added to tradable goods and services), while a DRC of less than one implying the production is efficient and makes a positive contribution to domestic value addition. The improved lentil varieties had a comparative advantage in domestic production for import substitution since its DRC is less than unity (0.72), whereas it is opposite for local variety (1.01).

However, the overall DRC scenario indicates that the production of local lentils was not so advantageous in Bangladesh since the value of DRC is greater than or close to unity (Table 7). The present DRC estimate is higher than the estimates of 0.39, 0.62, and 0.43 found respectively by Tithi and Barmon (2018), Kazal *et al*. (2013), and Rashid and Hasan (2012). The findings indicate the need for higher dissemination of the existing improved variety and strengthening research towards the generation of new lentil varieties along with better crop management techniques for achieving a higher comparative advantage in domestic production.

Table 7. Economic profitability and DRC of improved and local variety lentils production at import parity level

Particulars	Highly-intensive growing area		Medium-intensive growing area		Low-intensive growing area		All area	
	Impr.	Local	Impr.	Local	Impr.	Local	Impr.	Local
A. Traded input (Tk/MT)	**3933**	**6143**	**4359**	**5713**	**4892**	**6127**	**4344**	**5965**
Urea	834	1261	857	1266	1044	1285	907	1278
TSP	2067	3421	2171	3241	2613	3452	2249	3348
MoP	764	1099	851	1107	977	1090	848	1088
DAP	268	362	479	99	258	300	340	251
B. Non-traded inputs & domestic resources (Tk./MT)	**36795**	**52503**	**40903**	**58094**	**37003**	**44973**	**38340**	**52107**
Human labour	14237	19424	14844	20857	16562	19301	15103	19895
Land preparation	3923	5800	4593	6416	4905	6433	4438	6219
Seed	2831	4292	2868	4342	2906	3780	2866	4149
Other fertilizers	787	618	679	235	261	97	602	318
Manure	665	115	2137	2829	401	0	1122	1034
Pesticide	755	1190	1108	1082	556	93	828	806
Irrigation	1434	2460	757	596	474	933	924	1322
Interest on OC	211	302	230	299	228	278	223	293
Land use	11951	18301	13685	21438	10710	14058	12234	18070
C. Total input cost (A+B)	**40728**	**58646**	**45262**	**63807**	**41895**	**51100**	**42684**	**58073**
D. Output price (Tk./MT)	**57766**	**57766**	**57766**	**57766**	**57766**	**57766**	**57766**	**57766**
E. Net return (D-C)	17038	-880	12505	-6040	15872	6667	15083	-306
F. BCR (D/C)	1.42	0.98	1.28	0.91	1.38	1.13	1.35	0.99
G. Value added (D-A)	53834	51623	53408	52054	52875	51639	53422	51801
E. DRC (B/G)	0.68	1.02	0.77	1.12	0.70	0.87	0.72	1.01

Problems of lentil cultivation

Both improved and local lentils producers in the study areas mentioned numerous common issues regarding the problems of lentil production, but the magnitudes of their statements were not the same at all. The majority of the farmers (40-53.3%) opined about the attack of foot rot and stemphylium blight diseases. The leaves of the infected plants become yellow or reddish after 20-25 days of sowing, and the tip of the plant dries slowly due to attack of foot rot disease. This problem was more vital for local cultivars compared to improved varieties. Adverse weather (dense fog, excessive rain, heat, etc.) was another severe problem faced by 15.4-19.2% of respondent farmers. The infestation of lentils by insects (Aphids & cutworm) was reported by 8.3-9.2% of the farmers to be harmful for lentil cultivation. Some respondent farmers were facing the unavailability problem of quality lentil seed in the study areas. The lower yield of local lentils was mentioned as a crucial problem by 15% of farmers. The other problems faced by both types of farmers were lack of cash, the higher price of labour, and the low market price of lentils (Table 8).

Table 8. Problems of lentil cultivation in the study areas

Type of problems	Improved lentil farmer (*n=240*)		Local lentil farmer (*n=120*)	
	N	%	N	%
1. Infection of foot rot & stemphylium diseases	96	40.0	64	53.3
2. Adverse weather (fog, excessive rain, heat)	37	15.4	23	19.2
3. Lack of irrigation facility	28	11.7	12	10.0
4. Infestation of insects (Aphids, *Katui*)	22	9.2	10	8.3
5. Lack of quality seed	10	4.2	8	6.7
6. Lack of cash	15	6.3	7	5.8
7. Scarcity and higher cost of labour	12	5.0	8	6.7
8. Low yield	7	2.9	18	15.0
9. Low market price	5	2.1	3	2.5
10. Others*	8	3.3	6	5.0

Note: *Higher cost of inputs, low germination of seed, crop dies due to excessive salt, lack of tillage machinery, bad soil quality, etc.

III. CONCLUSIONS AND RECOMMENDATIONS

The average yield of improved variety is much higher than the yield of local cultivars. The highest yield has been found in medium-intensive growing areas due to the use of better variety and higher levels of inputs. The cultivations of both improved and local lentils are highly profitable from the financial point of view but moderately and negatively profitable from an economic perspective respectively. The prices of pesticides, seed, cowdung, and DAP fertilizer were common factors that had a negative significant effect on the net return of both improved and local variety lentil production. Although the domestic production of improved lentils has a comparative advantage, the production of local cultivars has no comparative advantage due to lower production, higher production costs, and the lower import price of lentils. These findings are true for all categories of the study areas. The overall production problems are not severe to both improved and local variety producing lentil farmers in all categories of the study areas. However, the infection of diseases and some abiotic stresses are the major bottlenecks of lentil cultivation.

It is vital to encourage farmers to cultivate and expand their lands for the cultivation of improved lentil varieties to improve soil fertility, increase the comparative advantage of production, raise the benefit of farmers, and achieve self-sufficiency in pulses in Bangladesh. Therefore, the following measures should be taken by the Government for further improvement of lentil cultivation in Bangladesh.

- The adequate supply of high-yielding and disease-resistant seeds of improved lentil varieties should be ensured at the farm level. The Field Service Wing of DAE should take initiatives through their related projects in this issue in association with national research institutes (i.e., BARI, BINA) and BADC.

- The current agricultural extension services in most of the areas are more dynamic and active compared to the past. Therefore, this department should be made more strengthened for disseminating the improved lentil technologies among farmers.
- Farmers need hassle-free credit facilities. Credit facilities with favorable terms and conditions should be extended to the enthusiastic lentil farmers.
- The appropriate measures for reducing the wage rate of labour and ensuring the irrigation facility may be the stimulus of expanding lentil cultivation in the study areas.
- Finally, the ongoing research on pulses for evolving high-yielding new lentil varieties along with improved management technologies should be strengthened.

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