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Technical, Al locative and Economic Efficiency of Citron (*JaraLebu*) Cultivation in Some Selected Areas of Sylhet District in Bangladesh

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Abstract—*Low productivity of citron is mostly due to the inability of the farmers to utilize the available technologies fully, resulting in lower efficiencies of production. Profitability and Data Envelopment Analysis (DEA) were used to estimate profitability, technical, al locative, cost, scale and pure technical efficiency in the citron cultivation on 70 farmers in Joyntapur and Guwainghatupazila of Sylhet district in Bangladesh. The study has indicated that citron cultivation is profitable agribusiness, but many of the citron farms have shown technical, al locative and economic inefficiency problems. The profitability analysis showed that the cost of production of citron was estimated Tk. 4,39,627 per hectare ; while the gross margin and net return were Tk. 11,12,476 and Tk. 10,55,776 respectively. The study also showed that on an average, the mean technical efficiency of citron was 0.514 represented that 49% inefficiency existed in the study area. The mean al locative efficiency was 0.564. The mean cost efficiency was found to be 0.283 represents the citron growers did not follow cost optimization. On the other hand the scale efficiency was 0.718 indicating that 28% inefficiency also remained in citron cultivation. On an average, the cost minimizing quantity of cowdunge was estimated to 20,206 kg/ha as against to actual of 100097 kg/ha implied that manure was really overused by 499% which the growers could be reduced without reducing the output. Divergence estimated between technically efficient inputs level and actual inputs use were 16% for manure, 2% for pesticides, 18% for bamboo use, 0.74% for irrigation and 17% for labour respectively. The study furthermore exposed that all the divergent of user inputs looked to be positive indicates that inputs applied for citron cultivation were more or less similar to technically inefficient level permits. These finding suggests that citron production in the research location would be significantly improved through training the farmers to be technically efficient.*

Keywords*: Efficiency, Profitability, Citron, Bangladesh.*

Introduction

Bangladesh is an agriculture based country, more than 40.6% labour force directly or indirectly depends on agriculture, whereas 10.98% of GDP is derived from agriculture (BBS, 2018).Bangladesh is blessed with many tropical horticultural (or fruit) species mainly due to its favorable geo-climatic conditions. More than sixty local or native fruits have been grown in the country for decades (Hosssain,1998).The total cultivated area of fruit crops in the country is about 0.69 million ha which is about 5% of the total cropped area. Beside the estimated fruit production in the country is 1.49 million tons and yield per year is 8.24 tons/ha (Abedin, 2006).The gross incomes from fruit crops are estimated to about 4.7 times higher than that of other crops in Bangladesh (Uddin & Hasan, 2002).Citrus fruits have long been valued as part of a nutritious and tasty diet. It is well established that citrus and citrus products are a rich source of vitamins, minerals and dietary fiber (non-starch polysaccharides) that are essential for normal growth and development and overall nutritional well-being. Lemon is very important citrus among many types of citrus fruits produced in Bangladesh. Soil and temperature of Bangladesh are favorable for lemon cultivation. In Bangladesh, about 69,32M.tomof lime and lemon are grown annually in 6371 hectares of land (BBS, 2017). With globalization and the establishment of world trade organization (WTO) the export opportunities of citrus fruits increase significantly. Therefore citrus grower faced increased competition in the world market level. In Bangladesh, the productivity per unit area and overall production need to be increased considerably in order to stand in international competition. Citron (C*itrus medica*) is called '*JaraLebu'* in Bangladesh. *Jara* lemon is the first citrus fruit that is exported from Bangladesh to Europe. The countries of the European Union, gulf region such as Kuwait, Saudi Arabia, UAE and Qatar are potential markets for *Jara* lemons of Bangladesh. But due to attack on canker disease European Union banned *Jara* lemon import from Bangladesh in 2008. According to the plant protection wing of the Department of Agricultural Extension (DAE) 106 tons of *Jara* lemon was exported from November last year to May 2011. (The Daily Independent; 30th July, 2012). Sylhet is well thought-out as a special agricultural zone in Bangladesh. This region is famous for citrus fruit cultivation. The region has the great potentialities for fruit cultivation and higher yield can be obtained by adopting with modern packages of technology developed by

Horticultural Research Centre of Bangladesh Agricultural Research Institute. So far, several studies have been conducted on various aspects of production and marketing of these local fruits in various parts of the country Hossain & Uddin, 2005; Uddin *et al.,* 2005a; Uddin *et al.,* 2005b;Uddin&Hasan, 2002 for example). Efficiency is an important factor of productivity growth as well as stability of production in developing agricultural economics. In view of slow growth and increasing instability in production, the economy of Bangladesh is expected to be benefited to a great extent from technical, al locative and economic efficiency studies. Estimates on the extent of inefficiencies could help decide whether to improve efficiency or to develop new technology to raise fruit productivity. To capture the ability of farmers in achieving the maximum reliable crop output with minimum level of inputs under existing resource endowment and available technologies, careful examination of farm specific technical efficiency of the farmer is necessary. Increased yield can result from the development and adoption of new technologies and improvement in the economic efficiency of farming operations. However, no systematic studies have yet been undertaken to cover costs, economics and efficiency of citron (*Jaralebu*) cultivation in the north-eastern territory of the country. These studies will emphasize the production and productivity, profitability to policy reform option for problem solving and strengthening the lemon subsector. The present study will be helpful for lemon growers, scientists and policy makers emphasis solving Jara improvement and development policy and implementation. With this view in mind, the present study is a modest attempt to assess the technical, al locative and economic efficiency of citron cultivation in Sylhet district. The specific objective(s) of the study are: i. to assess profitability of citron cultivation; ii, to quantify the determine levels of technical, al locative and economic efficiency of citron cultivation and iii, to draw policy recommendation for the development of citron cultivation.

Materials and Method

The present study was based on primary data collected through face to face interview by using the structured interview schedule. A total of 70 growers taking 35 growers from each upazilawas selected by the simple random sampling method during the year 2017-18. Both tabular and econometric techniques were used to analyze the collected data. To calculate the economic performance of citron cultivation descriptive statistics such as the average, percentage, total cost, gross return, gross margin, net benefit and benefit cost ratio etc. were used.

Gross Return

$GR_i = \sum_{i=1}^{n} QiPi$

Where, GR_i= Gross Return from i^{th} product (Tk. ha^{-1})

Q_i= Quantity of the ith product (kg)

P_i= Average price of the ith product (Tk.)

I= 1, 2, 3………., n.

Gross margin

Gross margin was calculated among the difference between gross return and total variable costs. That is, GM= GR-TV Where, GM= Gross margin, GR= Gross Return, TVC= Total variable cost.

Net return

A net return was calculated by deducting all costs (variable and fixed) from gross return. The following equation will be used to determine the return of citron production.

$\prod = P_y Y - \sum_{i=1}^{n}(PxiXi) - TFC$

$\prod$ = Net return (Tk. ha^{-1})

P_y= Per unit price of the product (Tk. kg^{-1})

Y= Quantity of the production ha^{-} (kg.)

P_{xi} = Per unit price of $thti^{th}$product (Tk.)

X_i= Quantity of the ith inputs ha^{-} (kg)

i= 1, 2, 3………, n (number of variable).

Benefit Cost Ratio (BCR)

The BCR is a relative measure, which is used to compare benefit per unit of cost. The BCR was estimated as a ratio of gross returns and gross costs. The formula calculating BCR (undiscounted) was as such: Benefit Cost Ratio = Gross benefit / Gross cost

Technical, Al locative, Cost and Scale Efficiency

To assess the technical, al locative, cost, scale and economic efficiency Data Envelopment Analysis Programme (DEAP) package developed by Coelli (1996) was follow

Technical Efficiency

For citrus cultivation the input variables were organic and inorganic fertilizers; insecticides and labour used in different inter-cultural operations. Thus the use of input oriented approach has more appeal as opposed to the output-oriented model. In this study, output-oriented VRS DEA model was applied to measure pure Technical Efficiency (TE), Technical efficiency as well as input oriented VRS DEA, Al locative Efficiency (AE), Cost Efficiency (CE) and Scale Efficiency (SE). The following DEA model was used for calculating technical efficiency for citrus cultivation,

$\text{Min}^{\theta\lambda}\ \theta,$

Subject to $-y^{i} + Y\lambda \geq 0$

$\theta x^{i} - X\lambda \geq 0$

$N1'\lambda = 1$, (VRS constraint), and

$\lambda \geq 0$, …………………………………..[1]

Where, subscript i represent the i^{th} farm; θ is a scalar indicating the technical efficiency index whose values rangefrom 0 to 1 indicating technically efficient farm; λ is a N×1 vector of constants; Y is a vector of output quantities and X is a vector of observed inputs. N1 is an N×1 vector of ones .The first constraint is with respect to the output. The term $-y_i$ of the left hand side of the constraint is the vector of output of the i^{th} farm compared to the output vector of the theoretically efficient farm ($Y\lambda$).

Al locative and cost efficiency

Working on the premise that al locative efficiency reflects the ability of a farm to use the inputs in optimal proportions given their respective prices, the problem revolves in revenue maximization or cost minimization. Following Coelli (1996), al locative and cost efficiencies were obtained by solving the following cost minimization DEA problem:

$\text{Min}^{\lambda, x_i^*}\ w_i' x_i^*$,

Subject to $Y\lambda - y_i \geq 0$

$x_i^* - X\lambda \geq 0$

$NI'\lambda = 1$, (VRS constraint), and

$\lambda \geq 0$, …………………………………[2]

Where, w_i is a vector of the input prices for the i^{th} farm and x_i^* (which is calculated by the model) is the cost minimizing vector of the input quantities for the i^{th} farm, given the input prices w_i and the output levels y_i . N1 and λ are as defined above. The total cost efficiency of the i^{th} farm is then calculated as the ratio of the minimum cost (computed using x* and actual prices) to observed cost. Mathematically, this can be written as:

$$CE_i = w_i' x_i^* / w_i' x_i$$

The al locative efficiency then is computed as: $AE_i = EE_i / TE_i$

The linear programming problem defined in equations [1] as input-oriented model and cost minimization model [equation 2] which estimate the technical efficiency (θ) and the cost minimizing vector of input quantities (x_i^*). Estimates farm specific economic and technical efficiency were computed using DEAP 2.1 (Coelli, 1996).

Scale Efficiency

Scale efficiency is calculated by conducting both a CRS and a VRS DEA. One then decomposes the TE scores obtained from the CRS DEA into two components, one due to scale inefficiency and one due to "pure" technical inefficiencies (Coelli*etal.,* 1998). The scale inefficiency measure can be roughly interpreted as the ratios of the average product of a farm at the point of operation on the VRS frontier to the average product at a point operating at a point on (technically) optimal scale (point of intersection of the VRS and CRS frontier). Operationally, scale efficiency has been defined by the following formula:

$SE = TE_{CRS} / TE_{VRS}$ (where,$TE_{CRS} = SE * PTE$

Pure Technical Efficiency

A pure technical efficiency (PTE) measures the firms; success in using best available technology. The overall technisa efficience (CRS TE) canbedecomposed in two components, namely pure technical efficiency and scale efficiency so that TE= PTE*SE

Results and Discussion

The aim of analyzing costs and returns is to determine the amount of profit of a producer is to making from a particular commodity production within the given technology and investment. The profitability of a commodity production depends on its prices, cost of production and available technology. The study showed that on an average per hectare cost of production of *Jaralebu* was found to be Tk.4, 39,627(Table1). The study revealed that among the cost of cultivation application of Cowdung incurred the highest cost (67.72%). The variable cost was found to be higher (4, 49,262Tk/ha) at Gowainghat while it was the lowest (3,15,591Tk/ha) Jaintapur. But on the other hand fixed cost was found to be higher at Jaintapur as compared with Gowainghat. The average per hectare yield of citron was found to be16433 pieces/ha (Table 2). The average price of citron was found Tk. 91/pieces. The net return of *Jaralebu* cultivation was found to be higher (11, 99,414Tk./ha) at Jaintapur compared with Gowainghat (8,94,789 Tk/ha) due its higher yield and lower cost cultivation. The average benefit cost ratio of *Jaralebu* was 3.40 which implied that the farmers of *Jaralebu* could earn Tk 3.40 with the investment of 1.00 Tk. The rate of return (BCR) over total cost was higher and estimated return was also positive indicates that *Jaralebu* cultivation was profitable in both the areas. The mean technical efficiency level of the citron cultivation was found be 0.514suggests that the level of technical efficiency is not so good but moderate(Table3). The score clearly represents that around 49% inefficiency existed in the study area for *Jara* cultivation. The mean al locative efficiency score was estimated to be 0.564. However, the score of al locative efficiency indicates that there was nearly 44% inefficiency remained in Jara production. The mean cost efficiency was estimated at 0.283 implying that exactly 71.7% of the cost inefficiency exists among the sampled farmers. That indicates that the Jara production in the study did not follow cost optimization. The study also showed that the average scale efficiency was estimated at 0.751 (75.1%) indicating that almost 25% scale inefficiency exist which were due to differences in the operation of the farms between CRS and VRS frontier. The mean pure technical efficiency was estimated as 0.718 i.e. 71.8%, representing that, around 28% inefficiency remained in *Jar* production. The empirical results (TE= 0.514, STE= 0.751 and PTE= 0.718) provide some important insights. Firstly, there are significant possibilities to increase the efficiency level of *Jara* cultivation in Sylhet district. The average overall technical inefficiency could be reduced by 49% on an average by operating at optimal scales through eliminating pure technical inefficiencies. Secondly, the results also indicated that pure technical inefficiency for *Jaralebu* cultivation makes a greater contribution to overall inefficiency. On an average the study revealed that the cost minimizing quantity of manure was estimated to be 20206 kg/ha as against to actually use 100097 kg/ha suggesting that actual use was overshoot by 499%, which could be reduced without reducing the output of *Jaralebu* (Table 4.). In the same way the cost minimizing pesticides, bamboo, labour and irrigation estimated at 38 bottle /ha, 246 pieces/ha, 95 man-days/ha and 3.69 times/ha respectively. Whereas, in per hectare, the farmers used on an average 88 bottle pesticide 1827 piece bamboo, 346 man-days labour and 3.5 times irrigation for *Jara* cultivation. Certainly, the amount of pesticides, bamboo, labour and irrigation can be minimized by 189%, 895%, 383% and 49% respectively to acquire efficiency in production of *Jara* lemon in the study areas. Divergence estimated between technically efficient inputs level and actual inputs use were 16% for manure, 2% for pesticides, 18% for bamboo use, 0.74% for irrigation and 17% for labour respectively (Table 5).Surprisingly, all divergences appeared to be positive, indicating that inputs actually applied per hectare for *Jara* cultivation were more or less similar to technically efficient level permits ; therefore, it suggests that there is needed to provide training to farmers on *Jaralebu* cultivation in order that the farmers to be technically efficient.

Conclusion and Recommendation

The present study signifies that the current situation of *Jaralebu* production in Sylhet region was profitable but not efficient. It was evident that who used overdoses of inputs regard to cost minimizing inputs. However, farmers needed to concentrate on efficient production because the technical, al locative, cost, scale and pure technical efficiency were not at a satisfactory level. Although *Jara* lemon is grown in Bangladesh for a long time, very little attention has been given to its production. Based on the following recommendations, it is possible to increase the production and export of *Jaralebu* efficiently and effectively: i. First of all, training on *Jara* lemon production is badly needed to improve its production in an efficient way, ii. BARI and other research institutions have to work on developing the improved as well as disease and pest resistant varieties of *Jara* lemon, iii Research is also needed to discover the remedial measures of a*canker* disease locally known as *blood cancer* for *Jara* production and iv. Government should ensure the credit facilities to farmers by lowering interest rate and intensive monitoring through both institutional and non-institutional sources for *Jara* cultivation and take steps to smooth the way of its export system.

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Table 1: Cost of production of Citron (*jaralabu*) cultivation in the study area

Parameter	Location		All
	Joyantapur	Guyanghat	
A.Variable Cost tk/ha)	**315591**	**449262**	**382927**
Human Labour (Hired)	70800	83100	76950
Manure	202845	316203	259524
Pesticides	15523	10887	13205
Bamboo (as a pillar)	13901	21841	17871

Irrigation	12522	17231	15377
A. Fixed Cost tk/ha)	**61800**	**51600**	**56700**
Human Labour (Family)	31800	21600	26700
Rental value of land	30000	30000	30000
Total Cost (A+B)	**377390**	**500862**	**439627**

Source: Authors' estimation, 2018

Table 2: Profitability of Citron cultivation in the study area

Parameter	Location		All
	Joyantapur	Guyanghat	
Yield(Piece/ha.)	17858	15007	16433
Price (tk/piece)	88	93	91
Gross return (tk/ha)	1571504	1395651	1495403
Total variable cost (tk/ha)	377390	449262	382927
Total Cost (tk/ha)	378551	500862	439627
Gross margin (tk/ha)	1255913	946389	1112476
Net Return(tk/ha)	1194114	894789	1055776
Benefit cost ratio	**3.32**	**1.88**	**2.40**

Source: Authors' estimation, 2018

Table 3: Technical, al locative, cost, scale and pure technical efficiency of citron (jara (labu) cultivation in the study area

Farms	TE	AE	CE	Scale	PTE
1	0.541	0.608	0.329	0.976	0.555
2	0.654	0.721	0.471	0.967	0.677
3	0.496	0.193	0.096	0.654	0.759
4	0.215	0.703	0.151	0.989	0.217
5	0.701	0.309	0.217	0.701	1
6	0.217	0.764	0.166	0.933	0.232
7	0.153	0.667	0.102	0.968	0.158
8	0.115	0.679	0.078	0.985	0.117
9	0.473	0.434	0.205	0.545	0.869
10	0.467	0.447	0.209	0.467	1
..	..	..	..	..	..
70	0.179	0.554	0.099	0.617	0.291
Mean	**0.514**	**0.564**	**0.283**	**0.751**	**0.718**

Source: Authors' estimation, 2018

Table 4: Used of actual inputs as opposed to cost minimizing inputs in citron (Jaralebu) cultivation

Farm	Cowdung			Insecticides			Bamboo			Irrigation			Labour		
	Actual	CM	%	Actual	CM	%	Actual	CM	%	Actual	CM	%	Actual	CM	%
1	127139	28279	350	99	51	93	1647	333	394	5	5	3	231	129	79
2	69983	32991	112	103	60	73	2058	389	429	4	6	-29	309	150	105
3	238767	19062	1153	82	34	139	1647	225	633	2	3	-39	510	87	488
4	54188	9164	491	72	17	335	2058	108	1805	5	2	217	305	42	630
5	238767	27231	777	99	49	101	988	321	208	2	5	-57	263	124	112
..	..	..	..	,,	..	..	..	..	..	..	..	..	..	..	..
70	45316	5396	740	50	10	411	499	64	684	6	1	547	327	25	1230
Mean	**100096**	**20206**	**499**	**88**	**38**	**189**	**1827**	**246**	**895**	**4**	**4**	**49**	**353**	**95**	**383**

Source: Authors' estimation, 2018.

Table 5: Percent change in inputs required for the farm to be fully technically efficient in the selected areas.

	Output			Cowdung			Insecticides			Bamboo			Irrigation			Labour		
Farm	Actual	TE	%	Actual	TE	%	Actual	TE	%	Actual	TE	%	Actual	TE	%	Actual	TE	%
1	22230	40074	-45	127139	67380	89	99	95	4	1647	1262	30	5	5	0	231	231	-0
2	25935	38337	-32	69983	69983	0	103	95	9	2058	1892	9	4	4	0	309	250	23
3	14985	19741	-24	238767	150627	59	82	82	0	1647	1647	-0	2	2	0	510	360	42
4	7204	33178	-78	54188	54188	0	72	72	0	2058	964	114	5	5	0	305	245	25
5	21407	21407	0	238767	238767	0	99	99	-0	988	988	0	2	2	0	263	263	0
…	…	…	…	…	…	…	…	….	….	…	…	…	…	…	…	…	…	…
Mean			**-28**	**100096**		**16**	**88**		**2**	**1827**		**18**	**4**		**0.74**	**353**		**19**

Source: Authors'estimation, 2018.