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TECHNICAL EFFICIENCY OF OYSTER MUSHROOM PRODUCTION IN DONG HA CITY, QUANG TRI PROVINCE: AN APPLICATION OF OUTPUT ORIENTED DATA ENVELOPMENT ANALYSIS

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Abstract: Based on cross section data of 30 oyster mushroom farms in Dong Ha city, Quang Tri province, this study estimated their technical efficiency level by using output-oriented Data Envelopment Analysis (DEA). The empirical results indicate that oyster mushroom farms should expand their current level of output from 9 to 17% to be efficient. Moreover, the results also reveal that technical inefficiency of oyster mushroom in Dong Ha city, Quang Tri province was mainly due to scale inefficiency. Most of the farms should increase their current scale to improve their technical efficiency.

Keywords: Technical efficiency, oyster mushroom, output oriented DEA

1 Introduction

Cultivating mushrooms, especially Oyster mushroom on straw and sawdust in Dong Ha city of Quang Tri province, has been being considered as a mean of not only taking advantage of by-products of agriculture but also giving job opportunities and increasing returns for the farmers [2]. However, up to now, this model has been developed spontaneously and experientially in this area [6]. Many questions such as: whether the farmers could attain the level of production they should be comparing to the best practice farms, what their technical efficiency levels are, and how many percent of output should be expanded without using more input have still not been answered.

Using output-oriented Data Envelopment Analysis, this paper aims to answer the above questions by estimating the technical efficiency of oyster mushroom farms in Dong Ha city, Quang Tri province.

2 Data and Methodology

Data

Primary data of this research were based on farm level cross-section data of oyster mushroom in Dong Ha city, Quang Tri province in the crop year of 2014. The data are collected from a field survey in 2015. The sample size was 30 farm households, in which 24 farms used sawdust and 6 used straw to cultivate oyster mushroom.

Secondary data for this study were collected from Bureau of Statistics, Department of Agriculture and Rural Development of Quang Tri province. They were also from books, journals, research reports, previous studies and so on.

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Methodology

Efficiency can be considered in terms of input-orientation or output-orientation. In which, input-orientated efficiency finds out a target point maximizing the proportion reduction in inputs or produces a given level of output from an optimal combination of inputs. Meanwhile output-orientated efficiency finds out a target point that maximizes the proportional augmentation in outputs or produces the optimal output from a given set of inputs [5].

Up to now, most DEA applications to efficiency measurements in the literature have been input-based type. A few published applications of output-based efficiency have primarily focused on technical scale and congestion efficiency [3]. Meanwhile, in oyster mushroom cultivation, the amount of inputs used such as seedling, electricity and labor (except water) are almost the same for every farm, only the level of production is unknown. Therefore, output orientated data envelopment approach is appropriate to describe the production possibility situation.

The output-orientated VRS model used to estimate technical efficiency of oyster mushroom farms in this study is as follows:

$$Max_{\emptyset,\lambda}\ \phi,$$

$$\text{St} \qquad -\phi q_i + Q\lambda \geq 0$$

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

$$\sum_{i=1}^{N} \lambda_i = 1$$

$$\lambda \geq 0$$

Where $1 \leq \emptyset < \infty$, and $\emptyset - 1$ is the proportional increase in outputs that could be achieved by the i-th farm, with input quantities held constant. $1/\emptyset$ defines a technical efficiency score that varies between zero and one. The vector λ is an Nx1 vector of weights (constants) which defines the linear combination of the peers of the i-th farm. Q is a vector of output quantities and X is a vector of observed inputs. The farm is technically efficient and on the frontier if $1/\emptyset$ is equal to one. On the contrary, if $1/\emptyset$ is less than one, the farm is technically inefficient. That farm can still expand further the level of output produced without using more inputs [1, 5].

Output-oriented technical efficiency is studied to answer the question: "By how much can output quantities be proportionally expanded without altering the input quantities used?" and efficiency is measured by the ratio of OA and OB based on the figure below. In this figure, the firms which are on the frontier curve ZZ′ are technically efficient. Point A lies below the ZZ′ curve. Hence, A is an inefficient point. And the distance AB represents technical inefficiency that outputs could be expanded without requiring extra inputs [1, 5].

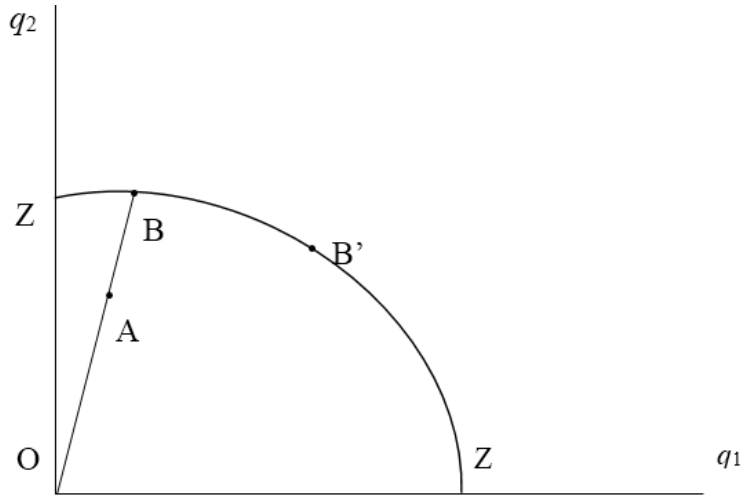

Fig. 1. Output-orientated measures

Source**:** [5]

This study used Vietnamese DEA add-in for Excel to estimate the technical efficiency of oyster mushroom farms in Dong Ha city, Quang Tri province [4].

3 Results and discussion

In Dong Ha city, two main materials used to create seedling bag in cultivating oyster mushroom are straw and sawdust. Table 1 presents a summary of descriptive statistics of inputs and output of 30 oyster mushroom farms, including 24 farms (accounted for 80%) used sawdust and 6 farms (only account for 20%) used straw in cultivating in 2014.

Table 1. Inputs and Output per square meter of Oyster mushroom farms in Dong Ha city, Quang Tri province

	Units	Sawdust bag group (n = 24)		Straw bag group (n = 6)		Total	
		Mean	St.Dev	Mean	St.Dev	Mean	St.Dev
Inputs							
Labor	Hour	12.657	2.872	19.305	8.504	13.986	5.131
Water	Cubic meter	0.023	0.006	0.030	0.012	0.024	0.008
Electricity	Kilowatt-hour	2.744	1.464	4.232	2.223	3.042	1.708
Seedling	Bag	18.439	4.556	28.072	14.244	20.365	8.174
Output							
Oyster mushroom	Kilogram	14.762	4.893	26.874	15.166	17.184	9.106

Source: Field survey in 2015

Table 1 shows that in order to cultivate, on average, from 18 to 28 seedling bags per square meter, a farm had to water from 0.023 to 0.03 cubic meter and use from 2.7 to 4.2 kilowatt-hour of electricity. Moreover, the family labor in an oyster mushroom farm, on average, had to spend from 12 to 19 hours per square meter per crop in seedling making, watering, harvesting and so on. In which, straw bag farms used more water, electricity and spent more time on cultivating than sawdust bag groups.

The average oyster mushroom production of those farms was from 14.7 to 26.9 kilograms per square meter, in which the production of straw bag group almost doubled the sawdust bag one.

Table 2 gives information on the range and the mean technical efficiency scores of samples which were categorized into sawdust and straw bag groups.

Table 2. Technical efficiency of Oyster mushroom farms in Dong Ha city, Quang Tri province

		Sawdust bag group (n = 24)		Straw bag group (n = 6)	
		TE_{CRS}	TE_{VRS}	TE_{CRS}	TE_{VRS}
Min		0.3750	0.6260	0.6340	0.6880
Max		1.0000	1.0000	1.0000	1.0000
Mean		0.8286	0.8766	0.8528	0.9131
St.Dev		0.1375	0.1281	0.1665	0.1385
Efficient farms	**No. of farms**	3	12	3	4
	%	12.5	50	50	66.7

Source: Field survey and authors' calculation in 2015

Notes: TE CRS: Technical efficiency under constant returns to scale

TE VRS: Technical efficiency under variable returns to scale

The result in table 2 shows the difference between VRS and CRS technical efficiency in both groups. This indicates the existence of scale inefficiency in the sample farms, in which assuming that all farms are operating at optimal scale (under constant return to scale - CRS), there were 3 out of 24 sawdust farms (accounted for 12.5%) and 3 out of 6 straw bag group farms (accounted for 50%) being CRS technically efficient with the means of 0.83 and 0.85, respectively. This means that under constant return to scale those farms could potentially expand the current level of output by 15 to 17 percent without requiring extra inputs.

Meanwhile, 12 out of 24 sawdust bag group farms (accounted for 50 percent) and 4 out of 6 (accounted for 66.7%) were technically efficient under variable return to scale (VRS) with the means of 0.88 and 0.91, respectively. This means that under variable return to scale, the oyster production could proportionally be increased by 9 to 12 percent without altering the input quantities used.

The results in table 3 indicate that in the sample, only 12.5% of sawdust bag group are scale efficient while 75% or 18 out of 24 farms should increase their scale to be efficient. 3 left farms were indicated to decrease their scale to gain efficiency.

The result in table 3 also shows that 50% of straw bag group were operating at optimal scale while 50% left should increase scale to be efficient.

Table 3. Summary of returns to scale results of Oyster mushroom farms in Dong Ha city, Quang Tri province

	Sawdust bag group		Straw bag group		Total	
	No. of farms	**%**	**No. of farms**	**%**	**No. of farms**	**%**
CRS	3	12.5	3	50	6	20
IRS	18	75	3	50	21	70
DRS	3	12.5	0	0	3	10

Source: Field survey and authors' calculation in 2015

Notes: CRS: Constant return to scale,
IRS: Increasing return to scale,
DRS: Decreasing return to scale

4 Conclusion

This study employed output-oriented data envelopment analysis to measure technical efficiency of oyster mushroom farms in Dong Ha city of Quang Tri province. The analysis results show that the mean technical efficiency of straw and sawdust bag groups were 0.85 and 0.83 under constant return to scale, and 0.91 and 0.88 under variable return to scale, respectively. Moreover, those results also revealed that technical inefficiency of oyster mushroom in Dong Ha city of Quang Tri province was mainly due to scale inefficiency.

Based on the above conclusions, some recommendations can be made. Oyster mushroom farms should expand their current level of output from 9 to 17% to be efficient. This information might be useful for local government authorities in training extension workers or operating training workshops. Moreover, most of the farms should increase their current scale to improve their technical efficiency.

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