TECHNICAL EFFICIENCY OF CABBAGE (BRASSICA OLERACEA) GROWING FARMS- AN OPPORTUNITY TO STABILIZE AGRICULTURE ECONOMY

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ABSTRACT

Vegetables have potential significance in terms of their use not only for their food and nutrition but also for affordable sources of essential vitamins and minerals globally. Cabbage (Brassica oleracea) is an economically important vegetable crop with the potential to increase the incomes of the farmers not only in open fields but also in greenhouses in Oman as Cabbage is more popular among customers throughout Arabian Peninsula countries and valuable with moderate retail prices than other vegetables. Hence, a survey was undertaken to investigate the technical efficiency of cabbage-growing farms in the Sultanate of Oman. The research estimated and examined the technical efficiency of okra-growing farms of different governorates of Oman. A sample of 89 cabbage-growing farms was selected, adapting the multistage sampling method. The interview schedules were followed for data collection in 2016 and 2017. The maximum likelihood method was used, and the Cobb-Douglas stochastic frontier production model was applied to the data collected. After performing various econometrics of software, the output of the Frontier 4.1 was found to be a good fit. The results of the investigation indicated that the mean technical efficiency for cabbage farms in Oman is estimated to be 85%, with a wide range from as low as 63% to as high as 100%. There exists a considerable possibility of increasing cabbage output by 15% with the current level of inputs employed by cabbage farmers. Cabbage-growing farms had enormous scope to improve their efficiency and increase productivity by following regular extension programs involving farmers in cultivating Cabbage.

Keywords: Technical Efficiency, Maximum Likelihood Method, Stochastic Production Frontier, Cabbage.

1. INTRODUCTION

Vegetables are known for both food and nutrition among customers on one hand while they are considered economic crops among the farmers to cultivate for their livelihoods (Al-Salmi et al., 2020). In addition, vegetable cultivation offers tremendous employment opportunities and means of earning for alleviating rural poverty (Schreinnachers et al., 2018). In the Arabian Peninsula, vegetables are grown under open fields and greenhouse conditions. The investigations of ICARDA's APRP (Arabian Peninsula Research Program) have shown that growing vegetables adapting protected agriculture has proved very successful in raising the livelihoods and economic stability of the farmers in the Arabian Peninsula in general (Osman et al., 2017; ICARDA 2019; ICARDA, 2020) and in Oman in particular (FAO, 2016; MAF, 2019). The total cultivated area in the Sultanate of Oman was found to increase by 3.9 percent by the end of 2022 to reach

276,000 acres from 266,000 acres by the end of 2021, with total agricultural production of 3.501 million tons, according to the statistics of the National Centre for Statistics and Information of which vegetables with a total area of 69,074 acres produced 1.137655 million tons (NCSI, 2022). Increasing vegetable production in Oman has been projected to contribute to government efforts to diversify the national economy (MAF, 2019). In Oman, open-field production of vegetables still exists with a simultaneous increase in their area under protected agriculture throughout all the governorates (AlSalmi et al., 2020). The area and production of vegetables have been significantly surging, mainly due to local demand.

Of the vegetables, Cabbage (Brassica oleracea) is both a subtropical and tropical vegetable crop having vitamins like A, C, and K, minerals like folate, potassium, and Magnesium and flourishes with antioxidants and phytonutrients that provide cellular protection (Shukla, 2022). The cabbage is one of the components of the vegetable cropping system in both open fields and protected agriculture in Oman (MAF, 2019). Cabbage has great potential to grow in Oman for fulfilling domestic needs and exporting products to neighboring GCC countries (Osman et al., 2017). Tridge (2022) reported an average yield of fresh cabbage to 28 t/ha under irrigated conditions in 2022 from FAO data with code 0358 in Oman under open field conditions as compared to the world average yield of 25 to 35 tons with a maximum of about 50 ton/ha according to FAO report (FAO, 2022) projecting to an achievable yield of as high as 85 t/ha under ideal climatic conditions and good irrigation and crop management. This indicates that the potential level of cabbage production in Oman is closely linked to crop production inputs and socio-economic factors. Hence, the study on the technical efficiency of cabbage production was undertaken to comprehend the input and output relationship to transform inputs into outputs at a certain level. The stochastic frontier production function (SPF) is often applied to estimate technical efficiency. This model has been widely employed to examine the technical efficiency of farming of various crops throughout the world. The technical efficiency analysis uses the Cobb-Douglas production function to describe the production elasticity of each input used and the input efficiency found in producing the output in the production system (Coelli et al., 1998). Simultaneously, SPF was employed in forestry (Sanusi et al., 2017), agriculture (Fernandez-Cornejo, 1994), horticulture (Zeibet et al., 1999), olericulture (Shrestha et al., 2016; Bozoglu & Ceyhan, 2007; Julie et al., 2017) in addition to dairy sciences (Mbaga et al., 2003). Recently, SPF was effectively employed to comprehend the technical efficiency of the production of different vegetable crops like sweet potato (Belete et al., 2016), tomato (Wahid et al., 2017), and Okra (Ume et al., 2018; Alabi et al., 2023). Recently, SPF has been applied in estimating technical efficiency in cabbage production (Abdulrahman et al., 2018; Zaenal et al., 2020; Miskiyah et al., 2021; Senbeta et al., 2023). All these studies in agriculture have recommended effective measures for raising production efficiency. Hence, the present study aimed to evaluate the technical efficiency of farms growing cabbages in Oman.

2. MATERIALS AND METHODS

The primary data on the study's aspects were collected through surveys conducted between 2016 and 2017 from 89 farmers growing Cabbage across four governorates of Oman, namely North Al Batinah, South Al Batinah, North Al Sharqiya, and Al Dakhiliya, which are known for agriculture activities. The variables were selected based on previous efficiency studies (Bozoglu & Ceyhan, 2007; Bellet et al., 2016; Julie et al., 2017). The total cabbage output (kg) was the dependent variable. In contrast, farm size (ha), fertilizer (kg/ha), labor (person-hours), seeds (kg/ha), irrigation water quantity (cubic meter/day), electricity cost (Omani Rials/month), and chemicals used (kg/ha) were independent (input) variables. The study also included three farm-specific variables used for the inefficiency model, viz. the farmer's age (years), the farmer's farming experience (years), and the farmer's level of education as zero (0) for no education and 1 for education.

The education level included illiteracy (no schooling), education until twelve (Years 1-12), and education beyond year 12. The study adopted the SFP approach to assessing the technical efficiency of these farms in Oman, and the inefficiency effects model of Battese and Coelli (1995) determined technical inefficiency. The data were subjected to analysis to estimate efficiency using both SHAZAM econometric software and the Coelli (1996) "FRONTIER 4.1" computer program.

3. RESULTS AND DISCUSSION

The maximum likelihood estimates for Cabbage are presented in Table 1. The model indicated that variables, namely farm size, electricity, chemicals, and water, were positive for cabbage production and significant ($p<0.05$). This means that these parameters lead to an increase in output. The coefficient of electricity has the highest value (elasticity), followed by water and farm size. The estimate of output elasticity of cabbage production for electricity was positive (34.76) and significant ($p<0.05$), meaning a 1 unit increase in input (Electricity, OMR) would lead to an increase in output by 34.76 kg. On the other hand, seeds, chemicals, labor, and fertilizer used were found to be negative and significant ($P<0.05$). In the inefficiency model, all three factors studied were found to be insignificant ($p>0.05$), with a positive coefficient of farmer's age while that of farmers' experience and education was negative.

Table 1. Maximum Likelihood Estimates of the Common Stochastic Production Frontier for Cabbage

Variable Name	Parameter	Coefficiient.	Standard Error	T-Ratio
Stochastic Frontier Model				
Constant	B_0	-0.87	0.99	-0.88
In(X1) (Farm size)	β_1	2.43	0.98	2.49
In (X2)(Fertilizer)	β_2	-2.44	0.89	-2.73
In (X3)(Labor)	β_3	-5.58	0.99	-5.64
In(X4)(Seeds)	β_4	-2.16	0.99	-2.18
In(X5)(Water)	B_5	4.01	0.85	4.69
In(X6)(Electricity)	B_6	34.76	9.11	3.82
In(X7)(Chemicals)	B_7	34.49	9.19	3.75
In (X1)*In (X1)	B_8	0.66	0.85	0.78
In (X2)*In (X2)	B_9	-0.13	0.25	-0.52
In (X3)*In (X3)	B_{10}	0.17	0.95	0.18
In (X4)*In (X4)	B_{11}	-0.26	0.51	-0.50
In (X5)*In (X5)	B_{12}	-0.23	0.16	-1.47
In (X6)*In (X6)	B_{13}	-19.15	0.50	-38.61

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In (X7)*In (X7)	B_{14}	-9.40	0.68	-13.87
In (X1)*In (X2)	B_{15}	-0.22	0.78	-0.28
In (X1)*In (X3)	B_{16}	-0.73	0.96	-0.76
In (X1)*In (X4)	B_{17}	-0.34	0.92	-0.37
In (X1)*In (X5)	B_{18}	0.13	0.70	0.18
In (X1)*In (X6)	B_{19}	-17.28	0.87	-19.87
In (X1)*In (X7)	B_{20}	16.48	0.87	19.01
In (X2)*In (X3)	B_{21}	0.17	0.57	0.31
In (X2)*In (X4)	B_{22}	0.01	0.31	0.03
In (X2)*In (X5)	B_{23}	0.20	0.52	0.39
In (X2)*In (X6)	B_{24}	-2.81	0.61	-4.62
In (X2)*In (X7)	B_{25}	3.36	0.74	4.55
In (X3)*In (X4)	B_{26}	0.56	0.86	0.65
In (X3)*In (X5)	B_{27}	0.50	0.74	0.67
In (X3)*In (X6)	B_{28}	85.76	0.88	97.02
In (X3)*In (X7)	B_{29}	-85.25	0.87	-97.60
In (X4)*In (X5)	B_{30}	0.10	0.45	0.22
In (X4)*In (X6)	B_{31}	6.58	0.80	8.23
In (X4)*In (X7)	B_{32}	-6.38	0.82	-7.82
In (X5)*In (X6)	B_{33}	-54.24	0.70	-77.27
In (X5)*In (X7)	B_{34}	53.57	0.67	80.31
In (X6)*In (X7)	B_{35}	28.54	0.82	34.68

Inefficiency Model				
Variable Name	**Parameter**	**Coef.**	**Standard Error**	**T-Ratio**
Constant (δ0)	δ_0	-0.14	0.92	-0.15
Farmer's Age (Z1)	δ1	0.01	0.01	0.78
Farmer's Experience (Z2)	δ2	-0.01	0.01	-0.73
Education Dummy (Z3)	δ3	-0.13	0.40	-0.33
Sigma Square	σ2	0.60	0.38	1.55
Gamma	γ	0.005	0.002	3.14

Table 2 presents a summary of the cabbage's technical efficiency. The mean technical efficiency for cabbage farms in Oman was estimated to be 85%, ranging from 63% to 100%. Therefore, it is possible to increase cabbage output by 15% with farmers' current level of inputs. However, 28 farms (31%) were the best among the farms evaluated as many, with 90-100% production efficiency.

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Table 2. Statistical Parameters of Efficiency Index (%) of 89 Cabbage Growing Farms of Oman

Efficiency Index (%)	Study Sample	
	Number of Farms	Percentage (%)
Less than 60	0	0
Between 60–70	6	7
Between 70–80	30	34
Between 80–90	25	28
Between 90–100	28	31
Mean Efficiency	85%	
Median	84%	
Maximum	100%	
Minimum	63%	
Standard deviation	0.94	
Sample size	89	100

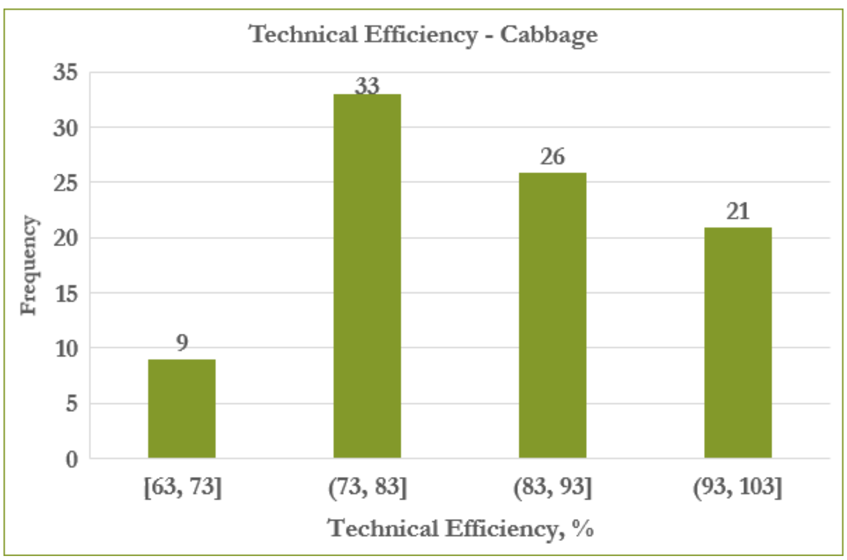

Fig. 1. The Distribution of Technical Efficiency Scores of Cabbage

The results on efficiency distribution (Fig.1) show that 33 of the farms in the sample are between 73% and 83% efficient. Furthermore, 26 farms were between 83% and 93% efficient, and the remaining 21 farms were the best, with technical efficiency between 93% and 100%.

The range of technical efficiency of cabbage production observed in the present studies was similar to the findings of previous recent studies conducted elsewhere in the world. The results of

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Abdulrahman et al. (2018) indicated the mean technical efficiency of the rain-fed cabbage farmers of Kaduna State, Nigeria, to be 0.80, implying that output fell by 20% from the maximum possible attainable level due to economic inefficiency of the farmers. The inefficiency model revealed that extension contact and educational level increased technical efficiency. In contrast, the results of Tegar et al. (2020) showed a mean technical efficiency of 94 percent for the farms of Chhattisgarh State, India, with a scope of just 6 % to approach 100 percent efficiency. The study suggested decreasing inputs like land size and seed and increasing inputs like fertilizer, agrochemicals, labor, and irrigation to maximize cabbage production through optimum management. In the study of Zaenal et al. (2020), it was observed that cabbage farming in the Getasan District of Indonesia had an average efficiency of 86.8% with a 13.2% opportunity to increase the efficiency. Their study recommended using these production inputs, such as seeds, organic fertilizers, and chemical fertilizers, to increase efficiency and get maximum profits. Similarly, Miskiyah et al., 2021 showed that land, labor, seeds, and organic and inorganic fertilizers were influential factors in obtaining the mean technical efficiency of 90.3%. A recent study by Senbeta et al. (2023) showed that the mean technical efficiency was 77.10 percent for cabbage-producing farms in the West Arsi Zone, Oromia Region, Ethiopia. Further, the technical efficiency of cabbage production was significantly and positively influenced by cabbage farming experience, education level, extension contact, and market information.

Our study covers a sample of 69 farms growing cabbage across prominent vegetable-growing wilayats of four governorates of Oman, namely North Al Batinah, South Al Batinah, North Al Sharqiya, and Al Dakhiliya. The joint document of FAO with the Ministry Of Agriculture & Fisheries on the Sustainable Agriculture and Rural Development Strategy (SARDS-2040) towards 2040 of the Sultanate of Oman listed cabbage as one of the vegetable crops in terms of land and water consumption. Our results revealed the potential of increasing cabbage production to 15% with levels of inputs/ variables studied. Thus there exist a potential to increase in production of country's vegetables like cabbage through for such improvements either related to genetic productivity or their crop husbandry practices to ensure agricultural sustainability. This could be the key to attaining not only self-sufficiency in the agricultural sector but also to maintaining economic sustenance through diversification of crops for cultivation as highlighted in SARDS-2040 developed by FAO along with Ministry of Agriculture & Fisheries, Sultanate of Oman (FAO, 2016; Alsalmi, 2020). The above observations would also apply to all GCC countries (Gulf Cooperative Council), the Arabian Peninsula, and the world.

4. CONCLUSIONS

The study's results indicated that the mean efficiency level of Cabbage was about 85%, indicating that 15% of the scope exists to raise the efficiency to 100% by varying the inputs considered in the study. Intensifying extension activities on cabbage cultivation among the farmers and arranging training programs to improve their skills would increase cabbage productivity.

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