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Technical Efficiency of Eggplant (*Solanum melongina* L.) Growing Farms in OMAN - An Opportunity to Stabilize the Agriculture Economy

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Abstract

Vegetables are important worldwide for food, nutrition, essential vitamins and minerals. Of the vegetables, eggplant (Solanum melongina L.) is economical for crop husbandry practices to increase the incomes of the farmers in both open fields and in plastichouses throughout Arabian Peninsula countries including Oman. It is also popular among the customers as it has moderate retail prices than other vegetables. Hence, a survey study was conducted to study the technical efficiency of eggplant-growing farms in the Sultanate of Oman in 2016 and 2017. 135 eggplant-growing farms were sampled following the multistage sampling method and the all required data viz. farm size (ha), fertilizer (kg/ha), labor (person-hours), seeds (kg/ha), irrigation water (cubic meter/day), electricity expense (Omani Rials/month) and chemicals used (kg/ha) besides farmers' age, experience and education were collected through one to one interview with the farmers in their fields. The maximum likelihood method and the Cobb-Douglas Stochastic Frontier Production model were applied to the data. The output of Frontier 4.1 was the best fit, as evidenced by the significance of statistics sigma squared ($p<0.05$). The results showed that the mean technical efficiency for eggplant farms in Oman was about 80%, with a wide range from from 16% to 87% depending on the nature of farms with respect to facilities. There existed as much as 20% of scope of attaining 100 % output with the adaptation of good agricultural practices (GAP) by the young farmers of Oman. The study uniquely identified the absence of significant ($p>0.05$) influence of any agriculture inputs considered for the study.

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Introduction

Vegetables are important not only among farmers for their livelihoods[1] as their cultivation brings employment opportunities and means of alleviating rural poverty.[2] Vegetables are the most essential and affordable sources of vitamins and minerals that reflect their nutritional potential to be regarded as quality foods among customers. Of the vegetables, eggplant (*Solanum melongena* L.) is a warm-weather crop primarily cultivated in tropical and subtropical regions. According to the FAO Statistical Database of 2024,[3] the world production for eggplants was 59.31 million in 2022, up 1.0% from 58.70 million metric tons in 2021. China was highest with 38.3 million metric tons in eggplants production contributing as high as 65% of global production, followed by India (12.8 million metric tons), Egypt (1.4 million metric tons), and Turkey (0.78 million metric tons).[4] Regarding nutritional value, eggplants are one of the healthier vegetables for human health, with a meager caloric value and a high content of vitamins, minerals, and bioactive compounds.[5,6]

The vegetables are grown both on open fields and in greenhouse conditions as growing vegetables adapting protected agriculture has proved to be very successful in raising the livelihoods and economic stability of the farmers not only in the Arabian Peninsula in general[7-9] but also in Oman in particular.[10,11] In Oman the total cultivated area in 2022 was 276,000 acres compared to 266,000 acres in 2021, an increase of 3.9 % with total agricultural production of 3.501 million tons.12 The vegetables shared with a total area of 69,074 acres with 1.137655 million tons in 2022. Such increase in vegetable production is not only due to local demand[1] but also to the government efforts in diversifying the national economy.[11] In Oman, the open-field production of vegetables is still found among the farmers with a gradual shift in the area under greenhouses in all the governorates.[1] Eggplant production in Oman totaled 38 thousand tons in 2022, with a 4.6% increase compared to 2021 figures.[12] This fact is considered a positive growth and indicator of the potential opportunities for eggplant cultivation in Oman and other countries.[10,11]

The present study applied Stochastic Production Frontier (SPF) to assess eggplant production efficiency. Earlier, several scientists used frontier applications in the production field in nonagriculture industries.[13-15] Simultaneously, SPF was employed in forestry,[16] agriculture,[17] horticulture,[18] olericulture[19-21] besides dairy sciences.[22] Of late, SPF was successfully used to study the technical efficiency of producing vegetable crops such as sweet melon,[23] tomato,[24] and Okra.[25,26] However, there is no research so far to understand the technical efficiency of eggplant production. Therefore, the present study was conducted to comprehend the technical efficiency of eggplants production in Oman.

Materials and Methods

Data and Variables

The primary data on eggplant production system, usage of inputs and farmers' data were collected related to the study and recorded in the questionnaires through surveys during 2016 and 2017. Massive data were collected from 135 farmers growing eggplants from selected farmers of North Al Batinah, South Al Batinah, North Al Sharqiya, and Al Dakhiliya governorates of Oman. The variables were selected based on the results of technical efficiency studies in the crops.[24,27,28] The total output in kilograms was the dependent variable. In contrast, independent / input variables were farm size (ha), fertilizer (kg/ha), labor (person-hours), seeds (kg/ha), irrigation water (cubic meter/day), electricity expense (Omani Rials/month) and chemicals used (kg/ha). The study also included three variables for the inefficiency model viz. the farmer's age (years), farming experience (years) and the education level (illiteracy (no school) and education).

Technical Inefficiency Model Adapted

Like many other agricultural commodities, the production of crops such as capsicum, cabbage, okra, eggplant, and tomato is naturally stochastic. Therefore, the SPH was applied to assess the technical efficiency of these farms in Oman. The present study adapted the technical inefficiency effects model suggested by Battese and Coelli.[29]

Resources and Data Analysis

Data were analysed to estimate the technical efficiency using both SHAZAM econometric software and the Coelli[30] "FRONTIER 4.1". The software referred to as SHAZAM is a very comprehensive tool for measuring econometrics, statistics, and analytics. It is quite popular worldwide as it offers various computations, builds models, checks hypotheses, and explains the variation among different variables.

Results and Discussion

The maximum likelihood estimate results for eggplants (Table 1) indicated that all the seven variables considered, such as farm size, fertilizer, labor, seeds, water, electricity, and chemicals, were not significant at 0.05 level ($p<0.05$) irrespective of their signs (+ ve or -ve). These results clearly indicated the absence of their influence on eggplant fruit yield. Without any previous research on eggplant, our results were compared with the results of research on the technical efficiency of growing other common vegetables like tomato[31] and okra (ladies finger), which are cultivated in Oman either in open fields or plastic houses. In the previous studies, farm size also did not influence the technical efficiency of okra production[32,34] and fertilizer dose had no influence on the technical efficiency of tomato production.[34] Similarly, labor use, seeds, and chemical application did not have any influence on the production efficiency of okra.[32,33] However, the absence of the influence of water in our investigation contradicted the results of similar research in tomato,[34] where the coefficient of irrigation was significant ($p<0.05$). However, the influence of electricity for irrigation on technical efficiency has not been evaluated in previous studies on crops.

Table 1: Maximum Likelihood Estimates (MLE) Results of the Common Stochastic Production Frontier for Eggplant with fruit yield (Y) as dependent variable

Variable Name	Parameter	Coeffiecient	Standard Error	T-Ratio
Stochastic \ Frontier Models				
Constant (Intercept)	B_0	-6.53**	2.05	-3.19
In (X1) (Farm size)	β_1	-1.70	1.37	-1.24
In (X2) (Fertilizer)	β_2	0.98	1.08	0.91
In (X3) (Labor)	β_3	2.59	1.52	1.70
In (X4) (Seeds)	β_4	-0.30	1.13	-0.26
In(X5) (Water)	B_5	0.80	1.40	0.57
In (X6) (Electricity)	B_6	0.39	1.30	0.30
In(X7) (Chemicals)	B_7	3.80	2.59	1.47
In (X1)*In (X1)	B_8	0.12	0.22	0.52
In (X2)*In (X2)	B_9	-0.14	0.07	-1.99
In (X3)*In (X3)	B_{10}	0.00	0.00	1.68
In (X4)*In (X4)	B_{11}	0.11	0.07	1.57
In (X5)*In (X5)	B_{12}	-0.28	0.10	-2.77
In (X6)*In (X6)	B_{13}	0.16	0.18	0.92
In (X7)*In (X7)	B_{14}	-0.13	0.32	-0.42
In (X1)*In (X2)	B_{15}	-0.11	0.19	-0.58
In (X1)*In (X3)	B_{16}	-1.20	0.38	-3.19
In (X1)*In (X4)	B_{17}	-0.20	0.18	-1.09
In (X1)*In (X5)	B_{18}	0.41	0.15	2.71
In (X1)*In (X6)	B_{19}	-0.41	0.31	-1.32
In (X1)*In (X7)	B_{20}	0.58	0.25	2.37
In (X2)*In (X3)	B_{21}	-0.43	0.31	-1.38
In (X2)*In (X4)	B_{22}	0.02	0.12	0.13
In (X2)*In (X5)	B_{23}	0.42	0.13	3.23
In (X2)*In (X6)	B_{24}	0.17	0.16	1.03
In (X2)*In (X7)	B_{25}	-0.35	0.16	-2.27
In (X3)*In (X4)	B_{26}	0.63	0.24	2.60

In (X3)*In (X5)	B_{27}	0.13	0.25	0.54
In (X3)*In (X6)	B_{28}	1.15	0.31	3.65
In (X3)*In (X7)	B_{29}	-0.51	0.35	-1.47
In (X4)*In (X5)	B_{30}	-0.11	0.11	-0.97
In (X4)*In (X6)	B_{31}	0.06	0.17	0.33
In (X4)*In (X7)	B_{32}	0.09	0.16	0.53
In (X5)*In (X6)	B_{33}	-0.22	0.19	-1.17
In (X5)*In (X7)	B_{34}	0.02	0.16	0.13
In (X6)*In (X7)	B_{35}	-0.33	0.28	-1.16

Table 2: MLE Results of Inefficiency effect model

Variable Name	Parameter	Coeffiecient	Standard Error	T-Ratio
Constant ($^{\delta}0$)	δ_0	-27.71	10.79	-2.57*
Farmer's Age (Z1)	δ_1	0.36	0.13	2.71*
Farmer's Experience (Z2)	δ_2	-0.20	0.11	-1.89
Education Dummy (Z3)	δ_3	-14.83	4.19	-3.54*
Sigma Square (σ2)	σ_2	19.33	6.45	3.00*
Gamma (γ)	γ	0.97	0.01	68.24**

In an inefficiency effect model, the parameters of variance viz. sigma squared was significant at 5%, indicating goodness of fit of the Translog production model, while the gamma value, significant at the 1% level indicated the normal distribution of error term (Table 2). The study considered farmer age, experience, and education in the inefficiency model. Farmer age was positive and significant ($p<0.05$), meaning that the older age of the farmers tends to make the farmers less efficient. Similar observations were made in previous studies on tomato[2] and Okra.[34] Of the other two factors about farmers such as education level and experience, only education level was found significant ($p<0.05$) with a negative sign. This indicated a shift in drive among the educated ones towards their interest and enthusiasm to engage in agriculture in Oman[1] for their livelihood.[1]

Table 3: Range and frequency distribution of efficiency index for farm samples studied

Efficiency Index (%)	Farm Samples	
	Number of Farms	Percentage (%)
Less than 60	2	1.5
Between 60–70	6	4.5
Between 70–80	26	19
Between 80–90	101	75
Between 90–100	0	
Mean Efficiency	81%	
Median	82%	
Maximum	87%	
Minimum	16%	
Standard deviation	0.65	
Sample size	135	100

Further, Table 3 includes the mean technical efficiency for eggplant farms in Oman. The mean technical efficiency was found to be 81%, with a range from 16% to 87%. Furthermore, 75% of the farms were 80% to 90% efficient, whereas 19% were between 70% and 80%. The results indicated that it was possible to increase eggplant output by 19-20 %.

Similarly, the histogram (Fig. 1) showing the distribution of technical efficiency scores indicated that as many as 101 farms had technical efficiency beyond 80%. In contrast, the remaining 34 farms showed less than 80% technical efficiency. In the absence of any influence of agriculture inputs considered in the study in the MLE, and education is significant and positive in the inefficiency model, the opportunity of 20% to increase the efficiency of eggplant production to achieve its highest level (100%) only rests on making young farmers more enthusiastic to have urge in relying on cultivation of vegetables like eggplant for their livelihood through their participation in various awareness and extension programs that are regularly conducted prior to planting and in harvesting time by the agriculture development centers/ units of the ministry of agriculture. The young farmers can also achieve this through one-to-one meetings with crop specialists or extension officials of the country, either at their respective offices or during their visits to the farmers' fields.

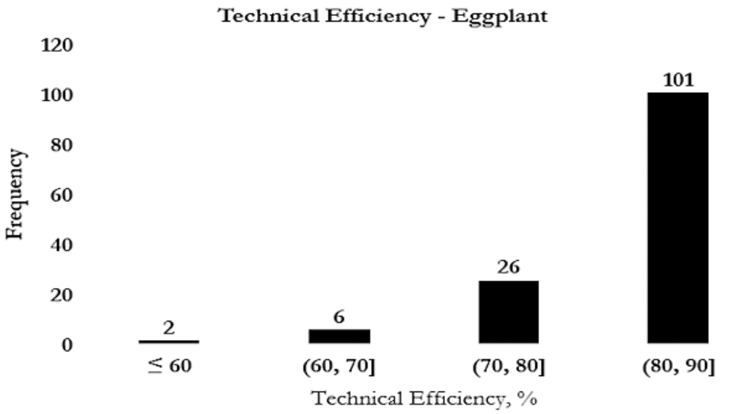

Fig. 1: Distribution of Technical Efficiency scores of Eggplant over the frequency of farms

The present study was more comprehensive including 135 eggplant growing farms of prominent vegetable-growing wilayats of four governorates of Oman namely North Al Batinah, South Al Batinah, North Al Sharqiya, and Al Dakhiliya governorates. The eggplants are considered as one of the leading crops in Oman.[1,10,11] Our results indicated 19-20% potentiality of increasing eggplant production. Thus, an increase in the production of eggplants along with other contemporary vegetables like tomato, okra, sweet pepper, and cabbage could contribute not only for self-sufficiency in the agricultural sector but also to national economic stability in agriculture by diversifying crops in Oman. This was highlighted in the Sustainable Agriculture and Rural Development Strategy (SARDS-2040) towards 2040 of Sultanate of Oman[10] developed by FAO along with Ministry of Agriculture & Fisheries, Sultanate of Oman. This also holds true for any Arabian Peninsula country and the world.

Conclusion

The results of the study indicated the mean technical efficiency of about 80%, indicating that 20% of the scope exists to raise the efficiency to 100% of eggplant production by educating the young farmers of the country in respect of good agriculture practices (GAP) as the factors/inputs related agriculture production system did not appear to have significant influence ($p>0.05$) to technical efficiency of the crop. Intensifying extension activities like training programs/ field visits for improving farmers' skills in GAP could increase eggplant production and contribute to national vegetable production in Oman.

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Conflict of Interest

The authors do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Author Contributions

- **Mouza Rashid Al-Salmi:** Execution of field experiment, data recording and compilation, statistical analysis and writing the manuscript;
- **Saleem Kaseemsaheb Nadaf:** Assisted in editing and finalization of manuscript.

Both listed authors read and approved the manuscript.

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