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Analysis of Technical Efficiency of Strawberry: A Special Case of Sheikhupura District

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Abstract

This study was carried out in district Sheikhupura of Punjab to figure out the technical efficiency of strawberry farmers through stochastic frontier approach. Multistage sampling technique was employed to get the data from 120 strawberry growers. Cobb Douglas functional form was selected through log likelihood ratio test for stochastic frontier analysis. According to the results, mean value of technical efficiency of farmers was recorded as 64 percent, with the further breakthrough of minimum and maximum value of technical efficiency was 0.39 to 0.97 respectively. All variables of production were found positively related to yield. Estimates of the production function showed that fertilizer, land preparation, pesticide, labor hours were significant. Similarly inefficiency determinants such as family size, experience and credit were significant ($P \leq 0.05$). All the inefficiency factors have expected negative sign except age of the farmers with positive sign.

Keywords: Correlation, Farmers, In-efficiency, Stochastic frontier analysis, Variables,

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Introduction

Fruits, vegetables and livestock products are the major source of macro and micronutrients. Fruits cultivation is an important strategy to handle the problem of food security and to reduce poverty. Fruit production share is low to overall economy yet it has great potential to contribute in economical growth and to improve the social and economic status of the rural community. Moreover fruits can generate more income as compared to micro-nutrients deficient staple food (Abedullah, 2006). Fruit cultivation is a labor intensive therefore it generates more employment. Despite an important sector of agriculture fruit production has faced many issues including improper marketing system, low output prices, inadequate supply of seed, less availability of financial resources and lack of extension services (Ahmed, 1992).

Greater opportunities for expanding growth rate are available in non-traditional or underutilized fruit crops. Among such crops, strawberry has been shown to be highly potential crop which offer huge amount of profit to the farmer in short tenure. Strawberry is a small berry, originated in the northern areas of Europe. A variety of strawberry species growing wildly all over the world, but only two species of strawberry are cultivated *Fragarin chiloensis* and *Fragarin Verginiana* (John, 1994). It has been noted that in Pakistan strawberry farmers may generate revenue 1000 to 10000 USD hectare^{-1}. The cost of production of Strawberry was estimated as high as 300 USD while the net income earned by strawberry production was approximately 1000 USD showing a remarkably high profit margin in strawberry cultivation as compared to all other important Rabi crops. Moreover the net revenue of strawberry crop was nine times higher than that of wheat and four times higher than that of sugarcane. However, price of the strawberry gradually decreases and comes down to Rs. 0.5 USD kg^{-1} when its production was at peak (Afridi, 2009). Consequently this study is designed to estimate the technical efficiency of strawberry producers with samples obtained from District of Sheikhupura.

Illiteracy and lack of knowledge about the non-traditional crops contributed toward the utilization precious resources in technically inefficient way. Factors such as small sized farms were considered as a big hurdle to take advantage from modern technology (Msangi, 2017). There has been very little work done in Pakistan on measuring the technical efficiency of fruits crops like strawberry. Previous literature showed that the work done in Pakistan relating strawberry was on the cost and revenue analysis (Afridi, 2009), Effectiveness and adoption (Khan, 1990), marketing and production (Amin, 1996), comparative advantage (Sadiq, 2009), production and constraints to producers and future prospects (Mabood, 1994).

Under these backgrounds, the study was designed to full fill the gap by establishing relationship between technical efficiency of strawberry and resource endowment. The study will able to understand, whether strawberry producers were managing their resources in technically efficient way or not and to find out the main reasons contributing towards low productivity.

Material and Methods

The multi stage sampling technique was employed to collect the data from 120 respondents, to figure out the technical efficiency of strawberry producers. In the first stage, Sheikhupura district was selected purposely, and to present the average socio economic and climatic conditions of Sheikhupura district, two tehsils namely, Ferozwala and Sheikhupura were selected in the second step. 6 major strawberry producing villages were selected randomly from each tehsil. Major strawberry producing areas in Sheikhupura district was identified by the help of agriculture extension department Sheikhupura. About 8 percent respondents were interviewed randomly from each village in the fourth stage, in continuation a well-structured questionnaire was formulated for the data collection.

The technical efficiency of strawberry growers was calculated by the help of stochastic frontier production function, which was proposed by (Aigner, 1977) and (Meeusen, 1977). The stochastic frontier production function generally takes the following form

$$Yi = f(X_i, \beta) + \varepsilon_i$$

In the model, Yi was representing the output level of the i^{th} farm; X_i was indicating the vector of physical inputs whereas β represents unknown parameters. Error term εi was comprised of two parts v_i and u_i, where v_i shows random error and connected with the random factors like measurement error in production and factors which were out of farmer's control, such as weather conditions, distribution of supplies and topography etc. Random error ***vi*** may be negative or positive and is anticipatedas independently distributed having zero mean, independent of ui and constant variances $\sigma^2_{v.}$ u_i was non-negative error term, capture inefficiency such as faults in crop management. Review of literature revealed that stochastic frontier production functions of Cobb-Douglas and translog specifications of stochastic frontier production modelare most commonly used in analyzing technicalefficiency in crop sector. The Cobb-Douglas form have advantage over the translog specification, as inclusion of square and interaction terms of the input variables inthe production model results into multi-collinearity problem, especially when the sample size was comparatively small. Therefore, the Cobb-Douglas functional form was generally employed to calculate the individual's technical efficiency and to examine those factors which affectit.

$$Ln\ Yi = \beta o + \beta 1\ Ln\ (X1) + \beta 2\ Ln\ (X2) + \beta 3\ Ln\ (X3) + \beta 4\ Ln\ (x4) + \beta 5\ Ln\ (X5) + \beta 6\ Ln(X6) + \beta 7\ Ln(X7) + Vi - Ui \quad \ldots\ldots\ldots (i)$$

The details of the variables used in the study are discussed in the following table

Table 1. variables used for Model (i)

Yi	Output of the strawberry (kgs) per acre by i^{th} farm.
X1	Number of runner plants per acre
X2	Number of tractor hours for land preparation
X3	Number of labor hours per acre
X4	Cost of pesticide per liter
X5	NPK in kg per acre
X6	Number of trolleys of FYM in kg per acre
X7	Number of irrigations per acre

ui_s were assumed to be half normal positive random variable related with farm related factors and technical inefficiency of the farm ranges between zero and one (Coelli, 1996).

$U_i = \delta + \delta 1\ (Z1) + \delta 2\ (Z2) + \delta 3\ (Z3) + \delta 4\ (Z4) + \delta 5\ (5) + \delta 6(Z6) + \delta 7\ (Z7) + \delta 8\ (Z8) + \omega_i$……(ii)

Where

Zi are the household and farm specific managerial characteristics of the farmer, correlates with inefficiencies of the ith farm and ω_i is the random variable, distributed normally.

Table 2. Variables used in Model (ii)

U_i	Random Farm specific variables
Z1	Farmer's age in years
Z2	Farmer's years of the schooling
Z3	Farming experience of farmer in years
Z4	Farm size (acres)
Z5	Dummy variable representing the strawberry grower's contact with the extension workers
Z6	Family size of the farmer in numbers

Results and Discussion

Average yield of strawberry producers was found to be 7926 kg, the minimum yield was reported as 4098 kg while the highest was noted as 16531 kg $hectare^{-1}$. On average there were about 34.9 tractor hours used $hectare^{-1}$ for the land preparation with minimum of 13.2 to the highest of 44.3 hours $hectare^{-1}$. Average labor hours were 7210. Plantation of runner plants varied among different farmers and it ranges from 86100 to 140220 plants $hectare^{-1}$. On average 122808 plants were planted $hectare^{-1}$ in the study area. Strawberry producers mostly used Urea, DAP, Ammonium nitrate and super phosphate to provide proper dose of NPK to the soil. On average farmers used 546 kg of NPK $acre^{-1}$ from different fertilizers, ranged from minimum of 282 kg to a highest of 787 kg of NPK $hectare^{-1}$. The organic

fertilizer usage of FYM was also reported in the study area, varied from 0.00 to 11 trolleys hectare^{-1}, on average 6.2 trolleys were used hectare^{-1} by farmers. Average cost of pesticide was 22 USD hectare^{-1}. The pesticide cost contributed significantly to the sustainable production and it ranged between 86 to 300 USD depending upon the intensity and types of insect and disease infestation. Total expenditures spent in various heads has been shown in table 3.

Table 3. Mean, ranges ± SD of important expenditures, farm inputs, population and strawberry yield

Parameters	**Mean (per hectare)**	**Minimum (per hectare)**	**Maximum (per hectare)**	**±SD**
Yield (kg)	7926.1	4098.4	16531.2	2765.0
No. of plants	122808.0	86100.0	140220.0	10066.9
Tractor hours	34.9	13.2	44.3	9.2
Labor hours	7210.3	2873.3	12054.0	1968.0
Pesticide cost (USD)	213.68	86.10	319.80	5805.6
NPK (kg)	546.1	282.9	787.2	120.9
FYM(trollies)	6.2	0.0	11.1	2.5
Irrigation (Numbers)	14.0	9.0	22.0	5.8
Farm specific variables				
Age of farmer	39	24	60	8.6
Schooling (years)	5	0	12	3.56
Experience (years)	5.6	1	12	3.15
Family size	11	3	20	5
Farm size (ha)	3.13	0.407	16.26	2.9471

The average farm size reported as 3.13 ha. There were 32 farmers out of 120 respondents who cultivated land less than 1 hectare for strawberry, and the other remaining farmers cultivated on more than 1 hectare of land. Most of the strawberry growers had education till primary or illiterate and the mean education level was 5 years of schooling. The education level varied from minimum of 0.00 to a maximum of 12 years of schooling. Average farmer's age was recorded as 39 years which varied from 24 to 60 years. Family size of the farmers varied between 3 to 20 members, with the mean value of 11 members. Average experience of the farmers in the strawberry cultivation was 5.6 years, which varied from 1 to 12 years of experience. About 69 percent farmers borrowed loan whereas 31 percent did not obtained loan for the production of strawberry.

Table 4. Credit based frequency distribution of respondents*

Respondents	Frequency	Percent
Yes	83	68.8
No	37	31.1
Total	120	100

*Source: Results of primary study

A maximum likelihood estimate of parameters is portrayed in Table 1 in which indicated that the coefficient of seedling is positive but not significant ($P \leq 0.05$). However the positive coefficients indicated that, increase in population of runner plants may increase the yield. These findings were in accordance with (Battese, 1997) and (Ahmed, 1992). The variables tractor hours and labor hours contributed positively and significantly towards the strawberry production. These results showed similarities with (Shafiq, 2000) and (Hassan, 2005) respectively. Inorganic fertilizer and farmyard manure also showed positive and significant results, and increased variables may increase the value of production in our study area. Same results were found by (Bakhsh, 2007) and (Battese (1996). According to the results, numbers of irrigations also had positive relationship with the production of strawberry. Table 5 showed the inefficiency model, the coefficient of family size'. These coefficients were estimated as negative and found significant, indicating those farmers having large family size are more efficient in the production as compared to the farmers having small families. Findings were in line with (Zavela, 2005). The coefficient was positive for age in years but it was not significant ($P \geq 0.05$) indicating that technically efficiency of younger farmers was higher than farmers of older age due to lesser efficient in the education and adoption. These results showed similarity with the finding of (Parikh, 1995).

Table 5. Maximum Likelihood Estimates for Parameters of the Inefficiency Effect Model

Variables	Coefficients	Standard error	T- value
Constant	2.214	0.539	4.101****
Tractor hours	0.141	0.073	1.909**
No.of seedlings	0.199	0.1172	1.629**
Pesticide cost	0.064	0.007	5.521****
Labor hours	0.198	0.078	2.522**
Irrigation	0.161	0.149	1.083*
FYM	0.070	0.030	2.360***
NPK	0.193	0.055	3.459****

*Source: Results of primary study

Table 6. Maximum Likelihood Estimates for Parameters of the Inefficiency effect Model

Variable	Coefficient	Standard error	T value
Constant	0.936	0.107	8.677****
Family size	-0.019	-0.002	-5.790****
Age	0.001	0.002	0.487
Farm size	-0.001	0.0011	-0.670
Experience	-0.022	0.005	-4.492****
Education	-0.005	0.005	-0.950
Credit	-0.154	0.040	-3.815****
Sigma squared ($\sum^2$)	0.031	0.004	7.588****
Gamma (ɣ)	0.999	0.255	3.917****

*Source: Results of primary study

Table 7. Frequency distribution of technical efficiency of strawberry growers*

Technical efficiency	Frequency	Percentage
Less than 50	21	23
50 – 59	19	21
60 – 69	20	22
70 – 79	13	14
80 – 89	12	13
Above 90	5	6
Maximum	0.97	
Minimum	0.39	
Mean	0.64	
Efficiency gap	0.58	

*Source: Results of primary study

The frequency distribution of strawberry growers is presented in Table 8. The results indicated that mean value of technical efficiency was 64 percent ranging from 39 to 97 percent. There was good potential to increase the productivity in the study area by 36 percent subjected to the efficient management of input resources. Efficiency gap between highest efficient and lowest efficient farmer is about 58 percent as portrayed in Table 7. The variable farm size had non-significant t-value ($P \geq 0.05$) with negative coefficient. This variable had negative relationships with the technical inefficiency as large farmers are technically efficient as compared to the small farmers. Experience in years was statistically significant ($P \leq 0.05$) and negative, indicating that farmers having more experience had less technical inefficiency in the strawberry production. Therefore experienced farmers still needed to learn strawberry production in best way. These finding had similarity with the result of (Lingard, 1983), but they were in contrast with (Amoloza, 1983). Education was negative but not significant ($P \geq 0.05$). Negative sign implies that more schooling years

will increase the efficiency and help to reduce the inefficiency. The variable credit had negative coefficient and statistically significant ($P \leq 0.05$) in the model. According to the results the farmers who took loan were found to be more technically efficient as compared to others in the sample farms, as reported by (Giannakas, 2001). The value of variance parameters of sigma square and gamma confirms our assumption of difference in level of technical inefficiency among farmers. The gamma estimate of 0.99 indicated the incidence of technical inefficiency affect in strawberry production.

Conclusion

The present study aims to measure technical efficiency of strawberry, to identify farm level practices followed by strawberry producers and to evaluate those factors which are the main grounds towards the technical inefficiency. By using farm level data, analysis was been carried out. The data was collected from 120 strawberry producers in district Sheikhupura during the year 2013. Results portray the average technical efficiency of strawberry growers was about 64 percent, having minimum value of 39 percent and maximum of 97 percent. These results indicating that efficient utilization of resources may increase the productivity by 36 percent. Socio economic factors which are negatively related with inefficiency were farm size, family size, credit, education and experience with values of coefficients, -0.001, -0.019, -0.15, -0.005,-0.02. The negatively related coefficients such as experience, credit and family size showed significant impact on inefficiency. Only the variable age showed positive relation with inefficiency.

References

Abedullah, K.B., & Ahmad, B. (2006). Technical efficiency and its determinants in potato production, evidence from Punjab, Pakistan. *The Lahore Journal of Economics*, *11*(2), 1–22.

Afridi, G. S., Ishaq, M., & Ahmad, S. (2009). Cost and revenue analysis of strawberry production in the sub-tropical areas of NWFP, Pakistan. *Pakistan Journal of life and Social sciences*, *7*(1), 59–65.

Ahmed, S. (1992). Determining the Economic Effectiveness of Cultivating Strawberry. *Progressive Farming,* 2(6), 24–28.

Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21–37.

Amin (1996). Progress and prospects of strawberry production in NWFP. Annual Report Agriculture Research Station North, Mingora, Swat. 212, 4–7.

Amoloza, J.T. (1983). The management factor in farming and the neison model. *Journal of Agricultural Economics and Development*, 13, 31–51.

Bakhsh, K. (2007). Analysis of technical efficiency and profitability of growing potato, carrot, radish and bitter gourd.Environmental and Resource Economics, University

of Agricultre Faisalabad, Pakistan.

Battese, G. E. & Broca, S.S. (1997). Functional forms of stochastic frontier production functions and models for technical efficiency effects: A comparative study for wheat farmers in Pakistan. *Journal of Productivity Analysis* 8, 395–414.

Battese, G. E., Malik, S.J. & Gill, M.A. (1996). An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. *Journal of Agricultural Economics*, 47, 37–49

Coelli, T. J. (1996). A guide to frontier version 4.1: A computer program for stochastic frontier production and cost function estimation. CEPA Working Papers 7/96, Department of Econometrics, University of New England, Armidale.

Giannakas, K., Schoney, R & Tzouvelekas, V. (2001). Technical efficiency, technological change and output growth of wheat farmers in Saskatchewan. *Canadian Journal of Agricultural Economics*, 49, 1350–1352.

Hassan, S. & Ahmad, B. (2005). Technical efficiency of wheat farmers in mixed farming system of the Punjab, Pakistan. *International Journal of Agriculture & Biology*, 7, 431–435.

John, K. (1994). Fruit size and general characteristics of strawberry varieties.Infos-Paris. 117, 10–23.

Khan.(1990). A study of adoption and effectiveness of recommended horticulture practices with special reference to strawberry fruit in Tehsil Babozai Distirct Sawat.Sarhad Journal of Agriculture, 2, 29–33.

Lingard, J., Castillo, L & Jayasuriya, S. (1983). Comparative efficiency of rice farms in central Luzon, the Phillipines. *Journal of Agricultural Economics*, 34, 163–173.

Mabood. (1994). The future prospects of strawberry production in Pakistan. Advisory Leaflet. 17(2), 51–52.

Meeusen, W. & Van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production function with composed error. *International Economic Review*. 18(2), 435–444.

Msangi, H.A. (2017). Examining the inverse relationship between farm size and efficiency in Tanzanian Agriculture (Doctoral dissertation, Sokoine University of Agriculture).

Parikh, A., Ali, F & Shah, M.K. (1995).Measurement of the economic efficiency in Pakistan Agriculture. *American Journal of Agricultural Economics*, 77, 657–685.

Sadiq, G. & Ishaq, M. (2009).Comparative advantage of strawberry production in subtropical areas of NWFP. *Pakistan Journal of Life and Social Sciences* 7(1), 59–65.

Shafiq, M. & Rehman, T. (2000). The extent of resource use inefficiencies in cotton production in Pakistan's Punjab: an Application of Data Envelopment *Analysis. Agricultural Economics*, 22, 325–330.

Zavela, H., Mabaya, E & Christy, R. (2005). Smallholders' cost efficiency in Mozambique: implications for improved maize seed adoption. Staff paper, SP-2005-04,

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