Measuring technical efficiency of phalsa production in Multan, Punjab, Pakistan

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Abstract

Agriculture is the backbone of economy, and the horticulture considers to be the most significant subsector of it, because the environmental conditions of Pakistan are favorable to grow almost 144 different types of fruits. Phalsa is among the most emerging horticultural crop in our south Punjab due to its high nutritional and economical value. Irrespective to phalsa benefits and usage, its productivity is falling day by day in Punjab. The objective of this study is to determine the factors of technical efficiency of phalsa growers in district Multan. We collected data from 150 phalsa growers of Multan district by using pre-tested structured questionnaire. We employed the Stochastic Frontier Analysis (SFA) for estimation. The findings of study shows that number of tillage practices, application of fertilizer & pesticides, labor and the landholding of famer are the significant factors associated with phalsa yield. The findings of SFA also describe the determinants of technical efficiency, that includes experience of phalsa cultivation, age of the farmer and the cultivation of other fruit orchard. The study suggests that technical efficiency of phalsa growers could be enhanced by 20% on an average by employing the available inputs and technologies efficiently.

Keywords: Phalsa. Multan. Technical Efficiency. Stochastic Frontier Approach

1. Introduction

Pakistan is an agro-based economy and agriculture sector is the third largest sector of Pakistan, contributing 22.7 percent share in GDP, which is absorbing 37.4 percent of total labour force (GOP, 2021). The sector has observed 4.40 percent growth rate in 2021-22 against 3.48 percent in 2020-21 (GOP, 2021). The horticulture sector considered one of the most significant sub-sectors of agriculture in the agro-based economy.

The diversified climate of Pakistan can tolerate almost each type of fruits cultivation and approximately 144 types of different dry and fresh fruits are being sold and consumed (D. Khan & Shaukat, 2006). The fruits that have luscious taste, huge potential and high value are being cultivated in diverse varieties. These fruits include mangoes, grapes, apples, citrus, peaches, phalsa, cherries and dates. Further the fruits that have an enormous potential to export are guava, loquat, plums and pears (PHDEC, 2020).

Phalsa (Grewia *asiatica* L.) is of Tiliacea family member and belongs to order Malvales (Morton, 1987) and it is called as Falsa or Phalsa in Pakistan. Phalsa is a diploid plant with somatic chromosome number (2n = 2x) of 32, which have appearance like a bush and cultivated for its small fruit crop. It is native to Southeast Asia and Subcontinent of India (Chundawat & Singh, 1980), but mainly it is cultivated commercially in western and northern states of India (Hays, 1953; Sastri, 1956). In the beginning of 20th century, phalsa was cultivated and well adopted in Indonesia and East Indies.

Phalsa plant is satisfactorily adoptive in warm climate and can grow in any type of soil with high fertility. Nearly 10 species of phalsa are being cultivating mainly in province Punjab of Pakistan (R. S. Khan et al., 2019; Ullah et al., 2012). Phalsa with its dark purple color (ripened) and unusual sweetened and acidic taste, it becomes famous among people. Phalsa is also known as a good source of vitamin A, B, C and rich in calcium, iron, potassium, carbohydrates and fiber which are essentials for a human being on daily basis (Netmeds, 2022).

In the province of Punjab, Pakistan, a wide range of delightful and valuable fruits are being grown on large scale. The Multan region falls in tropical to sub-tropical climate zone, having long and warm summer and mild winter, having severe weather conditions. As, phalsa plant can tolerate the maximum 45°C and chilling temperature for some days (Khurdiya & Anand, 1981), so the Multan region is favorable for phalsa production. In the Punjab, Phalsa cultivated on 1616 acres of land and produce 2981 tonnes of phalsa during 2019-20, that increase to 1946 acres of land under phalsa cultivation and produce 3270 tonnes of phalsa during 2020 (CRS, 2021). Whereas if we discuss about Multan division, phalsa was grown on 1206 (70.3% of Punjab) acres of land and production from this was 1667 (24.1% of Punjab) tonnes during 2020-21 (CRS, 2021).

In Pakistan, it is believed that the per acre productivity of fruits is lower than the other developed and more advanced countries (Memon et al., 2015). Consequently, regardless of benefits and uses of phalsa, both of its productivity and cultivation are diminishing day by day in Punjab. The low earnings to farmers, high production costs, low rate of innovation in technology and adoption of imperfect advanced farming methods are considered as the major reasons in diminishing the yield. Additionally, the current climate change scenario makes these problems more severe in a country.

Increasing the productivity of agriculture and poverty alleviation both are tangled issues mostly in less-developed countries (World Bank, 2016). Besides this, farmers try to increase their earnings by reducing the cost of production through following the three ways. First, minimization of inputs cost. Second, by development of high yield technologies which are cost effective too. Third, by adopting proper management practices. However, the cost of production can be reduced by advancing the management practices because we don't have control over prices of inputs and have limitations in technology development (Bashir et al., 2005). Advancing the management practices means technical efficiency in economic terms, which is define as measure of capability of a firm to produce maximum output by utilizing an assumed set of inputs (Pinello et al., 2016).

Punjab province yields virtuous quality and huge quantity of phalsa fruit. But, until now there is no research work has been done on phalsa cultivation in Pakistan economically. Hence, this study will be helpful in improving the efficiency and productivity of phalsa growers in future. In literature, Mehmood et al., (2020), Qamar et al., (2020) and Zia-Ul-Haq et al., (2015) discussed the importance of phalsa in medical and nutritional perspective in Pakistan framework but failed to describe the phalsa production. So, the existing literature shows that there is need to be explored the production side of phalsa in Pakistan framework. Hence, this study employed the stochastic frontier approach to determine the factors of technical efficiency of the Phalsa growers in district Multan, Punjab, Pakistan.

2. Technical Efficiency in Crop Production

The farmer's ability to maximize his produce given a specific combination of inputs and production technology, is known as technical efficiency of crop production. The magnitude of technical efficiency indicates the farmer's failure to achieve the maximum output level that can be achieved given a specific combination of inputs and production technology, whereas the maximum output level is represented by production frontier. Figure 1 represents the production frontier and technical efficiency level with condition of amount of input used (Battese, 1992), the vertical axis of the figure 1 represents the output level (Y) and the horizontal axis represents the level of input (X).

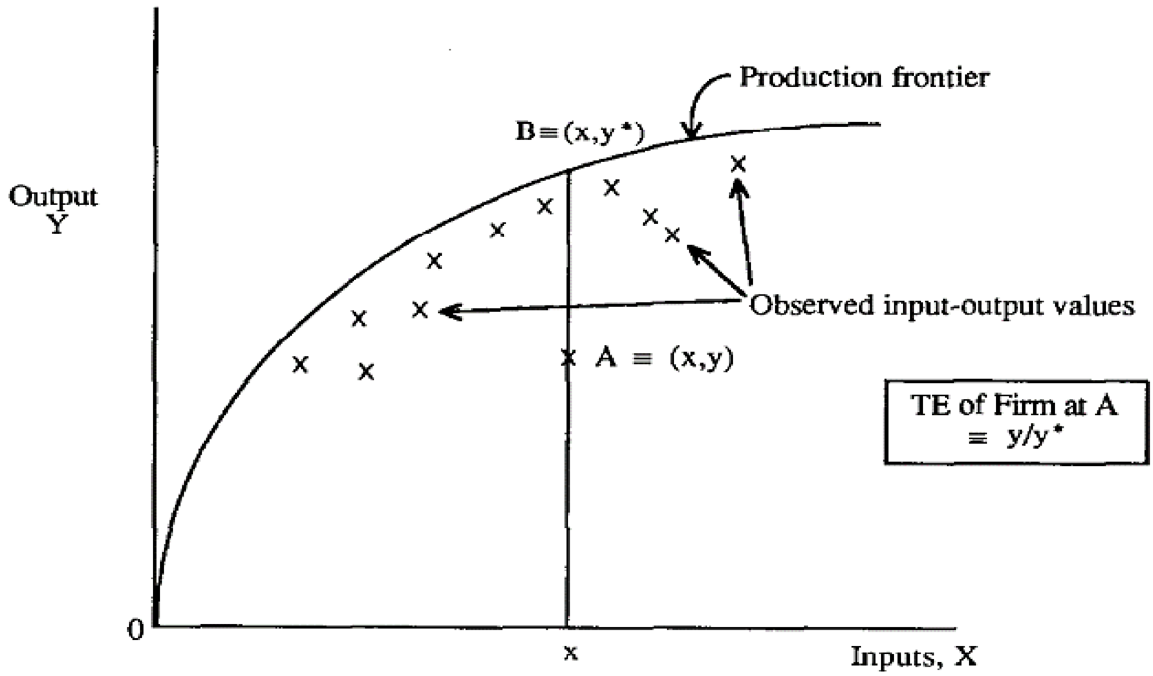

Figure 1: Production Frontier and Technical Efficiency of Input-Output Approach

Source: (Battese, 1992)

The difference between technical efficiency and technological change is very significant to understand. The technological change indicates a shift of production frontier from one point to another, that resembles that the new technology adoption increases the productivity of a firm (Bravo-Ureta et al., 2007). Whereas the technical efficiency describes the difference between observed output that achieved and potential output that can be achieved for a given inputs and technology.

Earlier studies employed the deterministic frontier approach to determine the technical efficiency of the producers, which supposes that any divergence from the frontier line is due to inefficiency of the producer. Let's say in agriculture crops case, production below frontier was inefficient. Though, the deterministic frontier overlooked the factors that are beyond the control of farmers, like climatic conditions that affect the efficiency of farmers to produce on frontier. So, the findings from deterministic frontier approach were susceptible to the variable selection and other data error (Odeck, 2001).

To address the limitations of deterministic frontier approach, the stochastic frontier approach was independently developed by Aigner et al., (1977) and Meeusen & van Den Broeck (1977). The stochastic frontier model is distinguished by its two-pronged error component, one of which is symmetric that captures statistical noise and external shocks, while the other is one-sided residual term that captures inefficiency, such as management flaws. Afterwards, the stochastic frontier approach has been improved in many ways.

3. Literature Review

In developing countries, literature on technical efficiency in agriculture sector is increasing. Kalirajan, (1991) applied translog frontier production function for calculating the rice famer's technical efficiency in India framework. He concluded this finding that by advancing the research methods, by implementation of modern technology and by increasing the extensions services, the technical efficiency can be enhanced. The technical efficiency of the famers of maize in Zambia is studied by (Chiona et al., 2014).

During his study he found that access to credit, extension services, off-farm income, usage of hybrid seed and age of farmer are the chief determining factor for technical efficiency. In Ghana, Essilfie et al., (2011) applied the stochastic frontier approach for calculating the technical efficiency of small-scale famers of maize. He underlined that the demographic factors such as age of farmer, years of schooling, size of the family and off-farm income had a great impact on technical efficiency.

Asogwa et al. (2012) determined the small-scale farmer's technical efficiency in Nigeria and elaborated the results of his study that technical efficiency has been influenced mainly from modern technologies of crops and extension services. Karimov (2014) scrutinized the cotton grower's technical efficiency in context of North-west Uzbekistan. The findings of his study elaborate that there is a significant association among technical efficiency and farm size, application of manure, access to credit, education of farmer, water services, drainage system, off-farm income and water facilities. By implementing the trans-log frontier production model, Carrer et al. (2015) inspected the citrus grower's technical efficiency in Brazil. He determined during his study that process of decision making and personal characteristics are important factors of technical efficiency.

Azhar (1991) calculated the technical efficiency of irrigated area in Pakistan by operating Cobb-Douglas function of production. He concluded his results and stated that the higher education is one of the most significant factors that play decisive role in enhancing the agricultural productivity. Haq et al. (2017) explored the technical efficiency of mango growers in district Muzaffargarh of province Punjab. They applied Cobb-Douglas production function by using the SFA technique. They stated that size of family, own power sources, experience, extension services and education had a significant impact on technical efficiency of mango growers. While orchard age, grower age, intercropping and size of orchard reduced the efficiency of mango growers in the study area. Fatima et al. (2016) studied the cotton producer's technical efficiency in Pakistan by applying the Cobb-Douglas Stochastic Frontier Analysis (SFA). Their results exposed that experience, distance from main market and education are the key factors of technical efficiency.

Ali et al. (2019) researched about the technical of growers of hybrid maize in KPK province of Pakistan by applying SFA technique. They identified that there is a significant association among technical efficiency and household's education, size of family, off-farm income, family members married, tractor drill, extension services, use of certified seeds, savings, irrigation via lined course, credit amount size and experience. Shahzad et al. (2016) investigated the technical efficiency of wheat produces in Punjab by employing DEA approach. They studied in seventeen districts of Punjab and elaborate their findings that technical efficiency of wheat producers can be enhanced by providing access to inputs, educating the farmers and building infrastructure i.e. roads. Nawaz et al. (2020) examined that technical, economical and allocative efficiency of the 240 wheat producers in district Rajanpur of province Punjab of Pakistan by applying the DEA approach. They concluded their result and stated that the mean allocative efficiency of wheat is 74 percent, mean cost efficiency is 53 percent and the mean technical efficiency is 70 percent of the wheat in study area. They also emphasized that by improving the technical efficiency and by using optimal proportion of resources the cost of production can be reduced by 30 percent.

As, the literature explored the technical efficiency analysis in agriculture sector mostly for major crops and major fruits in study area but failed to explore the phalsa technical efficiency in South Punjab region where the Multan division contribute almost 47 percent to total production in Punjab province of phalsa. So, there is need to explore the technical efficiency and factors effecting the phalsa production in Multan division, which will be helpful for phalsa growers in present and future situation about the phalsa production and factors that increase their technical efficiency.

4. Material and Methods

4.1. Study area and data collection

This study was carried out in south Punjab region of Pakistan. The reason behind the selection of this study area is that in south Punjab is hub of many fruits that are grown in warm climate and the Multan division contributes 61.9% (1206 acres) in total area cultivated in Punjab under phalsa and 50.9% (1667 tonnes) in production in Punjab under the phalsa crop (CRS, 2021).

The district Multan is comprised of four tehsils, that includes Multan City, Multan Saddar, Shujabad and Jalalpur Pirwala. Out of these tehsils, three were selected i.e., Multan City, Multan Saddar and Shujabad. The selection of respondents and sample size details are given in Table 1. The data was collected by using the well-structured questionnaire through purposive sampling in the study area. Face to face interview method was applied to collect data to ask about production and efficiency factors from the phalsa growers.

Table 1: Selection of Respondents

Districts	Tehsils	Villages	Number of Respondents
Multan	Multan City	Vehari Chowk	10
		Binda	10
		Borana Lagari	10
		Grewala	15
		Hum Rot	5
	Sub Total		**50**
	Multan Saddar	Sher Shah	20
		Bosan Road	15
		Dumra	5
		Neel Kot	10
	Sub Total		**50**
	Shujabad	Kotly Nijabat	15
		Mari Noon	10
		Lasury	15
		Gawen	10
	Sub Total		**50**
Grand Total			**150**

3.2. Econometric Model

In literature, various studies have been performed on technical efficiency analysis in agriculture sector by applying two different approaches. First approach is data envelopment analysis (DEA) and secondly parametric approach stochastic frontier analysis (SFA). We employed SFA technique in our study, because SFA approach is more reliable and comparable than DEA and SFA is able to do quantitative analysis of random variable can interpret them.

The general form of the SFA model is as follows:

$$y_i = f\ (x_i;\beta)\ \exp(v_i + u_i)$$

Where,

y_i = Output

x_i = Input

β = Estimated coefficient

v_i = Random error which is normally distributed

u_i = technical efficiency which is normally distributed

And $u_i$can be represented as:

$$u_i = z_i\delta + W_i$$

Where,

z_i = p x 1 vector of factors which may affect the efficiency

δ = 1 x p vector of parameters to be estimated

W_i = Random variable which is normally distributed

Technical efficiency is the ratio of observed output (y) to frontier output (y*) with having a condition on input level utilized by firm. So, the technical efficiency was calculated by:

$$TE = \frac{y_i}{y_i *} = \frac{y_i}{[f(x_i;\ \beta)\exp\{v_i\}]} = \exp(-u_i)$$

After calculating the technical efficiency of phalsa growers, a graph of kernel density was generated about technical efficiency distribution in the sample. The stochastic frontier of production and technical efficiency model were calculated by maximum likelihood method, using the Stata version 13 software.

4. Results and Discussion

4.1. Descriptive statistics

Table 2 in the following represents the summary of descriptive statistics of the respondents. According to estimates, the mean age of the respondents is 43 years, and the average farming experience is 16 years. Farmers those growing phalsa have on average experience of phalsa cultivation about 8 years. The farmers of the study area hold on an average of 4.12 acres of land for cultivation and having 02 laborer on their farm for work. The mean value of yield of phalsa growers in study area is 42.74 mound per acre that shows the average productivity of a farmers in Multan district, with 2100 average plant population per acre.

Table 2: Descriptive Statistics Summary

Variable	Mean	Std. Dev.	Minimum	Maximum
Continuous Variables (n=150)				
Age (years)	43.41	9.18	25	80
Farming experience (years)	16.71	6.84	4	40
Phalsa experience (years)	8.79	4.39	1	22
Land holding (Acres)	4.12	2.50	1	15
Labor (No. of Person)	2.30	0.95	1	5
Yield (mound per acre)	42.74	10.69	20	71
Plants (plants per acre)	2100	224.66	1500	3000
Tillage (no's)	2.33	0.49	1	3
Fertilizer (no. of application)	3.79	1.04	1	7
Irrigation Cost (rupees)	8348.33	4936.84	2000	22500
Pesticide (no. of application)	1.04	0.23	1	3
Fungicide (no. of application)	1.03	0.20	1	3
Pesticide Cost (rupees)	8088.28	6436.44	1777.78	80000
Binary Variables (n=150)				
Tube Well (yes=1, no=0)	0.04	0.19	0	1
Power Ownership (Rented=1, Own=0)	0.96	0.19	0	1
Credit Access (yes=1, no=0)	0.04	0.19	0	1
Other orchard (yes=1, no=0)	0.03	0.18	0	1

Source: (Author's Calculation)

On average, farmers applied tillage by 2 times, fertilizer by 3 times, pesticide by 1 time and fungicide by 1 time, and paid on average 8088 rupees for pesticides and 8348 rupees for irrigation. Whereas 4% of the farmers have tube well facility, 96% of the farmers utilized rented power source, 4% have access to credit facilities and 3% of the farmers also have other fruit orchards.

4.2. SFA estimation results

The table 3 indicates the maximum likelihood estimates of the stochastic production frontier and determinants/factors of the technical efficiency. All the coefficients of the productive factors in the estimated results are positive and significant at 1% level of significance, except tillage that is significant at 5%. The coefficient value of tillage indicates that a 1% increase in tillage practice increases the yield of phalsa by 8.6%, and vice versa. This estimate is consistent with Alam et al., (2014).

Table 3: Input Elasticities and Inefficiency Effects

Variable	Coefficient	Std. Err.	z	p>|z|
Productive Factors				
ln_tillage	0.086	0.043	2.01	0.022
ln_fertilizer	0.176	0.052	3.37	0.001
ln_pesticide	0.319	0.053	5.96	0.000
ln_labor	0.008	0.002	3.26	0.001
ln_landholding	0.077	0.031	2.54	0.011
_cons	3.323	0.136	24.41	0.000
Inefficiency Effects				
Phalsa Exp.	-0.021	0.010	-2.17	0.030
Age	0.0002	0.0001	1.76	0.039
Other orchard	0.217	0.105	2.06	0.039
_cons	0.358	0.142	2.52	0.012
Random Error				
_cons	-3.550	0.387	-9.16	0.000
Number of Observations	150			
Wald chi2(5)	90.77			
Prob > chi2	0.000			
Log Likelihood	55.089			

Source: (Author's Calculation)

The result indicates that 1% increase in the application of fertilizer increases the output by 17.6% and application of pesticide and fungicide increases the output by 31.9%. The estimates indicates that higher inputs employment results in higher production i.e. fertilizer and pesticides in our case. The same findings were recorded by Cen et al., (2020), Gagic et al., (2021) and Glover-Amengor & Tetteh (2009). Labor elasticity value indicates that a 1% increase in labor increases the yield of phalsa by 8%. The significance of labor indicates that phalsa growers rely greatly on the manual labor because the most the farming community in study area is small land holder farmers. Therefore, the farmers would concern to maximize the labor productivity intending to highlight the technical efficiency (Mango et al., 2015). The coefficient of landholding indicates that a 1% increase in landholding of farmer would increase the yield of phalsa by 7.7%. This estimate is consistent with the findings of Abate et al., (2019) and Dagar et al., (2021).

The determinants of inefficiency shown in table 3 includes phalsa growing experience, age of farmer and other orchard grown by the farmer along phalsa cultivation. The coefficient of phalsa growing experience is negative and significant at 5% level of significance, that depicts that higher experience of phalsa cultivation would results in lower inefficiency. The impact of age on inefficiency is estimated positive and significant at 5%, but the magnitude of impact is negotiable having estimated coefficient about 0.0002. Cultivating other orchard along with phalsa cultivation may increases the inefficiency of the phalsa growers.

Moreover, stochastic frontier approach has also a significant feature that it is able to deliver farm-specific estimates of technical efficiency. Figure 2 in the following illustrates the kernel density graph of the farm-specified, individual technical efficiency. The estimate of technical efficiency (TE) was calculated by analysis of SFA, that are presented in the table 4 below.

Table 4: Estimates of Technical Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
TE	150	0.795	0.099	0.519	0.957

Source: (Author's Calculation)

The average magnitude of the technical efficiency in the study area is 0.80 (80%), having standard deviation of 0.099. The estimate represents that the phalsa growers in the study area achieved 80% of the potential maximum production of phalsa by utilizing the given set of inputs and technology. The magnitude of technical efficiency ranges from 0.52 to 0.96 in the study area.

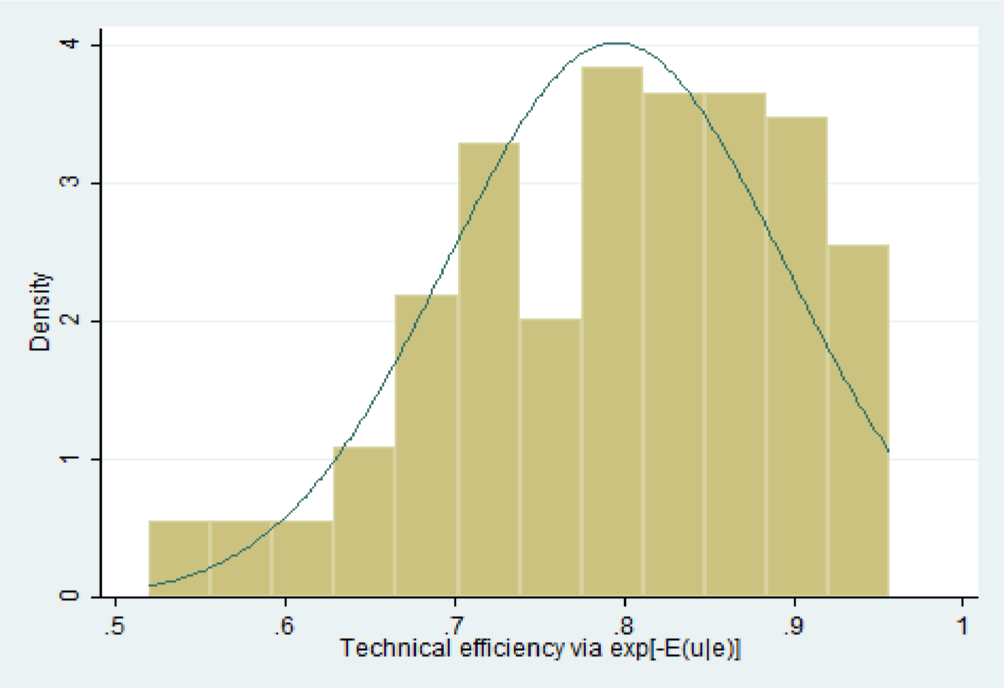

Figure 2: Kernel Density Graph of Technical Efficiency
Source: (Author's Calculation)

The potential for improving the average technical efficiency among phalsa growers in the study area is significant, at 20%. To achieve the optimal level of technical efficiency in phalsa production, they need to improve the farmer-oriented efficiency factors, like number of extension services and proper land utilization.

5. Conclusion and Recommendations

The findings of the study shows that number of tillage practices, application of fertilizer, application of pesticides, labor and the landholding of famer are the significant factors associated with phalsa yield in study area. The tillage practices have positive impact on phalsa yield but significant at 5%. Whereas the application of fertilizer & pesticides, number of labor and landholding also have positive impact on yield of phalsa with significance at 1%. The findings of SFA also describe the determinants of technical efficiency, that includes experience of phalsa cultivation, age of the farmer and the cultivation of other fruit orchard.

The policy implications based on the findings of the study are that the technical efficiency of the phalsa growers could be enhanced by 20% on an average by employing the available inputs and technologies efficiently. To achieve the optimal level of technical efficiency in phalsa production, there is need to improve the farmer-oriented efficiency factors, like number of extension services, proper land utilization and female participation in the agricultural practices.

The effective extension services would help the growers to increase their crop management practices and efficient utilization of resources. In study area, only 4% of the growers have access to credit facilities. The easy access to credit would also enhance the technical efficiency of growers, as it would help them to acquire the inputs on time and resultantly would increase efficiency. Though, this study has only calculated the technical efficiency of phalsa growers in Multan, Pakistan during a specific time. In future, one can study on technical efficiency of phalsa on a wider study area and suggest policy implication regarding efficient cultivation of phalsa growers.

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