Production Efficiency Analysis of Capsicum (Bell Pepper) Cropping System under the Tunnels in Punjab, Pakistan.

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association 49th Annual Meeting, Mobile, Alabama, February 4-7, 2017

Abstract
Technological change is one of the most effective ways to make improvements in crop yields. However, lack of ability or willingness of the producers to adopt technology and other institutional barriers cause slow adoption. Technological adoption for value added crop production in Pakistan is making progress with the introduction of tunnel technology. The present study investigated the technical efficiency and productivity of capsicum crop (Bell Pepper) grown under the tunnels in Punjab, Pakistan. The farm data were collected from 150 farmers through an interview questionnaire. The stochastic frontier analysis was used to measure the productivity and technical efficiency of capsicum crop grown under tunnels. The results of the study revealed that the average technical efficiency of sampled capsicum farms under tunnels was around 83%. The farmers can optimize the production frontier of the capsicum cropping system by overcoming the existing level of technical inefficiencies. The number of irrigations, pesticides, labor hour, land preparation and seed have been important inputs for capsicum cropping system production and technical efficiency among farmers in the study area. The access to credit and farmer's education have the positive relationship with technical efficiencies. Lack of credit and education cause significant production inefficiency.

Key Words: Technical Efficiency, Capsicum (Bell Pepper), Production Tunnels, Stochastic Frontier Analysis, Punjab, Pakistan

Introduction:
Generally, it is agreed that sustainable economic development depends on the elevation in productivity and efficiency in the agricultural sector. Agricultural sector not only reduce unemployment, but also provide a more equitable distribution of income as well as an effective demand structure for other sectors of the economy and this is empirically supported by [Bravo-Ureta and Pinheiro, (1993), (1997)].

For the development of the farm sector, technical progress has its significant role without any doubt. Therefore, the impact of adoption of new technologies on increasing farm productivity and income has grabbed the attention of many researchers and policymakers Hayami and Ruttan, (1985) and Kuznets (1966). However, during the last decade, developing world had been benefiting from major technological gains originating from the green revolution. Productivity gains arising from a use of existing technology are justified by [Bravo-Ureta and Pinheiro, (1993), (1997) and Squires and Tabor (1991)].

According to Dayal (1984), the major prerequisites of farm production are a modification from conventional farming to modern farming. Modern agriculture is a combination of technical change and advancement in production inputs. Farm average production can be increased considerably through modern farming techniques.

Tunnel farming is one of the major modifications in advanced farming techniques that is a manifestation of plastic-culture. The plastic-culture is known as usage of plastic material in the farm sector. First time tunnel farming was started in 1948, it was a cheaper form of greenhouse. Later on, more operative and economical sort of tunnel farming was introduced around the globe The Plastic tunnels have kind of diverse mechanism as tunnels are not artificially heated, and run under a small amount of environment control as compared to greenhouses. Above all tunnels are more cost-effective than greenhouses.

In 1970s the vegetables were successfully grown in tunnels.[1] Over the time tunnel farming turns out to be more prevalent among the vegetable farmers. Tunnel farming helps farmers to grow crops even in off-season. Due to controlled climate in tunnels, crops are grown 45 to 60 days earlier compared to the seasonal crops. Hence, it supported farmers to acquire higher prices of off-

[1]http://www.tunnelfind.co.za/index.php/what-is-tunnel-farming.html

seasonal crops as compared to seasonal crops. In Pakistan tunnel farming is not as old as in other countries, because the tunnel farming was introduced in Pakistan in 1990s. Until 2000 only few farmers were practicing tunnel farming. Punjab government took a major initiative in tunnel farming expansion by taking the ownership of tunnel farming culture in 2002-03. The government of Punjab in 2005 announced the project regarding tunnel technology advancement. Now in Punjab approximately 50,000 acres land is used for tunnel farming [Muhammad et al. (2015)].

Technological adoption in Pakistan's agricultural sector is now moving in a positive direction. In long-run technological adoption most probably sustenance in heightening the production, efficiency and cost effectiveness of agricultural sector of Pakistan. However, the role of high-tech farming may reduce without the positive contribution in farm manager education, technical skills, and managerial abilities. Farm manager's ability to take decision regarding input utilization plays a crucial role towards high levels of farm productivity and efficiency. Improved farm management practices may enhance the returns of technological adoption manifolds. The major objective of the present study is to estimate the technical efficiency and profitability of the farms that cultivate capsicum crops under the tunnels.

Materials and Methods:

The present study based on primary data, collected through detailed interviews based on a questionnaire. The capsicum crop has been taken for the analysis of the mono-cropping system under tunnels. Total 150 farms have been included in the sample. In this case, the number of the cities sampled, and the corresponding number of farms selected from each city is Faisalabad (45), Sumundri (51), Tandlian Wala (25), Toba Tek Singh (05) and Mammo Kanjan (24).

In conventional microeconomic theory, it is assumed that all economic agents are technically efficient. However, empirical analysis shows the contradictory outcomes, consequently neither all the economic agents are on the production frontier nor technically efficient in operating the minimum inputs on given technology to produce the maximum level of output as suggested by Kumbhakar and Lovell (2000).

When output is maximized from a given set of resources or resources are minimized for production of given output, only then the objectives of economic agricultural production are fulfilled. Efficient use of resources in the production process is the optimal productivity and in this context productivity and efficiency are synonymously used.

Efficiency is at the heart of economic theory. Theory of production deals with optimal use of resources and optimization means efficiency [Baumol, (1977)]. The Stochastic Frontier Analysis (SFA) method has been developed by the combination of traditional and frontier analysis in econometric literature. In traditional analysis, it is assumed that farm is at optimal level of output, given the set of inputs and fixed technology. This traditional regression analysis yields the average production function [Aigner et al. (1977)].

The concept of efficiency, introduced by Farrell (1957), is based on the identical deterministic production function which assumes that all the deviation from production frontier is due to variations in efficiency. In this framework, during the estimation process of production frontier, this concept ignores the impact of uncontrollable exogenous variables, such as natural adversities, weather conditions and measurement. Stochastic production frontier is a useful method of finding out the efficient use of resources on the farm. Aigner, et al (1977), Coelli and Battese (1988) and Coelli (1995) broadening the stochastic production approach have used it to calculate efficiency of farmers in resource use. The frontier analysis incorporates the issues of inefficiency in production function and assumes that farms are not always on the ‘best practice’ production level. The stochastic frontier model for capsicum production function by using maximum likelihood estimation is given as:

$$LnY_i = \alpha_0 + \sum_{i=1}^{6} \beta_{1i} \ln X_i + u_i - v_i$$

where Y_i is the capsicum yield per acre in kilograms, β is the unknown parameter to be estimated, X_i represents the set of independent variable and consist of as X_1 shows the land preparation hours per acre. X_2 represents the capsicum seed rate in grams per acre. X_3 shows the total number of pesticide spray per acre. X_4 shows the Nitrogen, Potassium and Phosphorus (NPK) ratio per acre. X_5 represents the total number of labor hours per acre. X_6 show the total number of irrigation per acre.

The basic feature of stochastic frontier production function is that it considers the composite error term. The error term is composed of two components. The systematic component is based on the traditional error term that permits to capture the farm's statistical noise and random variation of measurement error on the production or cost frontier, while the other component captures the one-sided inefficiency effects which are under the control farms.

$$\sigma^2 = \sigma_v{}^2 + \sigma_u{}^2$$

$$\gamma = \frac{\sigma_v^2}{\sigma_u^2}$$

The key parameter gamma (γ) is the ratio of errors, σ_v^2 and σ_u^2. The value of gamma (γ) is bounded between zero and one, where if $\gamma = 0$, inefficiency is not present, and if $\gamma = 1$, there is no random noise [Battese and Coelli, (1995)].

$$T.EF_i = \exp\ (-u_i) \qquad 2$$

Technical efficiency term consists of production level whose highest possible level equals 1. If technical efficiency score is less than 1 for each firm, inefficiency is going to affect the model.

The estimated value of γ in the capsicum production model is less than 1 (Table.2) and is significantly different from zero, thus, establishing the fact that a high level of inefficiencies exist in these capsicum farming systems under tunnels. These factors are generally based on farm-specific and management issues and influence the optimal level of technical efficiency of farms. A major expansion is the ranking of the inefficiency as an explicit function of variables which are firm-specific. The estimation of the stochastic frontier model can be done by a two-stage method. First the stochastic frontier is obtained and then the technical efficiency, which has been predicted, are regressed upon farm specific, management and socio-economic factors [Battese and Coelli (1993) (1995)]. The inefficiency model for the capsicum cropping system is given as:

$$U_i = \sum_{j=1}^{9} \delta_{1j} Z_j + wi \quad 3$$

The U_i term in equation no. 3 denotes the technical inefficiency and δ_m are unknown parameters in the capsicum production system to be estimated, Z_i shows the farm-specific and socio-economic factors of capsicum cropping system under the tunnels. According to Kumbhakar and Bhattachary (1992) farm technical inefficiency might be expected by the socio-economic and farm management factors. Hence inefficiency model is helpful in pointing out the factors that effected the technical efficiency of capsicum farms under the tunnels.

Hypothesis Testing for Capsicum Production Function:

Prior to estimation of capsicum cropping system model, it is important to check the few hypotheses. The first hypothesis applied on capsicum cropping system is that, no technical inefficiency effect present in the model. To check the validity of null hypothesis, Ordinary Least Square (OLS) and stochastic frontier models are estimated.

The log likelihood function values attained from stochastic frontier production model and (OLS) model for capsicum farms are 40.9 and -6.89, respectively.

$$
\begin{aligned}
Likelihood\ \ RatioTest &= -2\left[\ln H_0 - \ln H_1\right] \\
&= -2\left[-6.98 - 40.9\right] \\
&= \quad 95.76
\end{aligned}
$$

The calculated value of likelihood ratio (LR) test statistics rejected the null hypothesis of no technical inefficiency effect present in the Capsicum cropping system. The calculated value of LR test statistics is higher than the tabulated value of Chi-square at 5 percent of significance level, which is 5.14-19.04. This result depicted that Ordinary Least Square (OLS) is not fit for the sample data of Capsicum cropping system. Hence, stochastic frontier technique is used for the capsicum cropping system analysis.

The second null hypothesis for capsicum cropping system is that, socioeconomic and farm specific factors have no effect on technical efficiency of capsicum cropping system. The LR test is considered to check the validity of null hypothesis.

$$
\begin{aligned}
Likelihood\ \ RatioTest &= -2\left[\ln H_0 - \ln H_1\right] \\
&= -2\left[7.89 - 40.9\right] \\
&= \quad 66.02
\end{aligned}
$$

The results obtained from the LR test rejected the null hypothesis in favor of the alternative hypothesis. The calculated value acquired from LR test is greater than the Chi square tabulated value, which is 18.30. This result implies that socioeconomic and farm specific factors have the substantial influence on the technical efficiency of capsicum farm growers.

Table.1 Hypothesis Testing of Capsicum Production Model

Hypotheses	Log-Likelihood Value	Test Statistics Value	Critical Value $\chi^2 0.05$	Decision
$H_0 : \gamma = \delta_\circ = \delta_1 = \delta_2 ... \delta_9 = 0$	-6.98	95.76	5.14-19.04	Rejected
$H_0 : \delta_1 = \delta_2 = \delta_3 .... \delta_9 = 0$	7.89	66.02	18.31	Rejected

Results and Discussion:

The maximum-likelihood estimates (MLE) of the parameters of Cobb-Douglas stochastic frontier function according to Eq. (1), given the specifications for the inefficiency effects defined by Eq (2), estimates of the model were obtained using maximum-likelihood procedures, detailed by Coelli et al. (1998), by using FRONTIER 4.1 (Coelli, 1996). Keeping in view our objectives, the capsicum stochastic frontier is estimated. In the present model, total 15 variables are calculated out of which 6 are in the capsicum production frontier model (Table 2) and 9 are in the capsicum technical inefficiency model (Table 3). The results given in the Table (2) report the Capsicum production frontier model.

Table No. 2 Capsicum Stochastic Production Frontier

		OLS			MLE		
Variables	**Parameter**	**Coefficient**	**Std-err**	**t-ratio**	**Coefficient**	**Std-err**	**t-ratio**
Intercept	β0	0.452	1.408	0.321	3.86***	0.762	5.07
Seed rate	β1	0.665**	0.263	2.520	0.484***	0.144	3.34
Land preparation hours	β2	0.432***	0.118	3.654	0.343***	0.067	5.06
No. Pesticide Spray	β3	0.153	0.095	1.604	0.159**	0.065	2.42
NPK	β4	-0.041	0.072	-0.570	0.015	0.039	0.39
Labor hours	β5	0.721***	0.150	4.797	0.475***	0.095	4.96
T.no. Irrigations	β6	0.750***	0.126	5.908	0.236***	0.086	2.73
Sigma-Squared		**0.067**			**0.574**		
Gamma					**0.986**		
Log Likelihood		**-6.98**			**40.93**		

*:10% **:5% and ***1% significance

The coefficient of pesticide spray in capsicum cropping system is positive and significant. Pesticide spray is one of the most important inputs for growth and development of the plant as the pesticide spray protect the plants from the various kinds of the pests. In the study area, it is observed that as the number of pests' attack increases farmer apply more pesticide spray on the capsicum cropping system. According to Mbata (1988), Ogundele and Okoruwa (2006), Ali et al. (2013), Buriro et al. (2013) and Buriro et al. (2015) the productivity of crops is positively and significantly correlated with the application of pesticides spray.

The coefficient of capsicum seed rate is positive and highly significant. This result of the study implies that appropriate application of capsicum seed rate positively effects the growth of capsicum plants under tunnels, subsequently on capsicum output. This finding is in-line with Ahmad et al. (2002), Abedullah et al. (2006), Alam et al. (2012), Buriro et al. (2013), Ali et al. (2013), Husnain et al. (2015) and Buriro et al. (2015). These studies also explain that proper application of seed rate had a positive impact on a crop productivity.

The estimate of land preparation hours is found to be positive and significant. This result reveals that as the farmers spend more time for land preparation activities, it would correspondingly increase the output of capsicum crop. According to earlier studies, such as, Shah et al. (1994), Wilson et al. (2001), Coroppenstedt (2005) and Fatima and Khan (2015), as the number of ploughing for land preparation activities increases, it would augment the productivity of crop.

The estimate of number of irrigation also carries the positive sign and significant. The proper, timely and weighing scale application of the number of irrigations, puts in increasing the output of the capsicum crop in the study area. Hassan and Ahmad (2005), Koc et al. (2011), Alam et al. (2012), Hussain et al. (2012), Saddozai et al. (2013), Ali et al. (2013), Fatima and Khan (2015) and Hasnain et al. (2015) pointed out that the number of irrigations contributed positively and significantly in increasing the crop yield.

The result of the study reveals the coefficient of labor hours carries the positive sign and significant also. This result demonstrated that as the number of labor hour increase, it boosts the output of capsicum crop in the study area. The role of labor input in farm production process is very crucial specially in case of tunnel farming. Therefore, as labor spends more time on farmland in a dynamic and proficient manner, it will enhance the capsicum crop production. The previous studies [i.e. Abedullah et al. (2006), Bakhsh et al. (2007), Saeed and Khan (2007) Sadiq et al. (2009), Khan and Saeed (2011), Ali et al. (2013), Saddozai et al. (2013), and Ali and Khan (2014)] also found the similar findings and recommended that crop yield can be enhanced by increasing the labor hours or labor days.

The use of NPK fertilizers on capsicum crop shows the positive and insignificant effect on capsicum output under the tunnels. The earlier study of Sadiq et al. (2007) also found that DAP and Urea Application had a positive and insignificant effect on maize crop. Saddozai et al. (2013) stated that application of Nitrogen fertilizer had a positive but an insignificant influence on cotton crop. The farmers of the study area can capitalize the returns from fertilizer application, if farmers tested their farm soil with the help of soil sciences department on regular basis. Consequently, it will facilitate the farmers to apply only those fertilizers that are needed the most for their farm soil.

Capsicum Technical Inefficiency Model:

Efficiency of farms may also be affected by credit, education, experience and farm size [Kalirajan (1981)]. Usually, technical inefficiency is negatively related with these variables. Table. 3 displays the technical inefficiency model for capsicum cropping system.

Table No. 3 Capsicum Technical Inefficiency Model				
		MLE		
Variables	**Parameters**	**Coefficient**	**Std-err**	**t-ratio**
Farmers' age	δ1	0.042**	0.020	2.07
Farmers' education	δ2	-0.265***	0.069	-3.801
distance from main market	δ3	-0.001	0.003	-0.33
Access to Credit	δ4	0.601***	0.231	-2.59
Owner cum-tenant	δ5	-0.962**	-0.445	-2.161
Tenant	δ6	0.172	0.317	0.543
Tractor ownership	δ7	0.122***	0.329	3.7
Operational holding	δ8	-0.265***	0.066	3.99
Total. No. Tunnels	δ9	-0.137	0.108	1.27

**:5% and ***1% significance

The coefficient of age of farmers is positive and significant, showing that comparatively young farmers are more efficient technically than older farmers. The reason for this is younger farmers might dynamically take part in agricultural activities and their readiness to advance farming knowledge which is in line with the study of Coelli and Battese (1995). In the study area, the young tunnel adopters are more efficient in adopting and handling the new farm technologies compared to the old farmers.

In case of tenurial status variables, the base category is the farmer who owned the farm. Most of the tunnel adopters either owners or owner-cum-tenants. Hence, this technology is adopted by most of the farmers, who are financially sound. The tenant variable carries the positive, but insignificant relationship with technical inefficiency. The owner cum tenant variable has the negative and significant relationship with technical inefficiency. This result of the study illustrates that compared to the farm owner, the owner cum tenant farmers are more technically sound and efficient in capsicum cropping system farming under tunnels.

The coefficient of education carries the negative sign and significant. The explanation might be that education can increase the farmers' knowledge and their ability to adapt hence, to become more decisive. In addition, literacy aids farmers to adopt modern farm technologies which will enable them to attain higher levels of production with the same quantities of inputs. This observation is consistent with the studies of Adeoti (2002), Ajibefun et al. (2002), Bravo-Ureta and Rieger (1991) and Ogundari (2013). These studies confirmed that education is must to adopt new innovations and technologies that are imperative for enhancing farm productivity. According to (Nwaru, 2004) education helps to unveil the innate talents and inbuilt creative qualities of the farmers. Hence, making them more skillful and willing to change and take risks compared to the oblivious farmers.

The coefficient of distance from main market has inverse and insignificant relationship with technical inefficiency. This negative sign showing that as the distance from the main market increase, it contributes negatively to farm technical efficiency, but its implication is insignificant on the capsicum cropping system under tunnels.

The positive coefficient of tractor ownership in this study shows the inverse relationship with technical efficiency. Usually, farmers' ownership of tractor resulted in the timely commencement of land preparation and harvesting activities. In study area those farmers who owned the tractors are also performed the land preparation activities to other farmers' farms. It is another source of income for them. Therefore, farmers do not pay full consideration to their own land preparation actions. The prior studies of Hussain (1999) and Buriro et al. (2013) also report the similar findings.

The negative and significant impact of access to credit on technical inefficiency implies that access to credit is likely to enhance the technical efficiency of farmers in the capsicum cropping system under tunnels. Earlier studies of Ahmad et al. (2002) and Saeed and Khan (2007) also found the similar impact of access to credit on technical efficiency. The role of credit cannot be overemphasized in the agricultural productivity of the rural farmers of Pakistan. Due to failing farm product prices and demands, shortage of cash occurs and have an undesirable impact on timely operation and optimal input applications. Thereby, access to credit influences the farm level technical efficiencies significantly in the study area.

The estimate of operational holding under capsicum cropping system has the positive and significant relationship with technical inefficiency. The effect of farm size on farm technical efficiency is constantly questionable. Lau and Yotopolus (1971) using the profit function equation found that small farms have achieved higher technical efficiency levels than large farms. The earlier studies of Ahmad and Ahmad (1998), Saeed and Khan (2007), Alam et al. (2012) and Ali and Khan (2014) also report the inverse relation between operational holding and farms technical efficiency in Pakistan.

The estimate of the number of tunnels per acre on the capsicum cropping system under tunnels is positive, but insignificant. Although the positive sign indicates that as the number of tunnels increase, it adds to the technical inefficiency of the capsicum cropping system farms. But the implication of this result is insignificant.

Determinants of Technical Efficiency in Sole Capsicum Cropping System:

This section discusses the farm-specific and socio-economic factor's categories according to the average technical efficiency distribution of the sole capsicum cropping system. This section deals with the fact that how much technical efficiency can be achieved by a farm-specific and socioeconomic factors within each variable assigned category. Hence, it gives us a more comprehensive illustration of average technical efficiency distribution and farm-specific and socio-economic factors impact on technical efficiency.

The figure 1 shows the average technical efficiency distribution and categories of farmer's education in the sole capsicum cropping system under the tunnels.

The farmers with the primary level of education have the lowest average technical efficiency. The highest average technical efficiency belongs to the farmers that have an intermediate level of education, followed by above the intermediate level of farmers' education. Hence, as farmer's education increases in capsicum cropping system, it would subsequently increase the average technical efficiency of capsicum cropping system.

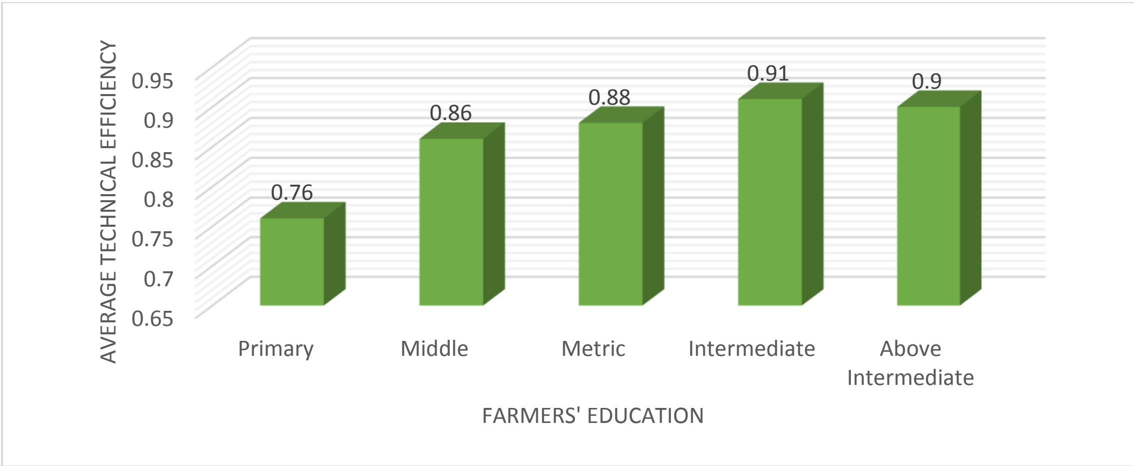

Figure 1. Average technical efficiency and farmer's education in sole capsicum cropping system

Figure 2 shows the average technical efficiency distribution with respect to the categories of farmer's age in capsicum cropping system.

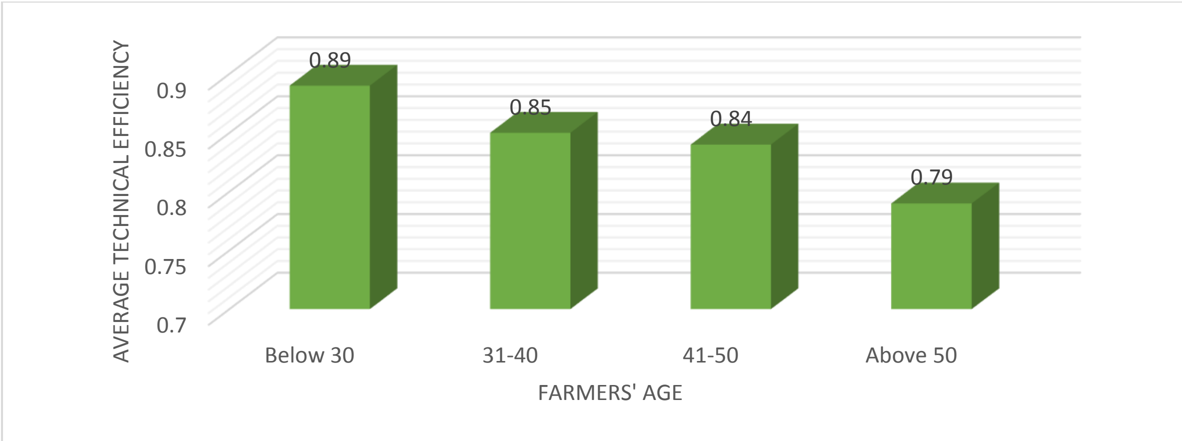

Figure 2. Average technical efficiency and age of farmer in sole capsicum cropping system

The decreasing trend in average technical efficiency with an increase in the farmer's age of the capsicum cropping system is quite evident in figure 2. The older farmers have the lowest and young farmers have the highest average technical efficiency. It is noticed that in the study area, those farmers new to the vegetable farming under tunnels are quite young and motivated to enhance the farm productivity by the adopting innovative farm technologies. Hence, in case of horticultural crops under the tunnels, the young farmers have higher level average technical efficiency.

The figure 3 shows the categories of farmer's access to credit and average technical efficiency distribution in the sole capsicum cropping system.

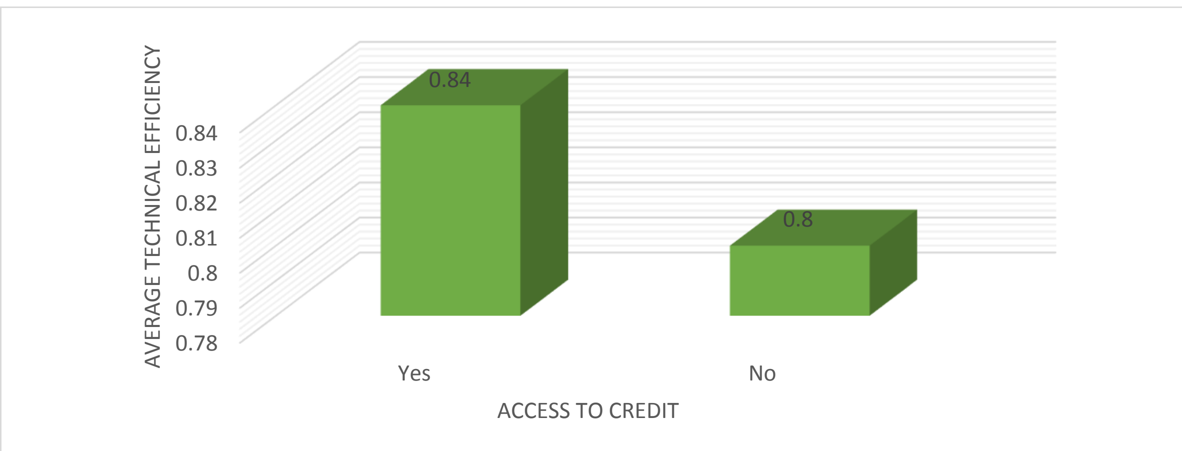

Figure 3. Average technical efficiency and farmer's access to farm credit in sole capsicum cropping system

The figure portrays that farmer's access to credit impact positively on the average technical efficiency of sole capsicum cropping system farming. The highest average technical efficiency achieved by those farmers who have access to credit. Farmers' access to credit resulted in timely application of farm input and adoption of innovative technologies. Hence, higher productivity and technical efficiency in sole capsicum cropping system.

The figure 4 shows the farm distance from main market categories and average technical efficiency capsicum in cropping system.

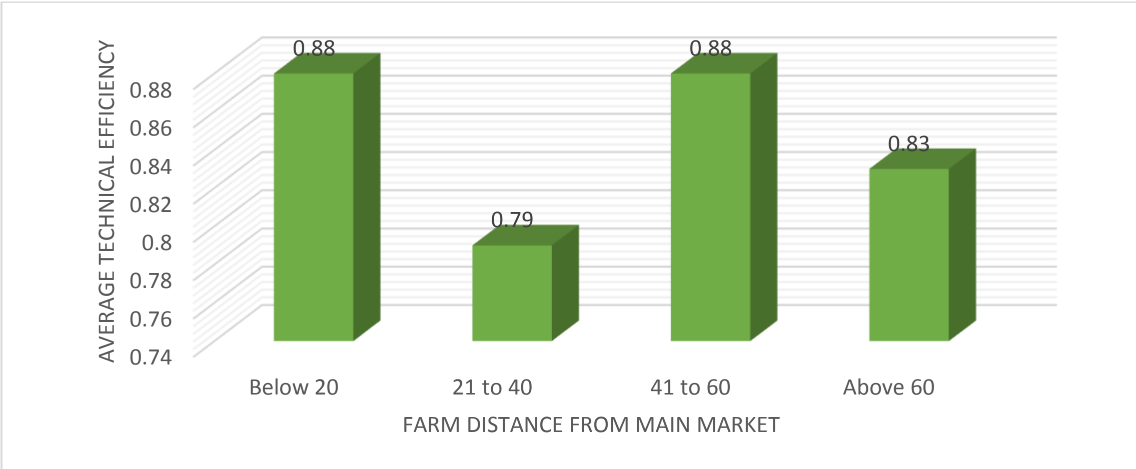

Figure 4. Average technical efficiency and farm distance from the main market in sole capsicum cropping system

The figure depicts the assortment trends among the average technical efficiency of the capsicum cropping system and farm distance from the main market. Those farms have the distance less than 20 kilometers and 41 to 60 kilometers from the main markets have the highest average technical efficiency. Due to the perishable nature of capsicum crops, farmers should sell their farm produce in the main market, consequently, they don't have to take back the surplus crops to the farms. Even though the vegetable farmers have to travel more are prefer to sell all the farm produce that they brought to the market, due to the perishable nature of capsicum crop and the lack of cold storage facilities in the study area. This is the reason, farms distance from main market variable gives the relatively insignificant impact on the technical inefficiency model in the sole capsicum cropping system.

The figure 5 shows the categories of operational holding under capsicum cropping system and its linkage with average technical efficiency.

Figure 5. Average technical efficiency and operational holding in sole capsicum cropping system

The figure demonstrates that those farms ranged from 6 to 8 acres have the highest average technical efficiency, followed by the farms that have 3 to 5 acres of operational holding under the capsicum cropping system. The lowest technical efficiency emanates by the farms ranged from 1 to 2 acres. Inclusively, the figure shows that technical efficiency of the capsicum cropping system increases as the operational holding under this system increases.

Frequency Distribution of Technical Efficiency of Capsicum Cropping System:

Figure 6 shows the frequency distribution of technical efficiency scores. The efficiency scores attained from SFA model indicate the existence of technical inefficiency in the capsicum cropping system under tunnels.

The gamma value in table (1) is around 0.98. It also confirmed that 98% of variation in the capsicum cropping system is due to the technical inefficiencies. The technical efficiency score of capsicum cropping farmers ranges from 0.20 to > 90%. Around 79.33% of the farmers ranges between 0.70 to <90. The mean efficiency of capsicum cropping system is around 0.83 %. This result indicates that in the study area 17% of technical inefficiency is present in the capsicum cropping system. This means that if the present condition and the level of resources and technology remains constant, 17% of output can be increased provided the inefficiency factors are fully catered. If we consider the point that the management of tunnel farming is quite new for the farmers of Pakistan, then this result of the present study reflects that capsicum farmers are under tunnels are doing the good job and considered efficiency stewards of resources available to them.

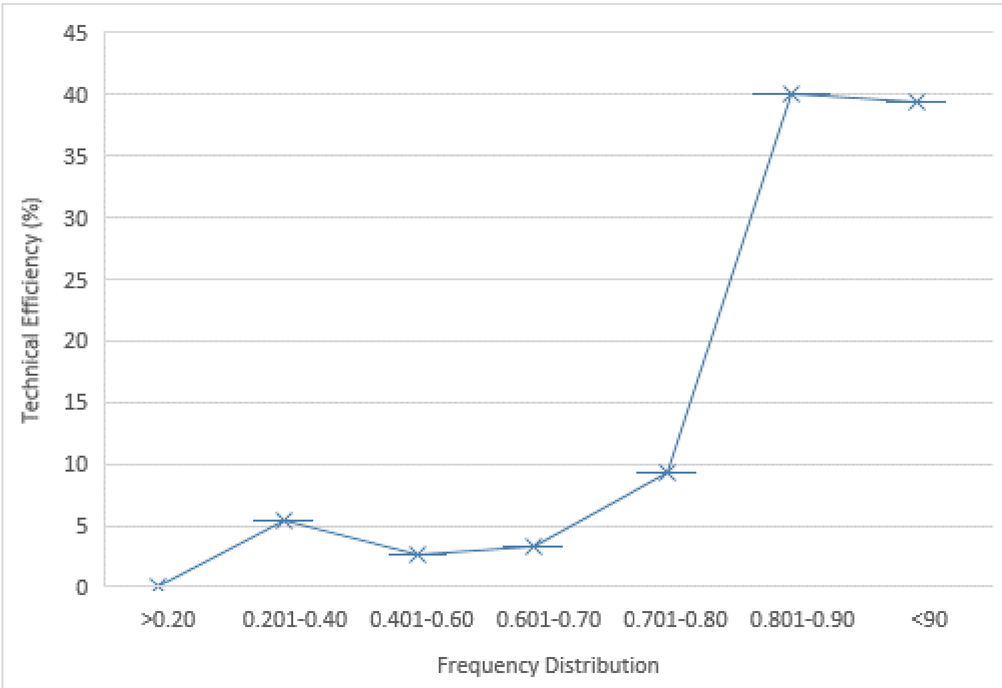

Figure 6 Frequency Distribution of Technical Efficiency of Capsicum Cropping System

However, farmers can still optimize the maximum level of production frontier of the capsicum cropping system by overcoming the existing level of technical inefficiencies. The production process can be transformed; new inputs' utilization complimented with mechanized farming can be introduced if production becomes a market oriented [Omiti et al. (2009)]. Utilizing such inputs can help farmers to be self-sufficient and have food security [Sienso et al. (2013)].

Gross Margin Analysis for Capsicum Cropping System:

The present study also used the gross margin analysis procedure to estimate the profitability of high-tech capsicum cropping system under tunnels. Table 4 shows the per acre gross margin analysis of capsicum crop under the tunnels.

Table. 4 Capsicum Cropping System Gross Margin Analysis				
Crop Revenue	**Rs.**	**Per acre**	**Value**	
A) Total Revenue	**Rs.**	**Per acre**	**721,267.00**	
Cost of Inputs Application Per Acre	**Unit**	**Quantity**	**Price**	**Value**
Tunnel cost	No	15.04	11,824.06	177,833.86
Land Rent	Acre	1.00	1,292.67	1,292.67
Capsicum seed cost	Pack	19.22	1,732.57	33,300.00
Deep ploughing cost	No.	3.58	1,319.33	4,723.20
Leveler cost	No.	1.00	1,374.00	1,374.00
Rotavator cost	No.	1.89	1,474.66	2,787.10
Bed-shedder cost	No.	1.00	3,168.66	3,168.66
Cultivator cost	No.	3.22	1,003.33	3,230.72
Ploughing and planking cost	No.	2.40	838.00	2,011.20
Green Manuring cost	Rs.		2,755.33	2,755.33
Urea cost	Bags	5.28	1,751.67	9,248.82
DAP cost	Bags	7.82	3,314.66	25,920.64
SOP cost	Bags	4.43	4,060.66	17,988.72
FYM cost	Trolley	5.03	1,967.74	9,894.86
Pesticide cost	No. of Sprays	23.28	1,126.58	26,226.78
Irrigation cost				
Harvesting, Threshing, picking cost	Rs.		36,076.67	36,076.67
Capsicum bag cost	Bags	848.30	33.40	28,333.22
Labor cost	No.	2.06	20,796.00	42,839.76
Capsicum transportation cost	Bags	848.30	33.50	28,250.55
B) Total Cost	**Rs.**	**Per acre**	**457,257.00**	
C) Gross Margin (A-B)	**Rs.**	**Per acre**	**264,010.00**	

The gross margin analysis of capsicum crop gives the total variable cost around PKR 457,257 and value of output approximately PKR 721,267. Subtraction of total cost from the total value of output yields the gross margin of PKR 264010 per acre. Capsicum in the mono-cropping pattern under the tunnels proved to be profitable and lucrative crop for the farmers of the study area.

In case of vegetable crops, the Cobweb theorem is quite pertinent to the crop pricing issue in Pakistan. Generally, there is no pricing standard practiced in the farm sector and specifically in case of vegetable crops. The volatility of farm produce prices generally diminishes the farm investment. It is a prerequisite to provide distinct attention to the high tech cropping systems in Pakistan. The introduction of a commercial farming system on one hand and institution of new demand model structure on the other hand, in high tech multiple cropping system may result in higher profitability. Hence, the returns to capsicum crop production can be manifold given that farmers opt for an optimal input mix and well managed farm practices.

Conclusion:

Several skills are required to efficiently manage the farm. These may not be acquired through a formal learning process, or may not be present in the farmers. But these skills can be included in the formal learning and teaching process and demonstrated to the farmers. Efficient farm management practices also depend on the goals of the farmers and their families. In the study area, the efficient use of inputs could potentially increase about 17% of capsicum output at given level of inputs, if each farm is technically efficient. Following are the suggestions to improve technical efficiency:

i) It is desirable to obtain an optimum level of capsicum crop output at a given level of inputs through elimination of technical inefficiency in capsicum cropping system under the tunnels.

ii) Farm efficiency of capsicum farms can also be increased by the identification of the factors that contributes positively in improvement of technical efficiency.

iii) The focus of agricultural policy should be count on the efficiency gains, because it is a source for improving the productivity and profitability of farm sector. Subsequently, it would improve livelihood of farmers and hence reduce the poverty of the sizeable population of Pakistan, as 44 percent of population in Pakistan, directly or indirectly engaged in the agricultural sector.

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