Research Article

Allocative Efficiency and Profitability Analysis of High-Tech Cotton-Melon Multiple Cropping System in Punjab, Pakistan

Hina Fatima[1*], Lal Almas[2] and Bushra Yasmin[1]

[1]Fatima Jinnah women University, Rawalpindi, Pakistan; [2]West Texas A and M University, Canyon, TX, United States of America.

Abstract | This study considered the cost efficiency analysis of cotton-melon cropping system under tunnels. The data were collected from 150 farmers; those were cultivating cotton-melon crops in combination under tunnels. The study area was Punjab, Pakistan. The stochastic cost frontier analysis was used to estimate the allocative efficiency of cotton-melon cropping systems efficiency. The result illustrates that none of the farmers to be optimally using their inputs. The average allocative efficiency was around 75%. Approximately 36 percent of farms allocative efficiency varies from 0.20 to 0.60. Around 60% of farms allocative efficiency ranges from 0.61 to above 0.90. The under and over-utilization of inputs such as land, seeds, fertilizers and pesticides reflect the general performance of the inputs in terms of their degree of changes in cotton-melon output to change inputs reflected by the allocative efficiency analysis. It is indispensable that policies aimed at adapting innovative farming techniques must be implemented in an efficient manner. Effectively implementation of agricultural schemes, formal education and in-formal education should be realized. During and after conducting the agricultural research, it is needed to recommend the farmers about the rate of inputs application i.e. seed, pesticide spray and NPK that are best suited to the local weather patterns and cropping systems.

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***Correspondence** | Hina Fatima, Fatima Jinnah Women University, Rawalpindi, Pakistan; **Emial:** hinnafatima@gmail.com
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Introduction

The agricultural sector has been the mainstream of Pakistan's economy since 1947. It emerged around the world during the 1940s to late 1970s. This revolution brought unprecedented growth in food production with the help of substantial technological innovations. According to Looney (1999), transformation in Pakistan's agricultural sector changed the conventional, complementary farm inputs, *i.e.* seeds, fertilizer, harvesters, sprays, *etc.* into High Yielding Seed (HYV) varieties, commercial fertilizers and advanced mechanization. These moderations take along the swift optimistic modifications in agriculture sector growth as well as on Pakistan's economy.

The opportunity to improve farm production is unstable due to inadequate availability of complementary farm inputs. Likewise, lack of credit facilities, deficiencies in technical information and inapt farm set-up are the major hindrances that ultimately lead to dismal progress in the farm production (Zelberman et al., 2012). According to Alam (2012) pesticides, fertilizers and high quality seeds are essential to accomplish a higher level of farm productivity. Johnston and Cowine (1969) analyzed that in the presence of rapid expansion in the world's population, the shortages in food supply can be overcome by the introduction of HYVs and commercial fertilizers. These development aids in relocating the stagnant farm output into multifarious farm production. According to (Macmillan et al., 1989), systematic changes in the use of farm inputs, like certified seeds and commercial fertilizers, modified the production structure of the Chinese farm sector. Ahmad and Ahmad (1998), Abedullah et al. (2007) and Alam (2012), highlighted the importance of in time availability of water for irrigation, to enhance the farm production.

Furthermore, to enhance the productivity and efficiency of the factors of production, farm manager's education played dynamic role. Zelberman et al. (2012) articulated that the economies of the developing countries are heavily dependent on the agricultural sector's performance and growth. However, the adoption of high-tech farming, in most of the developing countries showed fractional improvement. According to (Anderson, 1999) to earn full benefits of new technology, it is necessary that supply of knowledge regarding innovative technology must be delivered to all farmers without any barriers. It is required that before adopting any technology, farmer should be aware of its pros and cons.

Government should play its influential role and be responsible for all the types of institutional and extension services. According to Zelberman et al. (2012), adoption of new farm technologies heavily depends upon government policies. The success and diffusion of farm technologies cannot be achieved without government's supporting policies, such as subsidies, support price and nondiscriminatory circulation of farm inputs.

To measure relative efficiency of farm production system, two major competing methods SFA (Stochastic Frontier Analysis (Parametric) and DEA (Data Envelopment Analysis (non-parametric) are specifically used. Bauer (1990), Bravo-Ureta and Evenson (1994), Coelli (1995), Kalirajan and shand (1999) and Greene (2007) In stochastic frontier analysis the most commonly used functional forms is Cobb-Douglas production function. Most of the earlier studies used the Cobb Douglas production frontier for empirical analysis of the production function. (Ali and Flinn, 1989; Bravo-Ureta and Pinheiro, 1993; Battese and Coelli, 1996; Sharma et al., 1999; Ajibefun et al., 2002 and Kolawole, 2006).

According to Huq and Arshad (2010), due to scarcity of resources in present time, it is necessary to utilize all the natural resources efficiently. The study concluded that the cost of seeds, irrigation and labor, positively stimulate the vegetable production. Obare et al. (2010) examined the cost efficiency of small farm size potato growers. The results from stochastic dual frontier models revealed that institutional and socioeconomic factors such as credit facility, extension services and improved rural infrastructure did impact on allocative inefficiency of the Irish potato grower. According to Abedullah et al. (2006) for higher farm output and profitability, the extension service centers should work efficiently to provide awareness about new farm practices and other farms' research related activities. Khan and Saeed (2011) found the allocative inefficiency of the tomato crop in KPK, Pakistan. The study revealed that there is a possibility to increase the tomato crop productivity by improving the education, credit facilities and age of tomato growers. According to Byerlee (1987) though the introduction of the new input is helpful in increasing the farm production, yet the untrained application of new inputs distresses the production adversely. Thus, before deciding for the new technology, the need is there to improve farm growers' skills for the procuring best product. Afridi et al. (2009) take into account the short tenure crops that lead to high profit margins in Pakistan. Results show that short tenure crops, *i.e.* tomato, strawberry have lower costs and higher returns compared to wheat and sugarcane crops. The profitability of the horticulture crops is greater, relative to the long term crops. By focusing on the stated factors, the revenues of the farmers can be multiplied.

The major objectives of the present study are to find out that either cost inefficiencies present in the cotton-melon high tech multiple cropping systems or not. The other objective is to scrutinize the profitability of cotton melon cropping system farms under the tunnel by using gross margin analysis.

Materials and Methods

This research is based on the cost efficiency analysis of cotton-melon cropping system under the tunnels. The data of this study are collected from 150 farmers; those are specifically cultivating the cotton-melon crops concurrently under the tunnels. The study based on cross sectional data and the study area is district Faisalabad, located in Punjab province of Pakistan. The method used for the data collection is a questionnaire. The stochastic cost frontier analysis is used in this study to estimate the cotton-melon cost function.

The cost function for cotton-melon cropping system shows the relationship between the prices of inputs and the amount of output that can be produced at those prices. Given the data on price are available, the farms can reasonably be thought of as cost minimizes. In this scenario cost frontier, can be applied for the estimation of economic characteristics of the technology of production. The data at hand is the cross-sectional data the model for the cost frontier in its general form can be written as:

$$C_i \geq C(P_{1i}, P_{2i}, P_{3i}, ..., PN_i, Y_{1i}, Y_{21}, Y_{3i,} ..., YM_i) \quad (1)$$

Here:
C_i: depicts the observed cost for each firm I; P_{ni}: price of n^{th} input and m^{th} output is represented by Y_{mi}. C (.) is a concave, in prices, linearly homogenous and non-decreasing cost function. According to equation 1, the minimum cost is less than or equal to the observed cost. For the estimation of the equation 1, it is necessary to specify the functional for the given cost function.

The Cobb-Douglas functional form is most widely used in stochastic frontier analysis. The cost frontier with the Cobb-Douglas form can be written as:

$$\ln C_i = \omega_0 + \sum_{n=1}^{N} \omega_n \ln P_{ni} + \sum_{m=1}^{M} \omega_m \ln Y_{mi} + v_i \quad (2)$$

Here:
v_i: random variable which is symmetric. It represents the approximation errors and the statistical noise from other sources as well:
Equivalently, equation 4

$$\ln C_i = \omega_0 + \sum_{n=1}^{N} \omega_n \ln P_{ni} + \sum_{m=1}^{M} \omega_m \ln Y_{mi} + v_i + u_i \quad (3)$$

Where:
The allocative inefficiency depicted by the term, U_i: which is non-negative. The function is concave in inputs, linearly homogenous and non-decreasing. If the β_n is non-negative and following constraint is satisfied with it:

$$\sum_{n=1}^{N} \omega_n = 1. \quad (4)$$

Substitution of the constraint in 5, into 4 results in Cobb-Douglas cost frontier model, which is normalized by one of the inputs:

$$\ln(C_i / P_{Ni}) = \omega_0 + \sum_{n=1}^{N-1} \omega_n \ln(P_{ni} / P_{Ni}) + \sum_{m=1}^{M} \omega \ln Y_{mi} + v_i + u_i \quad (5)$$

$$\ln(C_i / P_{Ni}) = X_i^{'}\omega + v_i + u_i \quad (6)$$

Since V_i: symmetrically distributed

$$-\ln(C_i / P_{Ni}) = -X_i^{'} + v_i - u_i \quad (7)$$

As discussed earlier, allocative efficiency form cost frontier can be written as:

$$C.EF_i = \frac{C_i}{\exp(x_i\omega)} = \exp(-u_i) \quad (8)$$

Where:
C. EF$_i$: cost efficiency respective of the i^{th} farm and exp $(-u_i)$ is the conditional exponential composite error term that is based on the case of half normal distribution, suggested by Battese and Coelli (1995).

The estimation of cost frontier function requires a few changes in the error term signs v_i-u_i too. As in production function, we estimate the inefficiency effects, which lead farms to function below the production frontier. On cost frontier, the major purpose is the minimization of cost and maximization of output. It shows how farm operates above the frontier. The efficiencies that are estimated relative to cost frontier are known as cost efficiencies.

The Cobb-Douglas cost frontier model is as follows:

$$LnY_i = \omega_0 + \sum_{i=1}^{9} \omega_{1i} \ln X_i + u_i + v_i \quad (9)$$

To fulfill the necessary normalized condition, the unit cost has been estimated instead of per acre cost. This has been done to see the effect of change in a kg of input on the cost of the production, which seems more justified. Also, each input cost has been divided by the NPK cost per unit. This has been done to estimate the normalized cost function. The description of dependent and independent variables in the equation (9) is given as:

Y: Total cost per acre. This includes all the expenditures on inputs during crops production process; W_1: Total tunnel cost per unit. This has been obtained by dividing the total cost of the tunnel in rupees per acre by the total number of tunnels per acre; W_2: Total cost of melon seed. This has been obtained by dividing the total cost of melon seed in rupees per acre by the total quantity of grams of seeds per acre; W_3: Total cost of cotton seed per grams. This has been obtained by dividing the total cost of cotton seed in rupees per acre by the total quantity of seeds per acre; W_4: Total land preparation cost. This has been obtained by adding per unit cost in rupees of using all the tools for the land preparations; W_5: Total cost of Pesticide sprays per unit; W_6: Total cost of Farm Yard Manure (FYM) per trolley; W_7: Total labor cost per unit; W_8: Total output. This has been taken as the quantity index for the cotton-melon output in multiple cropping systems.

In order to estimate the cost inefficiency model of cotton-melon cropping system is follows as under:

$$U_i = \delta_0 + \sum_{m=1}^{9} \delta_m Z_{mi} + W_i \quad (10)$$

Where:
U_i: term used as dependent variable; U_i: represented as cost inefficiency in cotton-melon cost function.

The description of independent variables in cost inefficiency model is follows as below:

Z_i: symbolize the farm specific and socio economic factor; Z_1: shows the age of farmers in years; Z_2: represents the farmers' education in years; Z_3: shows the farm distance from main market; Z_4: stands for farmers' access to credit, this variable used as a dummy variable. If farmer has access, yes=1, otherwise zero; Z_5 and Z_6: variable used as dummy variables to capture the effect of tenancy status, where base category is farm owner; Z_5: dummy variable shows that if farmer is tenant=1, otherwise zero; Z_6: dummy variable represent dummy variable of owner-cum tenant farmer. If farmer is owner-cum tenant =1, otherwise zero; Z_7: dummy variable, which captures the effect of tractor ownership. If farmer is owner of tractor =1, otherwise zero; Z_8: variable stands for operational holding under cotton-melon cropping system; Z_9: variable portrays the number of tunnels under cotton-melon cropping system.

Result and Discussion

Prior to estimate the cotton-melon cost frontier functional form. This study has checked the restriction on the cost frontier model that either non-normalized cost functional form suitable for the present data or normalized functional form.

To check the hypothesis, the normalized functional form is divided by one of the inputs (NPK) in the model.

$$\begin{aligned} Likelihood\ RatioTest &= -2\left[\ln H_0 - \ln H_1\right] \\ &= -2\left[52.8 - 152.2\right] \\ &= \quad 198.8 \end{aligned}$$

Table 1: *Hypothesis testing of cotton-melon cost frontier*

Hypothesis	Log-Likelihood Value	Test Statistics Value	Critical Value X^2 0.05	Decision
$H_0 := \omega_1 = \omega_2 = \omega_3, \ldots, \omega_9 = 0$	52.8	198.8	5.99	Rejected

The result acquired from the log likelihood ratio test rejected the non-normalized functional form in favor of normalized cost frontier analysis (see Table 1). Hence the present study used the cotton-melon normalized cotton-melon cost frontier functional form in the present study.

In this study, Cobb-Douglas cost frontier analysis is used to estimate the cotton-melon cropping system. In the stochastic cost frontier, total 17 variables are calculated out of which 8 are in C-D cotton-melon cost frontier model and 9 are in the cost inefficiency model.

Table 2 shows the variables used in the present analysis have a direct relationship with a total cost of cotton-melon production. Except output coefficient, all the other estimates of the parameters of stochastic cost frontier model of cotton-melon farmers turned out to be positive. The coefficient of output is negative. The negative relationship between output and total cost per unit indicates the economies of size. The economies of size, condition have cropped up at the point when an increase in output resulted in a corresponding decrease in total cost of production. But the relationship between cotton-melon output and per unit total cost of production of cotton-melon cropping system is insignificant.

The coefficient of tunnels cost carries the positive sign

Table 2: *Cotton-melon C-D stochastic cost frontier*

		OLS			MLE		
Variables	**Parameters**	**Coefficients**	**Std-error**	**t-ratio**	**Coefficients**	**Std-error**	**t-ratio**
Intercept	β0	2.905	1.379	2.106	1.731	0.030	55.94
Output	β1	-0.011	0.058	-0.200	-0.010	0.001	-1.03
tunnel cost	β2	0.249	0.059	4.227	0.118	0.004	25.41
Melon seed cost	β3	0.150	0.074	2.029	0.063	0.001	32.12
Cotton seed cost	β4	0.201	0.082	2.438	0.559	0.002	22.43
Pesticide cost	β5	0.022	0.100	0.220	0.054	0.003	15.93
Labor cost	β6	0.309	0.109	2.823	0.315	0.009	31.82
FYM cost	β7	0.063	0.059	1.070	0.069	0.011	6.19
Land preparation cost	β8	-0.102	0.279	-0.368	0.311	0.009	32.46
sigma-squared		0.084			0.099		
Gamma						0.999	

and highly significant. The major reason behind this positive relationship is unpredictable weather conditions play an imperative role in tunnels structure. If it's damaged due to heavy rain or hurricane, farmers have to sentinel the tunnel construction. This result implies that as the number of tunnels if increases by one percent, the cost of production increases by 11 percent.

The coefficients for melon seed cost and cottonseed are positive and statistically significant. This result revealed that as the rate of seed application increases, it transports a consequent increase in the cost of production. Hence, cost of seed of both crops affect total cost of cotton-melon production significantly. Nkonya et al. (2005) articulated that purchased seeds had a positive impact on a farmer's productivity.

The estimated coefficients for cost of pesticide is positive and significant at 1%, pointing towards the fact that an increase in the application of pesticide spray lead to an increase in total production cost of the cotton melon cropping system. Thus, increased use of pesticides drive to enhance the total cost of production. Through proper application of pesticide spray farmers may be able to minimize the cost of production in an efficient manner.

The coefficient of labor wage has a positive sign and has a high level of significance. It implies that an increase in magnitude of labor hours result in a subsequent increase in total cost of cotton-melon production function. This result pointed out that labor is an important variable in the multiple farming system. However, the labor wages per worker in the study area is still quite low.

The coefficient of Farm yard manure (FYM) cost variable carries the positive sign and is significant. This result revealed that an increase in the amount of FYM would result in an analogous rise in total cost of cotton-melon cropping system. As compared to commercial fertilizer, FYM is used in small proportion in the study area.

The coefficient of land preparation cost is positive and highly significant. This result illustrates that as the magnitude of land preparation activity increases, it subsequently increases the total cost of production of cotton-melon cropping system.

A policy which can cause decreased in seed and pesticides cost will effectively increase farm's productivity and cost efficiency. There is immense need to minimize the production cost in an efficient manner. The purchasing of farm inputs at appropriate scale leads to an increase in input utilization efficiency.

Table 3 shows the cotton-melon cost inefficiency model. The cost inefficiency model demonstrates the factor that have influence on cost efficiency of the cotton-melon cropping system farms.

In the present analysis, the coefficient of age of farmer carries the positive sign and significant also. There is an indication of a non-linear relationship between the farmer's age and his/her level of allocative inefficiency. It is observed that as farmer's age increase in cotton-melon cropping system, there is the probability that farmers' allocative inefficiency is also increased.

Table 3: *Cotton-melon cost inefficiency model*

Variables	Parame-ters	Coefficients	Std-error	t-ratio
Age of Farmer	δ1	0.005	0.002	2.14
Farmers' education	δ2	-0.009	0.008	-1.14
Distance from main Market	δ3	0.006	0.001	5.41
Source of credit	δ4	0.347	0.048	7.19
Tractor Ownership	δ5	-0.172	0.060	-2.84
Tenant	δ6	1.892	0.170	11.09
Own cum-tenant	δ7	2.091	0.170	12.25
Operational holding	δ8	-0.113	0.011	-10.10
T.No. Tunnels	δ9	-0.079	0.010	-7.61

The coefficient of farmer's education is negative. But it is insignificant. Generally, a farmer's formal educational level is associated with the ability of a farmer to manage his/her farm. Generally, it is assumed that formal education level is predicted to affect the cost efficiency. This result demonstrates that a farmer's education level has a positive effect in expanding the cotton-melon farming system allocative efficiency, but insignificant. The result of this study is in line with studies of Nganga et al. (2010), Hyuha et al. (2007), Rahman (2003), Kolawole (2006), Ogunniyi (2011) and Abu and Asember (2011). An effort to improve farmer education is very important. Allocation of huge budgets and greater investment in this area is needed to get the significant impacts on resource allocation efficiently.

The coefficient of operational holding is negative and highly significant. This result demonstrates that as operational holding increase it would correspondingly decrease the allocative inefficiency. This result of the present study is consistent with the preceding studies, Collie (1996), Hassan and Ahmad (2005), Abedullah (2006) and Sadiq et al. (2009). Hence, the larger the operational holding, lower will be the allocative inefficiency level of cotton-melon cropping system farms.

Achievement of maximum allocative efficiency is halted in the presence of inadequate infrastructure. The coefficient of distance from main road is positive and significant. The reason for this positive and high significance could be linked to the fact that markets are usually quite far from the cotton-melon' farms; and relatively more is consumed on transportation of crops from farm to market. Allocative efficiency can help in a way to understand the effect of available facilities to transport the crops to the market through the effect of infrastructure (*i.e.* Road conditions, transport availability, farm distance from main market). Using a related factor, Okike (2001) used the stochastic frontier model to show the effect of the high cost of transportation increased the allocative inefficiency of the farmer.

The coefficient of tractor ownership is negative and significant. This result depicts that those farmers have their own tractor have a higher probability of being allocatively efficient compared to those farmers that do not have their own tractor. This finding can be explained by the fact that the use of own tractor translates into an improvement in allocative efficiency and resultantly an improvement in overall efficiency.

Tenancy status variables used as a dummy variable. The base category is farm owner. The coefficients of the tenant and the owner cum tenant holds the positive sign and highly significant. The result illustrates that tenant and owner cum tenant farmer being allocatively inefficient compared to the farmers those have their own farms. The plausible explanation could be the fact that farm owners are allocatively more efficient because they do not need to pay the land rent. Farm owners do the certain types of farm activities that benefited them in the long run. Thus, the larger the land farmers own, higher will be the allocative efficiency level of cotton-melon cropping system farmers.

The result of allocative inefficiency model of cotton-melon cropping system explore that as number of tunnels increase per acre, it would result in a corresponding decline in allocative inefficiency. The negative coefficient of the number of tunnels revealed that economies of scale is extant in case of tunnels. Hence, as the number of tunnels increase the allocative inefficiency decreased in cotton-melon cropping system.

The coefficient of access to credit is positive and significant. It has a significant effect on allocative inefficiency. The explanation following this positive relationship between access to credit and allocative inefficiency of cotton-melon farmers in the study area is that instead of using the credit in farm productive activities, most of the cotton-melon farmers used it to recompense previous debt, daily requirements of households and other family ceremonies. In fact, a few farmers in study area consumed that credit to innovative farm activity or to the purchasing of the farm inputs. The result of the present study is consistent along with the empirical support of Bravo-Ureta and Pinheiro (1997), Khan and Saeed (2011), and Abdulai and Huffman (2000).

Figure 1 shows the frequency distribution of allocative of cotton-melon cropping system farms by using stochastic frontier.

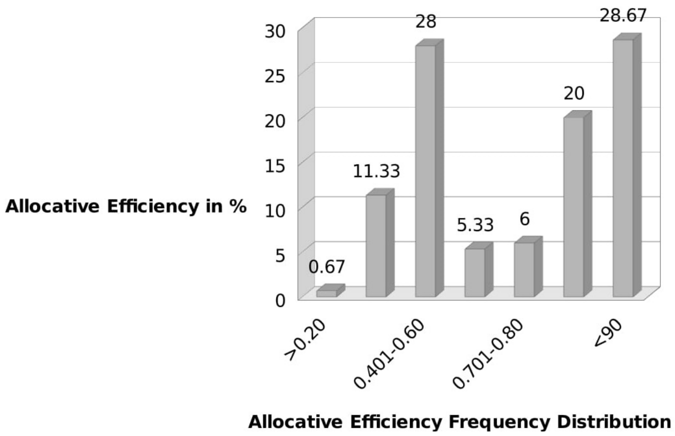

Figure 1: *Allocative Efficiency Analysis of Cotton-Melon Cropping System*

The range of allocative efficiency in SFA lies between 0.20 and above 0.90. The minimum and maximum level of allocative efficiency in case of SFA is 0.18 and 0.96, respectively. The least allocatively efficient farms are 18%, whereas the most allocatively efficient farms are 96% allocatively efficient. In case of SFA analysis about 60% of the farmers have allocative efficiency range from 0.61 and above 0.90, and 39.33 percent farmers have allocative efficiency from below 0.20 to 0.60.

The SFA efficiency analysis shows the presence of allocative inefficiency in cotton-melon cropping system. An average measure of allocative efficiency of cotton-melon cropping system 0.75 is recorded in the study area. This suggests that respondents are about 75% allocatively efficient. Thus, if the average cotton-melon farmers in the area wanted to attain the optimum level of allocative efficiency shown by most efficient farmers, then they should comprehend a cost saving of 25%. The under and over-utilization of variable inputs such as land, seeds, fertilizers and pesticides and irrigations reflect the general performance of the inputs in terms of their degree of changes in an average cotton-melon produce to change inputs reflected by the allocative efficiency analysis. In accordance with the criteria of efficiency criteria, SFA analyses depicts that relatively most of the respondents were fairly efficient in allocating their cost structure in course of cotton-melon production; however, there is room for improvement to minimize the cost of production by improving the utilization of production factors and using available technology in an efficient mode, the potential can be explored by farmers to further enhance cotton-melon production and profit. Table 4 shows the gross margin analysis of cotton-melon farms.

The cotton-melon combination with the multiple cropping under tunnels, gross margin analysis shows a total cost is around 267313.42 and the total value of output is about 370459.75 the difference of the total cost and the total revenue here gives the profit around 103146.33 per acre.

Contrary to the expectations, the combination of melon and cotton was least lucrative and besides that some farmers reported negative returns. One of the reasons may be the unfamiliarity of the farmer of cotton-melon crop combination. The farmers may have been incapable to decide the optimal mix of inputs to be utilized in the combined cultivation of a cash crop with the vegetable. The seed rate and the types and number of sprays, may be inappropriate. It has often been the case in the study area that the pesticide spray which was used to cure the disease, was for the cure of any other disease, not for one, which had infected the farmers' crop. Farmers due to lack of awareness blindly follow their fellow farmers to opt for the sprays. But the fellows' crop may have been affected by some other disease or he may also be using the wrong kind of spray. These farmers have to follow each other as they have the least contact with the extension services and other research institutes by their own will. Also, the other extension service providers and government research institutes are least interested in providing them the services. Hence farmers get on the bandwagon and try to follow each other. The tunnel farming is an expensive high-tech farming in which farmers grow off season crops. The returns to this crop production can be manifold given that farmers opt for optimal crop combination and optimal input mix. The farmer has to be very discreet in taking all the decisions from crop selection to the final stages of production. Input mix should be applied optimally and according to the crop combination. Otherwise, the resources will be wastes, heavy costs will be borne and, the production will be suboptimal as well. Hence, farm management is very crucial in these types of farming specifically.

Table 4: *Cotton-melon gross margin analysis*

Crop Revenue	**Rs.**	**Per acre**	**Value**	
Melon Crop Value	Rs.	Per acre	244430.42	
Cotton Crop Value	Rs.	Per acre	126029.33	
Total Revenue	Rs.	Per acre		370459.75
Cost of Farm Inputs Per Acre				
Input	**Unit**	**Quantity**	**Price**	**Value**
Tunnel cost	No	20.81	4267.55	88807.71
Land Rent	Acre	1	12753.33	12753.33
Melon seed cost	Pack	12.43	2528.33	31427.14
Cotton seed cost	Kg	2.58	1829.17	4719.26
Deep ploughing cost	No	1.13	1087.33	1228.68
Leveler cost	No	1	1897.33	1897.33
Rotavator cost	No	1.15	1246.66	1433.66
Bed-shedder cost	No	1	3042.00	3042.00
Cultivator cost	No	3.19	1010.00	3221.33
Ploughing and planking cost	No	1.22	756.00	922.33
Green manuring cost	Rs.	--	2487.00	2487.00
Urea cost	Bags	4.49	1841.33	8267.57
DAP Cost	Bags	4.37	3433.33	15003.65
SOP cost	Bags	1.12	4196.00	4699.52
FYM cost	Trolley	7.406	1731.92	12826.59
Pesticide cost	No. of Spray	17.91	1498.62	26840.42
Harvesting, threshing, picking cost	Rs.	--	35560.00	35560.00
Melon net Bags cost	Bags	694.36	13.34	9262.76
Labor cost/acre	No.	3.27	12646.03	41390.45
Melon transportation cost	Bags	694.36	24.86	17261.78
Cotton transportation cost	--	--	--	--
Total Cost	Rs.	per acre	267313.42	
Gross Margin (A-B)	Rs.	per acre	103146.33	

Conclusions

The findings of allocative efficiency analysis of cotton-melon cropping system revealed that farmers of the study area can minimize the cost of production by efficient inputs utilization. The average allocative efficiency is around 75%. Hence, it is needed that to decrease the costs of these variables in an efficient manner. The inefficiency model also suggests that increasing the use of age of farmers, distance from main markets and non-availability of credit also added to the allocative inefficiency. High-tech or modern farming systems required more technical skills and expertise. Although Pakistani farmers have adopted the new technologies to some extent, but to maximizing the reimbursements from new technologies is a tough job for the farm community of Pakistan. Major reasons are the deficiency of the know-how regarding new technology and education. Consequently, keeping an eye on the sustainable solutions to enhance farm production is the prerequisite. These solutions include the enhancement of the farm managers' management expertise as well as developing the farm specific characteristics to make Pakistan's farm sector more competitive. It is also needed that to establish a policy at government level that will help to increase allocative efficiency in production among the farmers would bring about an increase in farm of the cotton-melon farmers in Pakistan. The inference of the preceding finding is that any policy providing affordable land, planting materials, fertilizer, agrochemical and labor would improve the profitability of farm production attributed to the fact that farmers would be able to move from the production phase of increasing returns to scale to the phase of decreasing returns to scale where profit would be maximized,

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through expanding inputs.

Auther's Contribution

This article is part of PhD. dissertation of Hina Fatima who presented the main idea, did literature review, collected and estimated the data, and wrote the manuscript. Dr. Bushra Yasmin (Supervisor) and Dr. Lal Almas (foreign supervisor) provided the technical back stopping and suggestions.

References

Abdulai, A. and W. Huffman. 2000. Structural adjustment and economic efficiency of rice farmers in Northern Ghana. Econom. Dev. Cult. Change. 48(3): 503-20. https://doi.org/10.1086/452608

Abedullah., K. Bakhsh and B. Ahmad. 2006. Technical efficiency and its determinants in potato production evidence from Punjab, Pakistan. Lahore. J. Econom. 11(2): 1-22.

Abedullah., S. Kouser and M. Khalid. 2007. Analysis of Technical Efficiency of Rice in Punjab (Pakistan) Implication for future Investment Strategies. Pak. Econom. Soc. Rev. 45(2): 231-244.

Abu, O. and D.J. Asember. 2011. Opportunities for Smallholder Spinach Farmers in Nigeria: A Profit Efficiency Analysis. J. Econ. 2(2): 75-79.

Afridi, G. S., M. Ishaq and S. Ahmad. 2009. Cost and revenue analysis of strawberry production in the sub-tropical areas of NWFP, Pakistan. Pak. J. Life Soc. Sci. 7(1): 59-65.

Ahmad, M. and A. Ahmad. 1998. An analysis of the sources of wheat output growth in the barani area of the Punjab. Pak. Dev. Rev. (autumn): 231–249.

Ajibefun, I.A., G.E. Battesse and A.G. Daramola. 2002. Determinants of technical efficiency in small holder food crop farming: Application of stochastic frontier production function. QIJA. 41 (3): 225-240.

Anderson, R.L. 1999. Cultural strategies reduce weed densities in summer annual crops. Weed Technol.13: 314-319.

Alam, A., K. Hajime, M. Ichizen, I. Akira, M. Esham and Faridullah. 2012. Technical efficiency and its determinants in potato production: Evidence from northern areas in Gilgit-Baltistan of Pakistan. IJRMEC. 2 (3): 1-17.

Ali, M. and J.C. Flinn. 1989. Profit Efficiency among Basmati Rice Producers in Pakistan Punjab. Am. J. Agric. Econom. 71: 303-10. https://doi.org/10.2307/1241587

Asravor, J.E., E. Onumah and B.Y. Osei-Asare. 2016. Efficiency of chili pepper production in the volta region of Ghana. J. Agric. Ext. Rural Dev. 8(6): 99-110. https://doi.org/10.5897/JAERD2016.0765

Battese, G.E and T.J. Collie. 1995. A model for technical inefficiency effects in a Stochastic Frontier Production function for Panel Data. J. Empir. Econom. (20): 325-332.

Battese, G.E and T.J. Coelli. 1996. Identification of factors which influence the technical inefficiency of indian farmers. Aus. J. Agric. Econom. 40: 103-128.

Barns, A. 2008. Technical efficiency estimates of Scottish agriculture: A note. JAE. 59 (2): 370-376. https://doi.org/10.1111/j.1477-9552.2008.00156.x

Bauer, P.W. 1990. Recent developments in the econometrics estimation of frontiers. J. Econ. 46: 39-56.

Bravo-Ureta, B.E. and A.E. Pinheiro. 1993. Efficiency analysis of developing country agriculture: A review of the frontier function literature. Agric. Res. Econom. Rev. 22(1): 88-101. https://doi.org/10.1017/S1068280500000320

Bravo-Ureta, B.E. and A.E. Pinheiro. 1997. Technical, Economic, and Allocative Efficiency in Peasant Farming: Evidence from the Dominican Republic. Dev. Econom. (1): 48–67.

Bravo-Ureta, B.E. and R.E. Evenson. 1994. Efficiency in agricultural production: The case of peasant farmers in Eastern Paraguay. JAE. (10):27- 37. https://doi.org/10.1016/0169-5150(94)90037-x

Byerlee, D. 1987. Maintaining the momentum in post-green revolution agriculture: A micro-level perspective from Asia. Department of agricultural economics, Michigan State University. MSU International Development paper No. 10

Coelli, T.J. 1995. Recent developments in frontier modeling and efficiency measurement. Aus. J. Agric. Econom. (39):219-245.

Coelli, T.J. 1996. A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program, CEPA Working Paper No. 8/96, ISBN 1 86389 4969, Department of Econometrics, University of New England. pp. 49.

Coelli, T.R., D.S. Pardse and G.E. Battese. 1998. An introduction to efficiency and productivity analysis. Kluwer Academic, Boston. https://doi.org/10.1007/978-1-4615-5493-6

Greene, H. 2007. The Econometric Approach to Efficiency Analysis. H Fried, K Lovell and S. Schmidt, eds., Oxford University Press.

Haq, A. and M.F. Arshad. 2010. Technical efficiency of chili production. Am. J. Appl. Sci. 7 (2): 185-190. https://doi.org/10.3844/ajassp.2010.185.190

Hassan, S. and B. Ahmad. 2005. Technical efficiency of wheat farmers in mixed farming system of the Punjab, Pakistan. Int. J. Agric. Biol. 7 (3): 431-435.

Johnston, F.B and J. Cowine. 1969. The seed-fertilizer revolution and labor force absorption. Am. Econom. Rev. 4 (59): 569-582.

Hyuha, T.S., B. Bashaasha, E. Nkonya and D. Kraybill. 2007. Analysis of Profit efficiency in rice production in Eastern and Northern Uganda. Afr. J. Agric. Res. Econ. 15(4): 243-253.

Kalirajan, K. and R.T. Shad. 1986. Estimating Location-specific and Firm-specific Technical Efficiency: An Analysis of Malaysian Agriculture. J. Dev. Econo. (11): 147-160.

Khan, H. and S. Imranullah. 2011. Measurement of technical, allocative and economic efficiency of tomato farms in Northern Pakistan. International conference on management, economics and social sciences (ICMESS'2011) Bangkok Dec. 2011.

Kalirajan, K.P and R.T. Shand. 1999. Frontier production functions and technical efficiency measures. J. Econ. Surv. 13: 149-172.

Kolawole, O. 2006. Determinants of profit efficiency among small scale rice farmers in Nigeria: A profit function approach. Res. J. Appl. Sci. 1 (1) 116-122.

Looney, E.R. 1999. Private sector investment in Pakistani agriculture: The role of infrastructural investment. J. Dev. Stud. 15(2):188-204.

MacMillan, J., J. Whalley and L. Zhu. 1989. The impact of China's economic reforms on agricultural productivity growth. J. Polit. Econom. 97: 781-807. https://doi.org/10.1086/261628

Nganga, S.K., J. Kungu, N.de Ridder and M. herrero. 2010. Profit efficiency among Kenyan smallholders milk producers: A case study of Meru-South District, Kenya. Afr. J. Agric. Res. 5(4): 332-337.

Nkonya, E., J. Pender, C. Kaizzi, E. Kato and S. Mugarura. 2005. Policy Option for Increasing Crop Productivity and Reducing Soil Nutrient Depletion and Poverty in Uganda. IFPRI ETP discussion paper 134. Washington, DC, International Food Policy Research Institute.

Obare, G.A., D.O. Nyagaka, Nguyo, W. and S.M. Mwakubo. 2010. Are Kenyan smallholders allocatively efficient? Evidence from irish potato poroducers in Nyandarua, North District. J. Dev. Agric. Econ. 2(3): 78-85.

Ogunniyi, L.T. 2011. Profit efficiency among maize producers in Oyo state, Nigeria. ARPN J. Agric. Biol. Sci. 6: 11-17.

Okike, I., M.A. Jabbor, V.K.V. Smith, J.W. Akinwumi and S.K. Ehui. 2001. Agricultural intensification and efficiency in West Africa Savannahs: Evidence from Northern Nigeria. Socio-economic and Policy Research Working Paper 33. ILRI, Nairobi.

Rahman, S. 2003. Profit efficiency among Bangladeshi rice farmers. Food Policy. 28: 487-503.

Sadiq, G.H., U. Zahoor, A. Farman, M. Khalid, S. Musawar and K. Inamullah. 2009. Technical efficiency of maize farmers in various ecological zones of AJK. Sarhad J. Agric. 25 (4):606-610.

Sharma, K.R., P.S. Leung and H.M. Zaleski. 1999. Technical, allocative and economic efficiencies in swine production in Hawaii: A comparison of parametric and nonparametric approaches. Agric. Econom. 20: 23-35. https://doi.org/10.1016/S0169-5150(98)00072-3

Zilberman, D., J. Zhao and A. Heiman. 2012. Adoption vs. adaptation, with emphasis on climate change. Annual Review of Resource Economics 4.

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