Research Article

# Determinants of Sugarcane Yield in District Charsadda, Pakistan

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**Abstract** | A survey was conducted to perform an economic analysis and to investigate determinants of sugarcane crop in district Charsadda in the year 2018. Three villages viz. Kamran Kalay, Aspandehri, and Sarfaraz Kalay were selected purposively. Primary data were collected with face to face interview method from 41 randomly selected sugarcane growers through structured questionnaire. The selection of farmers was based on proportional allocation technique in the selected villages. For data analysis, profit margin, gross margin and Cobb-Douglas production function were applied. The study found that the per acre profit of sugarcane was 289.82 US$. Labour and fertilizers costs were found major components in the total variable cost. The profit margin was obtained as 37.37%. Empirical results of regression model found seed, farm yard manure and fertilizer positive and significant determinants, with coefficients 0.5011, 0.2916 and 0.2796, respectively. While tractor and labour costs were noted insignificant. For the wider interest of sugarcane growers and for the growth of agriculture sector, the study recommends reduction in the prices of fertilizers and suggests the Government to develop high yielding Hybrid varieties and to improve the provision of certified/tested seed to the growers.

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## Introduction

Pakistan is an agriculture based country with more than 70 percent of its population depends on agriculture practices. Agriculture is the lifeline of Pakistan's economy that employs 42.3% of the labour force, contributes 19.5% to the GDP and provides raw material to many value added sectors. Thus this sector is crucial in addressing food security, poverty and economic development (GoP, 2017). Sugarcane is one of the best energy source for human being. Countries growing sugarcane worldwide are situated between the latitude 31degree S and 36 N of the equator spreading from subtropical to tropical zones (Natrajin, 2005). The area under cultivation of sugarcane is 28.3 million hectares with Brazil as a chief producer followed by India, China, Pakistan, Thailand and Mexico (FAO, 2010). Around 80% of the world sugar is extracted from sugarcane (GoP, 2010).

Sugarcane is the 2nd major cash crop of Pakistan and is highly fundamental for sugar related industries of the economy. It contributes 3.6% to agriculture value added and 0.7% to the GDP. During 2017-18, the production of sugarcane achieved a record maximum production of 81.102 million tons which was an increase of 7.4% over the output of last year 75.482 tons (GoP, 2018). In terms of area under sugarcane crop Pakistan ranks 4th, however, yield and repossession strapped down the country to 12th position among the world cane producing countries

(Mian and Saeeda, 2003). There are dynamic reasons in decline of sugarcane production, for example, low literacy rate, lack of extension services, miss-use of available resources, poor farmers, lack of agricultural technologies, absence of credit to farmers, absence of trainings and agriculture techniques to the farmers, inadequate use of fertilizers, poor irrigation water channels, lack of ICTs and many more constraints faced by the farmers (Iqbal, 2006).

According to FAO (2010) the annual production of sugarcane in Pakistan is 55,309 metric tons. The per capita consumption of sugar in Pakistan is 25.83 kg per year which is the highest in South Asia that is why around 99% of the sugar in Pakistan is made from sugarcane to fulfill the domestic demand (Azam and Mukarram, 2010). Being an agrarian economy, at present Pakistan is unable to achieve self-sufficiency in sugarcane and sugar production, even for own requirements. The deficiency is bridged by the import of sugar from the rest of the world (Alam, 2007).

Khyber Pakhtunkhwa is the 3rd largest province of Pakistan. Its contribution in terms of area and production of sugarcane crop to GDP is 9.5% and 9.7%, respectively (Khan *et al.*, 2012). Sugarcane output level in Khyber Pakhtunkhwa is (45 t/ha), which is less than the national average and other provinces (Tahir *et al.*, 2014). During 2016 per hectare yield of sugarcane of Punjab, Sind, Khyber Pakhtunkhwa, Baluchistan and Pakistan was recorded as 59, 57, 49, 45, and 58 tons, respectively (GoP, 2016).

This crop is the historical and major cash crop of district Charsadda. Main growing varieties in the district are 77/400, 44, Mardan-92, 48, 310 and 72082 (Hussain and Khattak, 2011). The production of sugarcane crop is prominent in farming community, because of passing on from generation to generation, however it is still labour intensive and its production is not mechanized. Farmers follow traditional methods of cultivation and have little know-how about pre-harvest applications like; appropriate usage of chemical fertilizers, FYM, pesticides, seed, inter-culturing, and timely irrigation (Nazir *et al.*, 2013).

The research in this area is quite limited in all the provinces of Pakistan (Ali, 2004). Batool *et al.* (2015) analyzing area and yield for sugarcane crop in Pakistan from 1980-2013 revealed that the forecasted area and yield have regular increasing trends for the coming five years from 2014-18. The increasing trend revealed that the farmers interest for cultivating more sugarcane crop is because of its high profit. Paulos and Ayenew (2016) found the coefficients of land holding area 0.33, land preparation costs of inputs 1.86, DAP 0.65 and urea 0.18 all significant at 1%. While the coefficients of education level and FYM cost were significant at 5% level with values of 0.24 and -0.04, respectively. The study recommended promotion of formal education and decrease in inputs cost of fertilizers especially, DAP and Urea. It was also suggested that the government and other related bodies should work to solve the problems of small land holding farmers.

Haq *et al.* (2016) noted age, experience and household size as statistically significant factors. The mixed cropping system was found the poorest management system in the efficiency scores. To increase the economic efficiency of farmers it was suggested to improve their skills through taking part in the extension and training programs. Faustino *et al.* (2018) applying Principal Component Analysis showed that out-growersugarcane farming is affected by; experience, family labour, access to credit and operational costs. Policy makers are therefore suggested to ensure title deeds and easy access to loan. Baiyegunhi and Arnold (2011) studying large-scale sugarcane farms in South Africa observed that high cost of inputs mainly affects production. They found that farm labour and fertilizer costs constitute greater share of expenses in sugarcane growing. Hussain and Khattak (2011) identified labour, capital, marketing costs, credit and finance as main factors affecting sugarcane output in district Charsadda. Azam and Khan (2010) reported land size, soil quality, irrigation type, labour availability, seed, fertilizer and capital as key factors that affects sugarcane yield. In assessing factors affecting sugarcane output; high input prices, low output prices, lack of scientific knowledge and payments delay were identified as the main hurdles in sugarcane farming (Nazir *et al.*, 2013).

Upret and Singh (2017) found man days, machine hours, fertilizers and insecticides positive and significant with coefficients 0.382, 0.012, 0.055 and 0.005%, respectively. The coefficient of animal cost was (-0.01) and significant. Owino *et al.* (2018) found positiveand significant coefficients of man days (0.382), tractor hours (0.012), fertilizers (0.055) and insecticides (0.005). Ali and Jan (2017) found land

area, human labour, tractor hours, irrigation, seed and urea significant and positive while DAP, pesticides and farmyard manure were found insignificant. The study showed that formal education of farmers increases inefficiency. It is suggested to provide quality extension services to farmers for enhancing productivity.

Nixon and Simmonds (2004) found significant and positive relationship between root length and air-filled porosity and concluded that green manuring on soil play an important role in sugarcane productivity. On the other hand, Pillay (1999) studied about the adoption of new varieties of sugarcane by non-miller planters. The author stated that new varieties and their information plays significant part in plantation. Yadav and Yaduvanshi (2001) observed that ratoon crop as well as plant crop has no effect on quality of cane juice. Thus the availability of Nitrogen fertilizer and organic carbon contents have been improved by the residues from green manure to the treatment of N fertilizer. Sharif and Chaudhry (1988), Khan *et al.* (2002) noted that the average output of sugarcane is much lower than the potential yield. They revealed that providing balanced dosage of NPK fertilizers for instance; the output has been enhanced up to 165.176 tons per hectare.

Keeping in view the importance of sugarcane crop, the present study attempts to make an economic analysis of sugarcane crop by using gross margin and profit margin and also to investigate into the determinants of sugarcane yield in the study area.

## Materials and Methods

This study is based on primary data collected from sugarcane growers in rural district Charsadda. Data were collected from three villages in district Charsadda namely, Aspandehri, Kamran Kalay and Sarfaraz Kalay. The farmers who were growing sugarcane were selected in the study area. These villages have access to canal irrigation water channels and the soil is famous for sugarcane production. A proportional sampling technique was applied to 41 sample respondents in the selected villages.

Data was collected through face to face interview from those farmers who were engaged in sugarcane production using random sampling method. The data was collected in local language Pashto in order to understand the important factors. Therefore, the author visited each and every field and home of the households. After data collection the collected information was tabulated in MS Excel and STATA software packages, in order to get the final results. Farm analytical techniques for example gross margin and profit margin were investigated to estimate the cost, returns and profitability of the crop. On the basis of total cost, return and cost analysis were estimated. To determine the influence of main variables in the sugarcane production, Cob Douglas production function was as a final estimation because it is the best fit of the sample data (Haq *et al.*, 2002; Hussain and Khattak, 2011; Sarkar *et al.*, 2010; Adhikari, 2011; Hussain, 2013).

*Analytical techniques*

1. Profitability of Sugarcane crop can be found when total cost of production per acre is subtracted from the total revenue per acre (Etuah *et al.*, 2013; Kuboja and Temu, 2013). It is represented by the formula given below:

$$Profitability\ (\pi) = TR - TC \quad ....(1)$$

Where;
TR= total returns; TC= total cost.

$$TR = Qi\ Pi = (Q^R\ x\ P) + (Q^S\ x\ P) \quad ....(2)$$

Where;
$Q^R$= Quantity of sugarcane per acre; $Q^S$= Quantity of straw (By product) per acre; P= price in US$.

$$TC = TVC + TFC \quad ....(3)$$

Where;
TVC= Total variable cost of (seed, labour, fertilizer, pesticides, tractor hours, and other costs) per acre; TFC= Total fixed cost (i.e. land rent).

Therefore,

$$\pi = Qi \times Pi - (TVC + TFC) \quad ....(4)$$

2. Profit Margin was also calculated. It is a percentage measurement of profit that expresses the amount earned per unit of sales (Investopedia, 2018).

Profit margin= Gross profit ÷ Sales revenue (Investopedia, 2018; Wikipedia, 2018).

3. To assess the determinants of sugarcane yield, following double-log model was applied using least square method which best fits the data (Haq *et al.*, 2002; Hussain and Khattak, 2011; Sarkar *et al.*, 2010; Adhikari, 2011; Hussain, 2013).

The Cobb-douglas production function is expressed as follow:

$$Yr = \alpha 0 + \beta 1X1 + \beta 2\ X2 + \beta 3\ X3 + \beta 4\ X4 + \beta 5\ X5 + \beta 6\ X6 + ei \ldots(5)$$

The model was linearized by transforming into double log form a follow so that it could be solved by the least square method.

$$\log Yr = \alpha 0 + \beta 1\ \log X1 + \beta 2\ \log X2 + \beta 3\ \log X3 + \beta 4\ \log X4 + \beta 5\ \log X5 + \beta 6\ \log X6 + ei \ \ldots(6)$$

Where;
Yr= Sugarcane Yield (Rupees/acre); α0= Log of α0 (constant/ intercept); β1-6= Slope coefficients of associated variables (i.e. output elasticities of associated variables); X1= Seed cost (per acre); X2= Labor cost (per acre); X3= Tractor cost (per acre); X4= Animal cost (per acre); X5= Fertilizer cost (per acre); X6= Farm yard manure (per acre); $e_i$= error term; Dependent variable= Sugarcane (per acre); Independent variables= cost of various inputs including seed, labour, fertilizer, tractor, animal and farm yard manure.

## Results and Discussion

### *Cost analysis*

The Production of sugarcane crop incurs various cost of inputs that can be segregated into different components (Table 1). The total cost per acre of *Sugarcane* was estimated Rs. 81198.31. While the total variable cost and fixed cost were US$ 485.67 and US$ 239.25, respectively. The per acre cost components (i.e. seed, labour, fertilizer, pesticides, tractor, land rent etc.) are shown in the following table (Table 1). Land rent (total fixed cost) was the major component in total cost and accounted for 49.26%. In case of total variable cost labour, fertilizer, farm yard manure and cost of seed were found as main expenses. These were 22.53%, 13.14%. 8.39% and 8.34% respectively.

Table 2 reveals the summary statistics of both inputs used and yield of sugarcane in the study area. The minimum per acre yield of sugarcane noted US$ 493.46, while the maximum yield per acre was reported US$ 1435.52. Whereas in case of cost components, the minimum labour cost incurred was US$ 29.91 per acre and maximum was US$ 158.50. Similarly, the minimum cost on fertilizer, farm yard manure and seed cost per acre was noted US$ 43.66, 23.03 and 29.91, while the maximum was obtained as US$ 90.92, 89.72 and 53.83, respectively (Table 2).

**Table 1:** *Per acre cost of various inputs in sugarcane crop.*

| **Sugarcane** | | |
|---|---|---|
| Inputs used | US$ | % |
| Seed | 40.51 | 8.34 |
| Labour | 109.43 | 22.53 |
| Fertilizer | 63.81 | 13.14 |
| Pesticides | 12.46 | 2.57 |
| Tractor | 20.21 | 4.16 |
| FYM | 40.73 | 8.39 |
| TVC (a+b+c+d+e+f) | 246.42 | 50.74 |
| Fixed cost (Land rent) | 239.25 | 49.26 |
| Total cost | 485.67 | 100 |

**Source:** *Field Survey data, 2018.*

**Table 2:** *Summary statistics of various inputs and yield of sugarcane (US Dollars).*

| **Variable inputs** | **Obs** | **Mean** | **Std. dev.** | **Min.** | **Max.** |
|---|---|---|---|---|---|
| Seed | 41 | 40.51 | 7.25 | 29.91 | 53.83 |
| Labour | 41 | 109.43 | 19.23 | 37.38 | 158.50 |
| Fertilizer | 41 | 63.81 | 11.27 | 43.66 | 90.92 |
| Farm yard manure | 41 | 40.73 | 13.09 | 23.03 | 89.72 |
| Tractor | 41 | 20.21 | 6.74 | 11.21 | 38.37 |
| Animal | 41 | 12.17 | 2.42 | 5.98 | 14.36 |
| Production | 41 | 775.49 | 185.15 | 493.46 | 1435.52 |

**Source:** *Data analysis–STATA output, 2018.*

### *Return analysis*

From the study, it was found that the per acre gross returns from *Sugarcane* was US$ 775.49. The total cost of *Sugarcane* was estimated US$ 485.67. While per acre net returns were calculated at US$ 289.82 (Table 3).

### *Profitability of sugarcane crop*

To assess the profitability of sugarcane, the total cost of production per acre was deducted from the total revenue per acre. The resulting per acre profit of *Sugarcane* was obtained 289.82 US dollars in the study area (Table 4).

**Table 3:** *Average per acre gross and net returns of sugarcane crop.*

| Particulars | Sugarcane (Value in US$) |
|---|---|
| Returns from main product | 775.49 |
| Returns from by product | |
| Gross returns | Nil |
| Total cost | 775.49 |
| Net returns | 485.67 |

**Source:** *Author computation, 2018.*

**Table 4:** *Average per acre profit of sugarcane crop (US Dollars).*

| Particulars | Total revenue (TR) | Total cost (TC) | Profit (π) |
|---|---|---|---|
| Sugarcane | 775.49 | 485.67 | 289.82 |

**Source:** *Author computation, 2018.*

Profit margin for the understudy crop during 2018 was estimated at 0.3737. It reveals that every single rupee of investment in *Sugarcane* earned a profit of rupee 0.3737. Otherwise stated, profit margin for the studied *Sugarcane* was 37.37% (Table 5).

**Table 5:** *Profit margin per acre of sugarcane crop (in rupees) (US Dollars).*

| Particulars | (TR) | (TC) | Profit (π) | Profit margin |
|---|---|---|---|---|
| | 1 | 2 | 3=1–2 | 4=3÷1 |
| Sugarcane | 775.49 | 485.67 | 289.82 | 0.3737 |

**Source:** *Author computation, 2018.*

To estimate profitability on the basis of variable cost, gross margin was calculated. The gross margin for *Sugarcane* was US$ 529.07/acre (Table 6).

**Table 6:** *Average per acre gross margin of sugarcane crop (in rupees).*

| Particulars | Gross revenue US$ | TVC US$ | Gross margin US$ |
|---|---|---|---|
| 1 | 2 | 3 | 4=2-3 |
| Sugarcane | 775.49 | 246.42 | 529.07 |

*Source: Author computation, 2018.*

### *Contribution of factor inputs to sugarcane*

Results of Regression model estimated the va1ue of R-square as (0.9569). It shows that 95.69% of the total variations in yield of *Sugarcane* are explained by the explanatory variables that are included in the model. The highly significant value of F-test (125.73) shows that all the included variables are important for explaining the variations in the response variable which is, in this case sugarcane yield; implying best fit of the model (Table 7).

**Table 7:** *Inputs share to sugarcane crop per acre.*

| Independent variables | Coefficients | Std. error | t- value | Sig. |
|---|---|---|---|---|
| Constant | 1.4673 | 0.8118 | 1.81 | 0.080 |
| Seed | 0.5011 | 0.1704 | 2.94 | 0.006 |
| Labour | 0.0235 | 0.0414 | 0.57 | 0.574 |
| Tractor | 0.00099 | 0.0429 | 0.02 | 0.982 |
| Animal | 0.0631 | 0.0374 | 1.69 | 0.100 |
| Fertilizer | 0.2796 | 0.1109 | 2.52 | 0.017 |
| Farm yard manure | 0.2916 | 0.0825 | 3.53 | 0.001 |
| R square= .9569; Adj. R Square= .9493; F= 125.73*** (P value= 0.000); Highly Significant *** | | | | |

*Source: Data analysis– STATA output, 2018.*

### *Input-output relationship*

**Seed:** The seed cost was positive (0.5011) and highly significant at 1%, indicating that 1% addition in the seed cost lead to enhance the sugarcane yield by 0.5011% keeping other variables unchanged (Table 7). Owino *et al.* (2018) also found positive coefficients of seed cost 0.479, significant at 1%. Similarly, Upret and Singh (2017) reported the coefficients of seed cost 0.524 with (p<0.001). Husain and Khattak (2011) also revealed the coefficients of seed 0.871245 with (p<0.001).

### *Farm yard manure*

The coefficient of FYM cost was positive (0.2916) and highly significant at 1%, which shows that 1% increase in the FYM cost would raise the sugarcane productivity by 0.2916%, holding all other factors constant (Table 7). Paulos and Ayenew (2016) found FYM cost negative (-0.04) with 5% significance level. Habib *et al.* (2014) also reported significant and negative impact of FYM on sugarcane output with coefficient of (-0.07).

### *Fertilizer*

The fertilizer coefficient was positive (0.1109), with 1% significance level indicating that 1% increase in fertilizer use lead to enhance the yield by 0.1109% keeping all other factors constant (Table 7). Husain and Khattak (2011) also reported the coefficients of fertilizer positive 0.07891, at 5% level of significance. Upret and Singh (2017) revealed positive and significant coefficient of fertilizers 0.055, at 5% level of significance. Owino *et al.* (2018) found the coefficients of fertilizer cost 0.477 with positive and significant (p<.001).

*Labor*

The coefficient of labor cost was insignificant and positive (0.0235). It shows that if labor cost is increased by 1%, the yield would be increased by 0.0235% (Table 7). Findings of Husain and Khattak (2011) showed labour cost 0.12487, significant at 5%. Upret and Singh (2017) found positive and significant coefficients of human labour 0.382.

*Animal*

The animal cost is significant at 10% with value (0.0631), indicating that 1% raise in animal cost will lead to increase the sugarcane productivity by 0.0631% (Table 7). While Upret and Singh (2017) found the coefficient of animal cost negative and significant (i.e., -0.010).

*Tractor*

The estimated co-efficient for tractor cost was non-significant with positive value (0.00099). It shows that if tractor cost is increased by 1% it will raise sugarcane yield by very small amount of 0.00099%. Husain and Khattak (2011) revealed the coefficients of tractor 0.6712 with (p=0.0034). Upret and Singh (2017) reported machine hrs. significant and positive with value 0.012.

## Conclusions and Recommendations

The study was undertaken to perform economic analysis of sugarcane crop and to investigate the factors affecting sugarcane yield in district Charsadda. Data were gathered from 41 sugarcane farmers during the period 2017-18. The crop was analyzed on per acre basis. Gross margin, profit margin and Cobb-Douglas production function were estimated.

The study revealed that land rent was the major cost of production. Whereas, human labour was the leading cost in total variable cost category, followed by fertilizer, FYM and seed costs respectively. The total cost per acre of studied Sugarcane was estimated US$ 485.67 Per acre net returns were calculated at US$ 289.82. Profit margin was 37.37% and gross margin was US$ 529.07/acre. The study concluded that growing sugarcane crop is a gainful agro-enterprise in Charsadda district of Pakistan.

The results of log transformed linear regression model revealed that inputs such as; seed, FYM and fertilizer were positive and significant determinants while labour cost and tractor cost were insignificant contributors. Sugarcane growers should invest more in good quality seed, FYM and fertilizer for more productivity.

Agriculture is the prime source of living of rural people and is the mainstay of the economy of district Charsadda. Sugarcane crop not only generates employment and provides raw-material to sugar industries but also has a significant export earning potential. Many sugarcane growers are poor and hardly apply the required amount of inputs especially fertilizers, which are critical in sugarcane enhancement. It is necessary for the Government to formulate holistic measures for the wider interest of sugarcane growers. It is therefore, suggested that:

- As farmers are growing old varieties of seed, it is essential for the Government to develop high yielding hybrid varieties and to improve the provision of certified/tested seed to the growers.
- Inputs such as fertilizers and seed may be provided at cheaper rates.
- There is need to create awareness among farmers to apply the appropriate and recommended amount of fertilizes to the sugarcane crop for more yield to contribute significantly to production in the district.

## Novelty Statement

Experienced farmers have significant outcomes due to their improved inputs.

## Author's Contribution

Shahzad Khan contributed in the ideology of the paper and in all sections of the paper. Munir Khan and Inayatullah Jan contributed in analysis, results and discussion. Mahfooz Khan and Fida Muhammad Khan contributed in literature review and references.

*Conflict of interest*

The authors have declared no conflict of interest.

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