Research article

Determinants of Sugarcane Productivity in Pakistan (1981-2011)

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Abstract The paper evaluates the impact of water availability, fertilizer consumption and credit disbursement on sugarcane productivity in Pakistan using time series data over the period 1981-2011. The data has been taken from Economic Survey of Pakistan, Agricultural Statistics of Pakistan and National Fertilizer Development Corporation (NFDC). The study estimates log-log model using ordinary least square method. For checking the stationarity of the time series data, Augmented Dickey Fuller (ADF) test is used. The empirical findings reveal that the yield elasticities of water availability, fertilizer consumption and credit disbursement are 0.16, 0.14 and 0.04 respectively. It is recommended that water availability should be ensured by the government at the grass root level for higher sugarcane productivity. The farmers should be given support in consumption of fertilizer. Micro Agriculture credit should be given for sugarcane farmers for purchasing the inputs, technology and high yielding varieties.

Keywords sugarcane, productivity, water availability, agriculture credit

INTRODUCTION

Sugarcane is one of the important cash crops of Pakistan and is the important source of the livelihood of the poor community in rural areas. It is used for industries like sugar, chipboard, and paper. Looking over the statistical picture of sugarcane crop, its share in value added of agriculture and GDP are 3.4 percent and 0.7 percent, respectively. In the year 2008-09, the area under sugarcane crop was 1029 thousand hectares which was lower by 17.1% as compared to the year 2007-08. The production of the sugarcane was 50.00 million tons as compared to production of 63.9 million tons in the year 2007-08, showing 21.7% decrease against the year 2007-08. The deteriorating situation was mainly due to water shortages and shifting of the area for the cultivation of rice crop. The lack of in time payments to the farmers by the sugar mills was also the major factor (Government of Pakistan, 2009).

Sugarcane production showed significant fluctuations in the past. In 1960-61, the total area under sugarcane crop was 388 thousands hectares which has been increased to 1029 thousands hectares in 2006-07. On the other hand, in 1960-61, the total sugarcane production was 11641 thousands tonnes which has been increased to 54742 thousands tonnes in 2006-07. The total credit disbursement in the agriculture sector in Pakistan was Rs.103.78 million in 1960-61 which has been increased to Rs. 168830.46 million in 2006-07. The total fertilizer off-take in 1960-61 was 31.40 thousand nutrient tonnes, which has been increased to 3672 thousand nutrient tonnes in 2006-07 (Government of Pakistan, 2007).

The recent statistics reveals that the area under sugarcane crop is 988 thousands hectares in the year 2010-11 which is higher against the year 2009-10 of 943 thousands hectares. Similarly the sugarcane production also improved in the year 2010-11 against the year 2009-10. The production of the sugarcane in the year 2009-10 and 2010-11 was 49,373 thousand tones and 55,309 thousand tonnes respectively. It is also interesting to note that sugarcane yield in kilograms per hectare has also been increased to 55,981 kilograms per hectare in the year 2010-11 as compared to 52,357 in the year 2009-10. Agriculture production in general and particularly sugarcane production can be increased through applying appropriate agricultural input policy. The major agriculture inputs mainly credit disbursement, area under cultivation, water availability and fertilizer which matter much.

A very limited researchers conducted studies about the econometric analysis of different aspects of sugarcane crop. Ulveling and Fletcher (1970) estimated Cobb-Douglas production function using input elasticities as a quadratic function of a capital intensity index and determined the rate of returns to scale through incorporating the cost function. Alcantara and Prato (1973) conducted study in Brazil in which they estimated the returns to scale for sugar mills farms. The findings revealed that the elasticities for labor, land, fertilizer, pesticides and machinery/equipment were 0.340, 0.285, 0.351, 0.113 and -0.089 respectively. They recommended for government to increase the efficiency in sugarcane industry and focusing on expansion of sugarcane farms. Bhatti and Yanagida (1990) developed a supply response model and empirically estimated standard regression procedures. The principal factors affecting sugarcane supply response were the official procurement sugarcane for sugarcane paid at the sugar mill gate, the scale of operation and the relative returns to alternative uses of sugarcane.

Farooq et al. (1999) outlined the possible causes of wide spread cultivation of a non-recommended, high yielding but low in sucrose contents sugarcane variety i.e. Co-1148. It has created different problems for both the farmers and sugar mills. Ali et al. (2000) conducted study about fertilizer-use efficiency and cane yield under different nitrogen levels and weed management practices in spring planted sugarcane. He pointed out the average fertilizer use efficiency (FUE) to be 36.10 in weed-free crops compared with 21.94 in weedy crops, with corresponding yields of 99.87 and 75.94 t/ha. FUE ranged between 150 and 225 kg N/ha. Yadav and Yaduvanshi (2001) studied that the yield of millable cane from the planted sugarcane was affected by fertilizer N rather intercropped green manuring or plant arrangement. He observed that whether it is the plant cane or the ratoon crop, the quality of cane juice is not affected in either case. The organic carbon content and available N in the soils have been increased by residues from the green manures and N fertilizer treatments. Chattha et al. (2001) evaluated the effect of different production factors on the yield of 15 sugarcane cultivars in Punjab, India. The factors were mainly planting methods and date, soil amendments, irrigation and plant protection. Results revealed that sugarcane yield improved by 21.96% through trench planting, by 43.75% through effective weed control, by 34.50% through the integrated use of press mud and fertilizers, by 26% through skip furrow irrigation and by 50% with urea application by drilling. Through proper weed management he also observed 32% improvement in ratoon crop.

Muhammad, et al. (2001) observed that non-adoption of recommended agricultural technologies was the responsible factor for the low per hectare yield of crops. The data were collected from 191 sugarcane growers selected through stratified random sampling technique from 16 villages selected by using multistage sampling method. The data suggested that awareness and adoption of sugarcane production practices were very poor. Lack of awareness of recommendations appeared to be the major cause of non-adoption. Nixon and Simmonds (2004) investigated the impact of fallowing and green manuring on soil conditions and the growth of sugarcane in Swaziland. He observed that yields were improved from 129 tonnes per hectare to 141–144 tonnes per hectare after fallowing and green manuring. He also assessed positive relation between root length and air-filled porosity. Hussain et al. (2006) made economic analysis of sugarcane production in Pakistan using time series data ranging from 1990 to 2002. Their findings revealed that Pakistan has no comparative advantage in producing sugar at export parity prices although plays role as import substitution. Gana (2008) evaluated the sustainability of organic fertilizer on sugarcane production in Nigeria. He conducted experiments using plots with and without fertilizer application. The findings revealed that application of organic and inorganic fertilizers matters in sugarcane production.

Fernandez1 and Nuthall (2009) conducted a study in the Central Negros area, Philippines on sources of input use inefficiency through data envelope analysis. They have taken individual farms in which same type of input-output were used for which the mean relative technical, scale and overall technical efficiencies were determined and these indices were found as 0.7580, 0.9884 and

0.7298, respectively. The findings further revealed that technical inefficiency was the major source of overall inefficiencies as compared to scale effect. It was also found that farmer's age and experience, access to credit, nitrogen fertilizer application, soil type and farm size were positively associated with overall technical efficiency. Niamatullah et al (2010) assessed the impact of price of fertilizer and agriculture credit on sugarcane acreage in Khyber Pakhtunkhwa over the period of 1991-92 to 2007-08. Their findings revealed that price of fertilizer and agriculture credit were the influencing factors for sugarcane acreage.

OBJECTIVE

The significance of the sugarcane crop in the economy of Pakistan cannot be ignored. Unfortunately, there is dearth of studies over the issue under consideration. The present study will bridge this gap and attempts to estimate the impact of water availability, fertilizer consumption and credit disbursement on sugarcane productivity in Pakistan using time series data over the period 1981-2011.

METHODOLOGY

According to the classical economist, output (Q) is a function of labor (L) and the relationship is expressed as: Q = f(L)

The neoclassical economist added the capital (K) component in this production function, taking the form: Q = f(L,K)

In non-linear form, the relationship is expressed as:

$$Q = AL^{\alpha}K^{\beta}e^{\mu} \qquad (1)$$

This is the conventional Cobb-Douglas (1928) production function. α and β are the output elasticities of labor and capital respectively. 'A' is the rate of technology and μ is the random term, satisfying all the usual assumptions. Taking natural logarithm to both sides, the equation becomes:

$$\ln Q = \ln A + \alpha \ln L + \beta \ln K + \mu \qquad (2)$$

This model can be estimated by applying the ordinary least square method.

The model not only shows the input output relationship but also gives information about the rate of returns to scale.

The concern of this study is to evaluate the impact of major determinants of sugarcane productivity in Pakistan, so the following model is estimated using the ordinary least square method:

$$\ln(SY_t) = b_o + b_1 \ln(WA_t) + b_2 \ln(FC_t) + b_3 \ln(CD_t) + \mu_t \qquad (3)$$

Where

SY = Sugarcane yield (Kgs/Hectare) in Pakistan

WA = Water availability[1] (million acre feet) in Pakistan

FC = Fertilizer consumption for sugarcane crop (000 N/T) in Pakistan

CD = Credit disbursement[2] (Rs. in million) in Pakistan

't' is the time period and μ is the random term satisfying all the usual assumptions.

The data on these variables has been taken from Economic Survey of Pakistan, Agricultural Statistics of Pakistan and National Fertilizer Development Corporation (NFDC).

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[1] The crop specific water consumption data is also not available; therefore, it has been obtained by multiplying the water availability for Kharif (season) crop by its corresponding weight. The weights used were obtained dividing the area under sugarcane crop by total cropped area.

[2] The data on crop wise credit disbursement is not available. This variable is constructed by multiplying the total credit disbursement by weights and the weights have been obtained by dividing the area under sugarcane crop by total cropped area.

For checking the reliability of the regression results, equation-3 has been checked for econometric properties. Augmented Dickey-Fuller (1981) test has been used for checking the stationarity of the data[3]. Variables which were non-stationary at level have been made stationary after taking first difference and second difference. To detect the long-term relationship among the series, the Cointegrating Regression Durbin Watson (CRDW) test[4] of Sargan and Bhargawa (1983) has been used. Furthermore, to check the stability of the coefficients, the cumulative sum and cumulative sum of square residuals have been plotted. A statistical package Eviews is used for deriving the results.

RESULTS AND DISCUSSION

The results given in table 1 showed that the water availability for sugarcane crop has the highest elasticity (highest contribution towards sugarcane yield) as compared to other determinants. A one percent increase in the water availability for sugarcane crop increases sugarcane yield by 0.16 percent. The coefficient of WA is statistically significant at 5% and 10% level of significance. Water availability is the crucial policy variable for policy makers in Pakistan. The worsening situation of water availability may be a serious threat for sugarcane yields in future. Because, the water availability has declined from 100 million acre feet in the year 2007-08 to 80 million acre feet in year 2009-10 (Economic Survey of Pakistan, 2010).

Table 1 Regression results of the determinants of sugarcane productivity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	9.45	0.13	73.52	0.00
ln (WA)	0.16	0.07	2.290	0.03
ln(FC)	0.14	0.04	3.819	0.00
ln(CD)	0.04	0.01	3.072	0.01
R-squared	0.87	Adjusted R-squared		0.86
F-statistic	61.62	Prob(F-statistic)		0.00
Durbin-Watson stat	1.57			

The yield elasticity of FC and CD are 0.14 and 0.04 respectively. These coefficients are also statistically significant and show positive impact on sugarcane yield. Fertilizer also place importance because its consumption reduced from 340.77 thousands, NT in the year 2001-02 to 314.64 thousands NT in the year 2010-11 (Economic Survey of Pakistan, 2011). Among the other factors, fertilizer supply is important which is continuously affected by ongoing power crisis. The availability of the compressed natural gas, shortage of electricity, destructive rains in Sindh Province and increasing prices of fertilizer also supplemented the issue.

Credit disbursement issue if tackled well, can enhance sugarcane productivity. The small farmers not only are deprived from receiving the loans but also these are not given at the time when it is required for purchasing farm inputs. Further the total supply of agriculture credit reduced by 6.5% and 6% in the years 2009-10 and 2010-11 respectively (Economic Survey of Pakistan, 2011).

In addition, agriculture research and development (R&D) expenditures[5] can also increase sugarcane productivity through introducing high yielding varieties. In Pakistan, it is 0.59% of the total GDP in the year 2008 as compared to 2-3% in developed countries (Pakistan Council for Science and Technology, 2009). According to World Development Report (2008), developing countries invest only one-ninth of what industrial countries put into agriculture R&D as a share of agriculture GDP.

[3] The Akaike Information Criterion (AIC) has been used to select the optimum ADF lag.
[4] It is used to test the null hypothesis that the value of *d* is equal to 0.
[5] Due to non availability of data, the variable R&D expenditures is not included in the model. Similarly, having too many complications with using climatic variables, these have not been incorporate in the model.

The overall test of significance, depicted by the value of F-statistics, favors the model. The fit is also good shown by the high value of R-square (0.87). The Durbin Watson statistics shows that there is no serious problem of auto correlation.

The ADF test results shows that ln(SY) and ln(WA) are stationary at level while ln(CD) and ln(FC) have been made stationary after taking the first difference (Table 2). This may provide some doubts to have spurious regression. But the Durbin Watson value 1.57 (Table 1) evidences that the variables included in the model are cointegrated. Because this value exceeds the critical values provided by Sargan and Bhargawa[6].

Table 2 ADF test results for stationarity (including both intercept and trend)

Variable	I(0)		I(1)		
	Test Statistic	Critical value 5%	Test Statistic	Critical value 5%	Results
Ln(SY)	-4.05[0]	-3.50	-	-	I(0)
ln(WA)	-4.04[0]	-3.51	-	-	I(0)
Ln(FC)	-1.91[0]	-3.53	-6.72[0]	-3.53	I(1)
ln(CD)	-1.98[1]	-3.50	-5.69[0]	-3.50	I(1)

The cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) plots show stability in the coefficients of the model estimated. Both the plots (Fig. 1 and Fig. 2) fall within the critical bounds of 5 percent representing that the model is stable structurally.

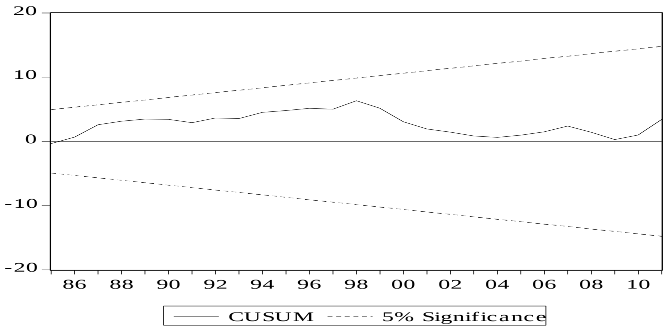

Fig 1 Plot of cumulative sum of recursive residuals

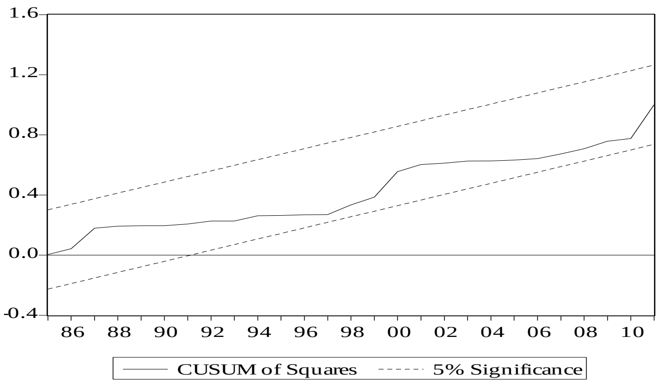

Fig 2 Plot of cumulative sum of square residuals

6 According to Sargan and Bhargawa (1983), the critical values at 1%, 5% and 10% level of significance are 0.511, 0.386 and 0.322 respectively, for testing the null hypothesis that the value of *d* is equal to 0.

CONCLUSION

It is concluded that the policy variables, water availability, fertilizer consumption and credit disbursement have positive and significant impact on sugarcane productivity. It is recommended that the government should make efforts to increase water availability which is becoming worsening in Pakistan. This may create problem for food security in general and particularly for sugarcane productivity in future. The policy options for this can be increasing investment in the water and irrigation system. Agriculture micro credit programs should be improved to assist sugarcane farmers in purchasing the inputs and high yielding varieties. Agriculture R&D expenditures must be increased for ensuring higher productivity. It is also worth mentioning that sugarcane productivity can also be increased through appropriate sugarcane input-output policy, farm subsidies, technology etc but due to data availability constraint, these have not been included in the analysis.

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