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DETERMINANTS OF SUGARCANE YIELD DIFFERENTIALS ACROSS SELECTED DISTRICTS OF CENTRAL PUNJAB: AN EMPIRICAL INVESTIGATION

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ABSTRACT

The study was planned at Social Sciences Research Institute, PARC, AARI, Campus, Faisalabad during 2013 to identify yield differentials and their variation factors in sugarcane through descriptive and empirical investigation across three major sugarcane producing districts in central Punjab viz Faisalabad, Jhang and Chiniot. The primary data for the purpose of analysis were collected with sample size of 150 sugarcane growers. According to descriptive analysis 60 percent sugarcane growers were of middle age with more than 50 percent having 20-40 years of farming experience. In the study area sugarcane growers were mostly small and medium farmers, 43 percent and 42 percent respectively. Majority sugarcane growers (74%) cultivate sugarcane on 1-5 acres operational land. Average per acre yield was reported highest in Jhang 815 mounds followed by 750 mounds in Faisalabad and 746 mounds in Chiniot. The regression estimates showed positive relation of seed cost, fertilizer cost, irrigation cost, harvesting cost and net revenue with yield per acre and variables are statistically significant at 1 percent level ((irrigation cost, harvesting cost and net revenue) and 10 percent (seed and fertilizer cost) level of significance. The estimated co-efficients showed that 1 percent increase in seed cost, fertilizer cost, irrigation cost and harvesting cost brought about 0.152 percent, 0.038 percent, 0.049 percent and 0.386 percent increment in per acre sugarcane yield. Any increase in net revenue will bring 0.114 percent increase in per acre sugarcane yield. Dummy variables for district Jhang and Faisalabad showed positive sign and significant at 1 percent level. The estimated parameters indicated that per acre sugarcane yield achieved at Jhang and Faisalabad was 0.126 percent and 0.107 percent respectively higher than that of Chiniot district. It is concluded that Jhang district has comparative edge for producing sugarcane crop with higher yield per acre than other districts Faisalabad and Chiniot.

KEYWORDS: ***Saccharum officinarum;*** **Sugarcane; yield differentials; empirical investigation; variation factor; Jhang; Pakistan.**

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INTRODUCTION

The major sugarcane producing countries of world are Brazil, India, China, Pakistan, Colombia, Thailand, Mexico and Egypt (6). Pakistan is the 4th largest country in the world in terms of area under sugarcane cultivation, 14th in production and 60th in yield. Sugarcane average yield in the world is almost 60 metric tons per hectare and in Asia 65 metric tons, whereas in Pakistan it is estimated 46 metric tons per hectare. Whereas, in Punjab estimated yield is 55.8 kg per hectare during 2011-12 (2, 4, 13). The main sugarcane growing districts in Punjab are Faisalabad, Jhang, Toba Tek Singh, Chiniot, Sargodha and Gujrat. Punjab contributes almost two-third of the total sugarcane production in Pakistan and half of it comes from these four districts i.e., Faisalabad, Jhang, Sargodha and TT Singh (3).

Sugarcane the second important cash crop has the strong influence on the well being of sugarcane growers as it contributes to their major income. The financial constraints of Pakistani farmers hinders the adoption of new technologies, use of fertilizers and other quality inputs and eventually sugarcane yield. Sugarcane is allied with high cost of production as it involves many costly operations and management issues. Yield differentials are very prominent across different sugarcane growing districts mainly due to the variation in the management practices. Yield differentials are attributed to the factors beyond farmers' control like weather, pests, genetic variability and timing (12).

Low sugarcane yield is of concern in many countries as being cash crop and export commodity it has strong influence on economy as a whole. In this regard many studies have been conducted in past to identify the factors affecting sugarcane yield in order to address the problems of low sugarcane yields across different countries. According to Narayan (11), area harvested, labor force, fertilizer use and prices paid to growers have strong positive effect on sugarcane production. Dlamini and Masuku (7), employed cob-Douglas production function to identify factors affecting sugarcane yield in Swaziland and came up with the findings that farm size, labor, basal fertilizer and top dressing fertilizer applications have positive impact on sugarcane production.

Another study conducted by Daniel (6), postulated positive impact of farm size, hired labor, fertilizer and pesticide use on sugarcane yield. The study conducted by Hussain and Khattak (8), concluded that sugarcane production have direct association with area under sugarcane, tractor hours used for

sugarcane cultivation, fertilizer use and seed use. Keeping in view the previous work done to identify factors having impact on sugarcane production, present paper has been designed to empirically investigate the cost factors and revenue association with yield per acre of sugarcane in selected districts of central Punjab (Jhang, Faisalabad and Chiniot) and to examine the yield differentials across district through empirical investigation.

MATERIALS AND METHODS

The study was planned in Social Sciences Research Institute, PARC, AARI, Faisalabad and field survey for data collection was conducted in April 2013. The primary data were collected from three major sugarcane producing districts of central Punjab viz Faisalabad, Jhang and Chiniot having sample size of 150 sugarcane growers (50 from each district). To identify the factors affecting yield per acre of sugarcane crop a double log regression model was employed to check the significance of independant variables on dependant variable. The general functional form of the proposed models is as follows;

$$ln\ Y = \beta_0+\beta_1\ ln\ X_1+\beta_2\ ln\ X_2+\beta_3\ ln\ X_3+\beta_4\ ln\ X_4+\beta_5\ ln\ X_5+\beta_6\ ln\ X_6+\beta_7\ ln\ X_7+\beta_8\ D_1+\beta_9\ D_2 + \mu_i$$

Where;

Y	= The dependant variable and
X_n	= Other explanatory variables
β	= Coefficient of elasticity and
D_1 and D_2	= Dummy variables.

The specified estimated model sugarcane crop is as follows;

$$ln\ Y_F = \beta_0 +\beta_1\ ln\ SC_s +\beta_2\ ln\ IC_s+\beta_3\ ln\ FC_s+ \beta_4\ ln\ HC_s + \beta_5\ ln\ NR_s + \beta_6\ D_1 + \beta_7\ D_2 + \mu_i$$

Where;

- The dependant variable is yield per acre of sugarcane crop (Y_F).
- The independant variables are seed cost (SC_s),
- Irrigation cost (IC_s), fertilizer cost (FC_s), harvesting cost (HC_s) sugarcane net return per acre (NR_s).
- Dummy for district Jhang (D_1) and dummy for district Faisalabad (D_2).
- D_1 states 0 for Faisalabad and 1 for otherwise whereas D_2 states 0 for Chiniot and 1 for otherwise. District Chiniot has been taken as the reference category in order to avoid the problem of multi-collinearity.

RESULTS AND DISCUSSION

Socio-economic characteristics

Percentage distribution of sugarcane growers according to their age, education and experience has been incorporated in table 1 to highlight the socio-economic attributes of sample. The age of the sugarcane growers ranged from 21-68 year. Overall 26.3 percent sugarcane growers were young and lie in age bracket of 21-40 years whereas majority 60.7 percent were middle aged having 41-60 years age, only 14.0 percent sugarcane growers reported their age above 60 years. District - wise analysis indicate that in Jhang sugarcane farming were mostly done by the farmers having 40 years above age, whereas in Faisalabad majority (80 percent) sugarcane growers were middle aged (41-60 years) and in Chiniot involvement of middle aged (54 percent) and young (32.0 percent) farmers in sugarcane farming is prominent.

Table 1. Percentage distribution of respondents by age, education and farming experience across districts as collected through survey.

Variables	Jhang	Faisalabad	Chiniot	Overall
Age				
21-40	32.0	12.0	32.0	25.3
41-60	48.0	80.0	54.0	60.7
Above 60	48.0	8.0	14.0	14.0
Education				
Illiterate	8.0	24.0	-	10.7
Primary	32.0	20.0	88.0	46.7
Middle	28.0	6.0	12.0	15.3
Metric	26.0	36.0	-	20.7
Intermediate	6.0	14.0	-	6.7
Farming experience				
1-20	44.0	36.0	40.0	40.0
21-40	46.0	62.0	48.0	52.0
Above 40	10.0	2.0	12.0	8.0

Overall 10.7 percent respondents were illiterate, 46.7 percent had primary education, 15.3 percent had middle education, 20.7 percent had metric education and only 6.7 percent had intermediate level of education. The percentage of illiterate sugarcane growers were prominent in Faisalabad (24.0 percent) followed by 8.0 percent in Jhang. According to education profile of Jhang district primary, middle, metric and intermediate education levels were attained by 32 percent, 28 percent, 26 percent and 6 percent sugarcane growers respectively. In Faisalabad 20 percent had primary

education, while 6 percent, 36 percent and 14 percent sugarcane growers had middle, metric and intermediate education respectively. In Chiniot majority farmers had primary education 88.0 percent where as 12 percent attained middle education. The analysis however, clearly indicates that Chiniot district lagged behind in education than Jhang and Faisalabad.

As far as the farming experience is concerned, overall 40 percent growers were having 1-20 years experience, 52.0 percent had 21-40 years farming experience and 8 percent had 40 years above experience of sugarcane farming. This showed that majority of interviewed sugarcane growers were experienced farmers. Percentage of growers lie in 1-20 years experience bracket were 44, 36 and 40 in Jhang, Faisalabad and Chiniot respectively, whereas 46 percent, 62 percent and 48 percent growers from Jhang, Faisalabad and Chiniot respectively had 21-40 years sugarcane farming experience. Only a few (2%) growers from Faisalabad, 10 percent from Jhang and 12 percent from Chiniot had more than 40 years farming experience.

Farm characteristics of respondents

Percentage distribution of respondents according to their operational land and area under sugarcane given in table 2, has been categorized in 4 different ranged 2-11 acres, 12-21 acres, 22-31 acres and above 32 acres. Overall results indicated that 43.3 percent growers had 2-11 acres, 42 percent had 12-21 acres, 10.7 percent had 22-31 acres and only 4.1 percent had more than 32 acres operational land. More than 32 acres operational land was reported by 4 percent and 8 percent growers in Faisalabad and Chiniot while no grower from Jhang hold more than 32 acres operational land. Half of the growers from Jhang held 2-11 acres operational land, 38.0 percent had 12-21 acres operational holding and only 12 percent had 22-31 acres operational land. In Faisalabad 42 percent growers had 2-11 acres, 40 percent had 12-21 acres and 14 percent had 22-31 acres operational land, whereas, in Chiniot 38 percent, 48 percent and 6 percent growers had 2-11 acres, 12-21 acres and 22-31 acres operational land respectively. The analysis indicates that majority of sugarcane growers were small and medium farmers.

The allocation of land for sugarcane production is also very important, area under sugarcane ranged between 1 and 20 acres in data set. Therefore four ranges have been made to see the percentage of farmers lying in each range. Overall majority of sugarcane growers 74 percent allotted 1-5 acres of

their operational land for sugarcane cultivation, 20.7 percent cultivated sugarcane at 6-10 acres operational land, 4 percent at 11-15 acres and only 1.3 percent at 16-20 acres. District wise analysis indicated that majority of growers across all districts, 94 percent from Chiniot, 76 percent from Faisalabad and 52 percent from Jhang allotted 1-5 acres of land for sugarcane crop. In Jhang district 34 percent growers cultivate sugarcane on 6-10 acres, 12 percent on 11-15 acres and only 2 percent on 16-20 acres, whereas in Faisalabad and Chiniot 22 percent and 3 percent respectively grow sugarcane on 6-10 acres, only 2 percent of growers from Faisalabad cultivate sugarcane on more than 16 acres.

Table 2. Distribution of respondents by operational land and sugarcane area across districts as noted through survey.

Variables	Jhang	Faisalabad	Chiniot	Overall
Operational land				
2-11 (acres)	50.0	42.0	38.0	43.3
12-21 (acres)	38.0	40.0	48.0	42.0
22-31 (acres)	12.0	14.0	6.0	10.7
Above 32 (acres)	-	4.0	8.0	4.1
Sugarcane area				
1-5 (acres)	52.0	76.0	94.0	74.0
6-10 (acres)	34.0	22.0	6.0	20.7
11-15 (acres)	12.0	-	-	4.0
16-20 (acres)	2.0	2.0	-	1.3

Production practices and input use

Production is influenced by the variations in the adopted production practices and input use by growers within and across the regions/districts. The better adopted management practices have the positive impact on the yield performance of any crop. Table-3 figure out the average number of different adopted production practices and input use per acre across selected districts. The analysis indicated that combined average rotavator, cultivator, planking and leveling has been estimated 1 time, 2.7 times, 1.7 times and 1 time per acre respectively. Across districts average per acre rotavator application was estimated more than 1 times in Jhang and Chiniot whereas 1 time in Faisalabad and this difference is statistically significant across districts at 1 percent level. Sugarcane is a deep rooted crop so for land preparation average number of cultivator used per acre was estimated almost 3 times in Jhang, 4 times in Faisalabad and almost 2 times in Chiniot and this difference is statistically significant at 1 percent level across districts.

Average number of planking applications per acre was estimated 2 times in Jhang and Faisalabad whereas 1 time in Chiniot and this difference across district is highly significant. Leveling and furrow making was done on average 1 time across all districts. Average hired labor for seed sowing was estimated 3 persons/acre in Jhang and Chiniot whereas more than 4 persons/acre in Faisalabad with the combined average of approximately 3 persons/acre and this difference is statistically highly significant across districts. Combined average of irrigations were estimated approximately 21 irrigations, highest average noticed in Chiniot approx 22 irrigations, followed by Faisalabad 21 irrigations and Jhang almost 19 irrigations. The combined average use of DAP per acre was estimated 1.3 bags and this average was same across all districts where as the use of urea fertilizer vary across districts. Combined average urea application was estimated 2.5 bags per acre and were estimated on average 2.7 bags/acre in Jhang, 3.2 bags per acre in Faisalabad and 1.5 bags per acre in Chiniot and this difference is statistically highly significant. Insecticide sprays were recorded 1 spray per acre across all districts.

Table 3. Average number of applied production practices and input use for sugarcane crop

Variables	Jhang	Faisalabad	Chiniot	Overall	F-stat
Rotavator	1.1 (0.14)	1.0 (0.20)	1.3 (0.4)	1.0 (0.3)	12.759***
Cultivator	2.9 (0.7)	3.8 (0.7)	1.5 (0.6)	2.7 (1.2)	137.947***
Planking	2.1 (0.7)	2.1 (0.4)	1.2 (0.4)	1.7 (0.6)	35.276***
Levelling	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	-
Furrow making	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	-
Earthing up	1.0 (0)	1.0 (0)	0.4 (0.5)	0.8 (0.4)	73.500***
Labor hired for seed sowing	3.1 (0.6)	4.3 (0.9)	3.0 (0)	3.4 (0.9)	72.327***
Manual weeding	1.0 (0)	0.9 (0.3)	1.0 (0)	1.0 (0.2)	4.261*
Irrigations	18.6 (3.1)	21.1 (2.6)	22.3 (2.2)	20.6 (3.1)	25.438***
DAP (bags)	1.2 (0.4)	1.3 (0.5)	1.3 (0.5)	1.3 (0.5)	2.202
Urea (bags)	2.7 (0.7)	3.2 (0.6)	1.5 (0.5)	2.5 (0.9)	115.122***
FYM (trolley)	2.6 (0.5)	2.4 (0.6)	2.0 (0)	2.3 (0.5)	27.979***
Insecticide (sprays)	0.9 (0.3)	1.0 (0.1)	1.0 (0)	1.0 (0.2)	3.090*
Yield	815.0 (39.4)	750.0 (49.5)	746.0 (112.4)	770.3 (80.5)	13.523***

*** and * shows 1 and 10 percent level of significance**.** Figures in parenthesis are standard deviations.

Farm yard manure use was estimated overall almost 2 trolleys per acre, with highest application of approximately 3 trolleys in Jhang and 2 trolleys in

Faisalabad and Chiniot. Average yield per acre was estimated highest in Jhang 815.0 mounds followed by 750 mounds in Faisalabad and 746 mounds in Chiniot. The estimated average land preparation practices and fertilizer applications in Faisalabad are some more or less same as mentioned by Naeem *et al.* (10) while similar mean estimates were quoted by Ahmad *et al.* (1) for sugarcane crop in Jhang district.

Empirical analysis

Table-4 showed the seed cost, fertilizer cost, irrigation cost and harvesting cost are incorporated alongwith net revenue per acre and dummies for Jhang and Faisalabad for the purpose of empirical analysis of sugarcane crop. All costs have direct association with yield per acre and co-efficients shows that 1 percent increase in seed cost, fertilizer cost, irrigation cost and harvesting cost will bring 0.152 percent, 0.038 percent and 0.049 percent and 0.386 percent increment in sugarcane yield per acre. Any increase in net revenue will bring 0.114 percent increase in yield per acre. The positive correlation of fertilizer cost with sugarcane yield per acre was also justified by previous studies conducted by Dlamini and Musuku (7), Baiyegunhi and Arnold (5), Husain and Khattak (8) and Narayan (11). The estimated positive coefficients of all mentioned costs and revenue are statistically significant at 1 percent (irrigation and harvesting cost) and 10 percent (seed and fertilizer cost) level of significance respectively. The positive association of seed cost, fertilizer cost and irrigation with yield was found by Malaza and Myeni (9).

Dummy variables (Jhang and Faisalabad) showed positive sign which postulates that sugarcane attained yield per acre in Jhang and Faisalabad was 0.126 percent and 0.107 percent higher than attained yield/acre in Chiniot district (reference category) respectively. The coefficients of dummy

Table 4. Determinants of sugarcane yield differentials

Variable	Coefficient	t-statistics
Constant	-0.443	-0.714
Seed cost	0.152	2.390*
Fertilizer cost	0.038	2.362*
Irrigation cost	0.049	3.672***
Harvesting cost	0.386	11.525***
Net revenue	0.114	8.667***
District Jhang	0.126	5.539***
District Faisalabad	0.107	6.172***
R-square=0.827	Adjusted R^2=0.817	F-statistic= 83.536***

***and * shows 1 and 10 percent level of significance

variables for Jhang and Faisalabad are significant at 1 percent level. Dummy variable analysis however clearly indicates that Jhang district has

comparative edge for producing sugarcane crop with higher yield per acre comparative to other districts Faisalabad and Chiniot. Above mentioned regression model overall statistically highly significant at 1 percent level with the calculated F-value of 83.536. R-square and adjusted R-square values postulated 82 percent variation in dependant variables being explained by independant variables (Table-4).

CONCLUSION AND RECOMMENDATIONS

Sugarcane national average yield was reported low as compared to other sugarcane producing countries worldwide and in Asia. To uplift the national average it is important to check the areas that are lagging in the average sugarcane yield per acre to bring them in special focus in order to make them more competitive. Punjab being the major sugarcane producing province has great significance in the national average production.

The present study was designed to investigate the factors affecting sugarcane yield per acre and to check district wise differentials in sugarcane yield per acre. The study findings concluded that mostly sugarcane growers were middle aged and majority of them having sufficient experience of sugarcane farming. Mostly sugarcane growers were small and medium farmers and allocation of land for sugarcane was lie between 1-5 acres by majority sugarcane growers in study area. Application of management practices were estimated poor in Chiniot district with less use of cultivator, planking, earthing up, urea and FYM. Average yield per acre was estimated higher in Jhang followed by Faisalabad and Chiniot. The regression analysis reported positive impact of all cost variables (fertilizer, irrigation, seed and harvesting cost) with yield per acre and yield was estimated significantly higher in Jhang district than Faisalabad and Chiniot. It is however concluded that Jhang district has comparative advantage in producing sugarcane than other districts and low yield per acre in Chiniot has been attributed due to less use of management applications than other districts.

Farmer's should be encouraged to use the quality seed and sufficient amount of fertilizers to increase per acre productivity. The adoption of recommended land preparations practices should also be encouraged in order to improve the crop yield. Government extension department have to play their active role to enhance the farmer's knowledge and skills of better farm management practices. The provision of farm knowledge to farmers of less yield districts at priority basis is the need of the time as this is the only option that can help to increase the national average yield of sugarcane by increasing the average yield across different sugarcane producing districts.

Farmer field schools can be a good option for the knowledge and skill enhancement of sugarcane growers regarding farm practices and management attributes.

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Sonila Hassan	**:**	**Helped in conducting research and data analysis**
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Arshed Bashir	**:**	**Provided technical guidance**
Mazhar Abbas	**:**	**Helped in writeup preparation**