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ANALYSIS OF SUGARCANE PRODUCTION IN PUNJAB, PAKISTAN; CONSTRAINTS AND YIELD NEXUS

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Abstract

Purpose of study: For the previous couple of years, sugarcane crop production is under crisis for many reasons. This study aimed at exploring those reasons impeding the potential production of sugarcane in the Rahim Yar Khan district of Punjab, Pakistan.

Methodology: A total of 343 randomly selected sugarcane growers participated in this study as respondents. Data were collected through face-to-face interview techniques on a structured and validated questionnaire. Data were analyzed using both descriptive and inferential statistics through the Statistical Package for Social Sciences (version 22).

Results: Quantitative results indicated that the total production of sugarcane during the last two years dropped from 833 to 636 mounds per acre. The chi-square analysis confirmed that production, protection, climatic changes policy and financially associated factors had statistically significant ($P<0.05$) inverse impacts on sugarcane production. In contrast, the marketing factors were statistically non-significant for the production of sugarcane ($P>0.05$). The qualitative findings as perceived by key informants confirmed that non-availability of disease-resistant varieties, traditional irrigation mechanism, lack of proper plant protection measures, Integrated Pest Management (IPM), climate change, high cost of production, and sluggish policy had pressurized the sugarcane production.

Recommendations: It is suggested that the development of insect pests, diseasesand drought-resistant varieties should be launched. Efficient and alternate row irrigation system, climate change adoption strategies, integrated pest management, mechanized farming of sugarcane should be adopted in order to curtail the production cost and increase the level of production.

Novelty: Studies have been conducted to investigate the influencing factors on the yield of sugarcane but this is the first study that indicates the association of those factors that are hampering on-farm production of sugarcane crop in district Rahim Yar Khan, Punjab, Pakistan.

Keywords*: Alternative Row Irrigation, Sugarcane Production Challenges, Climate Change, Yield, IPM*.

INTRODUCTION

Sugarcane is an important cash crop (Munir *et al.*, 2020). A large proportion of people around the world relies on this crop for their industrial, economic, medical and dietary purpose (Rehman *et al.*, 2015). Sugarcane is widely cultivated in more than 100 countries and an extensive area of 28.3 million hectares and 1.69 million tons of production (Fair and Labor Association, 2019).

Brazil is the 1st largest producer of sugarcane, followed by India, China, Thailand, and Mexico (Government of India, 2017). Similarly, it has a significant role in obtaining different by-products such as refined sugar, molasses, brown sugar, jaggery, and various other valuable products like biogas production, pulp, bio-fertilizer, ethanol, and paper-making (Prasara & Gheewala, 2016).

For Pakistan, sugarcane is the second largest cash crop (Farooq and Gheewala, 2019). The total cultivated area of sugarcane was 1040 thousand hectares during 2019 while total production was 66.880 million tons in Pakistan (Government of Pakistan,2020). In Pakistan, sugarcane is grown in three zones; tropical Sindh, Sub-tropical Punjab, and temperate Peshawar valley (Pakistan Sugar Mills Association, 2019). Total sugarcane production was 46483 thousand tons during 2018-2019 while total cultivated area of sugarcane was 732.88 thousand hectares in Punjab (Abbas *et al.*,2020). It is the first major source of sugar in Pakistan (Qureshi & Afghan, 2005) and it provides the raw material for the agro-based industry.

The sugar industry in Pakistan is reported as the second largest industry after textile with a prolific socio-economic development by organizing rural communities, providing a source of income, and creating job employment for almost five million people (PSMA, 2019; Raza *et al.*, 2019). It is having almost 2.9 % share to agricultural value addition and 0.6 % in the overall gross domestic product (Government of Pakistan,2020). It is one of the important means of revenue as this crop

adds 50-60 billion rupees per year in taxes and duties to the government. It is the primary source of farmer's income and employment for about 100 thousand people (PSMA, 2019).

However, since last four years, a sharp decline in its production and area was observed in Punjab, Pakistan (Government of Punjab, 2019). Average yield during those four years oscillated between 50-57 tons per hectare and sugar recovery stood as only 9-10% compared to the potential production of 150-250 tons per hectare and 11-12% of sugar recovery. This indicates that the recovery of sugar from sugarcane is lower than potential in Pakistan because of various constraints such as production, protection (Nazir *et al.*, 2013), marketing (Sapkota *et al.*, 2017), climate change (Hussain *et al.*, 2018; Abid *et al.*, 2019; Chohan, 2019; Ambetsa *et al.*, 2020) and policy-related constraints (Raza *et al.*, 2019).

The decline of sugarcane yield causes distress to the sugar industry, people's livelihoods, and the national economy (Raza *et al.*, 2018). Several studies indicated that unapproved, nonresistant (Zulu *et al.*, 2019) low yielding, disease susceptible, wrongly selected varieties and lack of other cultural practices reduced yields in Punjab (Farooq & Gheewala, 2019).

An extensive literature on the production system of sugarcane in Pakistan exists with special emphasis on agronomic avenues (Ahmad, 2020; Iqbal & Iqbal 2014; Munir *et al.*, 2020). However, the field-based exploration is yet scanty. Despite this, the estimation of farmers' perceptions is one of the critical aspects of strategy development. Therefore, to bridge this research gap, the study was conducted to explore the association of those factors that are hampering on-farm production of sugarcane crop.

Hypothesis

H_1: Production, protection, economic, and marketing factors are associated with sugarcane production.

H_2: Climatic change is associated with sugarcane production.

H_3: Policy-related constraints are correlated with sugarcane production.

METHODOLOGY

The methodology of the research is proved helpful for any researcher in smoothly carrying research work without any hurdle. It consists of several steps that are completed sequentially in order to achieve results.

Study Area

District Rahim Yar Khan is the district of Punjab Province selected for this research. It is contributing almost 30% of the share in total sugarcane production of Punjab (GOP, 2017). It is on the border between Sindh and Punjab. District Rahim Yar Khan consists of four tehsils, namely Sadiqabad, Rahim Yar Khan, liaquatpur and Khanpur. It is considered an agricultural district in southern Punjab, where most of the population is associated with agriculture. It is a fertile area that produces sugarcane, wheat, cotton, maize, mango and many other crops.. It is one of the important crops that plays a prominent role in agriculture in this region. The main sugar mills in this area are Rahim Yar khan Sugar Mills, Gulf Sugar Mills, Jamlaldin Wali Sugar Mills and Hamza Sugar Mills. The total population of District Rahim Yar Khan is 477,000 and the literacy rate is 33.1% (Pakistan Bureau of Statics, 2020).

Research Design

Research design is a conceptual framework that helps solve the research problem after deciding the correct method. It is a suitable framework for a study and research-related decision as it determines how the relevant information for a study is obtained (Sileyew, 2019). Mix method research quantitative and qualitative design was used for data collection. The qualitative data helped the researcher validate the quantitative findings (Alise & Tedlie, 2010).

Sampling Procedures (Quantitative data)

A multistage random sampling technique was used for this research. At the first stage, district Rahim Yar khan was selected purposively as this is one of the largest sugarcane growing districts of Punjab. It consists of four tehsils, namely Sadiq Abad (SDK), Khanpur (KP), Liaquat Pur (LP), and Rahim Yar Khan (RYK). At the second stage, all tehsils in District Rahim Yar Khan were selected from the study area. In the third stage, the list of the registered growers was obtained from the Agricultural Officer (AO), Department of Agriculture (Extension wing) of the respective tehsil. The study population was comprised of all sugarcane registered growers (3193) of district Rahim Yar Khan. In this regard, a sample size of 343 was collected using an online website www.surveysystem.com by taking a confidence interval of 5% and a confidence level of 95 %. Finally, (151,92,49 and 51) respondents were selected randomly for data collection from each tehsil, respectively.

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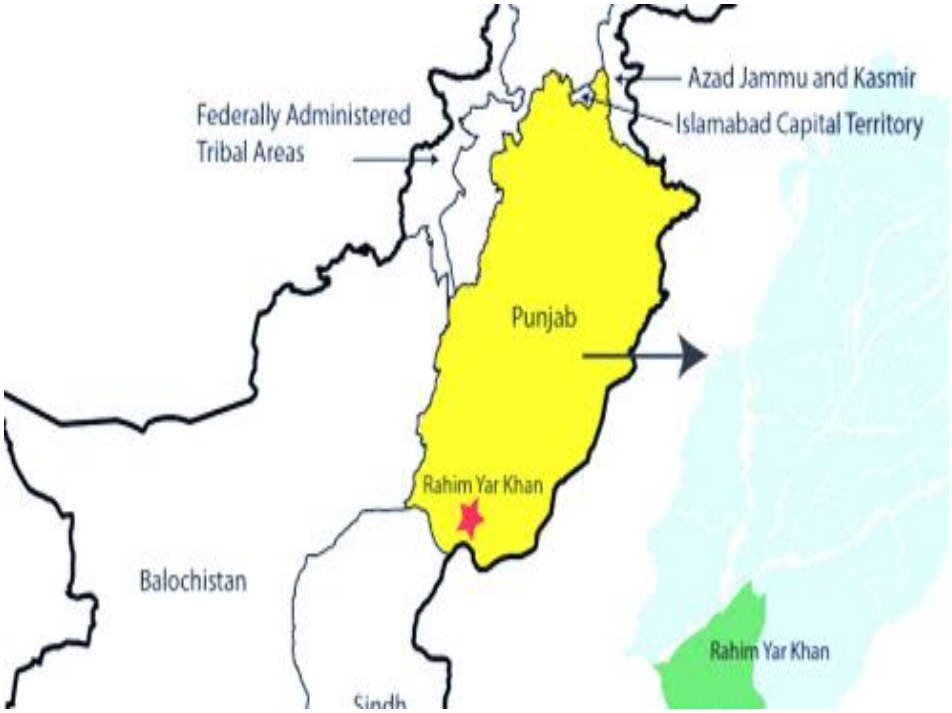

Figure 1: Map of district Rahim Yar Khan (Government of Pakistan, 2019)

Instrumentation and data collection

An interview schedule was developed for data collection. The quantitative data were collected through a structured questionnaire. The qualitative data were collected from key informants in order to validate the quantitative findings. The stakeholders included in the study were

Sr. No	key informants	Selection Procedures
1	Progressive farmers	one key informant was taken from each selected tehsil group (n=1 from each selected key informants /tehsil) and thus, a total of twelve key informant interviews were conducted in the study area.
2	Agricultural experts	
3	Sugarcane experts	

n= 12

Data Analysis

The quantitative data were analyzed using inferential statistics including Chi-square, co-efficient of determination and multiple regression analysis through the Statistical Package for Social Sciences (Victor, 2010).

Qualitative data analysis:

Qualitative data were analyzed through Content Analysis Technique (Nowell *et al.*, 2017).

Steps of Theme Development

The first step that the researcher took was to finalizing the collected data. In the next stage, the important points discussed by the informants were translated from the local language to English. In the third step, the researcher divided the data into different themes for identifying the most relevant themes. In the last step, the researcher identified themes presented in order to validate the quantitative findings. These themes were based on primary data and a literature review conducted by the researcher in the initial stage of the study.

RESULTS

Demographic Attributes

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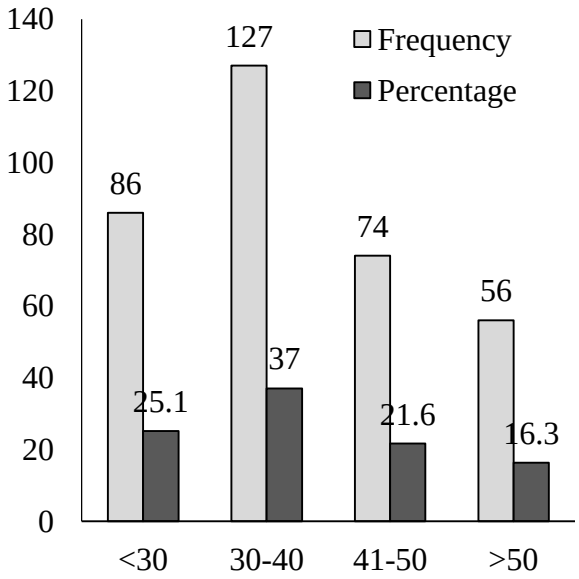


Figure 2: Age of respondents

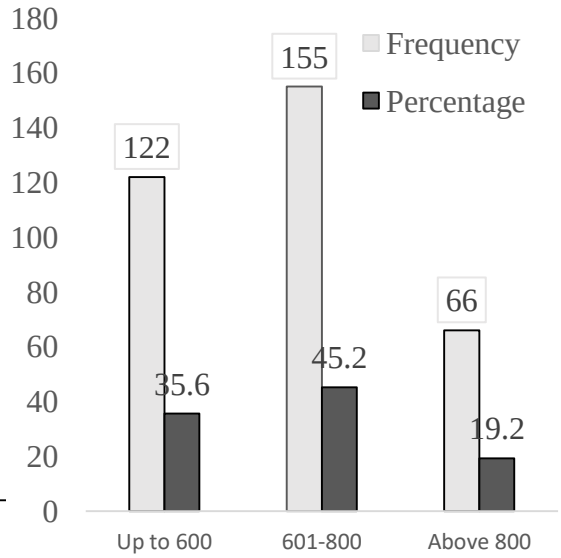
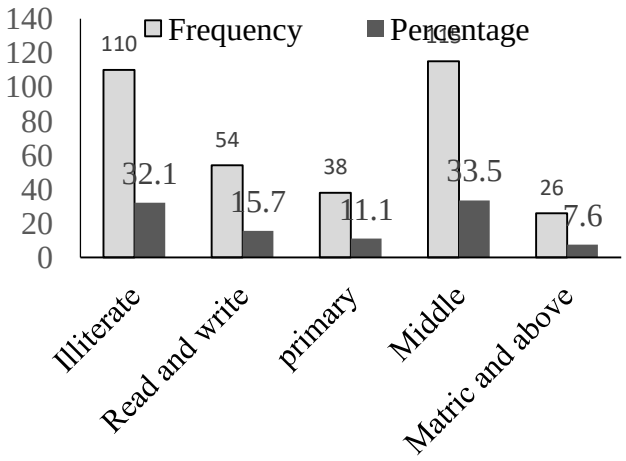


Figure 3: Sugarcane production in mounds/acre



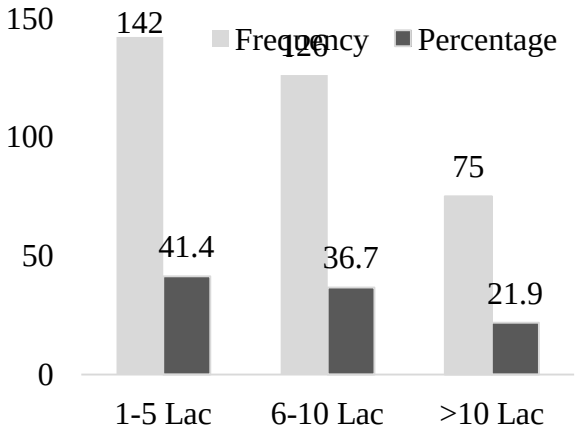


Figure 4: Education of respondents Figure 5 Income of respondents

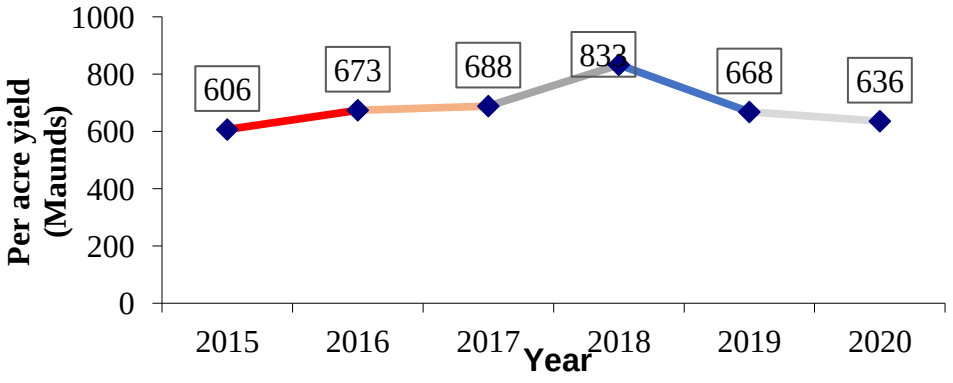


Figure 6: The perceived fluctuation of sugarcane production by respondents in the study area

Figure 2 depicts that almost one-fourth (25%) of the respondents in the age of <30 years and 37% were under the age bracket of 30-40. On the other hand, 21.6% of respondents were under the age of 41-50 years and 16.3% were above 50 years. The findings inferred that majority of the respondents (62%) were up to 40 years. The result of the present study is similar to the

findings of Girei & Giroh (2012) who revealed that the majority (69%) of the respondents were actively involved in sugarcane production.

Figure 3 shows the average sugarcane production since the last five years in the study area. It was observed that almost 36% of the respondents had average sugarcane production from the last five years were up to 600 mounds per acre. Figure 3 discloses that almost 45% of the respondents had average sugarcane production from the last five years to 601 to 800 mound per acre. The data show that only 19.2% of sugarcane growers had 800 average per acre sugarcane production from the last five years. While 36% of sugarcane growers had an average production was up to 600 mound per acre due to different factors. It implies that the majority of the farmers' average sugarcane production was between 600 to 800 mound per acre.

Figure 4 represents that 32.1% of the respondents were illiterate and 15.7% could read and write in the study area. On the other hand, 11.1% of the respondents had an education level of primary class and 33.5% had an education level of middle and 7.6% of respondents' education was matric and above.

Figure 5 presents that less than half of respondents' (41.69%) income was 1-5 lac and 6.71% of the respondents had 11-15 lac. Whereas, 9.33% of the respondents were earning 16-20 lac annually in the study area. On the other hand, 36.73% and 3.50% of the respondents were earning 6-10 lac and 21-25 lac, respectively. At the same time, 2.04% of the growers had more than 25 lacs annually.

Keeping in view the fluctuation of sugarcane production during the last few years (Government of Punjab, 2020), the respondents were inquired about this particular aspect in the context of the present study; the data were collected, presented in Figure6. It narrates that during 2015, the average sugarcane production was recorded as 606 mounds/acre and 673 mounds/acre average production recorded during 2016. This implies that over one year, the average production of sugarcane increased by 67 mounds/acre. Similarly, the average sugarcane production in 2017 was recorded as 688 mounds/acre while 833 mounds/acre in 2018. It infers that the average production of sugarcane increased by 145 mounds/acre during 2017-2018. In comparison, the average yield was 688 mounds/acre reported in 2019, followed by 636 mounds/acre recorded in 2020. It means that the average sugarcane yield reduced by 52 mounds/acre over the last two years.

Table 1: Perceived sugarcane production challenges faced by sugarcane growers

Sugarcane production challenges	M±SD	Impact of challenges
Production challenges		
Lack of approved varieties	4.02±0.82	High Extent
Poor irrigation practices	3.94±0.70	High Extent
Nonavailability of labor at the time	3.85±0.74	High Extent
Protection challenges		
Lack of knowledge about cultural practices	4.54±0.87	Very high Extent
Sugarcane pests and diseases	3.85±0.74	High Extent
Lack of awareness about pest resistant varieties	3.75±0.69	High Extent
Climate change challenges		
High/Low rainfall	4.22±0.97	High Extent
Drought	3.96±0.66	High Extent
High/Low Temperature	3.56±0.80	High Extent
Economic related challenges		
High input cost	4.44±0.20	High Extent
High transportation charges (carriage and handling)	4.03±0.61	High Extent
Price's variation of inputs	3.56±0.97	High Extent
Marketing related challenges		
Sugar industries situated at a long distance	4.80±0.48	Very high Extent
Delayed payments to farmers by sugar mills	4.47±0.95	Very high Extent
Harvesting delay due to late crushing	4.40±0.01	High Extent
Policy related challenges		
Buying sugarcane from less Support price	4.56±0.77	Very high Extent
Non-existence of effective farmers union	4.42±0.01	High Extent
Short measurement (deduction weight in the name of low of sugarcane recovery)	4.38±0.56	High Extent

Scale; 1=V. Low, 2=Low Extent, 3=Medium Extent, 4=High Extent, 5=V. High Extent

Table1 shows that the most prominent production constraints were lack of approved varieties (mean= 4.02±0.82) followed by poor irrigation practices (mean= 3.94±0.70) and non-availability of labor at the time. Whereas, majority protection

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constraints observed were lack of knowledge about cultural practices like intercropping and crop rotation (mean= 4.54± 0.87) and sugarcane pests and diseases (mean= 3.85± 0.74), respectively followed by lack of awareness about insect pests' resistant varieties of sugarcane. According to the evidence from Table 1, high/low rainfall (mean= 4.22±0.97), drought (mean= 3.96±0.66), and high/low temperature (mean= 3.56±0.80) were the major weather threats faced by the growers, respectively. The more prominent economic constraints in the study area were high input cost (mean= 4.44±0.20) followed by high transportation charges . The data also depict that the location of sugar industries at long distances (mean= 4.80±0.48), delayed payments to farmers by sugar mills (mean= 4.47±0.95) and harvesting delay due to late crushing (mean= 4.40±0.01), respectively were prominent constraints. Whereas, buying sugarcane from less support price was a major policy-related constrain (mean= 4.56±0.77) followed by non-existence of effective farm union and short measurement.

Table 2: Association between production constraints and sugarcane production

Production constraints	Sugarcane production (Maunds/acre)			Total
	Low (Up to 600)	Medium (601-800)	High (Above 800)	
Low	16	33	5	54
	29.6%	61.1%	9.3%	100.0%
Medium	30	31	13	74
	40.5%	41.9%	17.6%	100.0%
High	76	91	48	215
	35.3%	42.3%	22.3%	100.0%
Total	122	155	66	343
	35.6%	45.2%	19.2%	100.0%
Chi-square = 11.63	d.f. = 4	P-value = .020*		
Gamma (λ) = -0.203		P-value = .024*		

Table 2 shows a significant ($\chi 2 = 11.63$, $p = .020$) association between production constraints and sugarcane production. Gamma statistic ($\lambda = 0.203$, $p = .024$) showed a significant and negative relation among the variables. If the farmers faced more constraints related to production technology, they had low production of sugarcane compared to those farmers who had faced less constraints. Above table also reflects that if the farmers faced low level constraints, then their sugarcane production was low (29.6%), medium (61.1%), and high (9.3%) sugarcane production. On the other hand, if the farmers faced high level constraints related to production, then they had low (35.3%), medium (42.3%), and high (22.3%) sugarcane production. So, it is clear from the above findings, constraints related to production had a negative impact on sugarcane yield.

Table 3: Association between protection and sugarcane production

Protection constraints	Sugarcane production (Maunds/ acre)			Total
	Low (Up to 600)	Medium (601-800)	High (Above 800)	
Low	12	26	12	50
	24.0%	52.0%	24.0%	100.0%
Medium	14	31	18	63
	22.2%	49.2%	28.6%	100.0%
High	96	98	36	230
	41.7%	42.6%	15.7%	100.0%
Total	122	155	66	343
	35.6%	45.2%	19.2%	100.0%
Chi-square = 13.55	d.f. = 4	P-value = .009**		
Gamma (λ) = -0.298		P-value = .000**		

Table 3 represents the association between protection constraints and sugarcane production. It was found from the above table, which displays a significant ($\chi 2 = 13.55$, $p = 009$) association between protection constraints of the respondents and sugarcane production. Gamma statistic ($\lambda = -0.298$, $p = .000$) showed a significant and negative relation among the variables. If the farmers faced more constraints related to protection, they had low production of sugarcane compared to those farmers who had faced less constraints. Above table also stated that if the farmers faced low level constraints, then their production was low (24%), medium (52%) and high (24%) sugarcane production. On the other hand, if the farmers faced high level constraints related to production, then they had low (41.7%), medium (42.6%) and high (15.7%) sugarcane production. So, it is clear from the above findings, constraints related to production had a negative impact on sugarcane yield. The results are in line with the study of Cheema *et al.* (2002), who reported that yield remains low in sugarcane production because sugarcane growers have poor production and protection practices due to a lack of proper strategies to mitigate the sugarcane

production threats. Similarly, other studies such as Dias & Sentelhas (2018), Zu *et al.* (2018), Gilbert *et al.* (2008), Mati &Thomas (2019), and Sengar (2018) revealed that sugarcane pests and diseases negatively affected the sugarcane crop yield.

Table 4: Association between climate change and sugarcane production

Climate change constraints	Sugarcane production (Maunds/acre)			Total
	Low (Up to 600)	Medium (601-800)	High (Above 800)	
Low	17	25	24	66
	25.8%	37.9%	36.4%	100.0%
Medium	63	80	21	164
	38.4%	48.8%	12.8%	100.0%
High	42	50	21	113
	37.2%	44.2%	18.6%	100.0%
Total	122	155	66	343
	35.6%	45.2%	19.2%	100.0%
Chi-square = 11.44	d.f. = 4	P-value = .022*		
Gamma (λ) = -0.169		P-value = .035**		

Table 4 presents the association between climate change constraints faced by the respondents and sugarcane production. The above table shows a significant ($\chi 2 = 11.44$, p = .022) association between climate change-related constraints and sugarcane production. Gamma statistic ($\lambda = -0.169$, p = .035) showed a significant and negative relation among the variables. If the farmers faced more constraints related to climate change, they had low sugarcane production compared to those farmers who had faced fewer constraints. The above table also declared that if the farmers faced low level constraints, then their production was low 25.8%), medium (37.9%) and high (36.4%) sugarcane production. On the other hand, if the farmers faced high level constraints related to production, then they had low (37.2%), medium (44.2%) and high (18.6%) sugarcane production as perceive by the respondents. So, it is clear from the above findings that constraints related to production negatively impacted sugarcane yield. Constraints related to climate change had a negative impact on sugarcane production. The results are in line with the study of Trenberth (2011), who reported that climate change is one of the emerging issues in the world. Livelihood and agricultural productivity were adversely affected by climate change. It is predictable to have a negative impact on sugarcane production. The findings of Moitinho *et al.* (2021), Triques *et al.* (2021), Marin *et al.* (2019), Käyhkö (2019), Pornprakun *et al.* (2019) who indicated that climate change is the major threat to sugarcane yield.

Table 5: Association between marketing constraints and sugarcane production

Marketing constraints	Sugarcane production (Maunds/acre)			Total
	Low (Up to 600)	Medium (601-800)	High (Above 800)	
Low	16	30	18	64
	25.0%	46.9%	28.1%	100.0%
Medium	80	91	29	200
	40.0%	45.5%	14.5%	100.0%
High	26	34	19	79
	32.9%	43.0%	24.1%	100.0%
Total	122	155	66	343
	35.6%	45.2%	19.2%	100.0%
Chi-square = 9.45	d.f. = 4	P-value = .051*		
Gamma (λ) = -0.092		P-value = .407^{NS}		

Table 5 represents the association between marketing constraints faced by the respondents and sugarcane production. It was found from the above table, which shows a significant ($\chi 2 = 9.45$, $p = .051$) association between marketing constraints and sugarcane production. Gamma statistic ($\lambda = --0.092$, p = .40) showed negative while insignificant relationship between the variables. It means, marketing problems had negative impact on production.

Table 6: Association between policy-related constraints and sugarcane production

Policy constraints	Sugarcane production (Maunds/acre)			Total
	Low (Up to 600)	Medium (601-800)	High (Above 800)	
Low	8	22	22	54
	14.8%	40.7%	40.7%	100.0%
Medium	94	94	31	219
	42.9%	42.9%	14.2%	100.0%

High	20	39	13	70
	28.6%	55.7%	18.6%	100.0%
Total	122	155	66	343
	35.6%	45.2%	19.2%	100.0%
Chi-square = 64.14	d.f. = 4	P-value = .000**		
Gamma (λ) = -0.592		P-value = .000**		

Table 6 represents the association between policy constraints faced by the respondents and sugarcane production. It was found from the above table which shows a significant ($\chi 2$ = 64.14, p = .000) association policy constraints faced by the respondents and sugarcane production. Gamma statistic (λ = -0.592, p = .000) showed a significant and negative relation among the variables. If the farmers faced more constraints related to policy, they had low production of sugarcane compared to those farmers who had faced less constraints. Above table also revealed that if the farmers faced low level constraints, then their production was low (14.8%), medium (40.7%) and high (40.7%) sugarcane production.

On the other hand, if the farmers faced high level constraints related to production, then they had low (28.6%), medium (55.7%) and high (18.6%) sugarcane production. So, it is clear from the above findings, policy-related constraints had a negative impact on sugarcane yield. Ali & Khan (2012) concluded that policy implication had an important concern to improve overall agricultural productivity in Pakistan. They further maintained that the current agricultural policy was unpredictable regarding sugarcane production, both in substituting imports and promoting exports.

Table 7: Association between economic constraints and sugarcane production

Economic constraints	**Sugarcane production (Maunds/acre)**			**Total**
	Low (Up to 600)	**Medium (601-800)**	**High (Above 800)**	
Low	50	61	44	155
	32.3%	39.4%	28.4%	100.0%
Medium	31	49	10	90
	34.4%	54.4%	11.1%	100.0%
High	41	45	12	98
	41.8%	45.9%	12.2%	100.0%
Total	122	155	66	343
	35.6%	45.2%	19.2%	100.0%
Chi-square = 16.80	d.f. = 4	P-value = .002**		
Gamma (λ) = -0.211		P-value = .006**		

Table 7 represents the association between economic constraints faced by the respondents and sugarcane production. It was found from the above table which shows a significant ($\chi 2$ = 16.80, p = .000) association of economic constraints and sugarcane production. Gamma statistic (λ = -0.211, p = .006) showed a significant and negative relation among the variables. If the farmers faced more constraints related to economic, they had low production of sugarcane compared to those farmers who had faced fewer constraints. Above table also declared that if the farmers faced low level constraints, then their production was low (14.8%), medium (40.7%) and high (40.7%) sugarcane production. On the other hand, if the farmers faced high level constraints related to production, then they had low (32.3%), medium (39.4%) and high (28.4%) sugarcane production. On the other hands, if the farmers faced had low level constraints, then their production was low (41.8%), medium (45.9%) and high (12.2%) sugarcane production. So, it is clear from the above findings, economic constraints had a negative impact on sugarcane yield. The present study results are similar to the findings of Iqbal & Iqbal (2014) who revealed that economic constraints had negatively influenced sugarcane production in Punjab.

DISCUSSION

The response of sugarcane growers of this study clearly indicated that most of them were under the age bracket of below 40 years. The result of the present study is similar to the findings of Girei & Giroh (2012), who specified that the majority (69%) of the respondents up to 40 years were actively involved in sugarcane production. Majorly respondents were illiterate. The results are in line with Naz *et al.* (2021), who revealed that about 45% of the respondents were illiterate in south Punjab. The majority of respondents (41.69%) were earning 1-5 lac. Singh *et al.* (2019) revealed that income had a positive association with sugarcane production. From the response of the sugarcane growers of this study clearly indicated that most of them perceived a lack of approved varieties and poor irrigation practices, lack of knowledge about cultural practices like intercropping and crop rotation were major production constraints. Results of this study are similar to the findings of Mahmood *et al.* (2016) who reported that the spread of unapproved and nonresistant, low-yielding, disease susceptible varieties under local conditions are the main reason for reducing sugarcane yield in Pakistan. Unavailability of resistant varieties reduced sugarcane production factors (Ahmad, 2020; Zulu *et al.*, 2019; Ambetsa *et al.* 2020). In the present study,

the shortage of irrigation water was identified as a major production constraint that adversely negatively impacted sugarcane production. Results are similar to those of Farooq & Gheewala (2019) reported that irrigation has a significant and positive association with sugarcane production. Similarly, Linstead *et al.* (2015) concluded that in Pakistan almost 400m3 of irrigation water is required for producing one ton of sugarcane. Watto & Mugera (2015) they pointed out the potential of water productivity is not achieved in Pakistan due to poor and traditional methods of irrigation. Baillie (2004) identified that irrigation management strategies were effective under the limited supply of irrigation for improving sugarcane production. The findings of Dias & Sentelhas (2018) and Zu *et al.* (2018) recommended that sugarcane production is associated with many factors, including water deficiency and improper mode of irrigation. In the present study, the lack of knowledge of agronomic practices and sugarcane pests and disease were the major constraints perceived by the growers. The results are in line with Mati & Thomas (2019) who revealed that different factors such as improper agronomical practices and lack of crop rotation were major constraints in reducing the sugarcane protection. Similarly, Pervaiz *et al.* (2013) reported that different protection factors were reported to be barriers to sugarcane. Among these lack of information about identifying sugarcane pests and diseases, financial conditions, high prices of inputs like pesticides, and lack of resistant varieties against sugarcane pests. The findings of the current study are similar to the findings of Raza *et al.*, (2019), who indicated that sugarcane pests were important factors that adversely affected sugarcane production. Sengar (2018) reported that sugarcane pests and diseases negatively affected the sugarcane crop yield and further maintained that the development of sugarcane pests' resistant varieties was fundamental to increase and maintain the average yields. The findings of the current study are similar to Lechenet *et al.* (2017), who had indicated that the majority of the respondents were unable to practice IPM due to a lack of technical knowledge, practical skills, and awareness related to the identification of sugarcane pest and their management. Similarly, Wijnands (2012) reported that sugarcane farmers were unaware of integrated pest management technique and their effectiveness. Wheeler *et al.* (2000) endorsed that climate change was one major factor in reducing sugarcane production. It was also indicated that global warming and increasing greenhouse gas emission resulted in the increased intensity and frequency of extreme weather events. Muhammad *et al.* (2001) had also reported that it was very difficult to increase the area for sugarcane so efforts should be made to increase the yield production at the same cultivated area, the per hectare yield production must be improved by adapting modern technologies suited for changing the environment. Similarly, Abid *et al.* (2019) reported that sugarcane production may have been adversely affected and would continue to be significantly affected by the increase in frequency and intensity of extreme environmental conditions due to climate change. Hussain *et al.* (2018) indicated that changes in temperature, rainfall, floods, drought, salinity stresses, and frosts have been found major factors for lowering sugarcane production. Regarding the specific study of sugarcane production constraints conducted by Iqbal (2014), who indicated top most constraints faced by the cane growers reading policy-related were high price of pesticides, machinery, lack of ground irrigation, lack of information sources about production, protection, and marketing, top-down approach, political interference in policymaking. Similarly, Ali & Khan (2012) reported that the current agricultural policy was unpredictable and discriminated against sugarcane production, both in terms of substituting imports and promoting exports. This situation portrays that all the above-discussed production constraints contribute negatively and reduce sugarcane productivity and yield. Therefore, proper adoption strategies can be effective in terms of reducing sugarcane production constraints. Gangwar *et al.* (2017) suggested that ratoon management as the best strategy that helped to increase the sugarcane grower's income and productivity of the sugarcane grower. The findings are validated by the discussion made with the agriculture experts on adopting water conservation practices for sugarcane production. It was explored by the key informant interviews that an efficient irrigation system had proved among better strategies to overcome the shortage of irrigation, but the majority of the farmers in the area irrigated their land through the conventional method of irrigation.

One of the key informants reported that "…...*since last two years, my sugarcane average production is reduced due to pests and diseases in this case i have no information about the recommended pesticides used to reduce the effect of these pests and diseases*".

One of the key informants opined, "……Sugarcane crop was adversely affected since last two years by high temperature and shortage of water which resulted in the loss of per hectare yield of sugarcane". One of the key informants reported that "……. *I am a progressive sugarcane grower and adopt irrigation techniques such alternate row irrigation and furrow irrigation which are helping me saving irrigation water and the cost*".

During the key informant interview with the progressive sugarcane growers, it was explored that plenty of water was required to irrigate because the sugarcane crop was one of the most water consuming crops.

One of the respondents commented: "…… *IPM adoption strategies were not properly adopted due to lack of appropriate dissemination of information by various officials on the adoption of integrated pest management" …… They don't give us any useful information and mitigation strategies to overcome this issue."*

One of the key informants reported that, "…. *The government is not providing us information and subsidies loan in terms of approved varieties and it is not making friendly policies according to the small farmers' ground situation, and this situation*

is becoming worst with time. I wish this government provide me subsidies and make favorable policies for the small farmers".

CONCLUSION AND RECOMMENDATIONS

This study concludes that the sugarcane crop is under pressure due to some technical and environmental constraints.. As it is found that production-related challenges, erratic climate change, economic barriers, plant protection, and policy-driven challenges had a statistically significant relationship with the downfall of sugarcane production. The major challenges in sugarcane production were lack of resistant varieties and poor irrigation practices due to the conventional irrigation method. Lack of knowledge about cultural practices about sugarcane pests and disease and lack of awareness about pest resistant varieties. Furthermore, high/low rainfall, high input cost of fertilizer and pesticides, long-distance, high transportation charges, delayed payment, harvesting delay due to late crushing ,less support price by the government for sugarcane growers and lack of farmers union formation were reported major constraints in the study area.

Based on the findings, training should be given to farmers about the judicious use of inputs, approved varieties, integrated pest management practices, and technical knowledge to minimize the sugarcane production challenges and enhance sugarcane yield and productivity through the adoption of recommended production technology. Furthermore, integration of sugarcane production strategies and holistic efforts (from all stakeholders) are required to minimize the sugarcane production challenges and enhance the sugarcane productivity and income of the growers.

FUTURE THRUST

Present research would provide an in-depth analysis of the sugarcane production challenges. The current study findings can be used for policy guidelines, strategies, and recommendations for the benefits to the selected areas and also other districts of Punjab.

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