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OPTIMIZATION OF SUGARCANE CULTIVAR ADOPTION UNDER SHORKOT AND JHANG CONDITIONS

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Abstract

A study was conducted at Merik Sial Research Farm, Kashmir Sugar Mill, Shorkot to evaluate six promising sugarcane varieties regarding their quantitative and qualitative traits. The experiment followed a Complete Block Design (RCBD) with three replications. Analysis of variance (ANOVA) indicated significant ($p \leq 0.05$) differences among the varieties for both quantitative and qualitative traits. CPF-253 demonstrated a significantly higher cane yield (1100 Md/acre) compared to other varieties, followed by YTFG-236 with a yield of 967 Md/acre. YTFG-236 exhibited the highest sugar recovery percentage (11.38%), while SPF-213 showed the lowest (9.30%). Although, YTFG-236 was also found to be more susceptible to pest attacks (23%). A recent study surveyed sugarcane growers across different agroecological conditions in Shorkot and Jhang, Central Punjab of Pakistan, during the 2023-24 season. The study found that approximately 60-70% of the sampled growers cultivate recommended varieties such as CP-77400, CPF-253, YTFG-236, CPF-237, HSF-240 and SPF-213. Among these varieties, CPF-253 received positive feedback from growers, especially regarding its ratoon potential, resistance to pests and diseases, cane yield and intentions for adoption in the upcoming season. However, YTFG-236 was less favored due to its susceptibility to borer damage. According to Kashmir Sugar Mill laboratory reports, CPF-237 and CPF-253 exhibited the highest recovery averages from December to February, at 10.87% and 10.84%, respectively.

Keywords: Sugarcane, Variety, Yield, Sugar Recovery.

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INTRODUCTION

Sugarcane, a tropical crop primarily grown in Khyber Pakhtunkhwa, Punjab and Sindh, is an essential raw ingredient for the nation's second-largest agro-based sugar industry. It plays a crucial role in employing millions of individuals in both rural agrobusiness and non-farming communities. Additionally, it serves as a significant source of livestock feedstuff during the winter term. Sugarcane contributes 3.7 percent to agriculture's rate count and 0.9 percent to the GDP. In the 2022-23 period, sugarcane cultivation expanded to 1,319 thousand hectares, marking a 4.7 percent increase from the previous year's 1,260 thousand hectares. The rise in cultivated area can be attributed to the attractive market prices observed in the preceding year. Furthermore, production witnessed a 2.8 percent growth, reaching 91.11 million tonnes compared to the previous year's 88.651 million tonnes (Government of Pakistan, 2022-23). This crop faces various challenges, including low-average production per unit area, suboptimal sugar recovery and higher production costs. Additionally, a significant issue lies in the prevalent use of traditional, low-yielding varieties instead of adopting more advanced and high-yielding alternatives, serving as the primary cause for diminished cane and sugar yields. The choice of variety plays a pivotal factor influencing both the increase and decrease in cane yield per unit area (Mian, 2006). Addressing the issue of low sugarcane yield and sugar recovery can be partially mitigated through the cultivation of recently developed and advanced sugarcane varieties (Chattha *et al.*, 2006). Considerable endeavors are underway to enhance cane production through the introduction of high-yielding varieties and the implementation of improved crop production techniques (Gill, 1995). Likewise, choosing an appropriate variety for cultivation in a specific agroecological zone is essential to investigate its quantitative and qualitative attributes. (Hassan *et al.* 2017). The primary hindrances to sugarcane yield in Pakistan are the cultivation of low-yielding varieties, suboptimal production technologies, and challenging semi-arid conditions. The improvement of sugarcane production necessitates the adoption of promising varieties and appropriate technologies by growers. Overcoming these challenges requires the appraisal of both local and exotic cane germplasm to evaluate the inherent diversity within sugarcane germplasm. Knowledge about inherent variety is essential for good breeding programs. Exploring new assets of inherent variety empowers breeders to advance cultivars that can withstand evolving emerging diseases, climatic variations, environments and pests. Suitable inherent diversity makes species to show resistant to pests and disease and adapt to changing climatical environments. The plant genital capitals of a crop species serve as the foundational substantial for breeding new and resistant crop varieties. These varieties, in turn, establish the groundwork for more productive and adaptable production systems capable of addressing both biotic and abiotic stress (Naidu *et al.*, 2017). This research is based on achieving specific objectives, including assessing the varietal composition of sugarcane across farms of diverse categories and ecologies in Pakistan, analyzing the adoption of sugarcane varieties from different perspectives using various indicators, proposing strategies to further encourage

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the adoption of high-yielding varieties in the study area and providing formal and informal measures to promote the adoption of recommended varieties in the research area.

MATERIALS AND METHODS

Experiment 1.

To evaluate the adoption of sugarcane varieties at both farm and mill levels, a field trial was conducted at the Merik Sial research trial of Kashmir Sugar Mill. The trial was followed a complete block design (RCBD) with three replicates, ensuring standard practices such as irrigation, fertilizer application, seed rate, sowing method and sowing date as per recommendations. Six sugarcane varieties (CP-77400, YTFG-236, CPF-253, CPF-237, HSF-240 and SPF-213) were included in the study. Data were collected on both quantitative (cane yield t/ha) and qualitative (Brix %, POL %, Purity % and Recovery %) attributes. Brix % represents the percentage of total soluble solids in cane juice, comprising both sugar and non-sugar constituents. This parameter was conducted in the cane juice research laboratory using a hydrometer provided by the Kashmir Sugar Mill. Pol % indicates the percentage of concrete cane sucrose present in the juice. This was calculated by with a polarimeter also from the Kashmir Sugar Mill laboratory. Purity% was calculated based on the methodology outlined by Islam *et al*. (2011).

Purity% = POL % / Corrected Brix % x 100

Using the SJM formula, the sugar recovery was calculated following the quality assessment of the sample that was sent to the Cane Lab of the Kashmir Sugar Mill, Shorkot;

Sugar Recovery (%) = [S (JM)×Pol%×Extraction of juice× Efficiency of boiling house]/[J(S-M)]

Where S is 100% sugar, M is 40% molasses purity, J is juice purity and Pol% is juice (sucrose%) percentage Efficiency of the boiling house is 0 98, juice extraction is 0 80.

The percentage of infected plants was found by using the following formula, by (Mendes *et al*., 1980):

% of infected plants = No. of naturally infected plants /No. of total grown plants x 100

The recorded data was subjected to statistical analysis following the methodology stated by (Freed, 1990) via Statistix 8.1. The Least Significant Difference (LSD) test at a 5% probability level was employed to analyze all sugarcane varieties (Steel *et al*., 1997).

Experiment 2.

A questionnaire survey was conducted in the Shorkot and Jhang areas of Central Punjab, Pakistan, targeting 50 progressive sugarcane growers. The survey aimed to gather data on sugarcane varieties, including their ratoon potential, yield, vulnerability to pests and diseases and adoption remarks by the growers. The questionnaire, designed to evaluate

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sugarcane varieties, was administered to the growers after the sugarcane harvest, in collaboration with the senior Cane department team of Kashmir Sugar Mill. Evaluation criteria were based on a ranking system ranging from (very poor=1, poor=2, average=3, good=4, very good= 5).

RESULTS

Experiment 1.

Cane Yield (Md/acre):

Figure 1 illustrates notable variations ($p< 0.05$) among different varieties. CPF-253 exhibited the highest cane yield along with YTFG-236 at 1100 Md/acre and 967 Md/acre, respectively. On the other hand, CPF-237 demonstrated the lowest yield at 848 Md/acre.

Borer Percentage:

Data presented in Fig.2 indicate notable variances among sugarcane varieties concerning their susceptibility to *C. agamemnon* infestation. YTFG-236 exhibited the highest infestation rate at 23%, alongside CP-77400 at 13%. In contrast, SPF-213 demonstrated the lowest infestation rate at 6%.

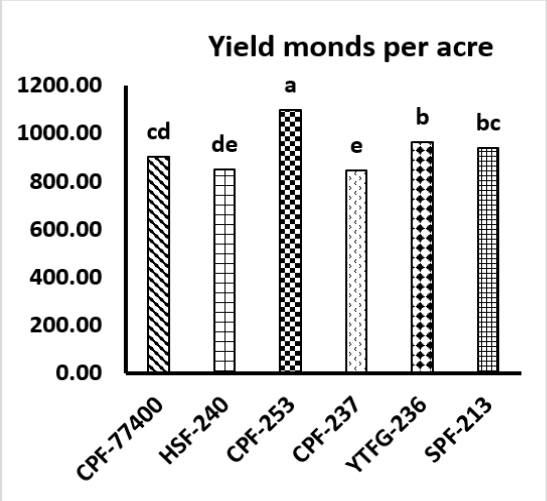

Fig 1: Yield comparison of Sugarcane varieties.

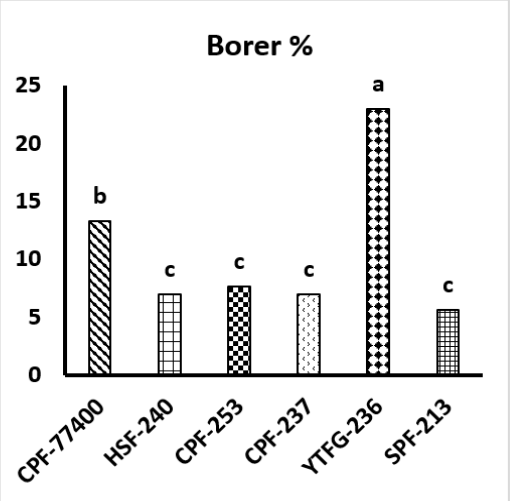

Fig 2: Borer % comparison in sugarcane varieties.

Brix % and Pol %

Analysis of data in Figures 3 and 4 revealed notable differences among varieties regarding brix % and pol %. SPF-213 recorded the lowest brix % at 19.05, whereas CPF-253 displayed the highest at 21.85% (Figure. 3). Similarly, YTFG-236 and CPF-253 showcased the maximum pol % at 19.20 and 18.84, respectively, while SPF-213 exhibited the minimum pol % at 16.09 (Figure 4).

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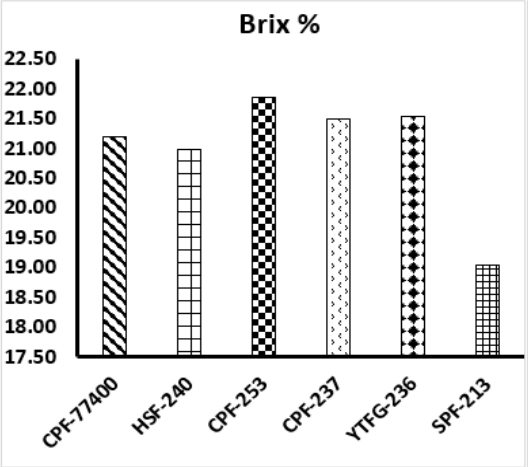


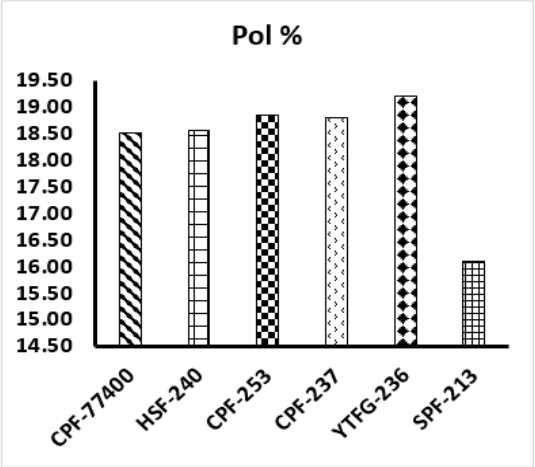


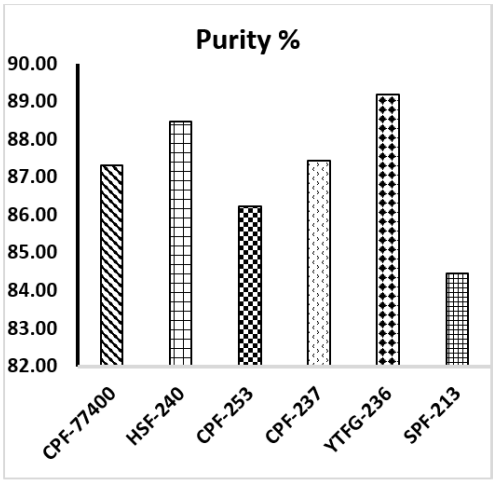
Fig 3: Brix % comparison in sugarcane varieties. Fig 4: Pol % comparison in sugarcane varieties.

Purity%

The study of revealed notable differences among the varieties for purity % (Figure 5). YTFG-236 displayed the maximum purity % at 89.8%, while SPF-213 exhibited the lowest at 84.6%.

Sugar recovery

Significant variations were found among all the varieties for recovery (Figure 6). YTFG-236 showed the highest recovery along with CPF-237 at 11.38 and 11.00, while SPF-213 demonstrated the lowest at 9.30.



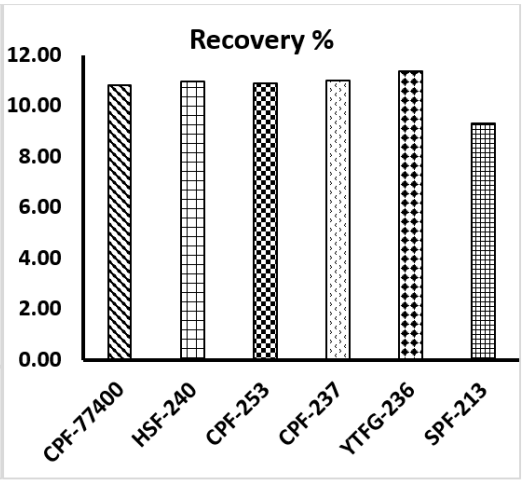


Fig 5: Purity % comparison in sugarcane varieties. Fig 6: Recovery % comparison in sugarcane Varieties.

Correlation Analysis

Pearson correlation was performed to estimate the association among quantitative and qualitative traits (Table 1**)**. In this study, traits such as Borer %, Brix % and Pol % had a

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positive correlation with yield, while purity and recovery percentage had a negative correlation. Moreover, Recovery % also shown highly significant correlation with Borer % and a negative correlation with yield. It suggests that the higher the Borer % lower the yield and recovery.

Table 1: Pearson Correlation Analysis of yield, Borer%, Brix%, pol%, purity% and recovery%.

	Yield	Borer %	Brix %	Pol %	Purity %	Recovery %
Yield	1					
Borer %	0.13**	1				
Brix	0.21**	0.37**	1			
Pol	0.06**	0.49**	0.97ns	1		
Purity	-0.310**	0.64**	0.67**	0.82*	1	
Recovery	-0.010**	0.54**	0.93ns	0.99ns	0.88*	1

* p<=0.05, ** p<=0.01, ns p>=0.05

Experiment 2.

Survey Depiction:

Table 2 shows the **Ratoon Potential,** HSF-240 demonstrated the highest ratoon potential with a score of 4.3, followed closely by SPF-213 at 4.2. CPF-237 exhibited the lowest ratoon potential with a score of 3.0. **Pest and Disease Attack,** YTFG-236 had the highest susceptibility with a score of 3.0. SPF-213 had the lowest susceptibility to pest and disease attacks, scoring 4.7. CPF-237 and HSF-240 were also low relatively susceptible, scoring 4.6 and 4.5 respectively. **Yield,** CPF-253 demonstrated the highest yield potential with a score of 4.47. HSF-240 and CPF-77400 also exhibited high yields, scoring 4.16 and 4.15 respectively. YTFG-236 had the lowest yield potential with a score of 4.00. **Adoption,** HSF-240 were the most adopted varieties, each scoring 4.3. CPF-77400 and CPF-253 were also well-adopted, scoring 4.1. YTFG-236 had the lowest adoption rate with a score of 2.8.

Table 2: Survey Data of Ratoon, Pest and Disease, yield and Adoption Remarks

Variety	Ratoon	Pest and Disease attack	Yield	Adoption Remarks
CPF-77400	4.1	4	4.15	4.1
HSF-240	**4.3**	4.5	4.16	**4.3**
CPF-253	4.1	3.5	**4.47**	4.1
CPF-237	3.7	4.6	4.00	3.7
YTFG-236	4.1	3	4.00	2.8
SPF-213	4.2	**4.7**	4.00	4

HSF-240, CPF-253, CP-77400 and SPF-213 appear to be promising varieties, performing well in terms of ratoon potential, yield, and adoption rates. However, CPF-237 and YTFG-236 appear to be non-promising varieties due to low yield and growers' adoption remarks.

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Recovery Report:

Table 3 presents the monthly recovery percentage average data collected from the laboratory of Kashmir Sugar Mill. In December, CPF-253 and CPF-237 achieved the highest recovery percentages of 9.81 and 9.75, respectively, while YTFG-236 recorded the lowest recovery percentage of 9.19. Moving to January, CPF-237 and CPF-253 exhibited higher recovery percentages of 10 and 9.94, respectively, whereas CP-77400 and YTFG-236 had the lowest recovery percentages of 9.36 and 9.39, respectively. In February, HSF-240, CPF-237, and CPF-253 attained the highest recovery percentages of 9.93, 9.88 and 9.73, respectively, while CP-77400 displayed the lowest recovery percentage of 9.44.

Table 3: Month-wise recovery % of Sugarcane varieties.

Variety	Dec	Jan	Feb	Average
CPF-77400	9.41	9.36	9.44	**9.403**
HSF-240	9.68	9.87	9.93	**9.827**
CPF-253	9.81	9.94	9.77	**9.840**
CPF-237	9.75	10	9.88	**9.877**
YTFG-236	9.19	9.62	9.76	**9.523**
SPF-213	9.38	9.39	9.46	**9.410**

CPF-237, CPF-253, and HSF-240 demonstrated maximum recovery during all months and maintained higher recovery averages compared to other varieties, respectively. Conversely, CP-77400, YTFG-236, and SPF-213 exhibited the lowest recovery percentages among the varieties, respectively.

DISCUSSION

The adoption of suitable sugarcane cultivars plays a pivotal role in enhancing agricultural productivity and ensuring sustainable sugarcane production under diverse agro-climatic conditions. In the present study, the optimization of sugarcane cultivar adoption under Shorkot and Jhang conditions was investigated, aiming to provide valuable insights into maximizing yield potential, resilience to environmental stressors and overall profitability for farmers in these regions. Through a comprehensive examination of various cultivars, their performance and their adaptability to local climatic and soil conditions, this research sheds light on the critical factors influencing cultivar selection and adoption like yield. Scientific advancements in agriculture and its sub-sectors primarily aim to improve farm yield, benefiting both farmers and the economy of a country. Our yield result aligning closely with the findings of Sarwar *et al*. (2018) at 109.9 t/ha, but slightly lower than 113.38 t/ha reported by (Khan *et al.,* 2013). Borer infestations pose a significant threat to agricultural productivity and economic stability for farmers. By opting for resistant varieties, farmers have the potential to mitigate these losses. The impact of borers on sugarcane varieties and yield can be substantial, potentially leading to significant losses in production. Studies have shown that borer infestations can reduce sugarcane yield by up to 30% in severely affected areas (Duhra and Sharma, 1993). Additionally, certain

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sugarcane varieties may exhibit varying levels of susceptibility to borer damage, further emphasizing the importance of selecting resistant cultivars to mitigate yield losses. Our results of variation among sugarcane varieties regarding borer infestation are similar to the finding of Salman *et al*. (2014). Both brix % and pol % of cane juice are crucial qualitative parameters utilized for assessing maturity. Following brix % and pol % holds significance as another important parameter. Variations in Brix and Pol percentages can significantly impact the yield and quality of sugarcane, with certain varieties demonstrating higher sugar content and thus greater profitability. Research by Ahmed *et al.* (2007) highlights that sugarcane varieties with higher Brix and Pol percentages tend to exhibit better sucrose recovery rates, ultimately leading to increased yields and economic returns. Therefore, selecting and cultivating sugarcane varieties with optimal Brix and Pol percentages is crucial for maximizing productivity in the sugar industry. Our results contradict the findings of Panhwar *et al*. (2017) but are consistent with those of Khalid *et al*. (2014), possibly due to the consistent expression of genes governing these attributes. Purity, as indicated by the sucrose content relative to other components in sugarcane juice, is a critical factor affecting both the quality and yield of sugarcane. Studies by Abu-Ellail *et al.* (2020) suggest that certain sugarcane varieties exhibit inherently higher purity levels, improving sugar recovery rates during processing. Varieties with higher purity not only contribute to better quality sugar production but also potentially enhance overall yield, making them favorable choices for cultivation in the sugar industry. Our study also consistent with the findings of (Sajjad and Khan, 2009). The recovery rate, which measures the efficiency of sugar extraction from sugarcane, plays a crucial role in determining both the yield and profitability of sugarcane cultivation. Research conducted by Gulati *et al.* (2015) indicates that certain sugarcane varieties exhibit higher recovery rates due to their genetic characteristics, leading to increased sugar production per unit of cane harvested. Selecting varieties with superior recovery potential can thus significantly enhance both yield and economic returns in the sugar industry. Our findings found similar with results were reported by earlier researchers (Sarwar *et al*., 2011; Khalid *et al.*, 2014). They assessed six approved sugarcane varieties for various juice quality, milling, and processing parameters such as CCS % (commercial cane sugar), juice extraction %, pol extraction %, BHR % (boiling house recovery), overall recovery %, and sugar recovery % using a hydraulic press at 1400 bars pressure. A study conducted by Kumar *et al*. (2012) similar to our results, revealed a positive correlation between borer infestation levels, Brix %, Pol % and sugarcane yield. Their findings suggested that sugarcane varieties with higher resistance to borers tended to exhibit elevated Brix and Pol percentages, leading to improved sucrose content and subsequently higher yields. This study underscores the importance of pest resistance and sugar content in sugarcane breeding programs to enhance productivity and profitability in the sugar industry. Contrary to common expectations, two separate studies by Shahzad *et al.* (2017) and Ahmed and Awadalla, (2016) independently revealed a negative correlation between recovery rates and sugarcane yield. Their research indicated that while higher recovery rates are typically associated with better sugar extraction efficiency, they often coincide with decreased overall yield due to a potential trade-off with biomass

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production. This suggests that focusing solely on maximizing recovery rates may not always result in optimal yields, highlighting the need for a balanced approach in sugarcane cultivation practices.

CONCLUSION AND RECOMMENDATIONS

The selection of site-specific varieties with higher cane production and superior sugar recovery could significantly impact the prosperity of both farmers and industrialists. This study offers valuable insights into how various sugarcane varieties respond to the agroecological conditions of Shorkot and Jhang. Results reveal that CPF-253 yielded the highest cane production at 1100 Md/acre, coupled with good sugar recovery at 10.90% and low susceptibility to pest and disease attacks. On the other hand, YTFG-236 exhibited the highest sugar recovery at 11.38% compared to other varieties, but due to insufficient awareness among farmers regarding its handling and its greater susceptibility to pests, it showed poor adoption remarks by growers. Therefore, further studies should prioritize these two varieties for variety development. There is an urgent need to implement extension programs to educate farmers on the latest production technologies and initiate breeding programs to introduce new high-yielding varieties that are resistant to pests. Both the government and sugar mills should collaborate to raise awareness among farmers about modern production technologies, aiming to maximize yield potential and ensure the efficient utilization of resources, particularly fertilizers, water and land.

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