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Research Article

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UNLOCKING COMMERCIAL POTENTIAL: CPF 249, A MEDIUM-MATURING SUGARCANE VARIETY FOR PUNJAB

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ABSTRACT

The substantial growth of sugar industry and the need to ensure national food security entail the extension of crushing season for sugar mills in Punjab by introducing medium and late maturing sugarcane varieties. The variety CPF 249 is a cross of CP 87-1628 × CP 84-1198, developed from fuzz imported in 2002 from the Sugarcane Station, Canal Point, USA, and subsequently grown as clone no. S2003 US-704 at the Sugarcane Research Institute, Faisalabad. Following successful initial selection, CPF 249 underwent four years of testing in preliminary, semi-final, and final varietal trials from 2008 to 2012. This medium-maturing variety demonstrates high tonnage and superior sugar recovery compared to other medium-maturing varieties such as CPF 247, SPF 245, and HSF 240. Furthermore, CPF 249 exhibits resistance diseases and insect pests, positioning it as an excellent alternative to SPF 245, SPF 234, and HSF 240 throughout Punjab. Economically, it offers a significant advantage, yielding an additional profit of Rs. 223,000 over SPF 245, Rs. 138,000 over HSF 240, and Rs. 54,000 per hectare compared to other local checks.

Key words: Sugarcane, CPF 249, variety, preliminary trial, sugar recovery

INTRODUCTION

The modern sugarcane species, *Saccharum spp.*, has its origins in the hybridization of *Saccharum officinarum*, *S. barberi*, *S. sinense*, and wild relatives such as *S. spontaneum* (Gravois *et al*., 2008). The high level of heterozygosity in sugarcane is sustained through vegetative propagation. Climate change factors, including sudden fluctuations in day and night temperatures, altered rainfall patterns, and increased CO_2 concentrations, significantly impact crop growth and development across all climatic zones. These changes lead to both abiotic stresses, such as heat stress, drought, and flooding, as well as biotic stresses from new pathogens, insect pests, and weeds, ultimately reducing crop growth, yield, and quality (Fisher and Maurer, 1978). Additionally, these stressors can hinder the crop canopy's ability to absorb solar radiation and its efficiency in converting this energy into biomass, thereby affecting the internal microclimate of cropping systems (Pezzopane *et al*., 2015).

CPF 249 is a cross of CP 87-1628 × CP 84-1198 and its fuzz was imported in 2002. CP 84-1198 is cultivated on 1.2% of the EAA (Everglades Agricultural Area) sugarcane land. More than 80% cultivated sugarcane area of Florida is under CP cultivars (VanWeelden *et al*., 2017). CP87-1628 is also a good variety and it showed significant production in the agro-climatic conditions of Thatta, Sindh (Gujar *et al*., 2011). The characterization on the basis of morphology and quality CP 87-1628 showed variation among local and exotic genotypes *(Shahzad et al*., 2016). HSF 240 and SPF 234 were used as checks with high sucrose content, yield potential and disease resistance (Tabassum *et al*., 2018).

The sugarcane variety CPF 249 was approved for commercial cultivation in 2016 by the Sugarcane Research Institute (SRI), Faisalabad. It was released due to its superior performance in terms of tonnage, sugar recovery, and tolerance to diseases and pests compared to CPF 247, SPF 245, and HSF 240. Notably, CPF 249 does not produce offshoots or sprouts during the growing season, allowing it to achieve greater height and utilize agricultural inputs more efficiently. The designation "CP" refers to Canal Point, while "F" stands for Faisalabad, the location of the SRI. As farmers adopt this variety, it is expected to not only enhance sugar recovery patterns in mills but also provide higher economic returns compared to other cultivars.

MATERIAL AND METHODS

Import of fuzz and selection at early stages: A summary of the release of CPF 249 is shown in table 1.

Sugarcane does not flower in Faisalabad due to the semi-arid climatic conditions.

Table 1: Summary of the approval of CPF 249 sugarcane cultivar for general cultivation

Year	**Stage**
2002	Import of true seed from CP, raising of fuzz and establishment of seedlings at SRI
2003	Planting sugarcane seedlings in the field and selecting desired clones, including the clone S2003 US-704
2004	Nursery- I, Assessment of clones based on desired traits
2005	Nursery-II, Evaluation of clones on the basis of desired traits
2006	Preliminary varietal trial (N-III)
2007	Seed increase for further propagation
2008-09	Semi-final and disease and insect pests study
2009-10	Final varietal trial, disease and insect pests study and botanical description (DUS test)
2010-11	National uniform yield trial (NUYT) and zonal testing at farmers field
2011-12	National uniform yield trial (NUYT) and zonal testing at farmers field
2012-13	Ratoon and agronomic studies

To raise fuzz and establishment of seedlings having diverse genetic make-up, the soil under tunnels was prepared well to make fine and raised seed beds under shade. Well decomposed potting media prepared locally were used on these beds to get good germination. Recommended plant protection measures are adapted. Germination data were recorded, and seedlings aged 45 to 60 days were transferred to earthen pots. Well established seedlings of 90-120 days were transplanted into the field for further evaluation during September/October. A single row of each clone (plot size: 4 m × 1.2 m) was planted in Nursery I, with three check varieties repeated in each group of 20 clones. Selection was based on visual assessments of cane growth, stand, lodging, pith quality, disease resistance, and insect pest attack, as well as quality performance measured by brix readings using a hand refractometer. The selected clones were then promoted to Nursery II for further evaluation. In Nursery II, a double row of each clone (4 m × 2.4 m) was planted, with three control varieties repeated in each group of 20 clones. Subsequently, the selected clones advanced to Nursery III for additional studies.

Replicated Yield Trials: The performance of CPF 249 was evaluated at the Sugarcane Research Institute (SRI), Faisalabad alongside standard cane varieties SPF 245 and HSF 240. Additionally, CPF 249 was tested at the Sugarcane Research Station (SRS) in Khanpur and the Sugarcane Research Sub-station (SRSS) in Bahawalpur, both of which have arid climates, using standard varieties HSF 240 and SPF 234, respectively. The variety was also assessed on farmers' fields across Punjab Province and in National Uniform Yield Trials (NUYT) conducted nationwide. The experiments were designed using statistical methods at SRI Faisalabad, SRS Khanpur, and SRSS Bahawalpur. The recommended seed rate of 10 tons per hectare and fertilizer @ 168-112-112 NPK per hectare as source of urea, DAP and MOP was used. Urea was applied in three equal doses from the completion of germination until the earthing up of the crop and 16 irrigations (around 64 acre inches in total) were applied throughout the crop season. The data on germination, tillering, cane stalk density, and cane yield were systematically recorded. For quality evaluation, fortnightly juice analysis was conducted to measure parameters such as brix, pol, purity, commercial cane sugar (CCS %), and sugar recovery %. These analyses were performed at the Sugarcane Technology Laboratory of SRI, Faisalabad. Canes were crushed using an electric cane crusher, which achieved approximately 70% extraction efficiency. Brix percentages were measured with a hydrometer calibrated at 20°C, while pol percentages were determined using Horn's dry lead sub-acetate method (Anonymous, 1970).

Commercial Cane Sugar (CCS %) was calculated using the formula:

$$CCS\% = 3P/2\ \{1-(F+5)/100\} - B/2\ \{1-(F+3)/100\}$$

where *P* represents pol %, *F* is fibre %, and *B* denotes Brix %.

Sugar yield was calculated using the following formula:

$$\text{Sugar Yield (CCS tons ha}^{-1}) = CCS\%/100 \times \text{Stripped Cane Yield}$$

The disease reaction of CPF 249 was evaluated under both natural and artificial inoculation against red rot. Observations were made on red rot, smut, pokkah boeng, mosaic virus, rust, and red stripe. Data on sugarcane borer infestations were collected at various selection stages. For identification purposes, morphological characteristics of the crop were recorded at the end of November for two consecutive years.

Table 2: Screening criteria for evaluating red rot resistance in sugarcane germplasm

Reaction of sugarcane genotypes to red rot disease	**Disease index (score)**
Resistant (R)	0.0 – 2.0
Moderately resistant (MR)	2.1 – 4.0
Moderately susceptible (MS)	4.1 – 6.0

Susceptible (S)	6.1 – 8.0
Highly susceptible (HS)	Above 8.0

Table 3: Criteria for screening of sugarcane genotypes against borers complex

Reaction	Inter-nodal damage %		
	Top borer	**Stem borer**	**Root borer**
Resistant (R)	0-10	0-10	0-10
Moderately Resistant (MR)	10.1-20	10.1-20	10.1-20
Susceptible (S)	20.1-40	20.1-40	20.1-40
Highly Susceptible (HS)	40.1 and above	40.1 and above	40.1 and above

Statistical analyses: The data were analyzed using the statistical software "Statistix 8.1" (McGraw-Hill, 2008).

RESULTS AND DISCUSSION

Morphological and agronomic description: Varietal description and characterization were done on 15th November at approximately the crop age of 9th months. The stalked characterization was done from inner row to un-expose to direct sunlight. However, phenotypic expression may vary from plant to plant due to growth difference, environment and cultural condition without any change in the genotype of cultivar. The stalk description were based on measurement of 10 stalks. CPF 249 shows greenish colour that becomes more purple when exposed direct to sunlight. The average mature height of stalk 440 cm. The internodal length 14 cm was having cylindrical shape with no splits and bud grooves. The size of buds is medium and ovate type and it is present above the growth ring Nodes were swollen growth rings. The colour of root zoon was yellowish green with two rows. The canopy of CPF 249 is erect. Surface of leaf blade is plan while average leaf blade length and width of CPF 249 is 155 cm and 4.6 cm, respectively. Leaf sheath length is 30 cm while spines are absent. It does not flower under climatic conditions of Faisalabad.

Performance of CPF 249 at Faisalabad: The cane yield performance of CPF 249, compared to standard varieties SPF 245 and HSF 240 from 2008 to 2012 that is presented in Table 4. On average, CPF 249 produced 32.27% and 28.43% higher stripped cane yield (114.24 t ha^{-1}) than SPF 245 and HSF 240, which yielded 86.37 t ha^{-1} and 88.95 t ha^{-1}, respectively. Cane quality was assessed in multiple trials at fortnightly intervals, and the sugar recovery data are shown in Table 4. CPF 249 exhibited a sugar recovery of 12.77%, compared to 11.60% and 12.59% for SPF 245 and HSF 240, respectively, representing 10.08% and 1.43% higher sugar recovery over the standard varieties. The difference in sugar recovery is largely determined by the genetic potential of sugarcane clones. The variation in sugar yield is attributed to the higher sugar content of the clones, coupled with their superior cane yield (Ahmad *et al*. 2022)

Performance of CPF 249 in Outfield Trials: The sugarcane variety CPF 249 was tested alongside the standard variety HSF 240 over four years at the SRS, Khanpur. The data in Table 5(a) indicate that CPF 249 produced 12.06% higher stripped cane yield compared to HSF 240. Similarly, CPF 249 was evaluated against the standard variety SPF 234 for three years at the SRSS, Bahawalpur. As shown in Table 5(b), CPF 249 demonstrated a 14.87% higher stripped cane yield than SPF 234. The superior performance of CPF 249 compared to other cultivars may be attributed to its unique genetic makeup, which allows it to adapt to various climatic conditions and respond variably for specific traits (Hassan *et al*. 2020)

Table 4: Summary of cane yield and sugar recovery performance of CPF 249 against commercial cultivars at Sugarcane Research Institute, Faisalabad

Year	Cane yield (t ha^{-1}) and sugar recovery%						Difference in yield (t ha^{-1}) and sugar recovery%				Percent (%) increase (cane yield & recovery%) over commercial cultivars			
	CPF 249		**SPF 245**		**HSF 240**		**SPF 245**		**HSF 240**		**SPF 245**		**HSF 240**	
2008-09	121.50	11.94%	91.47	11.92 %	95.31	12.58%	30.05	0.02%	26.20	-0.64%	32.83	0.17%	27.49	-5.09%
2009-10	127.16	13.07%	83.95	11.83%			43.21	1.24%			51.47	10.48%		
2010-11	101.73	12.24%	83.68	11.05%	82.60		18.05	1.19%		1.24%	21.57	10.77%		
2011-12	106.60	13.84%				12.60%			24.00				29.06	9.84%
Average	114.24	12.77	86.37	11.60%	88.95	12.59%	27.87	1.17%	25.29	0.18%	32.27	10.08%	28.43	1.43%

Table 5 (a): Summary of cane yield performance of CPF 249 compared with HSF 240 at Sugarcane Research Station Khanpur

Year	Cane yield (t ha^{-1})		Difference (t ha^{-1}) with HSF 240	Percent (%) increase over HSF 240
	CPF 249	**HSF 240**		
2008-2009	102.31	73.33	28.98	39.52
2009-2010	119.92	113.25	6.67	5.89

2010-2011	122.41	111.39	11.02	9.89
2011-2012	101.3	100.0	1.30	1.30
Average	111.49	99.49	12.00	12.06

Table 5 (b): Summary of cane yield performance of CPF 249 compared with SPF 234 at Sugarcane Research Sub-station, Bahawalpur

Year	**Cane yield (t ha^{-1})**		**Difference (t ha^{-1}) with SPF 234**	**Percent (%) increase over SPF 234**
	CPF 249	**SPF 234**		
2009-2010	121.19	107.41	13.78	12.83
2010-2011	121.60	103.49	18.11	17.50
2011-2012	124.67	109.00	15.67	14.38
Average	122.49	106.63	15.86	14.87

Disease and insect response: The sugarcane variety CPF 249 demonstrated resistance to all prevalent strains of red rot, as well as other diseases such as smut, pokkah boeng, red stripe, and rust, under both natural and artificial inoculation conditions (Table 6a). Moreover, CPF 249 showed tolerance to all sugarcane borers, as evaluated by dead heart incidence and cumulative internode damage under field conditions (Table 6b).

Table 6 (a): Disease reaction of CPF 249 and other commercial cultivar

Year	**Varieties**	**Reaction to diseases**					
		Red rot	**Smut**	**Pokkah boeng**	**Red stripe**	**Rust**	**Mosaic virus**
2008-09	CPF 249	R	R	R	R	R	R
	SPF 245	R	R	R	R	MR	MR
2009-10	CPF 249	R	R	R	R	R	R
	SPF 245	R	R	R	R	MR	MR
2010-11	CPF 249	R	R	R	R	R	R
	SPF 245	R	R	R	R	MR	MR
2011-12	CPF 249	R	R	R	R	R	R
	SPF 245	R	R	R	R	MR	MR

R = resistant, MR = moderately resistant

Table 6 (b): Tolerance of CPF 249 and other commercial cultivar to borers

Reaction to sugarcane borers				
Year	**CPF 249**		**SPF 245/HSF 240**	
	Dead heart (%)	**Cumulative internode damage (%)**	**Dead heart (%)**	**Cumulative internode damage (%)**
2009-2010	2.03	6.42	1.42	5.83
2010-2011	2.61	11.14	1.58	7.50
2011-2012	1.38	10.67	1.06	8.47
Average	2.01	9.41	1.35	7.27
Reaction	R	R	R	R

R= resistant, MR = moderately resistant

Ratooning ability : The ratooning ability of CPF 249 was evaluated at SRI, Faisalabad during 2012-13. CPF 249 produced a stripped cane yield of 74.7 t ha^{-1}, outperforming the standard variety HSF 240, which yielded 60.7 t ha^{-1}.

Economic benefit: The data in Table 7 demonstrate that, on average, CPF 249 produced 4.46, 2.76, and 1.08 t ha^{-1} more sugar yield compared to the standard varieties SPF 245, HSF 240, and other local check varieties, respectively. This resulted in an additional economic benefit of Rs. 223,000 per hectare over SPF 245, Rs. 138,000 over HSF 240, and Rs. 54,000 over other check variety(es) (SPF 234).

Table 7: Summary of economic benefits of CPF 249 over commercial cultivars

Location	**Variety**	**Cane yield (t ha^{-1})**	**Sugar recovery (%)**	**Sugar Yield (t ha^{-1})**	**Difference over SPF 245 (t ha^{-1})**	**Difference over HSF 240 (t ha^{-1})**	**Difference over local check (t ha^{-1})**	**Increased value over SPF 245 (Rs. ha^{-1})**	**Increased value over HSF 240 (Rs. ha^{-1})**	**Increased value over local check (Rs. ha^{-1})**
SRI, Faisalabad	CPF 249 SPF 245 HSF240	114.24 86.37 88.95	12.77 11.60 12.59	14.59 10.02 11.20	4.57	3.39		228500	169500	
SRS, Khanpur	CPF 249 HSF240	111.49 99.49	12.47 12.28	13.90 12.22		1.68			84000	
Out field trials	CPF 249 LC[1]	122.90 113.90	12.13 11.77	14.9 13.4			1.50			75000
Average	CPF 249 SPF 245 HSF240 LC	116.21 86.37 94.22 113.9	12.46 11.60 12.44 11.77	14.48 10.02 11.72 13.40	4.46	2.76	1.08	223000	138000	54000

[1]LC; local check

Sugar @ Rs. 50000/t

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AUTHORS CONTRIBUTION

M.U. Hassan, M.A. Mudassir and N. Fiaz conducted the research, collected and analyzed the data, and wrote the manuscript. M.S. Afzal, Z. Sikandar, M. Shafique, S.S. Hussain, F. Hussain. M.F. Ahmad, I. Rashid, M. Yasin and Salma Niaz contributed to the manuscript writing, while M. Zafar provided guidance to the entire team.

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AUTHORS CONFLICT

Authors declare that they have no conflicts of interest.

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