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Comparative Evaluation of Sugarcane Genotypes for Adaptability Stuides in the Agro-ecologies of Sargodha, Punjab, Pakistan

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Abstract. The aim of this study is to identify sugarcane genotypes that combine high yield and stability across environments to identify best potential cultivars of sugarcane for a region during the years 2017-18 and 2018-19. Fourteen sugarcane genotypes under varietal development programme of Sugarcane Research Institute, Faisalabad were evaluated in two different locations of northern region in Punjab, Pakistan for their yield response and stability in that ecology, The research trials was carried out in randomized complete block design with three replicates. The sugarcane genotype S2005-US-54 stand best performer by achieving cane yield of 122 t/ha and sugar yield of 15.52 t/ha at Bhalwal, while sugarcane genotype CPF-253 and CPF-252 produced high cane yield of 129 t/ha, 125 t/ha and sugar yield of 16.69 t/ha, 15.25 t/ha at Chelianwala respectively. The adaptability and stability studies of fourteen genotypes concluded that CPF-253, S2005-US-54, CPF-252 produced the highest cane yield of 123.5 t/ha, 121.5 t/ha, 115t/ha respectively and most of the productive genotypes being high yielding ability was best suited for planting in northern agro-ecologies in Punjab.

Keywords: stability, environment, genotype, potential, adaptability

Introduction

The sugarcane crop belongs to family Gramineae and is a complex hybrid of genus *Saccharum*. It is recognized worldwide for its capacity of high biomass production, impounding thousands of tons of atmospheric CO_2 during its development and it has a sustainable balance related to greenhouse gas emissions during its entire industrial process (Luo *et al*., 2015). It is the main economically exploited crop in Brazil, USA, Mexico, Pakistan used for the production sugar, biofuel and other by products. Additionally, the crop is liable for generating millions of jobs and definitely contributing to the sustainable and viable environment (Sabaghnia *et al*., 2006).

Sugarcane is a high value cash crop that has significance for the sugar and sugar related industries in Pakistan. As it contributed about 0.6 % to country GDP and 2.9 % of total value addition in agriculture with 66.880 MT sugarcane production during 2019-20 (Khaliq *et al*., 2020). Pakistan is placed at the fifth position in sugarcane acre age and production, while 15th position in sugar production in the world (Memon *et al*., 2010). The contribution of the Punjab in the total production is around 60% of sugarcane. However, the per acre yield of sugarcane in Pakistan (64.30 ton/ha) is very less than the varieties potential yield (110-140 ton/ha) as well as cane yield in different cane growing countries and world average yield of 72 ton/ha. This is due to lack of organic matter, poor crop rotations, use of un-approved quality cane varieties by farmers, low plant populations, absence of deep ploughing, incidence of red rot, white leaf disease, pests, weeds under climate change and lack of proper climate resilient varietal selection (Zubair *et al.*, 2019) along with many other agro-technological reasons.

In Pakistan, sugarcane is grown in various agro-ecological regions including in the southern Sindh with costal hot humid, in upper Sindh with very hot dry, southern and northern parts of Punjab and KP with frosty cool climate. Hereafter cane growing areas of Pakistan vary climatologically and crop has to endure the cruelty of the climate in the whole country. It needs for developing and identifying site specific varieties / genotypes for each agro-ecological region (Zubair *et al*., 2019).

The stable and best performer cultivars with wide adaptation can be identified and selected only through growing sugarcane genotypes in various agro-ecologies (Luo *et al*., 2015) with diverse environments. The

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appraisal of performance stability is important to identify constant performing and high-yielding clones / genotypes (Kang, 1997).

Varieties development and selection for different agro-climatic zones is the need of time (Khaliq *et al*., 2020). One genotype performs well in one place and fails to perform in other climatic zone. In Punjab, it was seen that sugarcane commercial variety SPF-234 affected severely in Faisalabad region and at the same time this variety dominates all existing cultivars in southern Punjab areas like Bahawalpur, Rahim Yar Khan. SPF-234 remained in field for more many years and superseded in cane yield and sugar recovery/yield. Now, with the passage of time, this variety is also losing its potential in southern Punjab (Sarwar *et al*., 2017).

The most popular variety among farmers HSF-240 in Pakistan was developed by Sugarcane Research Institute Faisalabad. This variety remained popularized in whole of country for decades. This is variety with good tillering, crop stand and resistant to lodging. HSF 240 is affected by smut diseases in ratoon (Khaliq *et al*., 2021). This ups and down in the potential of genotypes and susceptibility to different diseases is the result of climatic change.

To cope the issues of sudden incidence of diseases and pests, sustainable sugarcane production is important. The monsoon rainfall patterns is being changed during July to September due to climate change. This pattern may result in water stress in one area and water logging in other place by affecting the crop zones (Akter *et al*., 2015).

Response of sugarcane to different agro-climates and water scarcity with mitigation approaches and adaptation plans that can be employed in the sugarcane farming as a way of reducing losses in sugarcane production. Varieties plays a vital key role in increasing cane and sugar yield. Cultivation of good quality, disease free approved varieties improves yield and combat climatic issues (Sarwar *et al*., 2018).

Sugarcane research Institute Faisalabad under the umbrella of Ayub Agricultural Research Institute, Faisalabad has released twenty eight sugarcane varieties for general cultivation. Zonal testing of different clones/ varieties is a component of varietal development programme of this institute. The objective of this experiment was to study the stability in yield performance of sugarcane genotypes/cultivars under varied environmental conditions of northern zone of sugarcane.

Material and Methods

The basic and primary objective of Sugarcane Research Institute (SRI), Faisalabad is to develop and release sugarcane varieties/genotypes having all out sugar recovery with more tonnage. Two ways are take on for the development and evolution of new sugarcane variety for general cultivation *viz*. by importing the stumps of sugarcane of commercial varieties, as direct introduction

Table 1. Varieties under study in experiment:

Variety no.	Name of genotype/cultivar	Country origin of Fuzz and direct introduction	Developed by fuzz/ direct introduction
V1	CPF-246	Sugarcane field station (SFS), Canal point, America	fuzz
V2	CPF-247	Sugarcane field station (SFS), Canal point, America	fuzz
V3	CPF-248	Sugarcane field station (SFS), Canal point, America	fuzz
V4	CPF-249	Sugarcane field station (SFS), Canal point, America	fuzz
V5	CPF-253	Sugarcane field station (SFS), Canal point, America	fuzz
V6	CPF-250	Sugarcane field station (SFS), Canal point, America	fuzz
V7	CPF-251	Sugarcane field station (SFS), Canal point, America	fuzz
V8	S2003-US-778	Sugarcane field station (SFS), Canal point, America	fuzz
V9	S2005-US-54	Sugarcane field station (SFS), Canal point, America	fuzz
V10	S2006-SP-93	South African sugar association experiment station (SASES), Durban, south Africa	fuzz
V11	CPF-252	Sugarcane field station (SFS), canal point, America	fuzz
V12	S2008-FDS-19	Sugarcane Breeding Sub-station Murree	fuzz
V13	S2008-AUS-130	Bureau of Sugarcane Experiment Station (BSES), Meringa, Australia	fuzz
V14	CP-77-400	Sugarcane Field Station (SFS), Canal point, America	Direct introduction

method and by selection of the fuzz of sugarcane being imported from global breeding institutes and sugarcane breeding sub-station Murree. Fourteen varieties of caneed suger yielding, pest and disease resistant as indicated in Table 1.

The study was carried out on the fourteen sugarcane varieties for two consecutive year, 2017-18 and 2018-19 at two different locations of northern Punjab *viz*. sugarcane farm, Fatehpur, Noon Sugar Mills, Bhalwal. and Govt. Seed Farm, Mandi Bahauddin. The clones remain same on both locations as shown in Table 2.

Experimental procedure. The four feet apart trenches were made with the help of sugarcane ridger. The seed was prepared by labour by cutting whole cane into three Budded sets. These setts were planted in two parallel row by placing them end to end in ridges. The experiments were laid out in RCBD with 3 replications on an area of four kanal (70 m x 30 m). The recommended dose of fertilizer @168-112-112 Kg/ha NPK and seed rate@ 50000 TBS/ha was applied.

Crop husbandry. After sowing of crop, light irrigation were made following by 16-18 irrigations at different interval as per crop need and weather conditions till one month before crop harvest. As regarding with weeds management, dual gold @ 2.5 L/acre was applied with first irrigation as pre-emergence. Gang-V (Mesotrione +Atrazine) and sun star gold were applied to control weeds @ 2.5 L/ha and 50 g/ ha respectively at 50 days after planting. As regarding with mechanical control, rotary weeder was used at 40 days after planting. After ploughing with five tines hoeing cultivator, earthing up the crop after 110 days of crop planting (Khaliq *et al*., 2021).

Data collection and analysis. Data on germination (%), tillers / plant, number of canes/ha, cane yield (t/ha), sugarcane recovery (%) and sugar yield (t/ha) were recorded by using the standard procedure. The germination data was collected 45 days after planting and tillering data was collected at 90 days after planting of crop. The data on cane count, cane yield was collected at crop harvest and analyzed by employing the fisher's analysis of variance technique (Steel *et al*., 1997) compare the difference among treatments means by applying least significant difference test at 5% probability level. Twenty canes samples from each variety were collected for sugar analysis in Sugarcane Technology Labouratory, Faisalabad.

The crop was harvested after fourteen months' period of planting. The canes were de trashed by manually removing leaves and trash. The data was collected from each plot, averaged and converted into per hectare.

Results and Discussion

It is obvious from the Table 3 that clone S2003-US-778 gave the maximum germination of 58 % which was statistically at par with CPF-247, CPF-249 and S2008-AUS-130 giving germination of 52 %, 51 % and 50 % respectively. The variety CPF-252 gave the lowest germination of 35%. There are numerous factors that affects germination in sugarcane crop. Amongst them, genetics of clone, climatic conditions of the area, soil condition and sowing techniques. The germination of S2003-US-778 and CPF-247 is higher than other genotypes at Bhalwal location. These results are in line with Sarwar *et al.* (2018).

As regarding the number of tillers per plant under the environmental conditions of Bhalwal (Table 3), the variety CPF-249 gave the maximum no. of tiller/plant of 2.00 which was at par statistically with CPF-248, CPF-253, S2003-US-778, S2005-US-54, S2008-FDS-19 and S2008-AUS-130 producing no. of tiller/plant of 1.85, 1.75, 1.90, 2.00, 2.00 and 1.75 respectively. S2006-AUS-SP-93 gave the lowest no. of tillers per plant of 1.05 %. The cane account /ha is very important yield parameter. It is directly co-related to cane yield of sugarcane. The findings of Sarwar *et al.* (2018) and El-Geddawy *et al*. (2015) are agreement with these findings.

The clone S2006-US-658 produced the maximum no. of thousand canes/ ha of 115 at Bhalwal (Table 3) which

Table 2. Latitude, longitude, altitude and soil type of the experimental locations

Location	Latitude	Longitude	Altitude	Soil type*
Govt. seed farm, Mandi Bahu Din	N 32° 34' 26.994"	E 73° 29' 50.4420"	204 m	Silty clay loam
Research farm, Noon sugar mill, Bhalwal	N 32° 15' 55.4256"	E 72° 54' 16.9704"	178 m	Silty loam

(Soil and Water testing laboratory, Faisalabad*)

was statistically at par with CPF-249, CPF-253, CPF-251, S2003-US-778 and S2005-US-54 giving thousands canes/ha of 112,105,103,114,113 and 105 respectively. The lowest thousand cane /ha of 80 was given by CPF-246. The cane yield of 122 t/ha was given by S2005-US-154 which was the statistically the same as varieties of CPF-253 and S2008-FDS-19 of 118 t/ha and 122 t/ha respectively. The lowest cane yield 70 t/ha was given by CPF-247. As regarding sugar recovery, it is evident from Table 3, that CPF-247 gave the maximum sugar recovery of 13.69% which was statistically at par with CPF-248, CPF-249 and S2008-AUS-130 giving sugar recovery of 13.6%, 13.63% and 13.65 % respectively at Bhalwal. The CPF-77-400 gave the lowest sugar recovery of 11.55%. The findings of Akter *et al*. (2015) are agreement with these results.

The best sugar yielder variety is S2002-US-54 giving sugar yield of 15.52 t/ha which was the statistically at par with CPF-249, CPF-253 and S2008-FDS-19 giving sugar of 14.30 t/ha, 15.29 t/ha and 14.41 t/ha respectively. The findings of Sarwar *et al.* (2019) are agreement with these findings.

The second location where fourteen genotypes were planted at Mandi Bahu Din. It is obvious from Table 4 that CPF-248 produced the highest germination (54%) which was at par with sugar varieties CPF-247 (51%), CPF-251 (50%), S2003-US-778 (58%), S2006-SP-93 (49%), CPF-252 (47%), S2008-FDS-19 (53%), S2008-AUS-130 (48%), CP-77-400 (52%) and the clone S2003-US-127 gave the lowest germination (37%). As for as the maximum tiller/plant (2.33) were produced by S2003-US-778 which was statistically at par with varieties/ clones CPF-247 (1.70%), CPF-248 (2.05%), CPF-249 (2.20%), CPF-253 (1.80%), S2008-FDS-19 (2.05%), S2008-AUS-130 (1.85%) and CP-77-400 (1.70%) respectively. The findings of Akter *et al.* (2015) agrees with these findings.

It was revealed from (Table 4) that CPF-253 produced the maximum no. of thousand canes of 128 which was statistically at par with S2003-US-778 (124 thousand cane/ha) and S2005-US-54 (122 thousand canes /ha). The clone CPF-250 produced the lowest no. of thousand canes of 87 /ha. Sugar recovery (%) is a heredity character of each variety. Climate has minimum effect on the sugar recovery of variety. CPF-249 gave the maximum sugar recovery of 13.63 % which was statistically at par with S2006-SP-93. CP-77-400 gave the lowest sugar recovery of 11.60%. The findings of Akhter *et al*. (2018) agrees with these findings.

The yield and sugar recovery of both locations were averaged and then pooled data was presented in Table 5. The clone CPF-253 produced highest cane yield of 123.50 t/ha and stand first in tonnage in both locations with 59.35% more yield than check variety. The genotype S2005-US-54 achieved 121.50 t/ha cane yield and stand second in tonnage with 56.77% more cane yield over check. Similarly, 115.00 t/ha cane yield was produced by genotype CPF-252 with 48.38% more cane yield

Table 3. performance of different vartieties at farm, Noon Sugar Mill bhalwal.

Treatment	Germination (%)	Tillers/ plant	Cane account (000/ha)	Cane yield (t/ha)	Sugar recovery (%)	Sugar yield (t/ha)
CPF-246	47 BCD	1.35 DE	80 E	75 DE	11.82 F	8.86 G
CPF-247	52 AB	1.60 BCD	101 BCD	70 E	13.69 A	9.57 G
CPF-248	46 BCDE	1.85 ABC	95 D	80 D	13.60 AB	10.87 F
CPF-249	51 ABC	2.00 A	112 ABC	105 B	13.63 AB	14.30 ABC
CPF-253	43 CDEF	1.75 ABC	105 ABCD	118 A	12.96 CD	15.29 AB
CPF-250	41 DEF	1.50 CD	80 E	92 C	13.00 C	11.97 EF
CPF-251	45 BCDE	1.25 DE	103 ABCD	100 BC	12.98 CD	12.98 DE
S2003-US-778	58 A	1.90 AB	114 A	105 B	12.70 CD	13.63 CD
S2005-US-54	49 BCD	2.00 A	113 AB	122 A	12.73 DE	15.52 A
S2006-SP-93	38 EF	1.05 E	101 BCD	101 BC	13.41 B	13.38 CD
CPF-252	35 F	1.50 CD	115 A	105 B	12.64 EE	13.50 CD
S2008-FDS-19	44 BCDE	2.00 A	105 ABCD	115 A	12.54 EE	14.41 ABC
S2008-AUS-130	50 ABC	1.75 ABC	100 CD	103 B	13.65 AB	14.06 BCD
CP-77-400	48 BCD	1.60 BCD	98 D	98 BC	11.55 F	11.32 F
LSD 0.05	8.1986	0.3560	12.338	9.4753	0.2798	1.2749

Table 4. Performance of different varieties at Govt. Seed Farm Mandi Bhaudin

Treatment	Germination (%)	Tillers/plant	Cane account (000/ha)	Cane yield (t/ha)	Sugar recovery (%)	Sugar yield (t/ha)
CPF-246	42 CDEF	1.45 CDE	95 H	80 I	11.86 H	9.47 E
CPF-247	51 AB	1.70 ABCDE	111 DEF	85 HI	13.50 AB	11.44 B
CPF-248	54 A	2.05 ABC	101 GF	90 GHI	13.25 C	11.92 D
CPF-249	40 DEF	2.20 AB	120 BC	115 BCD	13.63 A	15.68 AB
CPF-253	39 EF	1.80 ABCD	128 A	129 A	12.94 D	16.69 A
CPF-250	37 F	1.40 ABCDE	87 I	97 FGH	12.73 E	12.34 D
CPF-251	50 AB	1.50 BCDE	113 DE	100 EFG	13.25 C	13.07 CD
S2003-US-778	53 A	2.33 A	124 AB	118 ABCD	12.23 G	14.23 BC
S2005-US-54	45 BCDE	1.06 E	122 ABC	121 ABC	12.77 DE	15.45 AB
S2006-SP-93	49 ABC	1.15 DE	111 DEF	122 ABC	13.60 A	16.59 A
CPF-252	47 ABCD	1.53 BCDE	116 CD	125 AB	12.59 EF	15.73 AB
S2008-FDS-19	53 A	2.05 ABC	108 EF	112 BCDE	12.45 F	15.56 BC
S2008-AUS-130	48 ABC	1.85 ABCD	105 FG	109 CDEF	13.39 BC	14.59 BC
CP-77-400	52 AB	1.75 ABCDE	100 GF	105 DEF	11.60 I	12.18 D
LSD 0.05	7.6861	0.7305	6.7901	13.309	0.2024	1.8517

Table 5. Summary of both locations pool data.

Sugarcane clones/ varieties	Cane yield (t/ha)	% increase
CPF-246	77.5	0
CPF-247	77.5	0
CPF-248	85.00	9.67
CPF-249	110.00	41.93
CPF-253	123.50	59.35
CPF-250	94.50	21.93
CPF-251	100	29.03
S2003-US-778	111.50	43.83
S2005-US-54	121.50	56.77
S2006-SP-93	111.50	43.87
CPF-252	115.00	48.38
S2008-FDS-19	113.50	46.45
S2008-AUS-130	106.00	36.77
CP-77-400	101.50	42.58

over check CPF-246. The findings of Akhter *et al*. (2015) agrees with these findings.

Conclusion

The adaptability and stability studies of fourteen genotypes concluded that CPF-253, S2005-US-54, CPF-252, produced the highest cane yield of 123.5 t/ha, 121.5 t/ha, 115t/ha respectively and are the most productive genotypes being high yielding ability is best suited for planting in northern agro-ecologies in Punjab.

Conflict of Interest. The authors declare that they have no conflict of interest.

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