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Genetic variability and character association of morphological and quality traits in advanced generation clones of sugarcane

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Abstract
This experiment was carried out using 50 sugarcane genotypes grown in randomized block design having three replications at the research farm of CCS HAU, RRS, Uchani, Karnal during spring season 2020-21. Seventeen morphological and quality traits were studied for genetic variability, correlation and path analysis. Analysis of variance (ANOVA) showed that mean sum of squares due to genotypes were highly significant for all the characters studied, indicating the presence genetic variability. PCV calculated for all seventeen characters were found higher than corresponding GCV, indicating slight affect of environment on expression. High heritability coupled with high genetic advance as percentage of mean was shown by number of tillers at 120 DAP, number of shoots at 240 DAP, single cane weight, cane length, cane yield and CCS (t/ha) indicated preponderance of additive genetic effect in the determination of these characters. Characters namely CCS (t/ha), single cane weight, cane girth, cane length, number of Millable canes at harvest, number of tillers at 120 DAP and number of shoots at 240 DAP had significant and positive correlation with cane yield. Path analysis revealed that highest positive direct effect on cane yield was exerted by CCS % at 10th month followed by CCS (t/ha), CCS % at 8th month, brix % at 8th month, number of Millable canes at harvest, single cane weight, purity % at 8th month, cane girth and number of tillers at 120 DAP. These characters can be utilized efficiently in further selection for yield improvement in sugarcane.

Keywords: Sugarcane, GCV, PCV, heritability, genetic advance, correlation, path, cane yield

Introduction
India has emerged as the largest producer as well as consumer and also the second largest exporter of sugar for season 2021-22. The consumption trends of sugar have shown a nominal growth of 2-4% per annum (Anonymous, 2022) [8]. Sugarcane (*Saccharum* spp. complex) is an economically significant crop that accounts for 70% of the world's sugar production and recently has gained better attention because of the potential of its by-products; ethanol, molasses, and bagasse, as important renewable biofuel sources. Sugar industry being the second biggest agro based processing industry after textile, contributes 2.0% of the gross domestic product in India.

Modern sugarcane cultivars are complex hybrids derived mostly from the interspecific crosses involving *Saccharum officinarum* L. ($2n = 80$) and the wild species *S. spontaneum* L. ($2n = 40 - 128$). The heterozygous and polyploid nature of this crop has resulted in generation of enormous genetic variability. The *Saccharum officinarum* is the chief source for genetic variability in sugarcane as compared to *S. spontaneum*, *S. sinense*, *S. barberi*. Development of new modern varieties is mainly governed by the extent of genetic variability in the base material. Perfect assessment of genetic diversity is vital in crop breeding as it helps in the selection of required genotypes and introgressing desirable genes from diverse germplasm into the available genetic base. The choice of genetically diverse parents is important in hybridization programme to generate variation for selection of useful recombinants. The amount of variability present in the breeding material can be validated by checking genetic parameters viz. genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance estimates. Estimation of GCV and PCV along with the heritability as well as genetic advance are used to improve any trait of sugarcane. Agronomic traits are quantitatively inherited and are greatly affected by the environment and hence direct selection may not be reliable. Correlation coefficient analysis can provide some help to breeders for selecting best parents. However, correlation coefficients, sometimes, may be deceptive and thus, need to be partitioned into direct and indirect effects.

Thus, it is important for a breeder to know how other characters affect a particular character before selecting the parental material for crossing purposes. A path coefficient analysis can effectively be used to partition correlation coefficient into direct and indirect effects. The direct effect of a character on yield and indirect impact through other characters can be calculated using path coefficient analysis. The path coefficient method (Wright 1921, 1923, 1934) [33, 35] provides a modest and flexible method of handling a wide variety of inbreeding problems. In order to have suitable choice of characters for selection of desirable genotypes the knowledge of nature and magnitude of variability, the association of component characters with yield and their contribution through direct and indirect effects is very essential.

Materials and Methods

This research was conducted at the research farm of CCS Haryana Agricultural University, Regional Research Station, Uchani, Karnal during the spring season 2020-21. Fifty sugarcane clones comprising 46 advanced generation clones and 4 check varieties were evaluated by planting in Randomized Block Design (RBD) with three replications. Each genotype was grown in 4 rows of 6m length with row to row spacing of 0.75m. Morphological and yield characters observed were number of tillers (thousand/ha) at 120 days after planting, number of shoots (thousand/ha) at 240 days after planting, cane yield (t/ha) at harvest, number of millable canes (thousand/ha) at harvest, cane length (cm) at harvest, cane diameter (cm) at harvest and single cane weight (kg) at harvest. The data of morphological traits was recorded from five randomly tagged plants of each genotype. Yield and its associated characters were first recorded on per plot basis and then conversion formula was used to calculate it for per hectare basis. Quality traits namely brix %, pol %, purity % and CCS % were observed after 8th and 10th month of planting while CCS (t/ha) and extraction % were studied at harvest. Analysis of variance was estimated according to Fisher (1925) to test the variations among genotypes by using F-test. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated according to the formulae given by Burton and Devane (1952) [10]. Heritability in broad sense and genetic advance was computed with the formulae given by Johnson *et al.* (1955) [19]. Formula given by Al-Jibouri *et al.* (1958) [5] was used to compute the correlation coefficients and these values were tested against standardized tabulated significant value of 'r' at (n-2) degree of freedom as given by Fisher and Yates (1963). These correlations among the different character combinations were utilized to construct the path coefficient analysis suggested by Wright (1921) [33] and used by Dewey and Lu (1959) [11].

Results and discussion

The analysis of variance for all the characters specified that varieties differed significantly for all the characters i.e. presence of sufficient variability, scope for further selection, breeding superior varieties and required genotypes. These variations had their foundations in genetic differences among the clones and considerable improvement can be accomplished by all these characters during selection. Similar results had been observed by earlier workers namely Patil *et al.* (2014) [27], Sanghera *et al.* (2014) [28], Gowda *et al.* (2016) [14] and Hiremath & Nagaraja (2016) [17]. The parameters like phenotypic and genotypic coefficients of variation, heritability in broad sense (h^2) and genetic advance as % of mean were assessed to know the nature and extent of variation existing among genotypes under study. The genetic variability parameters are presented in Table 2. Phenotypic coefficient of variation (PCV) was found slightly higher than genotypic coefficient of variation for all the seventeen characters studied which indicates that there has been the influence of environment on the expression of these characters. Moderate estimates (10-20%) of genotypic coefficient of variation and phenotypic coefficient of variation were recorded for number of tillers at 120 DAP followed by cane yield, CCS (t/ha), single cane weight, number of shoots at 240 DAP and cane length. These moderate values reveal that there is ample scope of improvement of these traits through direct selection. Lower values (<10%) of GCV and PCV were estimated for CCS % at 8th month, pol % at 8th month, brix % at 8th month, cane girth, CCS % at 10th month, pol % at 10th month, extraction %, brix % at 10th month, purity % at 8th month and purity % at 10th month. These lower estimates suggest that direct selection would give a little improvement of these traits. These results were in agreement with the findings of Bhatnagar *et al.* (2003) [9], Agrawal and Kumar (2017) [1], Kumar *et al.* (2018) [23], Ahmed *et al.* (2019a) [2] and Kumari *et al.* (2020) [21].

Heritability estimates along with genetic advance as percent of mean play an important role in determining the effectiveness of selection of a trait as suggested by Panse (1942) [25] and Johnson *et al.* (1955) [19]. The estimates of heritability (broad sense) and genetic advance as percent of mean for all the characters are presented in Table 2. High heritability coupled with high genetic advance as percent of mean was recorded for number of tillers at 120 DAP, number of shoots at 240 DAP, single cane weight, cane length, cane yield and CCS (t/ha) suggesting that these characters exhibit additive gene action and selection for these characters is going to be beneficial for further improvement in cane yield. Agarwal and Kumar (2017), Kumar *et al.* (2018) [22] and Ahmed *et al.* (2019a) [2] reported similar results. High heritability along with moderate genetic advance as percent of mean was observed for six characters *viz*., number of millable canes at harvest, cane girth, brix and pol % at 8th month and CCS % at 8th and 10th month. It implies that these traits are governed by non-additive gene action and it requires careful selection for the desired improvements. These results were in akin with the findings of Kumari *et al.* (2020) [21] for cane girth, brix % at 10th month, number of millable canes at harvest and CCS % at 10th month. Jain *et al.* (2001) [18] obtained similar result for cane girth and Khaled *et al.* (2013) [20] for brix %.

Selection on the basis of characters having strong positive correlation with cane yield and juice quality has been proven advantageous. Genotypic correlation coefficients were higher than the phenotypic correlation coefficients (Table 3) which implied that association was largely due to the genetic factors and selection can be carried out on the basis of phenotype. While in few cases phenotypic coefficients were higher than genotypic coefficients indicating that environmental factors suppressing the expression of those traits at phenotypic level. Both genotypic and phenotypic coefficients were almost in same direction and these results were in accordance with the findings of Parihar (2020) [26] and Hiremath *et al.* (2015) [16].

Cane yield showed strong significant and positive association with CCS (t/ha) and single cane weight at both genotypic and phenotypic level. Selection on the basis of these two traits will be rewarding. Moderate significant and positive genotypic and phenotypic correlation with cane yield was expressed by cane girth, cane length and number of millable canes at harvest while weak association was exhibited by number of tillers at 120 DAP and number of shoots at 240 DAP. Similar results were reported by Singh *et al.* (2005) [30], Mali and Patel (2013) [24], Kumar and Kumar (2014) [21], Hiremath *et al.* (2015) [16], Anbanandan and Eswaran (2018) [7], Ahmed *et al.* (2019b) [3] and Parihar (2020) [26]. Commercial cane sugar (t/ha) showed positive and significant genotypic and phenotypic association with cane yield, single cane weight, cane girth, cane length, number of millable canes at harvest, brix % at 8th month, pol % at 8th month, CCS % at 8th month, number of tillers at 120 DAP, number of shoots at 240 DAP and brix % at 10th month. Similar results had been reported by Singh *et al.* (2005) [30], Hiremath *et al.* (2015) [16], Ahmed *et al.* (2019b) [3] and Gowda and Saravanan (2016) [15].

The path coefficient analysis explains whether the association of cane yield with its component characters is due to the direct effects of component characters on cane yield or is a result of their indirect effects via some other characters. Path coefficient analysis revealed that CCS % at 10th month exhibited high positive direct effect on cane yield followed by CCS (t/ha), CCS % at 8th month, brix % at 8th months, number of millable canes at harvest, single cane weight, purity % at 8th month, cane girth and number of tillers at 120 DAP (Table 4). Selection on the basis of these characters will lead to higher cane yield and juice quality. These results were in accordance with Thippeswamy *et al.* (2003) [32] who reported that CCS % at 10th month, CCS per plot (Kg) and brix % exerted positive direct effect on cane yield. Singh *et al.* (2005) [30] detected that number of millable canes, stalk diameter and stalk weight had positive direct effect on cane yield, Hiremath *et al.* (2015) [16] observed positive direct effects of number of millable canes, single cane weight, CCS yield (t/ha), cane length and cane diameter on cane yield and Sanghera *et al.* (2017) [29] noted that CCS % at 10th month, cane girth and single cane weight showed positive direct effect on cane yield. Ali *et al.* (2019) [4] evaluated that brix % and sugar recovery % exerted positive direct effect on cane yield. Anbanandan *et al.* (2020) [6] found that CCS percent, brix percent and sucrose percent had positive direct effect on cane yield per plot. Cane width, number of tillers, cane weight, CCS % and CCS yield (t/ha) exhibited positive direct effect on cane yield as reported by Parihar (2020) [26]. Somu *et al.* (2020) [31] established that single cane weight, cane diameter and number of millable canes had positive direct effect on cane yield. Therefore, in order to increase cane yield, effective selection can be accomplished for the characters having high direct effects and for the traits through which indirect effects are mainly applied on cane yield.

In the present investigation, high heritability in association with high genetic advance as percent of mean was observed for number of tillers at 120 DAP, number of shoots at 240 DAP, single cane weight, cane length, cane yield and CCS (t/ha) suggesting that these characters are governed by additive gene action and selection for these characters would be effective for further improvement in cane yield. In sugarcane breeding, cane yield and sucrose content are most valuable traits, thus, the relationship of cane yield to sucrose content is of great interest. This study manifested that CCS (t/ha) and single cane weight are significantly and positively correlated with cane yield at both genotypic and phenotypic level. Selection on the basis of these two traits will be rewarding. This study also revealed that sugar yield could be improved by selecting genotypes having higher cane yield, single cane weight, pol % in juice, brix % and CCS %. High positive direct effect of commercial cane sugar, sugar yield, brix % and single cane weight with the high positive significant correlation with cane yield revealed that genotypes could be selected using combination of these characters as a criterion in sugarcane improvement programme.

Table 1: Analysis of Variance for yield and quality characters in Sugarcane clones

Sr. No.	Characters	Mean sum of squares		
		Replications(df: 2)	Treatments(df: 49)	Error(df: 98)
1	No. of Tillers at 120 days	238.337	1985.02**	125.8
2	No. of Shoots at 240 days	327.901	620.444**	62.81
3	No. of Millable canes at Harvest	147.374	270.207**	35.506
4	Single cane wt.(Kg)	0.001	0.049**	0.002
5	Cane length(cm)	42.839	1790.72**	53.162
6	Cane Girth (cm)	0.006	0.075**	0.005
7	Cane Yield (T/Ha.)	43.644	588.932**	26.316
8	CCS (T/Ha.)	0.488	8.173**	0.423
9	Brix % (8m)	0.378	4.678**	0.089
10	Pol % (8m)	0.175	5.179**	0.078
11	Purity% (8m)	2.41	13.035**	1.987
12	CCS % (8m)	0.086	2.969**	0.061
13	Brix % (10m)	0.08	2.198**	0.081
14	Pol % (10m)	0.076	2.342**	0.082
15	Purity % (10m)	0.546	7.402**	1.149
16	CCS % (10m)	0.047	1.356**	0.059
17	Extraction %	11.6	18.038**	3.618

** Significant at 1% level

Table 2: Mean, Range, Coefficient of variation, heritability (broad sense), genetic advance and genetic advance as percent of mean for Cane yield and Quality characters in sugarcane clones.

Sr. No.	Characters	Mean	Range		Coefficient of variation		Heritability	Genetic Advance	Genetic Advance as percent of mean
			Maximum	Minimum	GCV	PCV			
1	No. of Tillers at 120 days	145.91	199.75	100.55	17.06	18.71	83.13	46.76	32.05
2	No. of Shoots at 240 days	115.08	153.21	82.63	11.85	13.70	74.74	24.28	21.10
3	No. of Millable canes at Harvest (‘000/ha)	103.56	119.29	77.90	8.54	10.30	68.78	15.11	14.59
4	Single cane weight (Kg)	0.89	1.24	0.68	14.07	14.84	89.94	0.24	27.48
5	Cane length (cm)	212.68	255.07	149.73	11.32	11.82	91.59	47.45	22.31
6	Cane girth (cm)	2.54	2.92	2.24	6.00	6.60	82.57	0.29	11.23
7	Cane yield (t/ha)	89.22	118.40	68.42	15.35	16.39	87.70	26.42	29.61
8	CCS (t/ha)	10.82	14.47	8.31	14.86	16.03	85.93	3.07	28.37
9	Brix % (8m)	18.50	22.03	16.07	6.68	6.88	94.51	2.48	13.39
10	Pol % (8m)	16.10	19.47	13.40	8.10	8.29	95.60	2.63	16.32
11	Purity% (8m)	86.90	90.14	82.15	2.21	2.74	64.95	3.19	3.67
12	CCS % (8m)	11.05	13.44	9.01	8.91	9.19	94.05	1.97	17.81
13	Brix % (10m)	20.07	22.50	17.73	4.19	4.42	89.68	1.64	8.17
14	Pol % (10m)	17.63	19.68	14.86	4.92	5.18	90.22	1.70	9.64
15	Purity % (10m)	87.83	90.23	82.03	1.64	2.05	64.47	2.39	2.72
16	CCS % (10m)	12.15	13.55	10.01	5.41	5.77	87.97	1.27	10.45
17	Extraction %	57.71	69.82	52.34	3.80	5.03	57.06	3.41	5.91

Table 3: Genotypic and phenotypic correlation matrix of morphological and quality traits

		NT 120	NS 240	NMCH	SCW	CL	CG	CCS (t/ha)	Brix % (8m)	Pol % (8m)	Purity % (8m)	CCS % (8m)	Brix % (10m)	Pol % (10m)	Purity % (10m)	CCS % (10m)	Extraction %
CY	rg	0.247**	0.238**	0.442**	0.813**	0.527**	0.563**	0.926**	0.070	0.047	-0.056	0.039	-0.165*	-0.267**	-0.389**	-0.298**	-0.059
	rp	0.256**	0.266**	0.484**	0.773**	0.483**	0.470**	0.927**	0.073	0.048	-0.048	0.038	-0.157	-0.243**	-0.285**	-0.265**	-0.028
NT 120	rg		0.766**	0.745**	-0.156	0.375**	-0.255**	0.232**	-0.036	-0.033	0.004	-0.032	0.037	-0.036	-0.207*	-0.063	-0.151
	rp		0.696**	0.644**	-0.134	0.331**	-0.202*	0.237**	-0.023	-0.029	-0.020	-0.031	-0.004	-0.049	-0.119	-0.064	-0.108
NS 240	rg			0.925**	-0.296**	0.306**	-0.322**	0.201*	-0.092	-0.050	0.094	-0.034	0.053	-0.073	-0.371**	-0.118	-0.073
	rp			0.834**	-0.260**	0.238**	-0.253**	0.225**	-0.059	-0.039	0.038	-0.031	0.000	-0.092	-0.244**	-0.122	-0.081
NMCH	rg				-0.145	0.403**	-0.083	0.382**	-0.110	-0.048	0.155	-0.025	-0.035	-0.152	-0.385**	-0.192*	-0.093
	rp				-0.138	0.303**	-0.098	0.434**	-0.066	-0.035	0.059	-0.023	-0.053	-0.127	-0.223**	-0.151	-0.065
SCW	rg					0.387**	0.697**	0.793**	0.139	0.084	-0.124	0.063	-0.112	-0.141	-0.134	-0.148	-0.022
	rp					0.374**	0.610**	0.747**	0.123	0.081	-0.071	0.064	-0.101	-0.132	-0.116	-0.139	0.008
CL	rg						0.197*	0.441**	-0.186*	-0.218**	-0.234**	-0.226**	-0.205*	-0.260**	-0.277**	-0.275**	0.138
	rp						0.208*	0.399**	-0.171*	-0.201*	-0.179*	-0.208*	-0.181*	-0.240**	-0.234**	-0.253**	0.114
CG	rg							0.521**	-0.059	-0.049	0.000	-0.045	-0.166*	-0.157	-0.054	-0.150	-0.003
	rp							0.427**	-0.050	-0.047	-0.008	-0.044	-0.130	-0.138	-0.076	-0.137	-0.016
CCS (t/ha)	rg								0.323**	0.314**	0.157	0.306**	0.184*	0.111	-0.133	0.081	-0.184*
	rp								0.301**	0.290**	0.113	0.280**	0.171*	0.131	-0.035	0.111	-0.110
Brix % (8m)	rg									0.973**	0.534**	0.951**	0.726**	0.666**	0.169*	0.629**	-0.171*
	rp									0.953**	0.363**	0.913**	0.662**	0.617**	0.151	0.578**	-0.135
Pol % (8m)	rg										0.713**	0.996**	0.737**	0.698**	0.235**	0.667**	-0.233**
	rp										0.627**	0.994**	0.682**	0.651**	0.192*	0.616**	-0.157
Purity % (8m)	rg											0.769**	0.494**	0.539**	0.373**	0.543**	-0.333**
	rp											0.708**	0.397**	0.421**	0.219**	0.414**	-0.147
CCS % (8m)	rg												0.731**	0.700**	0.256**	0.671**	-0.252**
	rp												0.674**	0.648**	0.202*	0.615**	-0.162*
Brix % (10m)	rg													0.953**	0.330**	0.913**	-0.381**

	rp													0.927**	0.204*	0.866**	-0.275**
Pol % (10m)	rg														0.600**	0.994**	-0.341**
	rp														0.557**	0.990**	-0.233**
Purity % (10m)	rg															0.686**	-0.064
	rp															0.666**	-0.004
CCS % (10m)	rg																-0.318**
	rp																-0.208*

** = Significant at 1% level, * = Significant at 5% level (CY= cane yield, NT 120 = number of tillers at 120 DAP, NS 240 = number of shoots at 240 DAP, NMCH = number of millable canes at harvest, SCW = single cane weight, CL = cane length, CG = cane girth, CCS (t/ha) = commercial cane sugar tons per hectare, CCS % = commercial cane sugar percent, 8m = at 8th month,10m = at 10th month)

Table 4: Path coefficient analysis of morphological and quality traits

	NT120	**NS240**	**NMCH**	**SCW**	**CL**	**CG**	**CCS (t/ha)**	**Brix % (8m)**	**Pol % (8m)**	**Purity% (8m)**	**CCS % (8m)**	**Brix % (10m)**	**Pol % (10m)**	**Purity % (10m)**	**CCS % (10m)**	**Extraction %**	**rp with cane yield**
NT120	0.0077	-0.0146	0.0354	-0.0067	-0.0032	-0.0008	0.2155	-0.0056	0.0220	-0.0003	-0.0160	0.0022	0.0552	0.0723	-0.1072	0.0002	0.256**
NS240	0.0054	-0.0210	0.0459	-0.0130	-0.0023	-0.0010	0.2051	-0.0146	0.0292	0.0005	-0.0157	-0.0002	0.1035	0.1483	-0.2041	0.0002	0.266**
NMCH	0.0050	-0.0175	0.0550	-0.0069	-0.0029	-0.0004	0.3949	-0.0161	0.0263	0.0008	-0.0118	0.0305	0.1442	0.1351	-0.2521	0.0001	0.484**
SCW	-0.0010	0.0055	-0.0076	0.0499	-0.0036	0.0024	0.6801	0.0303	-0.0612	-0.0010	0.0330	0.0587	0.1496	0.0705	-0.2323	0.0000	0.773**
CL	0.0026	-0.0050	0.0166	0.0186	-0.0097	0.0008	0.3630	-0.0419	0.1519	-0.0026	-0.1066	0.1052	0.2719	0.1419	-0.4237	-0.0002	0.483**
CG	-0.0016	0.0053	-0.0054	0.0304	-0.0020	0.0040	0.3888	-0.0123	0.0352	-0.0001	-0.0227	0.0755	0.1566	0.0463	-0.2285	0.0000	0.470**
CCS (t/ha)	0.0018	-0.0047	0.0239	0.0372	-0.0039	0.0017	0.9103	0.0740	-0.2188	0.0016	0.1435	-0.0992	-0.1479	0.0211	0.1860	0.0002	0.927**
Brix % (8m)	-0.0002	0.0012	-0.0036	0.0061	0.0017	-0.0002	0.2741	0.2457	-0.7183	0.0052	0.4684	-0.3844	-0.6978	-0.0916	0.9666	0.0003	0.073^{NS}
Pol % (8m)	-0.0002	0.0008	-0.0019	0.0040	0.0019	-0.0002	0.2642	0.2341	-0.7540	0.0090	0.5098	-0.3964	-0.7361	-0.1166	1.0293	0.0003	0.048^{NS}
Purity% (8m)	-0.0002	-0.0008	0.0032	-0.0036	0.0017	0.0000	0.1033	0.0892	-0.4726	0.0143	0.3634	-0.2304	-0.4756	-0.1330	0.6925	0.0003	-0.048^{NS}
CCS % (8m)	-0.0002	0.0006	-0.0013	0.0032	0.0020	-0.0002	0.2546	0.2243	-0.7493	0.0101	0.5130	-0.3915	-0.7327	-0.1229	1.0278	0.0003	0.038^{NS}
Brix % (10m)	0.0000	0.0000	-0.0029	-0.0050	0.0018	-0.0005	0.1554	0.1626	-0.5145	0.0057	0.3457	-0.5809	-1.0480	-0.1240	1.4476	0.0005	-0.157^{NS}
Pol % (10m)	-0.0004	0.0019	-0.0070	-0.0066	0.0023	-0.0006	0.1191	0.1516	-0.4908	0.0060	0.3324	-0.5383	-1.1308	-0.3379	1.6560	0.0004	-0.243**
Purity % (10m)	-0.0009	0.0051	-0.0122	-0.0058	0.0023	-0.0003	-0.0316	0.0371	-0.1448	0.0031	0.1039	-0.1187	-0.6294	-0.6071	1.1141	0.0000	-0.285**
CCS% (10m)	-0.0005	0.0026	-0.0083	-0.0069	0.0025	-0.0005	0.1013	0.1420	-0.4641	0.0059	0.3153	-0.5029	-1.1198	-0.4045	1.6722	0.0004	-0.265**
Extraction %	-0.0008	0.0017	-0.0036	0.0004	-0.0011	-0.0001	-0.1002	-0.0331	0.1185	-0.0021	-0.0829	0.1595	0.2631	0.0022	-0.3481	-0.0019	-0.028^{NS}

Residual = 0.00213 (CY= cane yield, NT 120 = number of tillers at 120 DAP, NS 240 = number of shoots at 240 DAP, NMCH = number of millable canes at harvest, SCW = single cane weight, CL = cane length, CG = cane girth, CCS (t/ha) = commercial cane sugar tons per hectare, CCS % = commercial cane sugar percent, 8m = at 8th month, 10m = at 10^{th} month)

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