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EVALUATION AND IDENTIFICATION OF CLIMATE RESILIENT INTERSPECIFIC AND INTERGENERIC SUGARCANE HYBRID CLONES FOR WATER LOGGING TOLERANCE

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ABSTRACT

A research trial at Kalyanpur Research Farm, R.P.C.A.U., Bihar, evaluated 18 climate-resilient sugarcane clones and three check varieties under waterlogged and normal conditions using an ALPHA design with two replications. The study assessed sugarcane genotypes under waterlogging and normal conditions to identify climate-resilient clones for breeding and selection. Under waterlogging conditions, significant differences among genotypes were observed for the studied traits. Phenotypic coefficient of variance exhibited higher variability compared to genotypic coefficient of variation. Traits such as germination percentage at 45 days after planting (DAP), tillers at 90 DAP, single cane weight, brix percentages, cane yield, and many others exhibited significant heritability along with a substantial increase in genetic advance percentage over the means. In the normal field conditions, noticeable variations were also noted among different genotypes concerning the evaluated characteristics. The phenotypic variability index exceeded the genotypic variability index, suggesting that environmental factors contributed more to the overall variability. Traits such as single cane weight, number of millable canes, cane yield, germination at 45 DAP, tillers at 90 DAP, and sucrose percentage at 10 months demonstrated considerable heritability coupled with a genetic advance percentage ranging from moderate to substantial relative to the means.
***Keywords* :** Sugarcane, Waterlogging, Climate Resilience, PCV, GCV, Heritability.

Introduction

Sugarcane is a monocotyledonous plant cultivated in both subtropical and tropical areas, known for its capacity to accumulate significant levels of sucrose, a type of sugar, within its tissues. Now a days, sugarcane is considered a commercial crop which is primarily growing in South America, Asia, North/Central America, Australia, and Africa. Sugarcane is mostly a cross-pollinated crop. The vegetative propagation is done by mature cane setts possessing 2/3 buds which are carefully selected from mature canes. In 2014, global cane production was estimated to be approximately 1900 million tons, cultivated on nearly 2.75 million hectares. Brazil was the top manufacturer, with 737 million tons, (FAOSTAT, 2014). Sugarcane production is about six times that of sugar beets, the other major source of sugar. Uttar Pradesh recently stood up as the leading producer of sugarcane in India. According to the source of the Directorate of Economics and Statistics, Ministry of Agri.&FW. (2021-22) in India, sugarcane occupied a land area of 5.098 million hectares, yielding 430.50 million metric tons with a productivity rate of 84.44 tonnes per hectare. Similarly, in Bihar, sugarcane spanned 0.219 million hectares in coverage. Sugarcane yielded a production of 13.97 million metric tons and achieved a productivity of 66.25 tonnes per hectare.

Sugarcane breeding has been practiced in India for nearly a century. The intergeneric species are developed by crossing two different genera and interspecific species are developed by crossing two different species of the same genera. The first interspecific cross was created at the Sugarcane Breeding Institute (SBI) in 1912, Coimbatore, between *S. officinarum* & *S. spontaneum* (Nair, 2011). More than 90% of the country's sugarcane growing area is from SBI and associate centre-bred varieties (Nair, 2011).

Water logging is a common occurrence that severely limits the survival and development of sugarcane, resulting in a 15 to 45% reduction in sugarcane yield. Improving plants' capacity to adapt to changing weather patterns and lessening their vulnerability to biotic and abiotic stresses are crucial (Anna Durai and Kuruppaiyan, 2023). The extent of water logging damage is determined by genotypes, environmental conditions, developmental stage, and stress duration. The weather conditions that prevail during the various crop-growth stages have a notable impact on sugarcane juice quality and productivity. When the weather is dry, bright sunshine hours, with very little rainfall during the ripening period, sugar recovery is at its peak. These conditions promote rapid sugar accumulation. Climate conditions such as extremely high or extremely low temperatures degrade juice quality, thereby affecting sugar quality. The main objective of this research is to assess various morphological and biochemical characteristics of intergeneric and interspecific climate resilient sugarcane hybrids and to identify suitable hybrids which will be grown under waterlogging conditions.

Materials and Methods

An experiment is carried out in Selected climate-resilient sugarcane clones developed by incorporating genes from water logging parents that have been bred at SBI, Coimbatore in two sets where one is for normal conditions (Control) and the other is for waterlogging conditions. In an ALPHA LATTICE design with two replications, three blocks, and seven treatments per block, we have carried out an experiment that includes 18 sugarcane genotypes *viz.* ISH 501, ISH 502, ISH 512, ISH 519, ISH 524, ISH 534, ISH 536, ISH 548, ISH 567, ISH 584, ISH 585, ISH 587, ISH 590, ISH 594, ISH 823, IGH 829, IGH 833, IGH 834 and three check clones, BO 154, CoSe 95422, BO 91. Two rows of six meters each, separated by 0.90 meters, were used to grow each clone. Waterlogging water is kept at least 40–50 cm deep during the formative stage (June–September).

Five randomly chosen plants per genotype each replication was used to record observations for cane yield along with traits that contribute to yield. *viz.*, germination at 45 days after planting (DAP), number of tillers at 90 DAP, number of shoots before and after waterlogging, cane height before and at maturity under waterlogging, cane diameter at harvest, single cane weight at harvest, number of millable canes at harvest, brix percent, sucrose percent and purity% at 10 and 12 months, cane yield at harvest, CCS (Commercial Cane Sugar) percent at harvest, fiber percent at harvest, Pol (total soluble sugars) percent cane at harvest, number of nodes with aerial roots and juice extraction percent at harvest.

The mean values of each plot were used to perform the analysis of variance and covariance for individual characters and character pairs, respectively, using the method described by Panse and Sukhatme (1967) are shown in Tables 1a and 1b. Each trait's mean, standard error, critical difference, and coefficient of variation were determined and are shown in Tables 2a and 2b. The phenotypic and genotypic coefficients of variation were classified as low (<10%), medium (11–20%), and high (>20%) based on the method proposed by Burton and De Vane (1953). According on Lush's 1940 calculation, heritability was categorized as low (less than 30%), medium (30–60%), and high (more than 60%), as proposed by Johnson *et al.,* in 1955 (Tables 3a and 3b). Johnson *et al.* (1955) assessed genetic advancement as a percentage of mean and classified it as low (<10%), medium (11–20%), and high (>20%). For all statistical studies, software R (version 4.3.1) and OP stat were used.

Results and Discussion

Enhancing plant attributes to achieve agricultural and economic dominance stands as the primary objective of plant breeding initiatives. The advancement of crops significantly depends on the degree of genetic variability and its effective utilization by the plant breeder. The enhancement of any crop hinges on the scale of genetic differences and the measure of accessible genetic diversity.

The amalgamation of distinctions between genotypic and environmental factors, along with their interplay, can be determined by applying valuable biometric and genetic methodologies. A subset of these parameters encompasses coefficients of variability related to genotypic (GCV) and phenotypic (PCV) variations (Ranjan and Balwant (2017). Higher magnitudes of these coefficients denote a broader spectrum of diversity. Similarly, a minimal differentiation between GCV and PCV signifies diminished susceptibility to influences stemming from the environment. An additional measure of diversity rests in heritability a metric that quantifies the proportion of genotypic variance relative to phenotypic variance. This encapsulates a comprehensive understanding of heritability, furnishing insights into the fraction of observed diversity traceable to genetic distinctions.

The evaluations of heritability, though informative, do not inherently provide insights into the magnitude of advancement achievable through the selection procedure. These assessments acquire significant context when complemented by the concept of genetic advance (GA). Genetic advance represents the quantification of enhancement attainable via the implementation of selection techniques. Substantial genetic advance, coupled with robust heritability estimations, serves as a marker for elevated levels of additive gene action. In essence, these analyses yield a deeper comprehension of the potential strides that can be made in breeding endeavours, granting a more comprehensive view of the selection process's efficacy and the genetic intricacies at play within it.

The comprehensive examination of variance across all 22 attributes within the 21 genotypes in waterlogged and normal conditions unequivocally demonstrated substantial differences among the clones across the entire spectrum of traits. This signifies the presence of ample variability, consequently opening avenues for subsequent rounds of selection and the refinement of genetic materials to yield superior clones and more desirable genotypes. Earlier Hiremath *et al.,* (2016), Kumar *et al.* (2018), Ranjan and Balwant (2017), Sanghera *et al.* (2022). The researchers have documented a substantial degree of variability among the clones concerning all the parameters they investigated.

Under waterlogging conditions, the highest genotypic and phenotypic variance was observed in Cane height at harvest (475.15 and 631.98 cm) followed by number of shoots after waterlogging which were 241.91 and 272.76 thousand per hectare (000/ha) and cane yield at harvest (147.12 and 179.95 t/ha) respectively. Conversely, Single cane weight at harvest (0.0074 and 0.0089 kg) respectively exhibited the lowest genotypic variance. Under normal conditions, similar patterns were observed, with Cane height at harvest (cm) still leading in terms of genotypic and phenotypic variance (Number of shoots after waterlogging and Number of shoots before waterlogging followed in terms of genotypic and phenotypic variance. Once again, Single cane weight (kg) exhibited the lowest genotypic and phenotypic variance. Comparing both conditions, it is notable that Cane height at harvest consistently displayed the highest genotypic and phenotypic variance, indicating its genetic diversity and potential for trait improvement. Similarly, the Number of shoots after waterlogging remained among the traits with substantial genotypic variance in both conditions. The low genotypic and phenotypic variance observed for Single cane weight emphasizes its relatively limited genetic diversity in comparison to other traits. These findings shed light on the genetic potential and variability within these traits, highlighting areas where selection and breeding efforts can be effectively directed to enhance sugarcane performance under varying conditions.

The traits with higher GCV values, such as the Number of nodes with aerial roots and germination % at 45 DAP, exhibit notable variation in both waterlogging and normal conditions. Additionally, the presence of moderately variable traits like cane yield, number of shoots after waterlogging, and single cane weight suggests their potential for improvement through breeding efforts as described in Kumar *et al.,* 2018, Meheren and Abazied (2017). On the other hand, traits with lower GCV values, including juice-related attributes and certain purity percentages, exhibit limited variability, underscoring their stability within the given conditions. The characters with higher PCV values, such as the number of nodes with aerial roots, germination % at 45 DAP, and commercial cane sugar at harvest, display substantial variation in both waterlogging and normal conditions. Traits showing moderate PCV values, including Cane yield and various shoot-related attributes, suggest their potential for improvement through selection and breeding. Conversely, traits with lower PCV values, like juice-related attributes and certain purity percentages, exhibit constrained variation, reinforcing their stability within the given conditions. These findings assist breeders in identifying traits with potential for enhancement and variability, informing efficient selection strategies for improved sugarcane genotypes.

In the waterlogging condition, ECV patterns mirror the traits' responsiveness to environmental fluctuations. Traits such as Number of nodes with aerial roots displayed moderate ECV along with CCS (t/ha) at harvest, Cane yield at harvest and Germination at 45DAP indicating their sensitivity to environmental influences. In contrast, traits such as Fiber% at harvest, Sucrose percentage during 10 months and Pol% cane at harvest exhibited the least ECV, suggesting relative stability in the face of varying environmental conditions. Shifting to normal conditions, a similar trend emerged. Traits like Number of nodes with aerial roots demonstrated moderate ECV followed by commercial cane sugar, Cane yield, Germination % at 45 DAP and Tiller at 90 DAP indicating their responsiveness to environmental fluctuations.

Conversely, traits such as Fiber% at harvest, Commercial cane sugar %, Pol % at harvest, and Juice extraction % at harvest showcased lower ECV values, suggesting their consistency across varying environmental contexts. Intriguingly, Cane yield displayed an ECV value of 0.02, indicating minimal environmental influence. Traits with moderate ECV values, including shoot-related attributes and cane yield, exhibit responsiveness to environmental conditions in both waterlogging and normal contexts. Traits demonstrating lower ECV values, such as certain juice-related attributes, maintain stability across environments.

Comparing the heritability estimates under waterlogging and normal conditions, certain traits consistently exhibited higher heritability levels. Specifically, under waterlogging conditions, traits such as Brix% at 10 months, Brix% at 12 months, Sucrose% at 10 months, Sucrose% at 12 months, and Pol% cane at harvest demonstrated the highest heritability values. Similarly, under normal conditions, the traits with the highest heritability included juice-related attributes, such as Brix% at the 10th-month stage, Brix% at 12 months, Sucrose% at the 10th-month stage, Sucrose% at the 12th-month stage and commercial cane sugar%. The results were similar to the experiments conducted by Singh *et al.,* (2020), Sanghera *et al.* (2022), Meena *et al.* (2019). Moderate heritability was consistently noted for the trait purity at the 12th-month stage under both waterlogging and normal conditions.

According to genetic advances in the percent of mean under waterlogging and normal conditions, distinct patterns emerge across various traits. Under waterlogging conditions, the highest genetic advances were observed in traits such as Purity% at 12 months, Number of nodes with Aerial roots, CCS (t/ha) at harvest, Cane yield at harvest (t/ha) and Germination at 45DAP. The results were similar according to the Anbanandan and Eswaran (2018), Bairwa *et al.* (2017), Ahmed *et al* (2019). Moderate genetic advances were noted in Cane height at harvest (cm), Pol% cane at harvest, CCS% at harvest, Sucrose% at 12 months and Brix% at 12 months. Least genetic advances were seen in Fiber% at harvest, Juice extraction% at harvest, Purity% at 10 months and Cane height before waterlogging (cm). These findings underscore the trait-specific responses of sugarcane genotypes to different environmental conditions, emphasizing the significance of selecting and breeding for traits with higher heritability, as they are more likely to pass on their genetic attributes to subsequent generations, leading to improved and consistent trait expression in various environments. This comparative analysis aids breeders in understanding which traits are more influenced by environmental variations and which exhibit robustness, guiding their selection strategies for developing resilient and high-performing sugarcane genotypes. The findings of the investigation were consistent with prior studies by Chaudary (2001). Similar observations were reported by Singh. *et al.* (2020), Sanghera *et al.* (2022), Singh *et al.* (2010), Tyagi *et al.* (2011), and Belwal *et al.* (2020).

The performance of various sugarcane genotypes was evaluated under waterlogged and normal conditions. Clone ISH 567 demonstrated consistent high cane yield, showcasing its resilience across environments. Comparing both conditions, ISH 567, and ISH 584 maintained stable cane weights, while ISH 584 showed better performance under normal conditions. ISH 512 displayed superior pol values in both scenarios, highlighting its adaptability. In terms of juice extraction, ISH 501 consistently performed well, while variations in brix percentages were observed, with ISH 512 excelling under both conditions. Fiber content showed consistent trends, with IGH clones displaying notable superiority. BO 154 consistently performed well in CCS percentages, underlining its reliability. Germination and cane diameters also exhibited genotype-specific variations. These findings underscore the interplay of genetics and environment in shaping sugarcane traits, aiding in genotype selection for diverse conditions.

Conclusion

This experimental study finally concludes that traits like Cane height at harvest and Number of shoots after waterlogging consistently exhibit higher genotypic variance, while Single cane weight shows the lowest. Variability in traits such as number of nodes with aerial roots and germination percentage at 45 DAP indicates potential for improvement. Traits like Fiber% at harvest and certain juice-related attributes display stability. Higher heritability is seen in juice-related attributes across conditions, guiding selection. Genetic advances vary among traits, emphasizing trait-specific responses to environments and aiding breeders in targeted selection for resilient sugarcane genotypes. Promising genotypes like ISH 512, ISH 584, ISH 587, ISH 590, and BO 154 stood out under normal conditions. Similarly, for waterlogging conditions, ISH 512, ISH 567, ISH 584, ISH 587, ISH 590, and BO 154 were chosen as potential candidates for future breeding efforts, with BO 154, ISH 512, and ISH 590 standing out in both scenarios.

Table 1a: ANOVA Results for the Performance of 22 traits of Climate-Resilient Sugarcane Clones under Waterlogging Conditions.

No.	Traits	Mean Sum of Squares			
		Replication (d.f. = 1)	Treatment (d.f. = 20)	Block (d.f. = 4)	Error (d.f. = 16)
1	Germination at 45DAP	0.34	162.99**	0.36	6.53
2	Tillers at 90DAP (000/ha)	3.52	245.12**	5.96	24.83
3	Number of shoots before waterlogging (000/ha)	3.63	409.66**	8.71	28.05
4	Cane height before waterlogging (cm)	3.50	73.71**	2.10	37.68
5	Number of shoots after waterlogging (000/ha)	2.08	474.09**	1.83	31.6
6	Cane diameter at harvest (cm)	1.58	0.125**	1.11	0.02
7	Cane height at harvest (cm)	190.08	1192.77**	0.79	142.86
8	Single cane weight at harvest (kg)	1.501	0.02**	2.06	0.001
9	Number of millable canes at harvest (000/ha)	1.15	359.39**	6.40	17.37
10	Brix% at 10 months	1.49	5.22**	2.97	0.03
11	Sucrose% at 10 months	2.84	4.52**	1.62	0.07
12	Purity% at 10 months	1.79	7.13**	2.44	1.03
13	Brix% at 12 months	0.011	3.85**	0.0037	0.04
14	Sucrose% at 12 months	6.26	3.32**	5.55	0.10
15	Purity% at 12 months	9.36	2.57**	2.11	1.22
16	Cane yield at harvest (t/ha)	3.22	486.26**	2.59	18.72
17	CCS% at harvest	6.42	1.65**	1.07	0.07
18	CCS (t/ha) at harvest	8.33	5.67**	7.80	0.22
19	Fiber% at harvest	1.30	1.25**	2.74	0.16
20	Pol% cane at harvest	2.26	2.33**	6.62	0.07
21	Number of nodes with Aerial roots	9.69	5.08**	1.01	0.25
22	Juice extraction% at harvest	1.22	4.31**	5.07	1.15

*Significant at 5%, ** Significant at 1% level

Table 1b: ANOVA Results for the Performance of 22 traits of Climate-Resilient Sugarcane Clones under Normal Conditions.

No.	Traits	Mean Sum of Squares			
		Replication (d. f.) = 1	Treatment (d. f.) = 14	Block (d. f.) = 4	Error (d. f.) = 13
1	Germination at 45DAP	8.83	149.71**	2.09	3.41
2	Tillers at 90DAP (000/ha)	1.74	287.72**	1.22	28.27
3	Number of shoots before waterlogging (000/ha)	0.253	377.70**	1.03	41.13
4	Cane height before waterlogging (cm)	3.98	91.17**	1.78	45.73
5	Number of shoots after waterlogging (000/ha)	1.08	514.69**	9.04	30.85
6	Cane diameter at harvest (cm)	2.01	0.02**	9.96	0.005
7	Cane height at harvest (cm)	340.80	1096.8**	7.43	151.5
8	Single cane weight at harvest (kg)	2.138	0.016**	1.15	0.001
9	Number of millable canes at harvest (000/ha)	3.80	296.90**	8.20	17.97
10	Brix% at 10 months	3.54	4.69**	3.59	0.04
11	Sucrose% at 10 months	1.99	5.04**	4.54	0.06
12	Purity% at 10 months	1.24	10.40**	9.21	0.65
13	Brix% at 12 months	1.14	3.65**	4.43	0.03
14	Sucrose% at 12 months	2.30	3.43**	1.14	0.06
15	Purity% at 12 months	6.58	3.53**	8.90	0.89
16	Cane yield at harvest (t/ha)	1.62	327.07**	4.93	32.83
17	CCS% at harvest	6.97	1.81**	2.20	0.04
18	CCS (t/ha) at harvest	7.91	5.28**	1.31	0.49
19	Fiber% at harvest	7.73	1.44**	5.59	0.25
20	Pol% cane at harvest	2.16	2.29**	2.50	0.06
21	Number of nodes with Aerial roots	9.3	6.09**	3.33	0.36
22	Juice extraction% at harvest	4.99	4.29**	2.85	1.04

*Significant at 5%, ** Significant at 1% level

Table 2a: Mean performance of 21 clones for yield and yield attributing traits under waterlogging conditions

S. No	Parameters	Mean	SE(m)	CD at 5%	CV
1	Germination at 45DAP	38.03	1.84	5.44	8.63
2	Tillers at 90DAP (000/ha)	92.76	3.61	10.65	5.50
3	Number of shoots before waterlogging (000/ha)	114.64	4.16	12.27	5.42
4	Cane height before waterlogging (cm)	126.98	2.11	6.23	4.10
5	Number of shoots after waterlogging (000/ha)	100.04	4.06	11.97	5.73
6	Cane diameter at harvest (cm)	2.19	0.04	0.11	5.83
7	Cane height at harvest (cm)	227.88	7.23	21.33	4.49
8	Single cane weight at harvest (kg)	0.68	0.03	0.07	5.31
9	Number of millable canes at harvest (000/ha)	82.15	3.02	8.90	5.20
10	Brix% at 10 months	16.12	0.14	0.40	0.98
11	Sucrose% at 10 months	13.48	0.21	0.63	2.24
12	Purity% at 10 months	83.57	0.72	2.12	1.43
13	Brix% at 12 months	18.2	0.16	0.47	1.27
14	Sucrose% at 12 months	15.2	0.23	0.68	2.13
15	Purity% at 12 months	85.76	0.55	1.61	1.35
16	Cane yield at harvest (t/ha)	56.29	3.09	9.10	7.75
17	CCS% at harvest	10.36	0.2	0.59	2.73
18	CCS (t/ha) at harvest	5.82	0.34	1.01	8.31
19	Fiber% at harvest	13.79	0.31	0.91	3.77
20	Pol% cane at harvest	12.34	0.19	0.57	2.22
21	Number of nodes with Aerial roots	4.2	0.36	1.06	12.37
22	Juice extraction% at harvest	52.7	0.79	2.33	2.12

Table 2b: ANOVA Results for the Performance of 22 traits of Climate-Resilient Sugarcane Clones under Normal Conditions.

S. No	Parameters	Mean	SE(m)	CD	CV
1	Germination at 45DAP	37.21	1.63	4.80	6.09
2	Tillers at 90DAP (000/ha)	95.75	3.85	11.37	5.20
3	Number of shoots before waterlogging (000/ha)	116.56	4.57	13.49	6.59
4	Cane height before waterlogging (cm)	129.68	2.66	7.83	3.59
5	Number of shoots after waterlogging (000/ha)	100.12	3.93	11.59	4.35
6	Cane diameter at harvest (cm)	2.16	0.06	0.19	6.54
7	Cane height at harvest (cm)	235.77	8.62	25.44	6.27
8	Single cane weight at harvest (kg)	0.71	0.03	0.08	6.30
9	Number of millable canes at harvest (000/ha)	97.8	3.63	10.7	6.17
10	Brix% at 10 months	16.45	0.15	0.45	1.19
11	Sucrose% at 10 months	14.03	0.19	0.56	2.24
12	Purity% at 10 months	85.14	0.61	1.81	1.28
13	Brix% at 12 months	18.15	0.14	0.40	1.50
14	Sucrose% at 12 months	15.76	0.18	0.53	1.67
15	Purity% at 12 months	86.77	0.71	2.11	1.16
16	Cane yield at harvest (t/ha)	69.44	4.05	11.95	9.61
17	CCS% at harvest	10.8	0.16	0.47	0.59
18	CCS (t/ha) at harvest	7.5	0.5	1.47	10.60
19	Fiber% at harvest	13.38	0.36	1.07	3.93
20	Pol% cane at harvest	2.04	0.55	0.74	1.97
21	Number of nodes with Aerial roots	4.83	0.44	1.29	14.90
22	Juice extraction% at harvest	53.00	0.72	2.14	1.53

Table 3a : Genetic analysis for yield and yield attributing traits in 18 genotypes in sugarcane under waterlogged conditions

S. No	TRAITS	Vg	Vp	Ve	h^2	GCV	PCV	GA
1	Germination at 45DAP	76.98	82.27	5.29	92.27	23.69	24.65	46.86
2	Tillers at 90DAP (000/ha)	126.05	155.72	29.67	80.79	11.28	12.55	20.89
3	Number of shoots before waterlogging (000/ha)	168.0	209.88	41.88	84.91	12.16	13.2	23.09
4	Number of shoots after waterlogging (000/ha)	240.85	268.81	27.96	87.33	15.04	16.1	28.97
5	Cane height at harvest (cm)	471.15	628.98	157.83	89.3	1.59	5.32	0.98
6	Cane diameter at harvest (cm)	0.075	0.095	0.02	78.58	10.06	11.35	18.37
7	Single cane weight at harvest (kg)	0.0071	0.0083	0.0012	71.93	8.93	10.53	15.61
8	Number of millable canes at harvest (000/ha)	133.58	159.90	26.32	87.27	14.47	15.49	27.87
9	Cane yield at harvest (t/ha)	143.12	176.95	33.83	90.35	15.89	16.72	31.13
10	Number of nodes with Aerial roots	2.81	3.20	0.39	92.46	27.15	28.23	53.78
11	Brix% at 10 months	2.27	2.31	0.04	90.36	37.04	38.96	72.53
12	Brix% at 12 months	1.77	1.81	0.04	98.61	9.99	10.06	20.43
13	Sucrose% at 10 months	2.44	2.51	0.07	97.5	7.92	8.02	16.11
14	Sucrose% at 12 months	1.63	1.70	0.07	96.31	11.41	11.63	23.08
15	Purity% at 10 months	4.93	5.70	0.77	93.87	8.35	8.62	16.67
16	Purity% at 12 months	1.31	2.30	0.99	70.29	2.08	2.48	3.59
17	Fiber% at harvest	0.55	0.81	0.26	26.86	0.79	1.52	84.41
18	CCS% at harvest	0.85	0.90	0.05	74.33	5.39	6.25	9.58
19	CCS (t/ha) at harvest	2.33	2.86	0.53	90.92	8.57	8.99	16.84
20	Juice extraction% at harvest	1.60	2.63	1.03	92.08	28.33	29.52	56
21	Pol% cane at harvest	1.12	1.15	0.03	56.35	2.4	3.2	3.72

Table 3b : Genetic analysis for yield and yield attributing traits in 18 genotypes in sugarcane under Normal conditions

S. No	TRAITS	Vg	Vp	Ve	h^2	GCV	PCV	GA
1	Germination at 45DAP	78.98	84.27	5.29	93.73	23.88	24.67	47.63
2	Tillers at 90DAP (000/ha)	129.01	158.71	29.7	81.29	11.86	13.14	22.03
3	Number of shoots before waterlogging (000/ha)	171.0	212.85	41.85	80.34	11.2	12.51	20.71
4	Number of shoots after waterlogging (000/ha)	241.91	272.76	30.85	88.69	15.53	16.49	30.13
5	Cane height at harvest (cm)	475.15	631.98	156.83	75.18	9.24	10.66	16.41
6	Cane diameter at harvest (cm)	0.07	0.09	0.02	77.77	10.75	12.09	19.71
7	Single cane weight at harvest (kg)	0.0074	0.0089	0.0015	83.15	12.13	13.30	22.79
8	Number of millable canes at harvest (000/ha)	136.58	162.90	26.32	84.30	11.94	13.05	22.54
9	Cane yield at harvest (t/ha)	147.12	179.95	32.83	81.76	17.46	19.31	32.53
10	Number of nodes with Aerial roots	2.85	3.24	0.39	88.12	35.01	37.30	67.70
11	Brix% at 10 months	2.32	2.37	0.05	98.02	9.26	9.36	18.90
12	Brix% at 12 months	1.81	1.84	0.03	0.9836	7.48	7.41	15.11
13	Sucrose% at 10 months	2.48	2.55	0.07	97.23	11.23	11.39	22.82
14	Sucrose% at 12 months	1.68	1.74	0.06	96.28	8.23	8.39	16.64
15	Purity% at 10 months	4.98	5.73	0.75	86.94	2.62	2.81	5.03
16	Purity% at 12 months	1.32	2.34	1.02	56.45	1.32	1.76	2.05
17	Fiber% at harvest	0.58	0.85	0.27	68.90	5.73	6.90	9.79
18	CCS% at harvest	0.88	0.93	0.05	94.56	8.69	8.93	17.40
19	CCS (t/ha) at harvest	2.39	2.89	0.5	82.92	20.63	22.66	38.71
20	Juice extraction% at harvest	1.62	2.67	1.05	60.73	2.40	3.08	3.85
21	Pol% cane at harvest	1.11	1.18	0.07	94.20	8.20	8.45	16.40

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References

Ahmed, K. I., Patil, S. B., Hanamaratti, N. G., Nadgouda, B. T., and Moger, N. B. (2019). Genetic variability studies for yield and its component traits in selected clones of sugarcane. *Journal of Pharmacognosy and Phytochemistry*, **8**(2), 894 898.

Anna Durai, A. and Karuppaiyan, R. (2023). Potential parents for developing climate-resilient sugarcane varieties in India: A Breeding Perspective. In *Agro-industrial Perspectives on Sugarcane Production under Environmental Stress*, pp. 57-83. Singapore: Springer Nature Singapore.

Anbanandan, V., and Eswaran, R. (2018). Association analysis in sugarcane (*Saccharum officinarum* L.). *Journal Phytochemistry*, **7**(1S), 2675-2677.

Bairwa, A. K., Ram, R., Neetu, J. A., Singh, K., and Singh, S. P. (2017). Estimation of the extent of variability for different morphological and juice quality characters among early generation sugarcane clones. *International Journal of Current Microbiology and Applied Sciences*, **6**(2), 1272-1278.

Belwal, V., and Ahmad, S. (2020). Estimation of variability parameters in sugarcane under water logging conditions. *International Journal of Agriculture Sciences*, ISSN, 0975-3710.

Burton, Glenn, W. and de EH De Vane (1953). Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal,* **45**, 478-81.

Gulzar, S.S., Navdeep, S.J. and Aishwarya, S. (2022). Genetic Variations and Selection Coefficients for Agronomic, Physiological and Quality Traits towards Sugarcane Improvement for Waterlogged conditions. *Biological Forum – An International Journal*, **14**(2a): 286-293.

Hiremath, G., and Nagaraja, T.E. (2016). Genetic variability and heritability analysis in selected clones of sugarcane. *International Journal of Science Technology & Engineering*, **2**(8), 341-343.

Johnson, Herbert, W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybeans. *Agronomy Journal,* **47**: 314-18.

Kumar, P., Pandey, S.S., Kumar, B., Kamat, D.N., & Kumar, M. (2018). Assessment of genetic parameters for various productive traits in early maturing sugarcane. *Int. J. Curr. Microbiol. Appl. Sci*, **7**, 1387-1392.

Lush, Jay, L. (1940). Intra-sire correlations or regressions of offspring on dam as a method of estimating heritability of characteristics. *Journal of animal science*, **1**: 293-301.

Meena, D. S., and Meena, H. (2019). Studies on Genetic Variability, Heritability and Genetic Advance in Elite Genotypes of Sugarcane (*Saccharum officinarum* L.). *International Journal of Current Microbiology and Applied Sciences*, **8**(8), 1255-1259.

Mehareb, E.M. and Abazied, S.R. (2017). Genetic variability of some promising sugarcane varieties (Saccharum spp) under harvesting ages for juice quality traits, cane and sugar yield. *Open Access Journal of Agricultural Research*, **2**(2), 1-14.

Nair, N.V. (2011). Sugarcane Varietal Development Programmes in India. An Overview. *Sugar Tech*, **13**, 275–280.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical Methods of Agricultural Workers. 2nd Endorsement, *ICAR Publication*, New Delhi, India, pp: 381.

Ranjan, R., and Kumar, B. (2017). Study of genetic variability for cane yield and its component traits in early maturing sugarcane. *International Journal of Current Microbiology and Applied Sciences*, **6**(10), 1739-1748.

Singh, M.K., Pandey, S.S., Kumar, R., and Singh, A.K. (2010). Estimation of genetic variability, heritability and genetic advance in mid-late maturing clones of sugarcane. *Environment and Ecology*, **28**(4), 2301-2305.

Singh, R., Kamat, D.N., Kumar, B., Kumari, P. and Govindbhai, Z. R. (2020). Genetic Variability Analysis of Early Maturing Sugarcane (*Saccharum officinarum* L.) Clones Using Morphological Characters. *Current Journal of Applied Science and Technology*, **39**(26), 105-112.

Tyagi, V. K., Sharma, S., and Bhardwaj, S. B. (2011). A study on the nature and magnitude of variations in different traits in sugarcane. *Electronic Journal of Plant Breeding*, **2**(3), 334-341.