International Journal of Genetics
ISSN: 0975-2862 & E-ISSN: 0975-9158, Volume 10, Issue 5, 2018, pp.-425-433.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000226

Research Article

GENETIC VARIABILITY STUDIES IN SUGARCANE (Saccharum sp. Hybrid Complex) UNDER WATER STRESS AND NON-STRESS CONDITIONS

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Received: May 18, 2018; Revised: May 24, 2018; Accepted: May 26, 2018; Published: May 30, 2018

Abstract- This study reports the extent of genetic variability in elite sugarcane clones and varieties for cane yield components, quality and physiological traits as affected by water stress conditions. High PCV was recorded for specific leaf weight (g) under both the environments while high GCV for this trait was recorded under water stress (E2) only. For quality traits, high PCV and GCV was recorded for CCS (t/ha) under both normal (E1) as well as water stress (E2) environments. High heritability values for major economic traits like cane yield, commercial cane sugar tons per hectare, number of shoots thousand per hectare, brix (%) and pol percentage at 10 months and commercial cane sugar (%) under water stress (E2) conditions indicates that substantial improvement can be expected by giving emphasis on the selection of these traits under water stress conditions. In this study environmental influence on the expression of different traits was observed as indicated by the differences in parameters of variability. Genetic advance (GA) indicated for traits; cane yield, CCS (t/ha) and single cane weight under both the environments (E1 and E2) were having higher values and improvement can be expected by practicing selection for these traits. High heritability coupled with high genetic advance recorded for number of shoots at 120 days (000/ha), cane yield (t/ha), CCS (t/ha) under water stress (E2) environment indicated that direct selection of these traits under water stress conditions could be effective. Moderate values of h2 and GA for traits like relative water content (%) at 60 and 120 days, chlorophyll content and some quality traits indicates that direct selection could not be much effective for these traits.

Key words- *Sugarcane, water stress, variability, heritability, genetic advance*

Citation: Sanghera G.S., *et al*., (2018) Genetic Variability Studies in Sugarcane (*Saccharum sp. Hybrid Complex*) under Water Stress and Non-Stress Conditions. International Journal of Genetics, ISSN: 0975- 2862 & E-ISSN: 0975-9158, Volume 10, Issue 5, pp.-425-433.

Introduction

Water limitation is a major production constraint for sugarcane worldwide. However, to date, there has been little investigation of patterns of genetic variation in the response to water stress in sugarcane. It has been reported [1] that formative phase is the period when 70-80 % of cane yield is produced and drought during this stage affect cane yield adversely [2]. The tillering and grand growth stages of sugarcane crop, known as the sugarcane formative phase, have been identified and illustrated as the critical water demanding period in sugarcane [3]. Water relations in crop physiological processes and photosynthetic responses to water deficit stress during these growth stages could therefore be convenient in identifying drought tolerant genotypes [4]. Morpho-physiological attributes which impart resistance/tolerance or susceptibility to a biotic and abiotic stress are important from crop production point of view. A sugarcane variety possesses characteristic(s) divulging resistance/tolerance to an abiotic/biotic stress, with suboptimal cane and sugar yield, could be utilized as a parent for contributing the respective trait to the offspring. Adverse effects of water deficit on morphological, physiological, and biochemical processes can be confirmed in all plant parts. In condition of water stress, common physiological alterations included reduced leaf water potential and the relative water content [5], gaseous exchange as well as photosynthesis [4]. Therefore, metabolic changes such as enhanced osmoregulation [6] may occur along with significant changes on the plant growth, in response to the lower cellular turgor pressure [7]. Thus, physiological studies on sugarcane may identify clones more tolerant to water stress and ultimately improve crop productivity. Though breeding programmes in sugarcane with increased yield under normal conditions were attempted to improve drought tolerance, such studies have shown that varieties being tolerant remained turgid and maintained near- optimum growth for longer time [8]) that necessitates identification of drought tolerant genotypes with desirable agro-morpho physiological traits. Present study was envisaged to assess the genetic variability for cane yield components, quality parameters and some physiological traits under water stress conditions.

Materials and Methods

Present investigation was carried out at experimental area of PAU, Regional Research Station (RRS) Kapurthala, Punjab. The Experimental site is located at of 31.38°N longitude and 75.38°E latitude at an elevation of 225 m above mean sea level (amsl) having clay loam soils with pH of 8.3-8.7. The experimental plant material consisted of 30 diverse clones of Kharif sugarcane comprising nine commercial released varieties and twelve elite clone selections from Punjab, five introductions procured from RS Anakapalli and four ISH clones collected from SBI, Coimbatore. All the 30 clones were planted during spring 2016-17 in the first week of March in a randomized complete block design with two replications in normal (E1) and water stress (E2) environments. Standard agronomic practices as per package of practices of the PAU for field crops were followed to raise the ideal crop stand except irrigation in water stress (E2) environment. Irrigation was suspended for 2-3 weeks interval in water stress (E2) environment at critical growth stages of sugarcane viz., germination, tillering and grand growth stage. Each genotype was represented by a plot of four rows of 6m length each. Inter row spacing was maintained at 90 cm and seed rate in both the environments was kept 12 healthy buds per running 1 metre row.

The observations on different cane yield and component traits [Table-1] were recorded. However, physiological and quality traits were recorded / estimated at appropriate stages for each clone in each replication under both the E1 and E2 environments following standard procedures and protocols as below:

Physiological Traits

Relative water content at 60 and 120 DAP (%)

Fresh leaves were collected from five randomly selected plants from each clone in each replication in early morning hours and brought to lab. 10g leaf discs (fresh weight) from each genotype from each plot were submerged in distilled water in test tubes till saturation. After 6 hrs the leaf discs were removed from test tubes. Surface water of the discs was blotted off without putting any pressure and then they were weighed to obtain saturated weight. After drying the discs at 70°C for 72 hr their dry weight was determined. From these data RWC at 60 and 120 DAP was calculated following [9] as follows:

$$RLWC = \frac{Fresh\ weight - Dry\ weight}{Saturated\ weight - Dry\ weight} \times 100$$

Chlorophyll content (mg/l)

Chlorophyll content was estimated by following dimethyl sulphoxide (DMSO) method [10] and readings were taken using spectrophotometer.

Procedure: It is the easiest approach in which leaf discs of known area were cut and used for analysis. Five leaves were collected from five randomly selected seven-month-old plants from each clone in each replication in early morning hours and brought to lab. 0.1 g of leaf tissue of each sugarcane clone were cut into smaller pieces and placed in test tubes which contains 10 ml of solvent (DMSO). Test tubes were incubated in a water bath at 60-65ºC for an hour and cooled at room temperature for 30 min followed by filtration and absorption measured at 665 nm and 648 nm with a spectrophotometer. Blank determination was carried out with DMSO. The absorbance of the blank sample was subtracted from the absorbance readings of each sample before calculations.

Calculations

Chlorophyll concentration (a, b and total) was calculated as mg /g fresh weight by the following formulae [11] and expressed as mg/l.

Chlorophyll a (mg/g F.W) = (14.85 A_{665} -5.14 A_{648})

Chlorophyll b (mg/g F.W) = (25.48 A_{665} -7.36 A_{648})

Total chlorophyll (mg/g F.W) = (7.49 A_{665} + 20.34 A_{648}) \

Where: A_{665} = absorption value at 665 nm, A648= absorption value at 648 nm.

Stomatal frequency (no.)

Five leaves from five randomly selected plants of a clone from each replication were taken and brought to lab. The leaf membrane from the lower side of each leaf was peeled off by applying thinner on it followed by removal of leaf membrane by using cellotape. The cellotape containing the leaf membrane was placed on a glass slide and observed under compound microscope. Stomatal frequency was calculated by counting the number of stomata per microscopic field of the compound microscope. The mean of four microscopic fields considered as stomatal frequency of the genotype under study in both the environments and expressed as number of stomata per microscopic field.

Specific Leaf weight (SLW) (g)

For this all the leaves of a genotype from each plot under each replication at 120 days after planting were counted in field and carried to lab where they were kept in oven at 50°C for 24 hours. Specific leaf weight (SLW) was calculated using the following formula:

$$Specific\ leaf\ weight\ (g) = \frac{Dry\ weight\ of\ total\ leaves\ per\ plant\ (g)}{Total\ no.of\ leaves\ per\ plant}$$

Quality Traits

Five healthy canes of each genotype in each plot under each replication in both the environments were taken randomly at harvest and crushed with the help of crusher for juice extraction. The juice so collected was purified by adding lead acetate (1mg) to it and was thoroughly mixed by manual shaking. After having the precipitation, the juice was filtered to collect purified juice which was further used to estimate quality characters as follow:

Juice extraction (%)

The weight of randomly selected five healthy canes of each genotype under each replication was recorded. After crushing of these selected canes, the weight of cane juice was also recorded. The mean of both cane weight and juice weight of five canes was calculated. Extraction at 10 and 12 months expressed in percentage was calculated as the ratio of mean juice weight calculated under each replication and mean weight of cane calculated under each replication.

Extraction (%) = (Juice weight (kg) / Cane weight (kg)) × 100

Brix (%)

The prism face of the refractometer was cleaned and dried. A drop of distilled water was put on the refractometer prism to standardize it the zero reading. A drop of the purified juice was put on the prism and the reading was recordedand brix percentage in cane juice was calculated and expressed as percent.

Pol (%) in juice

One hundred ml of the filtered juice was transferred to 250 ml conical flask to which one gram of basic lead acetate was added, stirred well and allowed to stand for about an hour until clear supernatant obtained. This supernatant filtered through Whattman No. 40 filter paper. The filtrate was collected, and its polarization was recorded digital automatic polarimeter [12].

Purity (%)

The pol percent and brix percent calculated above were taken and purity at 10 and 12 months for juice of each genotype in each plot under each replication was calculated by using following formula and expressed as percent.

$$Purity\ (\%) = \frac{Pol\ \%}{Brix\ \%} \times 100$$

Commercial Cane Sugar (CCS) (%)

Commercial cane sugar (%) was calculated from the pol (%) and purity (%) at 10 and 12 months in juice using following formula:

$$CCS\ (\%) = \frac{0.292 * Pol\ \%\ ((0.035 * Purity\ \%) - 1))}{Purity\ \%} \times 100$$

Fibre content at harvest (%)

Fibre content in cane was estimated by Rapipol extraction method and calculations were made as per the formula [13].

Estimation of fibre per cent of cane by Rapipol Extraction Method

From 5 canes, top, middle and bottom portion (top from first cane, middle from second cane and bottom from third cane) was chopped into small bits. Later, 250 gms of chopped cane bits are taken by mixing and sampling and placed in the cup of the Rapipol extractor. Two litres of water were added and disintegrated in Rapipol extractor for five minutes. After decantation, two litres of water is added and mixed well for two to three minutes and decanted without any loss of fibre. The above procedure is repeated once again, filtered quantitatively through a fine mesh filter and finally transferred quantitatively to a bag of known weight. It was dried at 110°C to constant weight. The Fibre content (%) at harvest was calculated by following formula:

Fibre per cent= {(A-B)/C} ×100

Where,

A = Dry weight of bag + bagasse after drying (g)

B = Dry weight of bag alone (g)

C = Fresh weight of cane (g)

Pol (%) in cane

Pol in cane (%) at harvest represents the total pol present in the cane.

It is calculated by adding the pol percent in juice and pol percent in bagasse. For pol percent in bagasse 250 gm bagasse dipped in 2 litres distilled water was processed in Rapipol extractor for 15 minutes. The water containing bagasse juice was cleared with basic lead acetate and was thoroughly mixed by manual shaking. After having the precipitation, the juice was filtered to collect purified juice. The filtrate was collected, and its polarization was recorded digital automatic polarimeter which gives the value of pol percent in bagasse. Pol in cane at harvest (%) was calculated by following formula:

$$\text{Pol in cane (\%)} = \text{Pol in juice (\%)} + \text{Pol in bagasse (\%)}$$

Commercial cane Sugar (CCS) at harvest (t/ha)

Commercial cane sugar (CCS) at harvest was calculated using cane yield (t/ha) and commercial cane sugar percent (CCS %) as recorded earlier by using following formula:

$$\text{CCS (t/ha)} = [\text{Yield (t/ha)} \times \text{CCS\%}]$$

Statistical Analysis

The mean values of all the traits from each genotype in each replication were used for analysis of variance as per [14]. The analysis of the experimental design was based on the linear model with the help of software CPCS1 [15]. Further, analysis of variance was used for calculating genotypic and phenotypic coefficients of variance for all characters. Broad sense heritability and genetic advance were estimated according to the method suggested [16,17].

Results and Discussion

The minimum and maximum mean weekly temperature ranged from 2.00°C to 36.00 °C and from 7.00 °C to 46.00 °C, respectively. The total annual rainfall during crop season (Feb 2016-Jan 2017) was 110.5 mm. Rainfall was not evenly distributed throughout the cropping season which resulted in moisture stress conditions during the critical crop growth stages. In the present investigation, the moisture stress was experienced during germination, tillering and grand growth stage (formative stage). Data recorded for different parameters of cane yield and component traits, physiology, quality and disease screening were subjected to statistical analysis following standard procedures. The results of the study obtained on the analysis of variance and genetic variability parameters analysis of various traits in normal (E1) and water stress (E2) environments, drought susceptibility index is presented below:

Analysis of variance

The analysis of variance under normal (E1) and water stressed (E2) conditions was carried out for eight cane yield and component traits, seven physiological and thirteen quality parameters [Table-1]. Mean sum of squares for genotypes were found significant for all cane yield and component traits recorded in this study under both the environments, except for stalk length under normal (E1) environment. Analysis of variance revealed significant difference among clones and varieties used in the study for the cane yield and component traits. Significant variability for cane and component traits has also been documented [18]. Sanghera, *et al*., [19] reported highly significant differences among the 13 sugarcane clones for the characters (germination % at 45 days, number of tillers at 120 days, stalk length, stalk diameter, NMC and cane yield) under normal environment. Similarly, Khan, *et al*., [20] reported that the mean performance of the genotypes for cane yield and its components showed significant ($p \leq 0.05$) differences among the clones. Significant differences have also been observed among the sugarcane genotypes for single stalk weight and cane yield under prolonged drought stress [21].

For physiological traits, RWC at 120 DAP, total chlorophyll and specific leaf weight were significant under both the environments (E1 and E2), while RWC at 60 DAP and chlorophyll b were found to be significant under water stressed (E2) environment. Begum, *et al*., [22] showed significant difference among the sugarcane genotypes for total chlorophyll content under water stress (E2) conditions. The results given by Graca, *et al*., [23] showed a significant difference in relative water content (RWC) in the stressed plants compared to the irrigated plants.

Similarly, of the 13 quality traits studied at 10 months and harvest, clones behaved significantly and differentially for all the traits in both the environments except for purity (%) at 10 months under normal (E1) conditions. Tena, *et al*., [24] reported significant difference for all the quality traits of sugarcane under normal water conditions. The significant variances for different cane yield and component traits, physiological and quality traits in both the environments revealed that there exists sufficient genetic variability in the experimental material used for the present study. It will help to isolate specific clones suitable for water stress and non-stress conditions.

Genetic Variability Parameters

Genetic variability is the pre-requisite for the improvement of any trait. The range of mean values based on phenotypic expression could represent only a rough estimate of the variation or magnitude of divergence present among different genotypes. The estimates of genotypic and phenotypic coefficients of variation are more reliable estimates of extent of variability present within the experimental material. Similarly, knowledge of the heritability of character is important to the breeders since it indicates the possibility and extent of improvement that can be achieved through selection. So, these genetic variability parameters like mean, range, phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance for cane yield and component traits, physiological and quality traits were studied normal (E1) and water stress (E2) environments.

Cane yield and Component Traits

Cane yield and its component traits are most important traits for improvement of sugarcane. Germination percentage among the different clones ranged from 27.36 to 67.91 percent with mean value of 43.53 per cent under normal (E1) conditions and from 17.50 to 45.00 percent with a mean of 28.44 (%) under water stressed (E2) conditions. High magnitude of coefficient of variation i.e., PCV and GCV were recorded for germination (%) under both normal (E1) and water stress (E2) environments. High genotypic and phenotypic coefficient of variation for germination (%) under irrigated conditions was reported [25], while Singh, *et al*., [26] reported moderate coefficient of variation for germination percentage. Moderate to high heritability and genetic advance for germination (%) has been documented in earlier studies [27]. The number of tillers at 240 days is an important character contributing towards cane yield and ratooning ability. Under normal conditions (E1), number of tillers at 240 days ranged from 83.00 to 161.00 (000/ha) with a mean value of 122.00. The number of tillers under water stress conditions (E2) ranged from 51.00 to 104.00 with mean value of 84.00. Under water stress (E2) conditions, variety CoJ 64 produced maximum number of tillers at 240 days (140.00) followed by ISH 148, ISH 135, KV 2012-5, KV 2012-3, CoPb 92 and CoPb 13183. Number of tillers at 240 days exhibited moderate magnitude of all the variability parameters like PCV (17.87%), GCV (13.40%), heritability (56.28) and genetic advance (percent of mean) (20.72%) under normal (E1) environment and the corresponding figures in water stress (E2) environment were PCV (18.53%) and GCV (15.37%), heritability (68.74%) and genetic advance (percent of mean) (26.24%), respectively. Moderate heritability in sugarcane for number of tillers at 240 days was recorded [19] under irrigated conditions. The PCV and GCV values for NMC were moderate (17.77 and 13.55%, respectively) under E1 environment while high PCV (20.91%) and moderate GCV (15.35%) under E2 environment. The heritability (58.13 and 53.91, respectively) and genetic advance (21.28 and 23.22, respectively) for NMC were found to be moderate under both the environments [Table-2]. Sanghera, *et al*., [19] reported moderate heritability (72.49%) and moderate genetic advance for number of millable canes (NMC). This trait is an important component of cane yield and should given emphasis while selecting for higher cane yield in combination with other traits. Stalk length is a significant trait that directly contributes towards cane yield. Under normal (E1) conditions, it ranged from 192.50 to 308.33 cm with a mean of 267.48 cm and under water stressed (E1) conditions it was recorded to have range of 120.00 to 240.00 cm with a mean of 178.65 cm. Variability studies revealed that under normal (E1) environment, stalk length exhibited moderate PCV (11.52%), low GCV (8.08%), low heritability (49.48%) and low genetic advance (11.67%).

While, under water stress (E2) environment, moderate PCV (16.19%), GCV (14.27%), heritability (77.68%) and genetic advance (25.90%) were recorded for this trait [Table-2]. The results under normal water conditions are in accordance with studies conducted by Anbanandan and Saravanan, [28] who also reported low coefficient of variability and genetic advance for cane length. Moderate PCV, GCV and heritability were recorded for stalk diameter under both normal (E1) and water stress (E2) conditions [Table-2]. The genetic advance was recorded low (17.59%) under normal (E1) and moderate (21.61%) under water stress (E2) conditions. Since stalk diameter is a trait which directly affect the cane yield, moderate heritability and genetic advance for this trait would not give significant breeding advantage in successive selection cycles in different generations. The results under normal (E1) conditions are in corroboration with earlier study conducted [27]. Single cane weight (SCW) exhibited high PCV, GCV and genetic advance and moderate heritability under both normal (E1) as well as water stress (E2) conditions [Table-2]. Moderate heritability value was reported by Kumar, *et al*., [29] for single cane weight under water stress conditions. High PCV, GCV and genetic advance for single cane weight has also been reported in studies [30-24]. This trait is an important component of cane yield and should give emphasis while selecting for higher cane yield in combination with other traits. Cane yield of different genotypes under normal (E1) conditions ranged between 48.78 to 110.00 t/ha with a mean value of 76.40 t/ha. Clone CoPb 10181 had maximum cane yield of 110.00 t/ha under normal (E1) conditions followed by clones KV 2012-3 (100.69), CoPb 91 (97.43), L 818/07 (96.18) and CoPb 93 (94.33), however, minimum cane yield of 48.78 t/ha was recorded in clone CoPb 11211. Under water stress (E2) conditions, the cane yield was generally lower where it ranged from 25.42 to 76.39 t/ha with a mean value of 51.40 t/ha. In E2 environment, highest cane yield was recorded for the clone KV 2012-3 (76.39 t/ha) followed by clones CoPb 93 (68.25), KV 2012-1 (65.97), CoPb 10181 (64.31) and KV 2012-5 (64.24) while lowest cane yield was recorded for the genotype CoPb 11211 (25.42 t/ha). Clones KV 2012-1 and KV 2012-5 performed high with respect to cane yield under water stressed (E2) conditions. The magnitude of PCV for cane yield was high (20.36 and 21.69, respectively) under both E1 and E2 environments while moderate GCV was recorded (18.12%) under normal (E1) and high (20.73%) under water stressed (E2) conditions. The heritability (broad sense) for this trait was recorded to be moderate (79.15%) under E1 and high (85.37%) under E2 environment. The genetic advance was higher under both the environments [Table-2] which proposes an opportunity for the breeder to get selection advantage for cane yield in different conditions. Kumar, *et al*., [29] also reported high heritability and genetic advance as per cent of mean for cane yield under moisture stress environment. For normal water conditions, similar results were revealed by Chaudhary, [25] and Arora, *et al*., [30] who reported high genetic advance and high to moderate variability coefficients for cane yield under irrigated conditions. This suggests that a large proportion of the total variance is heritable, and selection of this trait would be effective under both normal (E1) and water stress (E2) environments.

Physiological Traits

Relative water content in leaf is an indicator of degree of tolerance of plants towards adverse conditions like water stress. These results were found in accordance with already reported findings in literature which state that drought-tolerant sugarcane genotypes exhibited high relative water content as compared to the drought-sensitive genotypes [4, 2]. For variability parameters studied, RWC at 60 days after planting exhibited low magnitude of PCV and GCV (6.11 and 3.67%) under normal (E1) environment whereas under water stress (E2) environment, a high magnitude of PCV and moderate GCV (20.37 and 11.61%) was recorded, respectively. However, the heritability and genetic advance was observed to be low under both the environments [Table-2].

Total chlorophyll content ranged from 5.22 to 8.87 mg/l with a mean of 7.23 mg/l under normal (E1) water conditions while under water stress (E2) conditions it ranged from 3.12 to 6.50 mg/l with overall mean of 4.81 mg/l [Table-3]. The maximum chlorophyll content under normal (E1) water conditions was recorded for variety CoPb 92 (8.87 mg/l), followed by clones Co 238 (8.77) and KV 2012-4 (8.62). The clone KV 2012-4 (6.50 mg/l) was found to possess highest total chlorophyll content under water stress (E2) conditions followed by clones ISH 148 (6.38) and KV 2012-3 (6.18). However, variety CoJ 88 (5.22 mg/l) was found to have minimum total chlorophyll content under normal (E1) water conditions while under water stress (E2) conditions clone CoPb 11214 (3.22 mg/l) had minimum total chlorophyll content. About 16 genotypes had higher total chlorophyll content than overall mean under normal (E1) water conditions and about 15 genotypes under water stressed (E2) conditions possessed higher total chlorophyll content value than the overall mean. These findings agree with the studies of Silva, *et al*., [4] who also reported that drought caused a decline in sugarcane leaf chlorophyll level, but this reduction varied among genotypes. Begum, *et al*., [22] and Jangpromma, *et al*., [31] reported that drought tolerant sugarcane cultivars were found to possess higher level of chlorophyll than drought susceptible cultivars. Variability parameters worked out for total chlorophyll content revealed moderate PCV (15.80%), low GCV (9.46%), heritability (35.88) and genetic advance (11.68%) under normal (E1) conditions whereas high PCV (20.88), moderate GCV (13.80%), low heritability (43.66) and genetic advance (18.78%) under water stress (E2) conditions [Table-2]. The specific leaf weight in the study varied from 3.23 to 7.48 g averaging 5.02 g under normal (E1) and 2.10 to 5.60 g under water stress (E2) conditions with a mean of 3.42 g. The clone CoPb 11214 (7.48 g) recorded the highest specific leaf weight whereas the clone CoPb 14212 (3.23 g) recorded lowest specific leaf weight under normal (E1) conditions [Table-3]. Under water stress (E2) conditions, the clone CoPb 11214 (5.60 g) recorded maximum specific leaf weight whereas variety CoJ 88 (2.10 g) had minimum specific leaf weight. Overall, the clone KV 2012-4 had maximum specific leaf weight under both normal (E1) as well as water stressed (E2) conditions. The specific leaf weight exhibited high PCV (29.44%), GCV (25.14%) and genetic advance (44.21%) values with moderate heritability value (72.90) under water stress (E2) conditions whereas under normal (E1) conditions high PCV (26.07%), Moderate GCV (14.48%), low heritability (30.87) and genetic advance values (16.57%) were recorded [Table-2].

Quality Traits

Sugar is the product of the sugarcane. The quality and quantity of the sugar depends upon the quality traits of sugarcane. As drought conditions interfere with sugar production by affecting growth rate, yield of the cane, juices of lower sucrose contents, purity, higher acidity, and the sucrose content of the stalk. So, it becomes necessary to select those quality traits which lead to high sugar recovery from sugarcane under water stress conditions. Studies on variability parameters for Brix (%) revealed moderate PCV, low GCV and genetic advance with high heritability values under normal (E1) environment whereas under water stress (E2) conditions moderate PCV and GCV, high heritability and moderate genetic advance were recorded [Table-2]. Moderate values of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) coupled with high heritability for brix percentage has been reported by Mehareb, *et al*., [32] and Sanghera, *et al*., [33] in sugarcane. Pol (%) in juice at harvest recorded moderate PCV and high heritability under both the environments, whereas low GCV and genetic advance under normal (E1) and moderate GCV and genetic advance under water stress (E2) environment [Table-2]. The results on variability parameters obtained in this study under normal (E1) environment were in accordance with earlier results [24, 29, 32]. High heritability and genetic advance for pol (%) has also been reported [33] in early maturing varieties of sugarcane under irrigated conditions. Contrary, low variability in sucrose percent has been reported by Hapase and Repale [34].

Conclusion: High heritability coupled with high genetic advance was recorded for number of shoots at 120 days, cane yield , CCS (t/ha) under water stress (E2) environment indicated that direct selection of these traits under water stress conditions could be effective for development of new varieties in rainfed conditions.

Application of research: Variability studies for cane yield, physiological and quality traits in sugarcane under water stress conditions are directly applicable for identification/development of new varieties suitable for rainfed conditions.

Table-1 Analysis of variance for different cane yield, its component, physiological and quality traits in sugarcane under normal (E1) and water stress (E2) environments

SN	Traits	Mean Squares					
	S.V.	Replications		Varieties/Clones		Error	
	Df	1		29		29	
	Env.	E_1	E_2	E_1	E_2	E_1	E_2
	Cane yield and component traits						
1	Germination (%)	2.59	60.11	220.15*	100.64*	45.23	17.30
2	No. of shoots at 120 days (000/ha)	232.04	1401.66	680.36*	442.61*	178.58	47.12
3	No. of tillers at 240 days (000/ha)	248.07	3226.65	738.14*	368.78*	206.48	68.32
4	No. of millable canes (000/ha)	1075.27	170.02	628.00*	357.33*	166.27	107.02
5	Stalk length (cm)	400.53	11070.36	1417.5	1485.66*	482.93	186.59
6	Stalk diameter (cm)	0.01	0.81	0.17*	0.10*	0.04	0.02
7	Single cane weight (kg)	0.16	0.03	0.30*	0.22*	0.05	0.02
8	Cane yield (t/ha)	32.27	240	433.6*	238.45*	50.47	10.76
	Physiological traits						
1	Relative water content (%) at 60 DAP	0.49	2.14	26.34	131.02*	12.38	66.77
2	Relative water content (%) at 120 DAP	0.04	136.68	110.32*	136.01*	30.57	69.65
3	Chlorophyll a (mg/l)	0.84	0.12	0.26	0.25	0.21	0.17
4	Chlorophyll b (mg/l)	2.21	2.04	0.65	0.52*	0.56	0.22
5	Total chlorophyll (mg/l)	0.99	1.11	1.78*	1.45*	0.84	0.57
6	Stomatal frequency (no.)	0.27	35.27	25.12	22.92	5.68	4.44
7	Specific leaf weight (g)	0.25	2.74	2.25*	1.76*	1.19	0.28
	Quality traits at 10 and 12 months						
1	Brix at 10 months (%)	0.03	0.14	5.39*	5.58*	0.54	0.32
2	Pol in juice at 10 months (%)	0.16	0.02	4.39*	4.29*	0.40	0.29
3	Extraction at 10 months (%)	108.72	24.34	29.52*	41.72*	9.52	6.71
4	Purity at 10 months (%)	1.77	1.39	22.87	23.96*	13.98	5.71
5	CCS at 10 months (%)	0.12	0.11	2.33*	2.21*	0.31	0.19
6	Brix at 12 months (%)	0.64	0.10	1.99*	2.37*	0.38	0.28
7	Pol in juice at 12 months (%)	0.02	0.10	2.25*	3.02*	0.40	0.16
8	Extraction at 12 months (%)	0.05	19.78	41.64*	34.54*	16.29	8.72
9	Purity at 12 months (%)	10.27	0.15	20.58*	21.34*	8.07	3.98
10	CCS at 12 months (%)	0.01	0.05	1.48*	1.93*	0.32	0.10
11	Fibre content at harvest (%)	4.75	0.06	2.28*	1.56*	0.61	0.60
12	Pol in cane at harvest (%)	0.03	0.09	1.48*	1.56*	0.32	0.42
13	CCS at harvest (t/ha)	0.24	2.49	8.29*	4.31*	0.93	0.16

* Significant at 5% level of significance

Table-2 Genetic variability parameters for cane yield, its components, physiological and quality traits in sugarcane under normal (E1) and water stress (E2) environments

Traits	PCV (%)		GCV (%)		GA (%)		h_{bs}^2	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
Cane yield and component traits								
Germination (%)	26.46	27.00	21.48	22.69	35.93	39.30	65.91	70.66
No. of shoots at 120 days (000/ha)	16.33	18.67	12.48	16.78	19.65	31.06	58.42	80.76
No. of tillers at 240 days (000/ha)	17.87	18.53	13.40	15.37	20.72	26.24	56.28	68.74
No. of millable canes (000/ha)	17.77	20.91	13.55	15.35	21.28	23.22	58.13	53.91
Stalk length (cm)	11.52	16.19	8.08	14.27	11.67	25.90	49.18	77.68
Stalk diameter (cm)	13.43	15.01	10.71	12.55	17.59	21.61	63.56	69.91
Single cane weight (kg)	28.36	34.62	23.75	30.88	40.97	56.72	70.12	79.53
Cane yield (t/ha)	20.36	21.69	18.12	20.73	33.20	40.82	79.15	85.37
Physiological traits								
Relative water content (%) at 60 DAP	6.11	20.37	3.67	11.61	4.54	13.63	36.06	32.48
Relative water content (%) at 120 DAP	12.87	23.79	9.68	13.52	15.01	15.82	56.60	32.27
Total Chlorophyll content (mg/litre)	15.80	20.88	9.46	13.80	11.68	18.78	35.88	43.66
Stomatal frequency (no.)	8.94	13.07	7.10	10.74	11.62	18.18	63.11	67.55
Specific leaf weight (g)	26.07	29.44	14.48	25.14	16.57	44.21	30.87	72.90
Quality traits								
Brix at 10 months (%)	10.63	12.08	9.61	11.40	17.90	22.16	81.77	89.06
Pol in juice at 10 months (%)	10.94	13.04	9.98	12.17	18.77	23.42	83.32	87.17
Extraction at 10 months (%)	8.94	10.74	5.90	9.13	8.70	7.59	51.21	72.30
Purity at 10 months (%)	4.91	4.72	2.41	3.70	2.44	5.98	24.14	61.51
CCS at 10 months (%)	11.81	14.20	10.35	13.02	18.68	24.59	76.81	84.06
Brix at 12 months (%)	5.73	6.62	4.73	5.88	8.05	10.75	68.20	78.81
Pol in juice at 12 months (%)	6.73	8.42	5.62	7.99	9.65	15.63	69.58	90.05
Extraction at 12 months (%)	9.73	9.78	6.44	7.56	8.77	12.03	43.76	59.69
Purity at 12 months (%)	4.19	4.13	2.77	3.42	3.77	5.84	43.69	68.59
CCS at 12 months (%)	7.92	9.86	6.38	9.34	10.57	18.24	64.76	89.83
Fibre content at harvest (%)	9.17	9.80	6.97	6.53	10.90	8.98	57.69	44.46
Pol in cane at harvest (%)	7.09	8.67	5.17	6.60	9.46	10.35	64.76	57.94
CCS at harvest (t/ha)	23.38	28.11	20.89	27.06	38.43	53.66	79.78	92.65

Table-3 Mean and percent decrease for cane yield and Component, physiological and quality traits in sugarcane traits under normal (E1) and water stress (E2) environments

S. No.	Genotype	Germination (%)			No. of shoots at 120 days (000/ha)			No. of tillers at 240 days (000/ha)			NMC (000/ha)			Stalk length (cm)			Stalk diameter (cm)			Single cane weight (kg)			Cane yield (ton/ha)		
		Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2
1	CoPb10181	58.00	30.00	48.28	135.00	93.00	31.11	132.00	91.00	31.06	119.00	69.00	42.02	283.33	150.00	47.06	2.90	1.64	43.45	2.02	1.23	39.11	110.00	64.31	41.54
2	CoPb13181	55.00	33.74	38.65	131.00	87.00	33.59	120.00	81.00	32.50	111.00	69.00	37.84	296.67	193.17	34.89	2.43	1.64	32.51	1.71	1.12	34.50	83.33	57.10	31.48
3	CoPb13182	27.36	17.62	35.60	137.00	77.00	43.80	134.00	74.00	44.78	128.00	65.00	49.22	303.33	176.20	41.91	2.50	1.60	36.00	1.52	0.98	35.53	79.69	51.39	35.51
4	CoPb13183	65.00	40.50	37.69	143.00	102.00	28.67	141.00	94.00	33.33	122.00	73.00	40.16	283.33	173.59	38.73	2.33	1.61	30.90	1.26	0.80	36.51	72.05	41.67	42.17
5	CoPb11214	54.67	32.00	41.47	142.00	85.00	40.14	139.00	80.00	42.45	116.00	65.00	43.97	246.67	140.00	43.24	2.17	1.21	44.24	0.99	0.52	47.47	68.75	36.46	46.97
6	CoPb11211	38.25	21.00	45.10	91.00	53.00	41.76	83.00	51.00	38.55	77.00	47.00	38.96	263.33	156.00	40.76	2.63	1.59	39.54	1.57	0.89	43.31	48.78	25.42	47.89
7	CoPb12181	32.22	22.32	30.73	119.00	78.00	34.45	113.00	72.00	36.28	100.00	68.00	32.00	259.17	174.90	32.52	2.25	1.57	30.22	1.07	0.67	37.38	54.51	38.19	29.94
8	CoPb12182	29.03	19.97	31.21	125.00	86.00	31.20	120.00	79.00	34.17	104.00	69.00	33.65	277.50	180.12	35.09	2.38	1.66	30.25	1.24	0.92	25.81	65.97	43.40	34.21
9	CoPb14212	33.00	23.00	30.30	117.00	76.00	35.04	111.00	72.00	35.14	107.00	69.00	35.51	240.83	176.20	26.84	2.08	1.50	27.88	0.75	0.51	32.00	57.12	38.19	33.14
10	CoPb14211	40.55	27.80	31.44	122.00	85.00	30.33	116.00	85.00	26.72	114.00	75.00	34.21	263.33	189.26	28.13	2.17	1.39	35.94	0.91	0.60	34.07	63.72	41.88	34.27
11	CoPb12212	38.06	22.19	41.70	157.00	81.00	48.41	150.00	80.00	46.67	131.00	67.00	48.85	292.50	180.12	38.42	2.52	1.54	38.89	1.54	1.01	34.42	82.64	53.84	34.85
12	L 818/07	51.80	26.43	48.98	153.00	79.00	48.37	148.00	76.00	48.65	144.00	72.00	50.00	255.50	140.00	45.21	2.00	1.02	49.00	0.92	0.48	47.83	96.18	52.08	45.85
13	KV2012- 1	28.33	21.00	25.87	109.00	76.00	30.28	107.00	74.00	30.84	97.00	69.00	28.87	296.83	220.00	25.88	2.67	1.93	27.72	1.84	1.40	23.91	91.49	65.97	27.89
14	KV2012- 2	36.39	28.00	23.06	102.00	76.00	25.49	95.00	72.00	24.21	88.00	69.00	21.59	278.33	210.00	24.55	2.75	1.96	28.73	1.74	1.35	22.41	76.39	59.03	22.73
15	KV2012- 3	39.44	29.00	26.47	134.00	96.00	28.36	131.00	94.00	28.24	127.00	93.00	26.77	253.50	190.00	25.05	2.43	1.85	23.87	1.99	1.52	23.62	100.69	76.39	24.13
16	KV2012-4	37.64	28.00	25.61	100.00	72.00	28.00	92.00	65.00	29.35	86.00	65.00	24.42	266.67	212.00	20.50	2.58	1.96	24.03	1.55	1.16	25.16	77.43	60.76	21.53
17	KV2012- 5	52.08	39.00	25.12	136.00	101.00	25.74	129.00	96.00	25.58	120.00	91.00	24.17	308.33	240.00	22.16	2.53	1.89	25.30	1.65	1.25	24.24	86.63	64.24	25.85
18	ISH 148	41.00	33.00	19.51	154.00	118.00	23.38	124.00	99.00	20.16	114.00	94.00	17.54	237.00	195.00	17.72	1.88	1.53	18.62	1.68	1.36	19.05	58.33	48.61	16.66
19	ISH 07	43.91	34.00	22.57	121.00	90.00	25.62	108.00	86.00	20.37	106.00	83.00	21.70	269.17	216.00	19.75	2.23	1.72	22.87	1.78	1.42	20.22	61.63	50.35	18.30
20	ISH 135	46.97	38.00	19.10	125.00	102.00	18.40	121.00	96.00	20.66	116.00	93.00	19.83	251.67	195.00	22.52	1.83	1.48	19.13	1.79	1.46	18.44	63.02	49.65	21.22
21	ISH 159	45.14	35.00	22.46	123.00	96.00	21.95	120.00	93.00	22.50	112.00	91.00	18.75	242.50	185.00	23.71	2.45	1.95	20.41	1.64	1.32	19.51	61.28	47.57	22.37
22	Co 238	42.78	31.00	27.54	132.00	95.00	28.03	129.00	92.00	28.68	125.00	88.00	29.60	283.33	193.17	31.82	2.53	1.82	28.06	1.71	1.25	26.90	85.29	61.58	27.80
23	CoJ88	32.64	17.50	46.38	111.00	61.00	45.05	110.00	58.00	47.27	109.00	56.00	48.62	206.67	120.00	41.94	2.43	1.40	42.39	1.02	0.59	42.16	81.21	51.26	36.88
24	CoS8436	47.02	28.00	40.45	124.00	67.00	45.97	118.00	65.00	44.92	108.00	63.00	41.67	192.50	126.00	34.55	2.63	1.58	39.92	0.96	0.54	43.75	72.69	46.52	36.00
25	CoPb91	39.53	21.00	46.88	100.00	65.00	35.00	99.00	62.00	37.37	81.00	48.00	40.74	290.00	160.00	44.83	3.10	1.72	44.52	2.24	1.31	41.52	97.43	59.00	39.44
26	Co 118	50.97	28.00	45.07	123.00	71.00	42.28	121.00	69.00	42.98	120.00	67.00	44.17	271.67	168.37	38.02	2.67	1.56	41.57	1.63	0.98	39.88	77.00	48.61	36.87
27	CoJ85	32.78	19.36	40.94	112.00	72.00	35.71	106.00	70.00	33.96	94.00	58.00	38.30	282.50	170.00	39.82	2.82	1.77	37.23	1.76	1.15	34.66	73.82	48.00	34.98
28	CoJ64	67.91	45.00	33.74	163.00	106.00	34.97	161.00	104.00	35.40	146.00	94.00	35.62	260.83	165.00	36.74	2.25	1.57	30.22	1.03	0.68	33.98	72.65	42.00	42.19
29	CoPb92	51.80	28.60	44.79	155.00	97.00	37.42	152.00	94.00	38.16	146.00	89.00	39.04	293.33	180.00	38.64	2.17	1.32	39.17	1.25	0.72	42.40	80.56	55.00	31.73
30	CoPb93	46.86	33.28	28.98	111.00	72.00	35.14	106.00	69.00	34.91	100.00	67.00	33.00	278.33	185.00	33.53	2.22	1.50	32.43	1.36	0.96	29.41	94.33	68.25	27.65
	GM	43.53	28.44	34.19	127.00	84.00	33.79	122.00	80.00	33.86	112.13	72.88	34.79	267.48	178.65	33.15	2.41	1.61	32.83	1.47	1.00	32.64	76.40	51.40	32.40
	Range	27.36-67.91	17.50-45.00	19.10-48.98	91.00-163.00	53.00-118.00	18.40-48.41	83.00-161.00	51.00-104.00	20.16-48.65	77.00-146.00	47.00-94.00	17.54-50.00	192.50-308.33	120-240	17.72-47.06	1.83-3.10	1.02-1.96	18.62-49.00	0.75-2.24	0.48-1.52	18.44-47.83	48.78-110.00	25.42-76.39	16.66-47.89

Table-3 Mean and percent decrease for cane yield and Component, physiological and quality traits in sugarcane traits under normal (E1) and water stress (E2) environments (Contd……)

Sr. No.	Genotype	RWC at 60 days			RWC at 120 days			Chlorophyll a			Chlorophyll b			Total chlorophyll			Number of stomata (no./microscopic field)			Specific leaf weight (gm)		
		Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2
1	CoPb10181	76.76	48.00	37.47	65.00	34.00	47.69	3.47	1.96	43.52	3.99	2.13	46.62	7.46	4.20	43.70	45.00	27.00	40.00	4.64	2.69	42.03
2	CoPb13181	76.12	52.00	31.69	73.96	45.41	38.60	3.31	2.19	33.84	4.03	3.05	24.32	7.34	5.06	31.06	44.00	28.00	36.36	5.28	3.13	40.72
3	CoPb13182	70.12	46.99	32.99	65.00	40.17	38.20	3.20	2.16	32.50	3.98	2.93	26.38	7.18	4.48	37.60	44.00	28.00	36.36	6.96	4.20	39.66
4	CoPb13183	73.53	49.34	32.90	53.29	29.00	45.58	3.31	2.23	32.63	3.75	2.36	37.07	6.95	4.23	39.14	47.00	32.00	31.91	4.48	2.98	33.48
5	CoPb11214	72.69	39.00	46.35	67.25	35.00	47.96	2.68	1.39	48.13	2.91	1.56	46.39	5.59	3.12	44.19	47.00	32.00	31.91	7.48	5.60	25.13
6	CoPb11211	76.37	52.82	30.84	77.30	43.00	44.37	3.16	1.93	38.92	3.56	2.40	32.58	6.71	4.02	40.09	48.00	35.00	27.08	5.83	3.40	41.68
7	CoPb12181	71.93	46.99	34.67	57.32	40.68	29.03	3.63	2.39	34.16	4.25	3.02	28.94	7.87	4.98	36.72	45.00	31.00	31.11	4.36	2.88	33.94
8	CoPb12182	80.25	65.00	19.00	64.58	46.50	28.00	3.01	1.98	34.22	3.29	2.03	38.30	6.30	4.19	33.49	47.00	35.00	25.53	4.94	3.34	32.39
9	CoPb14212	68.50	46.99	31.40	76.38	49.00	35.85	3.52	2.16	38.64	4.08	2.74	32.84	7.60	4.95	34.87	37.00	25.00	32.43	3.23	2.15	33.44
10	CoPb14211	72.99	53.59	26.58	60.13	30.00	50.11	2.95	1.83	37.97	3.41	2.36	30.79	6.36	4.32	32.08	41.00	29.00	29.27	4.25	2.75	35.29
11	CoPb12212	62.90	34.00	45.95	67.51	34.00	49.64	3.41	2.09	38.71	3.98	2.39	39.95	7.39	4.65	37.08	39.00	29.00	25.64	3.81	2.19	42.52
12	L 818/07	70.71	35.00	50.50	66.25	34.00	48.68	2.94	1.63	44.56	3.35	1.86	44.48	6.29	3.50	44.36	47.00	27.00	42.55	4.64	2.83	39.01
13	KV2012- 1	78.67	62.00	21.19	47.35	34.18	27.81	3.04	2.19	27.96	3.79	2.68	29.29	6.82	4.97	27.13	42.00	24.00	42.86	6.61	4.86	26.48
14	KV2012- 2	74.80	56.00	25.13	77.19	58.00	24.86	3.38	2.65	21.60	3.78	2.96	21.69	7.16	5.36	25.14	43.00	28.00	34.88	5.69	4.29	24.60
15	KV2012- 3	72.33	52.47	27.46	73.33	55.00	25.00	3.76	2.86	23.94	4.59	3.47	24.40	8.35	6.18	25.99	38.00	24.00	36.84	6.65	4.89	26.47
16	KV2012-4	75.32	54.82	27.22	55.58	41.11	26.03	3.84	2.95	23.18	4.79	3.63	24.22	8.62	6.50	24.59	45.00	23.00	48.89	6.75	5.10	24.44
17	KV2012- 5	72.32	53.25	26.37	61.67	48.00	22.17	3.40	2.46	27.65	4.06	3.09	23.89	7.46	5.54	25.74	41.00	25.00	39.02	5.39	4.28	20.59
18	ISH 148	69.92	56.00	19.91	63.14	52.00	17.64	3.67	2.84	22.62	4.51	3.62	19.73	8.18	6.38	22.00	51.00	30.00	41.18	5.25	4.12	21.52
19	ISH 07	70.35	58.00	17.56	64.10	53.00	17.32	2.99	2.43	18.73	3.55	2.79	21.41	6.54	5.26	19.57	42.00	24.00	42.86	4.68	3.73	20.30
20	ISH 135	72.19	59.00	18.27	67.55	55.00	18.58	3.09	2.59	16.18	3.30	2.83	14.24	6.38	5.29	17.08	52.00	31.00	40.38	4.98	3.98	20.08
21	ISH 159	69.02	54.00	21.76	61.89	51.00	17.60	2.76	2.19	20.65	3.33	2.76	17.12	6.09	4.90	19.54	41.00	22.00	46.34	4.64	3.69	20.47
22	Co 238	69.85	51.00	26.99	63.10	45.00	28.68	3.88	2.75	29.12	4.89	3.21	34.36	8.77	6.10	30.44	44.00	31.00	29.55	5.00	3.80	24.00
23	CoJ88	66.70	34.00	49.03	62.50	34.00	45.60	2.54	1.95	23.23	2.68	2.05	23.51	5.22	3.20	38.70	46.00	32.00	30.43	3.81	2.10	44.88
24	CoS8436	67.08	42.00	37.39	57.50	35.00	39.13	3.84	2.19	42.97	4.63	2.83	38.88	8.47	4.71	44.39	45.00	28.00	37.78	4.33	2.80	35.33
25	CoPb91	70.94	38.00	46.43	55.36	32.00	42.20	3.40	2.35	30.88	3.88	2.35	39.43	7.27	4.48	38.38	45.00	29.00	35.56	3.89	2.15	44.73
26	Co 118	71.58	44.00	38.53	76.67	46.63	39.18	3.55	2.21	37.75	3.93	2.32	40.97	7.98	4.69	41.23	43.00	26.00	39.53	5.00	3.02	39.60
27	CoJ85	73.70	50.32	31.72	70.00	45.52	34.97	3.44	2.18	36.63	3.63	2.35	35.26	7.07	4.38	38.05	38.00	27.00	28.95	5.35	3.26	39.07
28	CoJ64	69.93	43.86	37.28	68.81	46.33	32.67	2.99	2.21	26.09	3.06	2.16	29.41	6.55	4.11	37.25	41.00	28.00	31.71	3.54	2.39	32.49
29	CoPb92	73.45	41.00	44.18	67.26	37.00	44.99	3.59	2.19	39.00	4.74	2.75	41.98	8.87	5.05	43.07	47.00	33.00	29.79	5.42	3.31	38.93
30	CoPb93	69.97	45.42	35.09	69.18	49.00	29.17	3.81	2.65	30.45	4.47	3.21	28.19	8.27	5.60	32.29	42.00	28.00	33.33	4.01	2.80	30.17
	GM	72.03	48.82	32.39	65.20	42.61	34.58	3.31	2.25	31.88	3.87	2.66	31.22	7.23	4.81	33.50	44.00	28.30	35.34	5.02	3.42	32.45
	Range	62.90-80.25	34.00-65.00	17.56-50.50	47.35-77.30	29.00-58.00	17.32-50.11	2.54-3.88	1.39-2.95	16.18-48.13	2.68-4.89	1.56-3.63	14.24-46.62	5.22-8.87	3.12-6.50	17.08-34.39	37.00-52.00	22.00-35.00	25.53-48.89	3.23-7.48	2.10-5.60	20.08-44.88

Table-3 Mean and percent decrease for cane yield and Component, physiological and quality traits in sugarcane traits under normal (E1) and water stress (E2) environments (Contd……)

Sr. No.	Genotype	Brix at 12 months (%)			Pol at 12 months (%)			Extraction at 12 months (%)			Purity at 12 months (%)			CCS at 12 months (%)			Fibre at harvest (%)			Pol cane at harvest (%)			CCS at harvest (t/ha)		
		Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2	Mean E_1	Mean E_2	% ↓ in mean under E_2
1	CoPb10181	18.83	17.86	5.15	17.09	15.27	10.65	60.46	48.21	20.26	90.85	85.56	5.82	11.97	10.39	13.20	14.56	10.84	25.55	13.37	11.36	15.03	13.09	6.67	49.05
2	CoPb13181	18.58	17.85	3.93	17.68	15.90	10.07	58.88	51.21	13.03	95.17	89.10	6.38	12.64	11.03	12.74	11.66	9.45	18.95	14.04	12.26	12.68	10.54	6.25	40.70
3	CoPb13182	20.43	16.59	18.80	18.16	14.60	19.60	60.80	49.63	18.37	88.92	88.00	1.03	12.60	10.08	20.00	13.78	11.88	13.79	14.00	11.41	18.50	10.04	5.18	48.41
4	CoPb13183	18.94	17.62	6.97	16.80	14.97	10.89	56.76	47.29	16.68	88.69	84.98	4.18	11.64	10.16	12.71	11.44	9.36	18.18	13.04	11.56	11.35	8.36	4.24	49.28
5	CoPb11214	20.15	17.42	13.55	18.24	13.91	23.74	51.06	43.28	15.24	90.75	79.84	12.02	12.76	9.13	28.45	12.83	11.07	13.72	14.16	10.34	26.98	8.74	3.31	62.13
6	CoPb11211	19.26	17.05	11.47	17.61	13.69	22.26	59.87	46.58	22.20	91.43	80.34	12.13	12.37	9.01	27.16	12.54	8.50	32.22	13.77	10.31	25.13	6.06	2.27	62.54
7	CoPb12181	18.81	16.44	12.60	16.77	13.90	17.11	59.27	52.24	11.86	89.19	84.67	5.07	11.65	9.40	19.31	13.25	10.39	21.58	13.05	10.64	18.47	6.34	3.61	43.06
8	CoPb12182	17.80	15.42	13.37	15.30	12.65	17.32	58.27	44.86	23.01	85.93	82.01	4.56	10.43	8.42	19.27	11.59	9.12	21.31	11.84	9.76	17.57	6.92	3.63	47.54
9	CoPb14212	16.50	14.86	9.94	14.53	13.04	10.25	53.72	47.68	11.24	88.01	87.77	0.27	10.03	8.98	10.47	12.25	9.68	20.98	11.43	10.28	10.06	5.70	3.45	39.47
10	CoPb14211	18.77	16.11	14.17	16.23	12.90	20.52	54.05	42.18	21.96	86.49	80.11	7.38	11.10	8.48	23.60	14.39	10.35	28.08	12.51	9.95	20.46	7.13	3.53	50.49
11	CoPb12212	17.30	14.93	13.70	15.11	12.59	16.68	53.52	41.29	22.85	87.29	84.38	3.33	10.39	8.50	18.19	14.25	11.36	20.28	11.79	9.61	18.49	8.55	4.56	46.67
12	L 818/07	18.96	17.80	6.12	16.81	14.97	10.95	51.22	43.68	14.72	88.59	84.13	5.03	11.64	10.10	13.23	11.96	10.36	13.38	13.04	11.40	12.58	11.18	5.28	52.77
13	KV2012- 1	20.06	18.81	6.23	18.63	16.67	10.52	50.99	45.63	10.51	92.87	88.66	4.53	13.18	11.55	12.37	12.98	11.23	13.48	14.58	12.47	14.47	12.08	7.62	36.92
14	KV2012- 2	20.45	18.54	9.34	18.84	17.38	7.75	58.03	49.68	14.39	92.10	90.52	1.72	13.28	12.35	7.00	13.58	11.54	15.02	14.68	12.32	16.08	10.15	7.32	27.88
15	KV2012- 3	19.50	18.51	5.08	18.24	16.63	8.83	54.56	48.21	11.64	93.50	89.82	3.94	12.94	11.59	10.43	11.36	10.05	11.53	14.35	12.50	12.89	13.05	8.85	32.18
16	KV2012-4	20.69	18.73	9.47	18.30	16.29	10.98	57.88	50.31	13.08	88.53	86.95	1.78	12.66	11.18	11.69	14.21	12.24	13.86	14.07	12.07	14.21	9.78	6.79	30.57
17	KV2012- 5	20.10	18.66	7.16	17.42	16.02	8.04	56.47	47.65	15.62	86.67	85.88	0.91	11.93	10.93	8.38	12.36	10.84	12.30	13.34	11.61	12.97	10.41	7.03	32.47
18	ISH 148	18.11	17.39	3.98	16.05	14.71	8.35	47.79	43.25	9.50	88.59	84.56	4.55	11.11	9.95	10.44	12.32	10.85	11.93	12.52	12.31	1.68	6.50	4.84	25.54
19	ISH 07	18.10	17.52	9.47	16.17	15.10	6.62	53.18	46.49	12.58	89.36	82.94	7.18	11.24	10.11	10.05	13.28	11.21	15.59	12.65	12.08	4.51	6.97	5.10	26.83
20	ISH 135	19.45	17.94	7.76	17.36	15.27	12.04	39.39	35.12	10.84	89.23	85.12	4.61	12.06	10.36	14.10	12.96	10.63	17.98	13.46	12.16	9.66	7.59	5.11	32.67
21	ISH 159	19.02	17.26	9.25	17.61	15.23	13.52	54.25	46.39	14.49	92.62	88.23	4.74	12.45	10.52	15.50	13.27	11.20	15.60	13.85	12.08	12.78	7.59	5.02	33.86
22	Co 238	18.39	17.47	5.00	16.76	15.69	6.38	53.88	51.23	4.92	91.17	89.78	1.52	11.76	10.93	7.06	12.42	10.83	12.80	13.16	12.66	3.80	9.98	6.77	32.16
23	CoJ88	19.88	18.34	7.75	17.40	15.53	10.75	56.11	51.36	8.47	87.48	84.64	3.25	11.98	10.51	12.27	14.97	10.24	31.60	13.38	11.12	16.89	9.73	5.33	45.22
24	CoS8436	18.62	17.89	3.92	17.41	16.06	7.75	54.33	49.54	8.82	93.57	89.79	4.04	12.36	11.19	9.47	13.60	10.86	20.15	13.76	11.92	13.37	9.00	5.20	42.22
25	CoPb91	17.47	16.53	5.38	16.64	14.83	10.88	55.57	50.32	9.45	95.33	89.74	5.86	11.90	10.33	13.19	12.96	10.21	21.22	13.31	11.80	11.34	11.47	6.04	47.34
26	Co 118	19.47	18.30	6.01	17.12	15.81	7.65	63.54	56.22	11.52	87.96	86.51	1.65	11.81	10.81	8.47	13.65	11.02	19.27	13.22	12.04	8.93	9.09	5.26	42.13
27	CoJ85	19.00	17.99	5.32	16.08	15.00	6.72	58.69	47.21	19.56	84.60	83.36	1.47	10.88	10.07	7.44	13.96	10.25	26.58	12.29	11.46	6.75	8.08	4.78	40.84
28	CoJ64	18.05	17.36	3.82	17.45	15.23	12.72	57.91	54.23	6.35	96.65	87.78	9.18	12.56	10.50	16.40	14.91	11.25	24.55	13.96	11.55	17.26	9.19	4.39	52.23
29	CoPb92	19.61	15.99	18.46	17.37	13.57	21.88	55.24	49.17	10.99	96.90	88.66	8.50	13.47	10.80	19.82	14.58	11.96	17.97	14.88	12.44	16.40	10.86	5.94	45.30
30	CoPb93	19.30	17.59	8.86	18.70	15.59	16.63	53.09	48.32	8.98	88.57	84.77	4.29	12.03	9.19	23.61	11.85	9.35	21.10	13.43	10.84	19.29	11.25	6.22	44.71
	GM	18.98	17.37	8.53	17.12	14.96	12.60	55.29	47.54	13.77	90.23	86.06	4.70	11.96	10.21	14.53	13.12	10.60	19.02	13.36	11.47	14.02	9.18	5.32	42.11
	Range	16.50-20.69	14.86-18.81	3.82-18.80	14.53-18.84	12.59-17.38	6.38-23.74	39.39-63.54	35.12-56.22	4.92-23.01	84.60-96.90	79.84-93.74	0.27-12.13	10.03-13.47	8.42-12.35	7.00-28.45	11.36-14.97	8.50-12.24	11.53-32.22	11.43-14.88	9.61-12.66	1.68-26.98	5.70-13.09	2.27-8.85	25.54-62.54

Research Category: Genetic variability & crop improvement

Acknowledgement / Funding: Author thankful to Regional Research Station, Kapurthala, 144602, Punjab Agricultural University, Punjab, India

***Major Advisor: Dr Gulzar S Sanghera, Principal Scientist (PBG) Sugarcane**
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Research project name: Development of Climate resilient varieties of sugarcane suitable for Punjab conditions

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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