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ASSESSMENT OF VARIABILITY IN SUGARCANE (*SACCHARUM* SPP.) SEEDLINGS OF DIFFERENT CROSSES FOR QUANTITATIVE TRAITS

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ABSTRACT

Any breeding program's effectiveness depends on a number of variables and one of those variables that maximises the benefits of selection is the amount of variability present in the genotypes. Thus, study was carried out with the aim of estimating variability in the sugarcane seedlings. The sugarcane seedlings obtained from three different crosses are planted at Sugarcane Research Institute, Pusa, Bihar India in an un-replicated trail along with a check. The analysis was carried out using Windostat and R studio software. The one-way analysis of variance studies resulted in identifying highly significant variation within and among the crosses for most of the traits. Through general studies it was found that CoP 11437 GC had obtained highest mean over the check Rajendra Ganna 1 for the characters such as plant height, number of shoots per clump, leaf length, cane diameter, number of millable canes, and brix at 10th month. For the character brix at 10th and 12th months a positive skewness and negative kurtosis was observed which indicates the values are concentrated on right of mean for skewness and the distribution of progeny showed higher peaks for kurtosis. High variability was observed among the seedlings of each cross for traits like brix value at 10th and 12th months and cane yield per clump as these traits showed high range difference.

Key words : Crosses, Cane yield, Sugarcane seedlings, Variability.

Introduction

The richest source of carbohydrates for human nourishment comes from sugarcane, which is also a cash crop and a sweet source for our taste. Sugarcane is usually 3 to 4 m high and around 5 cm in diameter that develops lateral shoots at the base to produce many stems. When mature, the stems develop into cane stalk, which makes up about 75% of the whole plant. In the period of 2021-22, India is the largest sugar-producing country in the world, with an approximate yield of 36.88 million metric tons of sugar and became second largest exporter of sugar. The global sugar production summed up to be roughly 181 million metric tons in this period (Anonymous, 2021-22).

The majority of research is done on genetic variance in crop traits, as evidenced by the rapid advancement of science and technology in plant breeding (Sadras *et al.*, 2013). Reliable data on the presence of sufficient heritable genetic variation with predictable improvements in genetics for the desired trait within the available germplasm is necessary for the development of an improved sugarcane variety. Successful plant breeding relies heavily on genetic variability, which quantifies how often a population of plants exhibits traits that are different from one another and enables breeders to further enhance the traits to create novel varieties. A higher chance of improving a trait through selection is provided by a germplasm with a wider range of trait variation (Tolera *et al.*, 2023).

Effective genotype selection in the early stages of breeding programmes is the main challenge. Since sugarcane is extremely heterozygous in nature, the seedlings of the cross exhibit significant variation as a result of chromosomal abnormalities that occurred during the gamete development process (Potapova and Gorbsky, 2017). Examining separated seedlings sown from true seeds obtained through crossing is the first step in the selection process. The majority of research is done on genetic variance in crop traits, as evidenced by the rapid advancement of science and technology in plant breeding (Sadras *et al.*, 2013). Reliable data on the presence of sufficient heritable genetic variation with predictable improvements in genetics for the desired trait within the available germplasm is necessary for the development of an improved sugarcane variety.

Materials and Methods

Plant material

In the February of 2022 season, a trial was carried out using two general crosses *i.e.*, BO154 GC, CoP 11437 GC and one bi parental cross (Co 0238 × Co 775) seedlings that were raised from the fluffs of the crosses at National Hybridization Garden, SBI, Coimbatore by the breeders of Sugarcane Research Institute, Pusa, Bihar for evaluation.

Experimental details

An un-replicated trail was used to arrange the experimental materials for the purpose of selecting individual plants and the same check was replicated for each cross. After transplantation, from each slot of crosses ten seedlings were selected and tagging was done including the check (Rajendra Gaana 1) in order to collect quantitative data for this study.

Statistical analysis

The data was analysed using one way ANOVA, which was given by R.A. Fisher in 1928. In this study, one way ANOVA is performed to divide the data into groups and for its estimation different equations are used.

$$\bar{y} = \frac{1}{N}\sum_{i=1}^{k} \cdot \sum_{j=1}^{n_i} yij$$

Where, $\bar{y}$ = Grand mean; N = Number of samples; yij = Independent normal variables 1, 2, 3, …, k.

$$\text{Total mean sum of squares MST} = \frac{SST}{df(SST)} = \frac{SST}{N-1}$$

Where, SST = Total sum of squares, df = Degrees of freedom, N = Number of samples.

Assuming that the test conditions meet the criteria, the one-way ANOVA employs the subsequent test statistic:

$$F = \frac{MSC}{MSE}$$

Basic one-way ANOVA table:

Source of Variation	Sum of Squares (SS)	Degrees of freedom (df)	Mean square	F- Statistic	Tail area above F
Between groups	SSC	k-1	MSC	MSC/MSE	P- value
Within groups	SSE	N-k	MSE		
Total	SST	N-1			

Where, MSC = Mean sum of squares for treatment; MSE = Mean sum of error

Results and Discussion

Numerous investigations and computational analyses have demonstrated that the selection of individual clones is a feasible and economical approach for selection during the initial stages of sugarcane trials (Farrag *et al.*, 2018).

Analysis of variance

For the majority of the traits, except plant height and the number of shoots per clump, the one-way analysis of variance revealed highly significant differences among the 10 seedlings of each cross that were evaluated (Table 1). The results are found to be similar with the findings of Dena *et al.* (2018), Farnsworth and Arioli (2018), Farrag *et al.* (2018) and Xu *et al.* (2023). Since the differences between crosses account for a large portion of the variation within crosses, these seedlings have the potential to produce high cane and sugar yields over the subsequent stage of selection.

Variability studies

The general statistics for each cross along with check

Table 1 : One way ANOVA table for different traits of sugarcane seedlings.

Source of Variation	df	PH	LL	NS	B (10)	B (12)	CD	SCW	NMC/C	CY/C
Between crosses	2	34128.8	584.2*	142.4351	53.9*	140.6**	1.4*	1.3*	35.8**	84.3**
Within crosses	27	52591.6	5744.2	209.5	462.0	463.3	7.0	8.2	100.9	246.8
Total	29	86720.4	6328.4	351.9	515.9	603.9	8.4	9.5	136.7	331.1

Note: PH = Plant Height; NS/C= No. of Shoots per Clump; LL= Leaf Length; CD=Cane Diameter; SCW= Single Cane Weight; NMC/C= No. of Millable Canes/Clump; B (10^{th}) = Brix in 10^{th} month; B(12^{th}) = Brix in 12^{th} month; CY/C= Cane yield per Clump.

Table 2 : Descriptive statistics of different traits in sugarcane seedlings.

S. no.	Trait/ Cross Combination	Mean	SE	SD	Variance	Skewness	Kurtosis	Range		CV
								Min	Max	
1	**Plant Height**									
	Co 0238 x Co775	350	8.86	28.04	786.00	-0.348	-1.16	305	385	8.01
	BO 154	358	16.25	51.41	2643.07	-0.748	0.36	255	425	14.33
	CoP 11437	359	14.62	46.23	2137.78	0.727	-0.72	310	440	12.88
	Check	289	5.26	16.63	276.66	0.263	-0.17	265	320	5.76
2	**No. of Shoots per Clump**									
	Co 0238 x Co775	3	0.25	0.81	0.66	0	-1.39	2	4	27.22
	BO 154	5.5	0.62	1.95	3.83	-0.555	-0.29	2	8	35.0
	CoP 11437	8.3	1.32	4.16	17.34	0.727	0.83	3	17	50.18
	Check	6.1	0.38	1.19	1.43	-0.233	-0.37	4	8	19.63
3	**Leaf Length**									
	Co 0238 x Co775	146.3	3.10	9.81	96.23	0.075	-0.80	130	160	6.71
	BO 154	138.8	5.39	17.07	291.28	-0.899	1.62	102	164	12.30
	CoP 11437	148.2	4.31	13.65	186.40	0.375	-1.38	130	135	9.21
	Check	147.9	2.53	8.02	64.32	0.260	-0.20	170	162	5.42
4	**Cane Diameter**									
	Co 0238 x Co775	2.2	0.133	0.422	0.178	1.779	1.406	2	3	13.90
	BO 154	2.3	0.153	0.483	0.233	1.035	-1.224	2	3	20.96
	CoP 11437	2.6	0.163	0.516	0.267	-0.484	-2.277	2	3	14.44
	Check	2.1	0.1	0.316	0.1	3.162	10	2	3	11.32
5	**Single Cane Weight**									
	Co 0238 x Co775	1.2	0.2	0.632	0.4	-0.132	0.179	0	2	52.71
	BO 154	1.5	0.167	0.527	0.278	0	-2.571	1	2	38.79
	CoP 11437	1.3	0.153	0.483	0.233	1.035	-1.224	1	2	39.38
	Check	1	0	0	0	0	0	1	1	20.69
6	**No. of Millable Canes/Clump**									
	Co 0238 x Co775	2.8	0.249	0.789	0.622	0.407	-1.074	2	4	28.17
	BO 154	4.5	0.687	2.173	4.722	0.162	-0.771	1	8	48.29
	CoP 11437	5.4	0.686	2.171	4.711	0.658	-1.06	3	9	40.19
	Check	4.6	0.34	1.075	1.156	-0.322	-0.882	3	6	23.37
7	**Brix in 10th month**									
	Co 0238 x Co775	14.6	1.439	4.551	20.711	-1.249	0.678	6	20	31.28
	BO 154	16.6	1.185	3.748	14.044	-2.189	5.339	7	20	22.56
	CoP 11437	16.8	1.263	3.994	15.956	-1.281	1.298	8	20	24.05
	Check	17.8	0.249	0.789	0.622	0.407	-1.074	17	19	4.42
8	**Brix in 12th month**									
	Co 0238 x Co775	14.6	1.492	4.719	22.267	-0.789	0.532	5	20	32.32

Table 2 continued...

Table 2 continued...

	BO 154	18.3	1.096	3.466	12.011	-1.757	3.41	10	22	18.72
	CoP 11437	18.4	1.267	4.006	16.044	-1.145	0.699	10	22	21.31
	Check	19.6	0.34	1.075	1.156	-0.322	-0.882	18	21	5.36
9	**Cane yield per Clump**									
	Co 0238 x Co775	3.1	0.623	1.969	3.878	0.919	0.025	1	7	60.37
	BO 154	7.1	1.269	4.012	16.1	0.025	-0.884	1	13	59.23
	CoP 11437	5.9	0.623	1.969	3.878	-0.482	-1.229	3	8	30.19
	Check	5.3	0.597	1.889	3.567	0.079	-1.063	3	8	37.31

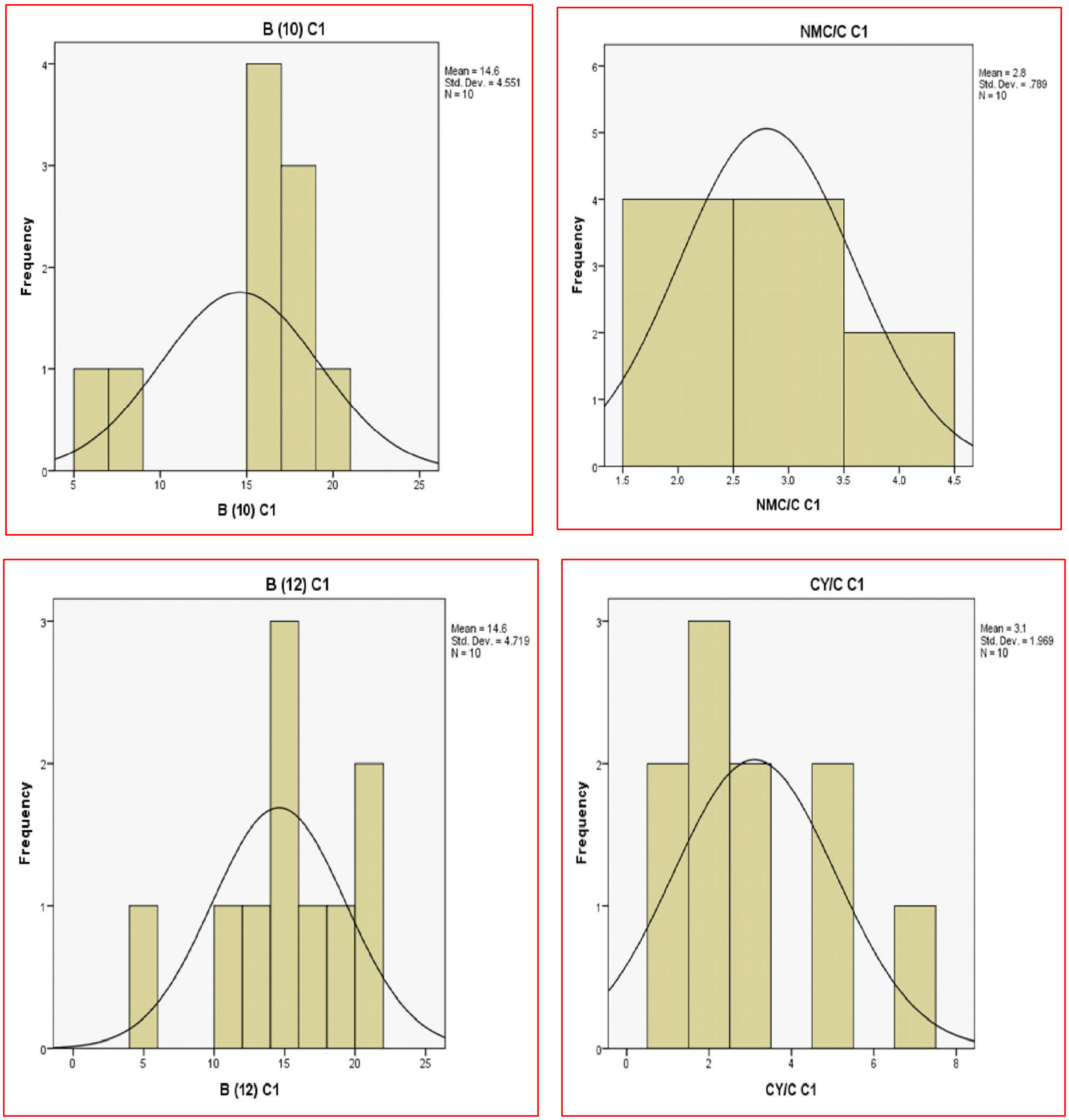

Fig. 1 : Frequency distribution of sugarcane seedlings for the trait's brix content, number of millable canes per clump and cane yield per clump (Co 0238 X Co 775).

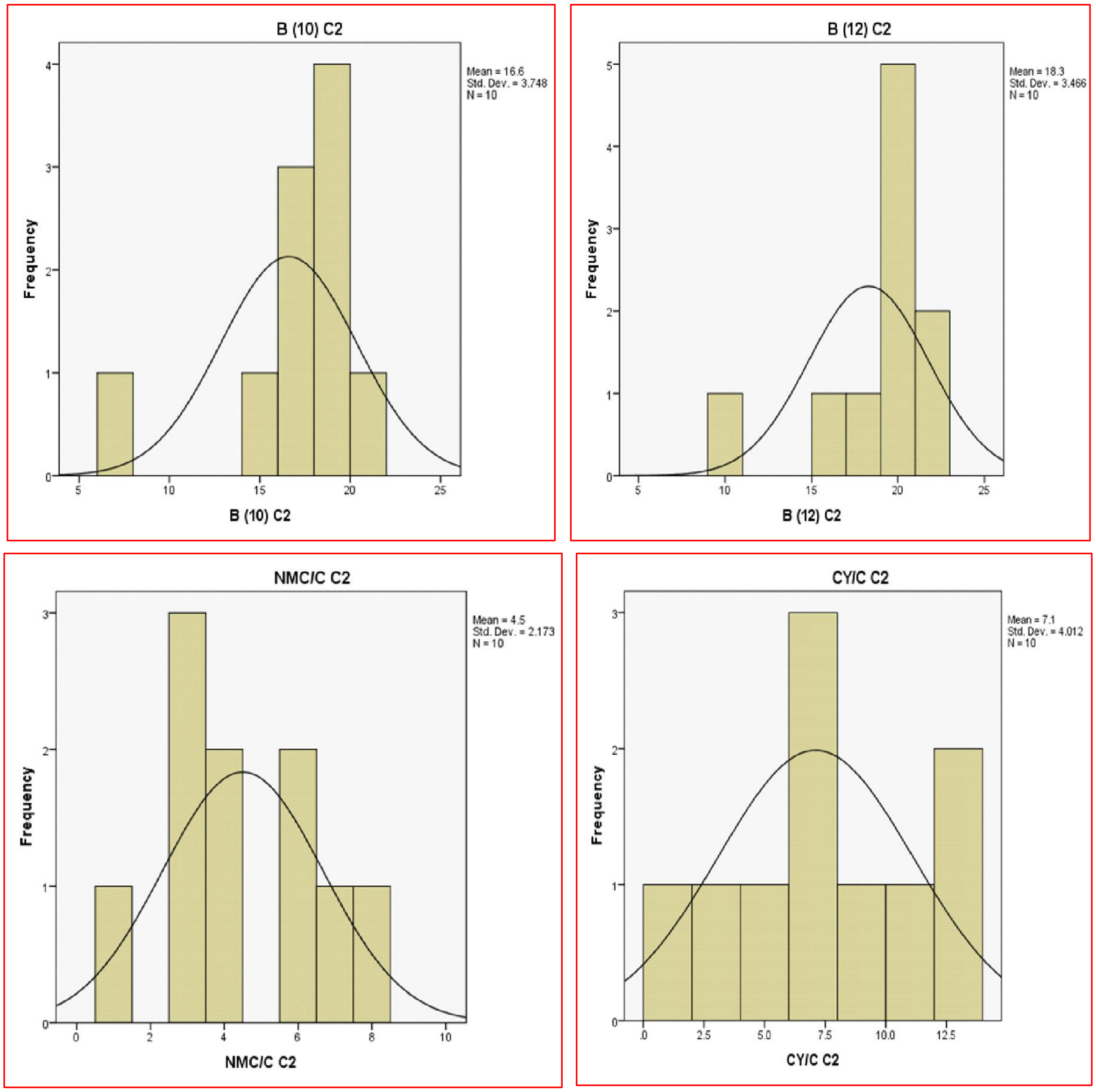

Fig. 2 : Frequency distribution of sugarcane seedlings for the trait's brix content, number of millable canes per clump and cane yield per clump (BO 154).

are represented in the Table 2. While assessing the various crosses to the check Rajendra Ganna 1, the mean performance for all the quantitative traits showed that the cross CoP 11437 GC produced the highest mean for the characters such as plant height, number of shoots per clump, leaf length, cane diameter, number of millable canes and brix at 10th month. The maximum range difference was observed in most of the traits like plant height, leaf length, number of shoots per clump, number of millable canes per clump, brix values at 10th and 12th months and cane yield per clump in all the cross combinations indicating selection of these crosses based on the following traits would be feasible for further breeding programmes. The results obtained through this study were in accordance with the findings of other researchers (Kumar *et al*., 2018; Thierry *et al*., 2018; Abu-Ellail *et al*., 2020; Tolera *et al*., 2023).

All the crosses for the trait brix at 10th and 12th months showed the values to be less than zero which represents positive skewness indicating the values to be concentrated on right of the mean while the values were greater than zero for kurtosis which represents negative kurtosis inferring the distribution of progeny to have higher peaks around the mean compared to normal distributions. This signified that the most of the seedlings from these crosses performed superior to the population mean. The results obtained are on par with the research done by Bharathi *et al*. (2017), Somu and Nagaraja (2018), Xu *et al*. (2023).

The highest brix value and cane yield in the cross Co 0238 × Co 775 was found to be in the eighth seedling and

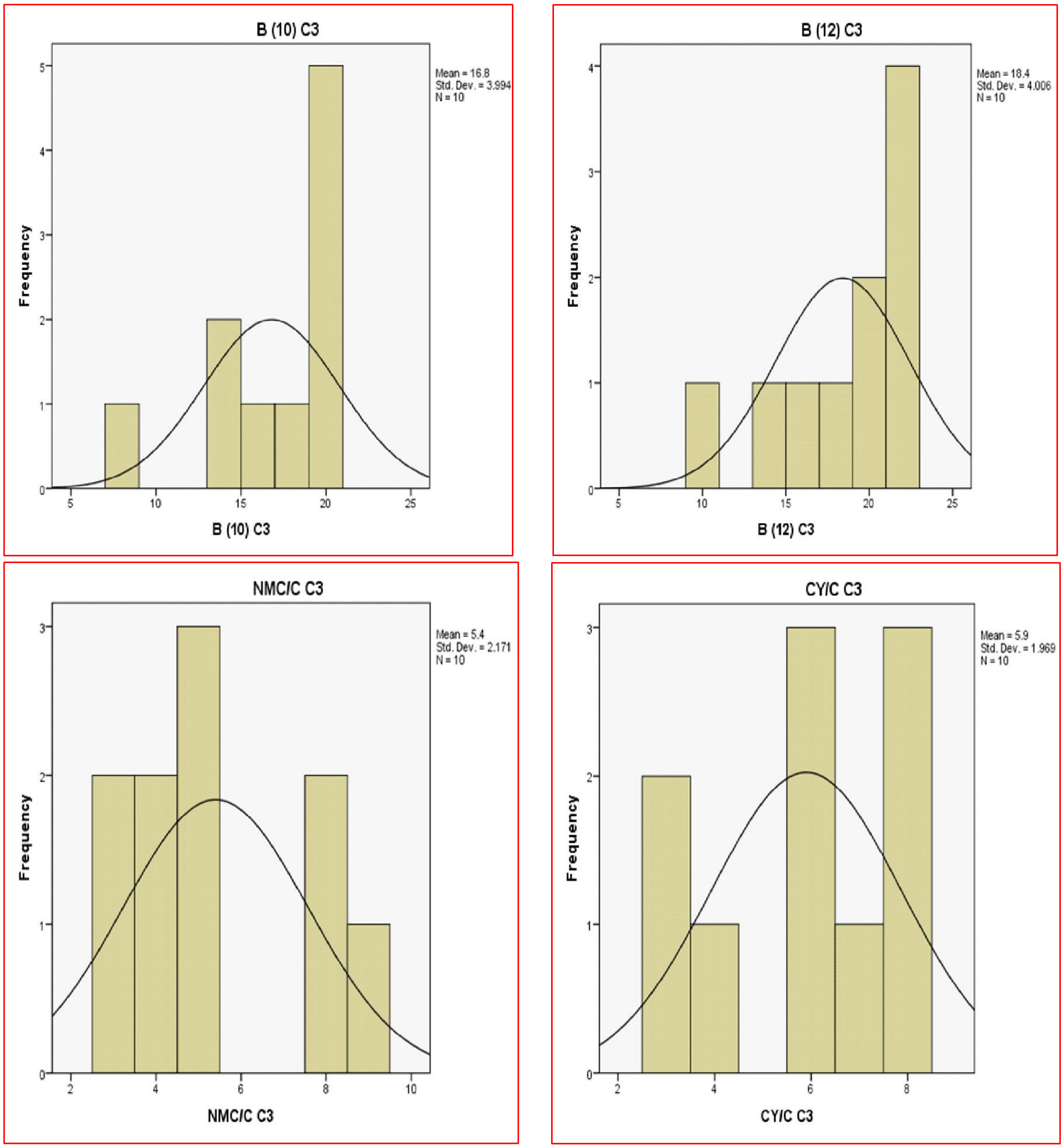

Fig. 3 : Frequency distribution of sugarcane seedlings for the trait's brix content, number of millable canes per clump and cane yield per clump (CoP 11437).

lowest in the first seedling, whereas for the cross BO 154 GC the highest value for brix at 10th month was observed in the third seedling and lowest in seventh seedling. Similarly for brix value at 12th month the sixth seedling showed highest value. For the same cross the cane yield was highest for fourth seedling and lowest for seventh seedling. The cross CoP 11437 GC represented highest brix value for the tenth seedling and for trait cane yield per clump the first seedling obtained highest value. When compared with the check Rajendra Ganna 1, it was evident from the result that none of the seedlings from the bi-parental cross Co 0238 × Co 775 had obtained high cane yield whereas few seedlings from the crosses BO 154 GC and CoP 11437 GC showed highest cane yield per clump over the check. Thus, Table 3 illustrates the extreme variability in the brix value at the 10th and 12th month in addition to cane yield for the ten seedlings chosen for the crosses Co 0238 × Co 775, BO 154 GC, and CoP 11437 GC. This in turn indicates within the seedlings much variation can be observed due to several factors and selection can be carried out at the initial stages of sugarcane trails. The research findings are in accordance with Afghan *et al*. (2013), Nisha *et al*. (2019), Saleem *et al*. (2023). Each cross-combination's progeny frequency distribution for millable cane and Brix content was calculated and graphically depicted in the Figs. 1-3.

Table 3 : Variability based on cane yield and brix values of sugarcane seedlings in different crosses.

Seedlings/ Traits	Co 0238 x Co 775			B0 154			CoP 11437		
	Brix % (10th month)	Brix % (12th month)	Cane yield /lump (Kg)	Brix % (10th month)	Brix % (12th month)	Cane yield /clump (Kg)	Brix % (10th month)	Brix % (12th month)	Cane yield /clump (Kg)
1	6	5	1.16	17	19.6	5.84	18.4	20	7.68
2	7	10	1.29	14.2	15	7.92	20.2	22	6.18
3	15	15	2.4	20	20.6	5.36	15	16.4	3.3
4	17	12	1.88	19.2	20	13.44	20	22	6.8
5	16	14	2.12	17	18.2	1.74	14	14	3.36
6	17	16	2.6	19.2	22	11.2	8	10.2	3.68
7	14.8	19	5.22	7	10	0.64	19	21	6.32
8	20	20	6.9	18	19.2	6.68	20	19	7.6
9	18.2	20	5.32	17.8	19	5.97	14	18	7.56
10	15	15	3.3	17	19	12	20.4	22	5.92
Check	18	21.4	8.05	18.2	21.6	8	18	21.2	7.4

Conclusion

The present study concluded that the one-way analysis revealed a high level of genetic variability among the assessed crosses and their seedlings and the additive effects predominated in explaining the genetic variation among crosses. The mean performance indicated that highest mean was obtained by the cross CoP 11437 GC for most of the traits over the check. The high variability in the brix value at the 10th and 12th month in addition to cane yield for the ten seedlings chosen from different crosses was observed indicating the selected crosses can be further used in clonal selection.

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