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Correlation Studies in Early Clonal Generation under Water Logging Condition in Sugarcane for Yield and Its Attributing Traits

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

An experiment was carried out during 2021-22 at Sugarcane Research Institute, Dr. RPCAU, Bihar using 24 clones that were planted in augmented design along with two checks. Data was recorded for the nine characters. There was a positively significant correlation found among cane yield and the following characteristics: cane diameter at harvest, number of millable canes at harvest, germination percentage at 45 days after planting, and number of shoots at 120 days after planting. Whereas, the number of aerial roots per node showed a negative correlation with cane yield. Traits *viz.*, germination % at 45 days after planting, number of shoots at 120 days after planting, cane diameter at harvest, single cane weight, number of millable canes at harvest, HR Brix in November

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had direct and positive effect on cane yield, among these, number of millable canes at harvest showed highest direct and positive effect followed by single cane weight on cane yield, whereas, plant height at harvest, number of aerial roots per node, HR Brix in December and January showed negative direct effect on cane yield. The characters that showed significant correlation and positive direct effect can be selected further to obtain higher cane yields in sugarcane.

Keywords: Cane yield; correlation; genotype; path coefficient; sugarcane.

1. INTRODUCTION

Sugarcane, Saccharum spp. hybrid complex, is an important cash crop that is grown in the tropical and subtropical parts of the globe to produce sugar (Singh et al., 2019). Sugarcane, which is a member of the Poaceae family, is often multiplied by stem cuttings. Both S. officinarum (2n = 80) and S. spontaneum (2n =40 to 128) contributed their chromosomes to the creation of the current sugarcane hybrids, which represent 2n=100 to 130 chromosomes. As S. officinarum and S. spontaneum have distinct fundamental chromosomal sets, the hybrid genome represents a set of complicated chromosome structure and recombinational event. That's way the present-day cultivars of showed highly sugarcane heterozygous, polyploid and complex genetic nature.

In 2021-22, the sugarcane producing area in the nation is around 5.098 m ha, with a production of 430.50 mt and a yield of 80.03 t/ha. In the same year, the sugarcane producing area in Bihar is around 0.219 m ha, with a yield of 13.97 mt and a productivity of 66.25 t/ha. Source: DES, Ministry of Agri. & FW.

While the use of high yielders with medium to high sucrose levels and the ability to withstand waterlogging greatly increases sugarcane productivity and production, it is still necessary to assess the adaptation of waterlogging-tolerant sugarcane varieties to replace outdated or old clones to address the issue of water-logging in areas where sugarcane is grown (Xiong et al., 2022). Analysis of correlation can be effectively utilized as a tool for calculating the relationship among various characters which further can be utilized for indirect selection to enhance yield (Dhami et al., 2018). Because they show the degree of relationship between two or more traits. correlations are crucial in crop improvement. The relative relevance of each independent variable is measured using path analysis to anticipate changes on the dependent variable. A normalized partial rearession coefficient" coefficient called as a "path separates the coefficient of correlation into

measures of indirect and direct effects (Phougat et al., 2017). Path coefficients demonstrate direct interaction between independent and dependent variables (Lidansky, 1988). Plant breeders have employed path coefficient analysis to help them uncover features that are beneficial as screening process to increase crop output (Milligan et al., 1990).

2. MATERIALS AND METHODS

This research was carried out during spring 2021 in Augmented Design with 24 clones and 2 checks planted in 4 rows, 6m long spaced at 90cm at SRI, Dr. RPCAU, Pusa, Samastipur, Bihar. `The experiment was carried out at SRI, Dr. RPCAU, Pusa, Samastipur, Bihar, situated between 25.97°N and 85.66° E at 51.8 m a.s.l. The plot selected for experiment was well levelled, but it is set to remain in waterlogging condition for 3 months with the average water depth of 25 to 45 cm. Five plants were picked at random from each plot so that observations could be made on them.

2.1 Statistical Analysis

2.1.1 Estimation of correlation coefficients

Correlation coefficients were calculated at phenotypic level using the formula suggested by Falconer (Falconer, 1964).

Phenotypic coefficient of correlation (rp) = r (xi, xj) p $=\frac{cov.(xi.xj)}{\sqrt{V}(xi)p.V(xj)p}$

Where

r (xi, xj)p = phenotypic correlation between ith and jth character

Cov. (xi, xj)p = phenotypic covariance between ith and jth characters

Var. (xi) p = phenotypic variance of ith characterVar (xj) <math>p = phenotypic variance of ith character

2.1.2 Path coefficient analysis

With cane yield as the dependent variable, the direct and indirect effects at the genotypic and phenotypic levels were estimated using the

Wright, (1921) and Dewey and Lu, (1959) recommended path coefficient analysis. The following equations were formed and solved simultaneously for estimating the various direct and indirect effects.

r1y = P1y r11 + P2y r12 + P3y r13 + Pny r1n r2y = P1y r21 + P2y r22 + P3y r23 . + Pny r2n Rny = P1y rn1 + P2y rn2 + P3y rn3 + Pny r3n Where,

1, 2...n = Independent variables y = Dependent variables r1y, r2y.. rny = Coefficient of correlation between causal factors "1" to "n" on dependent character y. P1y, P2y.Pny = Direct effects of character 1 to n on character y

The above equation can be written in matrix form as:



Direct effects were as follows

P1y = kΣ c1i r iy; i= 1 P2y = kΣ c2i r iy; i= 1 P3y = kΣ c3i r iy; i= 1

Residual effects, which measures the contribution of characters not considered, were obtained as:

$$Pxy = \sqrt{1} - p1x - (p1y rny + p2y rny + \dots + pny rny)$$

Where,

Pny = direct effect of xn on y rny = Correlation coefficient of xn on y

3. RESULTS AND DISCUSSION

Correlation analysis: Coefficient of correlations were computed for pairs of all the eleven quantitative characters and presented in Table 1.

Table 2 revealed that germination % at 45 DAP (0.338), no. of shoots at 120 DAP (0.316), cane diameter at harvest (0.469), no. of millable canes at harvest (0.307) showed positively significant correlation with cane yield whereas no. of aerial roots per node (-0.110) showed nonsignificant negative correlation with cane yield.

A number of traits were positively correlated with germination percentage at 45 days after planting; these included no. of shoots at 120 days after planting (0.664), no. of millable canes at harvest (0.475), and plant height (0.369) but single cane weight (-0.350) was correlated negatively with this trait.

Number of shoots at 120 DAP showed highly significant and positive correlation with number of millable canes per harvest (0.834) and highly negatively significant correlation with single cane weight (-0.683).

The trait single cane weight exhibited a highly negative correlation with the number of millable canes at harvest (0.840) and a positively significant relationship with HR Brix in November (0.312), December (0.322), and January (0.318).HR Brix in both the months showed highly significant and positive correlation with HR Brix in December (0.987) and HR Brix in January (0.986).

Kumar and Singh (1999) observed yield of cane was positively and significantly associated with germination %, no. of shoots and NMC. Setia et al. (2001) found that cane yield and germination percent were both significant and positively correlated. Sukh chain and Dhaliwal, (2005) stated that weak negative association existed among aerial roots. Additionally, there was a significant correlation among cane yield and NMC. Yahaya et al. (2009) stated that positive association existed among NMC, stalk girth and cane yield. Agrawal and Kumar (2017) found that cane diameter, NMC, germination % at 45 days, no. of shoots was significant and positively correlated with cane yield. Belwal and Ahmad (2020) revealed a substantial and positive association among cane yield and the no. of tillers and germination %. Viradiya et al. (2015)

showed that cane yield was positive and significantly associated with no. of shoots and NMC.

Path coefficient analysis: Direct and indirect influence of component characteristics on expression of cane yield can be seen in the coefficient of correlation, which describes the reciprocal interaction among two characters. The entire correlation coefficient may be broken down into direct and indirect effects by using path coefficient analysis.

Table 2 displays the results of analyzing the relationship between cane yield and its contributing factors using path coefficients.

1. Germination percent at 45 DAP vs. cane yield

Germination percent at 45 DAP showed positive direct effect on cane yield (0.093), coupled with high indirect and positive effect through no. of millable canes at harvest (0.760), indirect and positive effect through HR Brix in November (0.167), indirect and negative effect via single cane weight (-0.547) and negligible indirect effect through other traits.

2. Number of shoots at 120 DAP vs. cane yield

No. of shoots at 120 DAP showed direct and positive impact on yield of cane (0.011), coupled with high indirect and positive impact via number of millable canes at harvest (1.334), high indirect and negative effect via single cane weight (-1.066) and negligible indirect effect through other traits.

3. Plant height at harvest vs. cane yield

Plant height at harvest showed negative direct impact on yield of cane (-0.035), coupled with indirect and positive effect through no. of millable canes at harvest (0.123) and minimal indirect effect *via* other characteristics.

4. Cane diameter at harvest vs. cane yield

Harvest cane diameter had a direct and positive influence on cane yield (0.129), as did single cane weight (0.362) and HR Brix in November (0.208), as well as an indirect and negative effect through HR Brix in December (-0.127) and an insignificant indirect effect *via* other features.

Characters	G%	S120	PH	CD	SCW	NMC	NAR	B%	B%	B%	CY
				•				NOV	DEC	JAN	•
Germination at 45 DAP (%)		0.664**	0.369*	0.157	-0.350*	0.475*	0.239	0.179	0.135	0.158	0.338*
No. of shoots at 120 DAP (000/ha)			-0.002	0.066	-0.683**	0.834**	0.246	0.050	0.056	0.068	0.316*
Plant height at harvest (cm)				0.059	0.017	0.077	-0.062	0.082	0.022	0.045	0.212
Cane diameter at harvest (cm)					0.232	-0.013	-0.002	0.223	0.248	0.276	0.469*
Single cane weight (kg)						-0.840**	-0.046	0.312*	0.322*	0.318*	0.228
No. of millable canes at harvest (000/ha)							0.013	-0.273	-0.270	-0.256	0.307*
No. of aerial roots/node								0.230	0.215	0.232	-0.110
HR Brix in NOV									0.987**	0.986**	0.158
HR Brix in DEC										0.995**	0.159
HR Brix in JAN											0.180
Cane Yield (t/ha)											

Table 1. Phenotypic coefficient of correlation of eleven quantitative characters in sugarcane under water-logging condition

*, ** significant at 5% and 1% level, respectively

Table 2. Phenotypic path coefficient o	f eleven quantitative characters	in sugarcane under	water-logging condition
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Characters	G%	S120	PH	CD	SCW	NMC	NAR	B%	B%	B%	CY
								NOV	DEC	JAN	
Germination at 45 DAP (%)	0.093	0.007	-0.013	0.020	-0.547	0.760	-0.027	0.167	-0.069	-0.053	0.338*
No. of shoots at 120 DAP (000/ha)	0.062	0.011	0.000	0.008	-1.066	1.334	-0.028	0.047	-0.029	-0.023	0.316*
Plant height at harvest (cm)	0.034	0.000	-0.035	0.008	0.027	0.123	0.007	0.076	-0.011	-0.015	0.212
Cane diameter at harvest (cm)	0.015	0.001	-0.002	0.129	0.362	-0.021	0.000	0.208	-0.127	-0.093	0.469*
Single cane weight (kg)	-0.033	-0.007	-0.001	0.030	1.560	-1.345	0.005	0.290	-0.165	-0.108	0.228
No. of millable canes at harvest (000/ha)	0.044	0.009	-0.003	-0.002	-1.311	1.601	-0.001	-0.254	0.138	0.086	0.307*
No. of aerial roots/node	0.022	0.003	0.002	0.000	-0.072	0.021	-0.112	0.214	-0.110	-0.078	-0.110
HR Brix in NOV	0.017	0.001	-0.003	0.029	0.487	-0.437	-0.026	0.931	-0.506	-0.333	0.158
HR Brix in DEC	0.013	0.001	-0.001	0.032	0.502	-0.432	-0.024	0.919	-0.513	-0.336	0.159
HR Brix in JAN	0.015	0.001	-0.002	0.035	0.496	-0.409	-0.026	0.918	-0.511	-0.338	0.180

Residual value = 0.0483 *, ** significant at 5% and 1% level, respectively

5. Single cane weight vs. cane yield

Single cane weight showed high direct and positive impact on yield of cane (1.560), coupled with indirect and positive influence via HR Brix in November (0.290), high indirect and negative effect via no. of millable canes at harvest (-1.345), indirect and negative effect via HR Brix in December (-0.165), HR Brix in January (-0.108) and insignificant and indirect effect through other traits.

6. Number of millable canes at harvest vs. cane yield

No. of millable canes at harvest showed high direct and positive impact on yield of cane (1.601), coupled with indirect and positive effect through HR Brix in December (0.138), high indirect and negative effect via single cane weight (-1.311), indirect and negative effect via HR Brix in November (0.254) and negligible indirect effect through other traits.

7. Number of aerial roots per node vs. cane yield

No. of aerial roots per node showed negative direct impact on yield of cane (-0.112), coupled with indirect and positive impact through HR Brix in November (0.214), indirect and negative effect via HR Brix in December (-0.110) and there was indirect effect with other characters.

8. HR Brix in November vs. cane yield

HR Brix in November showed direct and positive impact on yield of cane (0.931), coupled with indirect and positive impact through single cane weight (0.487), indirect and negative effect via number of millable canes (-0.437), HR Brix in December (-0.506), HR Brix in January (-0.333) and negligible indirect effect through other traits.

9. HR Brix in December vs. cane yield

HR Brix in December showed negative direct impact on yield of cane (-0.513), coupled with high indirect and positive impact through HR Brix in November (0.919), indirect and positive impact via single cane weight (0.502), indirect and negative effect via no. of millable canes (-0.432), HR Brix in January (-0.336) and negligible indirect effect through other traits.

10. HR Brix in January vs. cane yield

HR Brix in January showed negative direct impact on yield of cane (-0.338), coupled with high

indirect and positive impact via HR Brix in November (0.918), indirect and positive impact through single cane weight (0.496), indirect and negative effect via number of millable canes at harvest (-0.409), HR Brix in December (-0.511) and negligible indirect effect through other traits.

The impact of additional potential independent variables on the dependent variable that was left out of the study is measured by the residual effect measure. Direct effects and basic correlation coefficients are used to estimate it. For phenotypic path coefficient analysis, the residual effect was 0.0483, meaning that the nine characters examined in path analysis contributed 4.83% of the yield per hectare as component characters.

Similar reports were also noted by several researchers viz., Chaudhary and Singh (1994) reported that the NMC and the weight of each individual cane contributed most directly to the cane yield. Setia et al. (2001) found that the number of millable canes had the greatest direct effect on cane yield according to studies on path coefficient analysis, Ahmed et al. (2019) reported that NMC at 12 months and SCW have positive high direct effect on cane yield. Tabassum et al. (2023) found that the number of millable canes (NMC) has the greatest direct effect on cane yield, Rahman et al. (2008) according to a study on path analysis, the most significant factors influencing cane production per hectare was the NMC per hectare. Yahaya et al. (2009) showed that the number of millable canes had the most direct effect on cane vield and Belwal and Ahmad (2020) showed that the NMC all had a high direct and positive effect on cane yield.

4. CONCLUSION

Coefficient of correlation studies showed that only four quantitative traits *i.e.*, germination % at 45 DAP, number of shoots at 120 DAP, cane diameter at harvest and number of millable canes at harvest showed positively significant association with cane yield. Germination % at 45 DAP, number of shoots at 120 DAP, cane diameter, single cane weight, number of millable canes, HR Brix in November had direct and positive effect on cane yield, among these, number of millable canes at harvest showed highest direct and positive effect followed by single cane weight on cane yield. Thus, the above traits must be taken into consideration for planning future breeding programme for higher yield under water-logging condition.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative Al technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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