

Correlation studies in early clonal generations under water logging conditions in sugarcane for yield and its attributing traits

ABSTRACT

An experiment was conducted 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 between 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 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

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 sugarcane showed highly heterozygous, polyploid and complex genetic nature.

In 2021-22, the sugarcane producing area in the nation is around 5.098 mha, 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 mha, 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 water logging greatly increases sugarcane productivity and production, it is still necessary to assess the adaptation of water logging-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 utilised as a tool for calculating the relationship among various characters which further can be utilised for indirect selection to enhance yield (Dhamiet *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 regression coefficient called a "path coefficient" separates the coefficient of correlation into measures of indirect and direct effects (Phougat *et al.*, 2017). Path coefficients demonstrated 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 processes to increase crop output (Milligan *et al.*, 1990).

Materials and methods:

The present investigation was conducted during spring 2021 in Augmented Design with 24 clones and 2 checks planted in 4 rows, 6 m long spaced at 90 cm at SRI, Dr. RPCAU, Pusa, Samastipur, Bihar. The experiment was conducted at SRI, Dr. RPCAU, Pusa, Samastipur, Bihar, situated between 25.97°N latitude and 85.66°E longitude at 51.8 m above MSL. The plots selected for experiment were well leveled, but it is set to remain in water logging 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.

Statistical analysis

Estimation of correlation coefficients

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

$$\text{Phenotypic coefficient of correlation (r}_p\text{)} = r(x_i, x_j)_p = \frac{\text{cov.}(x_i, x_j)_p}{\sqrt{V(x_i)_p \cdot V(x_j)_p}}$$

Where

$r(x_i, x_j)_p$ = phenotypic correlation between i^{th} and j^{th} character

$\text{Cov.}(x_i, x_j)_p$ = phenotypic covariance between i^{th} and j^{th} characters

$\text{Var.}(x_i)_p$ = phenotypic variance of i^{th} character

$\text{Var}(x_j)_p$ = phenotypic variance of j^{th} character

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 pathco

efficient analysis. The following equations were formed and solved simultaneously for estimating the various direct and indirect effects.

$$\begin{aligned}
 r_1y &= P_1y_{r11} + P_2y_{r12} + P_3y_{r13} \dots + P_ny_{r1n} \\
 r_2y &= P_1y_{r21} + P_2y_{r22} + P_3y_{r23} \dots + P_ny_{r2n} \\
 Rny &= P_1y_{rn1} + P_2y_{rn2} + P_3y_{rn3} \dots + P_ny_{rn3n}
 \end{aligned}$$

Where

1, 2, ..., n = Independent variables

y = Dependent variables

r_1y, r_2y, \dots, r_ny = Coefficient of correlation between causal factors "1" to "n" on dependent character y.

P_1y, P_2y, \dots, P_ny = Direct effects of character 1 to n on character y

The above equation can be written in matrix form as

ACB

$$\begin{bmatrix} r_{1y} & r_{12} & r_{13} & \dots & r_{1n} \\ r_{2y} & r_{21} & r_{23} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ r_{ny} & r_{n1} & r_{n2} & \dots & r_{nn} \end{bmatrix} \begin{bmatrix} P_1y \\ P_2y \\ \dots \\ P_ny \end{bmatrix} = \begin{bmatrix} y \\ \dots \\ \dots \\ y \end{bmatrix}$$

Then

$$B = (C - 1)A \text{ where } C^{-1} = \begin{bmatrix} c_{11} & c_{12} & c_{13} & \dots & c_{1n} \\ c_{21} & c_{22} & c_{23} & \dots & c_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ c_{n1} & c_{n2} & c_{n3} & \dots & c_{nn} \end{bmatrix}$$

Direct effects were as follows

$$P_1y = k \sum_{i=1}^n c_{1i} r_{iy}$$

$$P_2y = k \sum_{i=1}^2 r_{iy}$$

$$P_3y = k \sum_{i=1}^3 r_{iy}$$

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

$$P_{xy} = \sqrt{1 - p_1^2 x - (p_1 y r_{ny} + p_2 y r_{ny} + \dots + p_n y r_{ny})}$$

Where,

P_{ny} = direct effect of x_{ny}

r_{ny} = Correlation coefficient of x_{ny}

Results and Discussion:

Correlation analysis:

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

Table 3 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 non-significant 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. Sukhchain and Dhaliwal, 2005 stated that weak negative association existed among aerial roots. Additionally, there was a significant

correlation between cane yield and NMC. Yahaya *et al.*, 2009 stated that positive association existed between 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 between 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 between 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

ghHRBrixinDecember(-0.127)andaninsignificantindirecteffectviaotherfeatures.

5. Singlecaneweightvs.caneyield

Singlecaneweightshowedhighdirectandpositiveimpactonyieldofcane(1.560),coupledwithindirectandpositiveinfluenceviaHRBrixinNovember(0.290),highindirectandnegativeeffectviano.ofmillablecanesatharvest(-1.345),indirectandnegativeeffectviaHRBrixinDecember(-0.165),HRBrixinJanuary(-0.108)andinsignificantandindirecteffectthroughothertraits.

6.Numberofmillablecanesatharvestvs.caneyield

No.ofmillablecanesatharvestshowedhighdirectandpositiveimpactonyieldofcane(1.601),coupledwithindirectandpositiveeffectthroughHRBrixinDecember(0.138),highindirectandnegativeeffectviasinglecaneweight(-1.311),indirectandnegativeeffectviaHRBrixinNovember(-0.254)andnegligibleindirecteffectthroughothertraits.

7.Numberofaerialrootspnodesvs.caneyield

No.ofaerialrootspnodeshowednegativedirectimpactonyieldofcane(-0.112),coupledwithindirectandpositiveimpactthroughHRBrixinNovember(0.214),indirectandnegativeeffectviaHRBrixinDecember(-0.110)andtherewasindirecteffectwithothercharacters.

8.HRBrixinNovembervs.caneyield

HRBrixinNovembershoweddirectandpositiveimpactonyieldofcane(0.931),coupledwithindirectandpositiveimpactthroughsinglecaneweight(0.487),indirectandnegativeeffectvianumberofmillablecanes(-0.437),HRBrixinDecember(-0.506),HRBrixinJanuary(-0.333)andnegligibleindirecteffectthroughothertraits.

9.HRBrixinDecembervs.caneyield

HRBrixinDecembershownegativedirectimpactonyieldofcane(-0.513),coupledwithhighindirectandpositiveimpactthroughHRBrixinNovember(0.919),indirectandpositiveimpactviasinglecaneweight(0.502),indirectandnegativeeffectviano.ofmillablecanes(-0.432),HRBrixinJanuary(-0.336)andnegligibleindirecteffectthroughothertraits.

10.HRBrixinJanuaryvs.caneyield

HRBrix in January showed negative direct impact on yield of cane (-0.338), coupled with high indirect and positive impact via HRBrix 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), HRBrix 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 yield and Belwal and Ahmad, 2020 showed that the NMC all had a high direct and positive effect on cane yield.

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 positive significant association with cane yield. Germination % at 45 DAP, number of shoots at 120 DAP, cane diameter, single cane weight, number of millable canes, HRBrix 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.

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UNDER PEER REVIEW

Table1.Phenotypiccoefficientofcorrelationofelevenquantitativecharactersinsugarcaneunderwater-loggingcondition

Characters	G%	S120	PH	CD	SCW	NMC	NAR	B% NOV	B% DEC	B% JAN	CY
Germinationat45DAP(%)		0.664**	0.369*	0.157	-0.350*	0.475*	0.239	0.179	0.135	0.158	0.338*
No.ofshootsat120DAP(000/ha)			-0.002	0.066	-0.683**	0.834**	0.246	0.050	0.056	0.068	0.316*
Plantheightatharvest(cm)				0.059	0.017	0.077	-0.062	0.082	0.022	0.045	0.212
Canediameteratharvest(cm)					0.232	-0.013	-0.002	0.223	0.248	0.276	0.469*
Singlecaneweight(kg)						-0.840**	-0.046	0.312*	0.322*	0.318*	0.228
No.ofmillablecanesatharvest(000/ha)							0.013	-0.273	-0.270	-0.256	0.307*
No.ofaerialroots/node								0.230	0.215	0.232	-0.110
HRBrixinNOV									0.987**	0.986**	0.158
HRBrixinDEC										0.995**	0.159
HRBrixinJAN											0.180
CaneYield(t/ha)											

*,**significantat5%and1%level,respectively

Table 2. Phenotypic path coefficient of eleven quantitative characters in sugarcane under water-logging condition

Characters	G%	S120	PH	CD	SCW	NMC	NAR	B% NOV	B% DEC	B% JAN	CY
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
Can 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