Correlationstudiesinearlyclonalgenerationsunderwaterloggingconditionsinsugarcanefor yieldanditsattributingtraits

ABSTRACT

An experiment was carried outduring 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 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.hybridcomplex,isanimportantcashcropthatisgrowninthetropicalandsubtropicalpartsoftheglobetoproducesugar(Singh *et al.*, 2019).Sugarcane,whichisamemberofthePoaceaefamily,isoftenmultipliedbystemcuttings.Both*S.officinarum*(2n=80)and*S.spontaneum*(2n=40to128)contributedtheirchromosomestothecreationofthecurrentsugarcanehybrids,whichrepresent2n=100to130chromosomes.As*S.officinarum*and*S.spontaneum*havedistinctfundamentalchromosomalsets,thehybridgenomerepresentsasetofcomplicatedchromosomestructureandrecombinationalevent.That'swaythepresent-daycultivarsofsugarcaneshowedhighlyheterozygous,polyploidandcomplexgeneticnature.

In2021-22,thesugarcaneproducingareainthenationisaround5.098mha,withaproductionof430.50mtandayieldof80.03t/ha.Inthesameyear,thesugarcaneproducingareainBiharisaround0.219mha,withayieldof13.97mtandaproductivityof66.25t/ha.**Source**:DES,MinistryofAgri.&FW.

Whiletheuseofhighyielderswithmediumtohighsucroselevelsandtheabilitytowithstandwaterlogginggreatlyincreasessugarcaneproductivityandproduction,itisstillnecessarytoassessthedaptationofwaterlogging-tolerantsugarcanevarietiestoreplaceoutdatedoroldclonestoaddresstheissueofwater-logginginareaswheresugarcaneisgrown(Xiong *et al.*, 2022).Analysisofcorrelationcanbeeffectivelyutilizedasatoolforcalculatingtherelationshipamongvariouscharacterswhichfurthercanbeutilizedforindirectselectiontoenhanceyield(Dhami*et al.*,

2018).Becausetheyshowthedegreeofrelationshipbetweentwoormoretraits,correlationsarecrucialincropimprovement.Therelativerelevanceofeachindependentvariableismeasuredusingpathanalysistoanticipatechangesonthedependentvariable.Anormalizedpartialregressioncoefficientcalledasa"pathcoefficient"separatesthecoefficientofcorrelationintomeasuresofindirectanddirecteffects(Phougat*et al.*, 2017).Pathcoefficientsdemonstratedirectinteractionbetweenindependentanddependentvariables(Lidansky, 1988).Plantbreedershaveemployedpathcoefficientanalysistohelpthemuncoverfeaturesthatarebeneficialasscreeningprocesstoincreasecropoutput (Milligan*et al.*, 1990).

Materials and methods:

This researchwascarried out duringspring2021inAugmentedDesignwith24clonesand2checksplantedin4rows,6mlongspaced at90cmatSRI,Dr.RPCAU,Pusa,Samastipur,Bihar.`Theexperimentwascarried outatSRI,Dr.RPCAU,Pusa,Samastipur,Bihar,situatedbetween25.97^{o}Nand85.66^{o}Eat51.8ma.s.l. .Theplotselectedforexperimentwaswelllevelled,butitissettoremaininwaterloggingconditionfor3 monthswiththeaveragewaterdepthof25to45cm.Fiveplantswerepickedatrandomfromeachplotso thatobservationscouldbemadeonthem.

Statisticalanalysis

Estimationofcorrelationcoefficients

Correlationcoefficientswerecalculatedatphenotypiclevelusingtheformulasuggestedby Falconer,1964.

Phenotypiccoefficientofcorrelation(rp)=r(xi,xj)p=$\frac{cov.(xi.xj)}{\sqrt{V}(xi)p.V(xj)p}$

Where

r(xi,xj)p=phenotypiccorrelationbetweenithandjthcharacter

Cov.(xi,xj)p=phenotypiccovariancebetweenithandjthcharacters

Var.(xi)p=phenotypicvarianceofithcharacter

Var(xj)p=phenotypicvarianceofjthcharacter

Pathcoefficientanalysis

Withcaneyieldasthedependentvariable,thedirectandindirecteffectsatthegenotypicandphenotypiclevelswereestimatedusingtheWright,1921andDeweyandLu,1959recommendedpathco

efficientanalysis.Thefollowingequationswereformedandsolvedsimultaneouslyforestimatingthe variousdirectandindirecteffects.

r1y =P1yr11 +P2y r12+P3yr13.....+Pnyr1n

r2y =P1yr21 +P2y r22+P3yr23.....+Pnyr2n

Rny =P1yrn1 +P2y rn2+P3yrn3.....+Pnyr3n

Where

1,2.....n=Independentvariables

y=Dependentvariables

r1y,r2y.....rny=Coefficientofcorrelationbetweencausalfactors“1”to“n”on dependentcharactery.

P1y,P2y…….Pny=Directeffectsofcharacter1tononcharactery

Theaboveequationcanbewritteninmatrixformas

ACB

$$\begin{bmatrix} r1y1r12r13\ldots\ldots\ldots r1np1y \\ r2yr211r23\ldots\ldots\ldots\ldots r2np2y \\ .... \\ .... \\ rnyrn1rn2rn3\ldots\ldots\ldots\ldots 1pny \end{bmatrix} \quad \begin{bmatrix} \\ \\ . \\ . \\ \end{bmatrix}$$

Then

$$B=(C)\text{-}1A \text{ where } C\text{-}1= \begin{bmatrix} c11c12c13.....c1n \\ c21c22c23.....c2n \\ ... \\ ::: \\ ... \\ cn1cn2cn3.....cn1 \end{bmatrix}$$

Directeffectswereasfollows

$$P1y=k\Sigma c1iriy;i=1$$

P2y=kΣc2iriy;i=1

P3y=kΣc3iriy;i=1

Residualeffects,whichmeasuresthecontributionofcharactersnotconsidered,wereobtained as:

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

Where,

Pny=directeffectofxnony

rny=Correlationcoefficientofxnony

ResultsandDiscussion:

Correlationanalysis:

Coefficientofcorrelationswerecomputedforpairsofalltheelevenquantitativecharactersand presentedinTable1.

Table3revealedthatgermination%at45DAP(0.338),no.ofshootsat120DAP(0.316),canediameteratharvest(0.469),no.ofmillablecanesatharvest(0.307)showedpositivelysignificantcorrelationwithcaneyieldwhereasno.ofaerialrootspernode(-0.110)showednon-significantnegativecorrelationwithcaneyield.

Anumberoftraitswerepositivelycorrelatedwithgerminationpercentageat45daysafterplanting;theseincludedno.ofshootsat120daysafterplanting(0.664),no.ofmillablecanesatharvest(0.475),andplantheight(0.369)butsinglecaneweight(-0.350)wascorrelatednegativelywiththistrait.

Numberofshootsat120DAPshowedhighlysignificantandpositivecorrelationwithnumberofmillablecanesperharvest(0.834)andhighlynegativelysignificantcorrelationwithsinglecaneweight(-0.683).

Thetraitsinglecaneweightexhibitedahighlynegativecorrelationwiththenumberofmillablecanesatharvest(0.840)andapositivelysignificantrelationshipwithHRBrixinNovember(0.312), December(0.322),andJanuary(0.318).HRBrixinboththemonthsshowedhighlysignificantandpositivecorrelationwithHRBrixinDecember(0.987)andHRBrixinJanuary(0.986).

KumarandSingh, 1999 observedyieldofcanewaspositivelyandsignificantlyassociatedwithgermination%,no.ofshootsandNMC.Setia*etal*., 2001 foundthatcaneyieldandgerminationpercentwerebothsignificantandpositivelycorrelated.SukhchainandDhaliwal, 2005 statedthatweaknegativeassociationexistedamongaerialroots.Additionally,therewasasignificant

correlationamong caneyieldandNMC.Yahaya*etal.*, 2009statedthatpositiveassociationexistedamong NMC,stalkgirthandcaneyield.AgrawalandKumar, 2017 foundthatcanediameter,NMC,germination%at45days,no.ofshootswassignificantandpositively correlatedwithcaneyield.BelwalandAhmad, 2020revealedasubstantialandpositiveassociationamong caneyieldandtheno.oftillersandgermination%.Viradiya*etal.*, 2015showedthatcaneyieldwaspositiveandsignificantlyassociatedwithno.ofshootsandNMC.

Pathcoefficientanalysis

Directandindirectinfluenceofcomponentcharacteristicsonexpressionofcaneyieldcanbes eeninthecoefficientofcorrelation,whichdescribesthereciprocalinteractionamongtwocharacters. Theentirecorrelationcoefficientmaybebrokendownintodirectandindirecteffectsbyusingpathcoe fficientanalysis.

Table2displaystheresultsofanalyzingtherelationshipbetweencaneyieldanditscontributin gfactorsusingpathcoefficients.

1. Germinationpercentat45DAPvs.caneyield

Germinationpercentat45DAPshowedpositivedirecteffectoncaneyield(0.093),coupledw ithhighindirectandpositiveeffectthroughno.ofmillablecanesatharvest(0.760),indirectandpositiv eeffectthroughHRBrixinNovember(0.167),indirectandnegativeeffectviasinglecaneweight(- 0.547)andnegligibleindirecteffectthroughothertraits.

2. Numberofshootsat120DAPvs.caneyield

No.ofshootsat120DAPshoweddirectandpositiveimpactonyieldofcane(0.011),coupledw ithhighindirectandpositiveimpactvianumberofmillablecanesatharvest(1.334),highindirectandn egativeeffectviasinglecaneweight(-1.066)andnegligibleindirecteffectthroughothertraits.

3. Plantheightatharvestvs.caneyield

Plantheightatharveststhowednegativedirectimpactonyieldofcane(- 0.035),coupledwithindirectandpositiveeffectthroughno.ofmillablecanesatharvest(0.123)and minimalindirecteffect*via*othercharacteristics.

4. Canediameteratharvestvs.caneyield

Harvestcanediameterhadadirectandpositiveinfluenceoncaneyield(0.129),asdidsinglec aneweight(0.362)andHRBrixinNovember(0.208),aswellasanindirectandnegativeeffectthrou

ghHRBrixinDecember(-0.127)andaninsignificantindirecteffect*via*otherfeatures.

5. Singlecaneweightvs.caneyield

Singlecaneweightshowedhighdirectandpositiveimpactonyieldofcane(1.560),coupled withindirectandpositiveinfluenceviaHRBrixinNovember(0.290),highindirectandnegativeeff ectviano.ofmillablecanesatharvest(-1.345),indirectandnegativeeffectviaHRBrixinDecember(-0.165),HRBrixinJanuary(-0.108)andinsignificantandindirecteffectthroughothertraits.

6.Numberofmillablecanesatharvestvs.caneyield

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

7.Numberofaerialrootspernodevs.caneyield

No.ofaerialrootspernodeshowednegativedirectimpactonyieldofcane(-0.112),coupledwithindirectandpositiveimpactthroughHRBrixinNovember(0.214),indirectan dnegativeeffectviaHRBrixinDecember(-0.110)andtherewasindirecteffectwithothercharacters.

8.HRBrixinNovembervs.caneyield

HRBrixinNovembershoweddirectandpositiveimpactonyieldofcane(0.931),coupledwit hindirectandpositiveimpactthroughsinglecaneweight(0.487),indirectandnegativeeffectvianu mberofmillablecanes(-0.437),HRBrixinDecember(-0.506),HRBrixinJanuary(-0.333)andnegligibleindirecteffectthroughothertraits.

9.HRBrixinDecembervs.caneyield

HRBrixinDecembershowednegativedirectimpactonyieldofcane(-0.513),coupledwithhighindirectandpositiveimpactthroughHRBrixinNovember(0.919),indire ctandpositiveimpactviasinglecaneweight(0.502),indirectandnegativeeffectviano.ofmillablec anes(-0.432),HRBrixinJanuary(-0.336)andnegligibleindirecteffectthroughothertraits.

10.HRBrixinJanuaryvs.caneyield

HRBrixinJanuaryshowednegativedirectimpactonyieldofcane(-0.338),coupledwithhighindirectandpositiveimpactviaHRBrixinNovember(0.918),indirectandpositiveimpactthroughsinglecaneweight(0.496),indirectandnegativeeffectvianumberofmillablecanesatharvest(-0.409),HRBrixinDecember(-0.511)andnegligibleindirecteffectthroughothertraits.

Theimpactofadditionalpotentialindependentvariablesonthedependentvariablethatwasleftoutofthestudyismeasuredbytheresidualeffectmeasure.Directeffectsandbasiccorrelationcoefficientsareusedtoestimateit.Forphenotypicpathcoefficientanalysis,theresidualeffectwas0.0483,meaningthattheninecharactersexaminedinpathanalysiscontributed4.83%oftheyieldperhectareascomponentcharacters.

Similarreportswerealsonotedbyseveralresearchers*viz.*,ChaudharyandSingh, 1994 reportedthattheNMCandtheweightofeachindividualcanecontributedmostdirectlytothecaneyield.Setia*etal.*, 2001foundthatthenumberofmillablecaneshadthegreatestdirecteffectoncaneyieldaccordingtostudiesonpathcoefficientanalysis,Ahmed*etal.*, 2019reportedthatNMCat12monthsandSCWhavepositivehighdirecteffectoncaneyield.Tabassum*etal.*, 2023foundthatthenumberofmillablecanes(NMC)hasthegreatestdirecteffectoncaneyield,Rahman*etal.*, 2008accordingtoastudyonpathanalysis,themostsignificantfactorsinfluencingcaneproductionperhectarewastheNMCperhectare,Yahaya*etal.*, 2009showedthatthenumberofmillablecaneshadthemostdirecteffectoncaneyieldandBelwalandAhmad, 2020showedthattheNMCallhadahighdirectandpositiveeffectoncaneyield.

Conclusion

Coefficientofcorrelationstudiesshowedthatonlyfourquantitativetraits*i.e.*,germination%at45DAP,numberofshootsat120DAP,canediameteratharvestandnumberofmillablecanesatharvestshowedpositivelysignificantassociationwithcaneyield.Germination%at45DAP,numberofshootsat120DAP,canediameter,singlecaneweight,numberofmillablecanes,HRBrixinNovemberhaddirectandpositiveeffectoncaneyield,amongthese,numberofmillablecanesatharvestshowedhighestdirectandpositiveeffectfollowedbysinglecaneweightoncaneyield.Thus,theabovetraitsmustbetakenintoconsiderationforplanningfuturebreedingprogrammeforhigheryieldunderwater-loggingcondition.

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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

Table2.Phenotypicpathcoefficientofelevenquantitativecharactersinsugarcaneunderwater-loggingcondition

Characters	G%	S120	PH	CD	SCW	NMC	NAR	B% NOV	B% DEC	B% JAN	CY
Germinationat45DAP(%)	**0.093**	0.007	-0.013	0.020	-0.547	0.760	-0.027	0.167	-0.069	-0.053	0.338*
No.ofshootsat120DAP(000/ha)	0.062	**0.011**	0.000	0.008	-1.066	1.334	-0.028	0.047	-0.029	-0.023	0.316*
Plantheightatharvest(cm)	0.034	0.000	**-0.035**	0.008	0.027	0.123	0.007	0.076	-0.011	-0.015	0.212
Canediameteratharvest(cm)	0.015	0.001	-0.002	**0.129**	0.362	-0.021	0.000	0.208	-0.127	-0.093	0.469*
Singlecaneweight(kg)	-0.033	-0.007	-0.001	0.030	**1.560**	-1.345	0.005	0.290	-0.165	-0.108	0.228
No.ofmillablecanesatharvest(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.ofaerialroots/node	0.022	0.003	0.002	0.000	-0.072	0.021	**-0.112**	0.214	-0.110	-0.078	-0.110
HRBrixinNOV	0.017	0.001	-0.003	0.029	0.487	-0.437	-0.026	**0.931**	-0.506	-0.333	0.158
HRBrixinDEC	0.013	0.001	-0.001	0.032	0.502	-0.432	-0.024	0.919	**-0.513**	-0.336	0.159
HRBrixinJAN	0.015	0.001	-0.002	0.035	0.496	-0.409	-0.026	0.918	-0.511	**-0.338**	0.180

Residualvalue=0.0483

*,**significantat5%and1%level,respectively