SHORT, NON-REFEREED PAPER

PHENOTYPIC CORRELATIONS AMONG CANE QUALITY TRAITS MEASURED FROM UNSELECTED SUGARCANE BREEDING FAMILY PLOTS

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Abstract

Phenotypic correlations provide knowledge on trait interrelationships and potential for indirect selection in plant breeding. The objective of this study was to estimate the phenotypic correlations among quality traits in sugarcane breeding. Data for quality traits were measured from 20 stalks randomly chosen from the first 20 sub-plots of sugarcane families planted in two trials. The trials were laid out as randomised complete block designs with three replications at the Empangeni research station. Pearson's correlation analysis was done using Proc CORR in the statistical analysis system. Estimable recoverable crystal (ERC) % cane had significant (P<0.0001) correlation with Brix % cane (r>0.86), Pol % cane (r=0.99), BrixDM % cane (r=0.54), Purity % (r>0.86), and dry matter (DM) % cane (r>0.46), showing strong associations among sucrose traits. Because of the high associations with other sucrose traits, Brix measured using a hand-held refractometer could reduce costs associated with mill room analysis. Fibre % cane had significant (P<0.05) negative correlations with ERC % cane (r>-0.16), Pol % cane (r>-0.21), Brix % cane (r>-0.37) and BrixDM % cane (r>-0.90), indicating a decrease in sucrose content with an increase in fibre. However, Fibre % cane had a significant (P<0.0001) correlation with Purity % (r>0.46) and DM % cane (r=0.74), resulting from the coincidental increase in fibre with crop maturity. A low correlation between Brix and Purity (r>0.39) suggested a low prediction of maturity using hand-held refractometer measurements in unselected progenies in sugarcane family plots. Refractometer Brix will provide more progeny data and reduce costs of sucrose measurement.

Keywords: phenotypic correlation, Pearson, Spearman, sugarcane, quality traits

Introduction

Increasing sugar yield is the primary objective in sugarcane breeding programs. Sugar yield is a product of cane yield and sucrose content (Khan *et al*., 2012). Selection for multiple traits is required to develop balanced cultivars. Knowledge of trait association would assist in determining the possibility of indirect selection and impact of multiple trait selection (Tena *et al*., 2016, Liu *et al*., 2007).

Phenotypic correlation determines the interrelationship between two or more traits. In plant breeding, knowledge of the impact of selecting for one trait on the performance of other traits is important during multiple trait selection. Knowledge of genetic and phenotypic correlations can be used to determine traits for indirect selection in order to reduce the cost of plant breeding by focusing on traits that are less expensive to measure. Genetic correlations could be different from phenotypic correlations. Phenotypic correlations can also be used to determine optimum selection pressure to achieve multiple trait improvement in sugarcane breeding. The objective of this study was to determine the phenotypic correlations among quality traits in the SA sugarcane breeding program and implications on selection for quality traits.

Materials and Methods

Data were collected in stage 1 (mini-lines) trials of the coastal short cycle high potential breeding programme (CSCHP) planted at the Empangeni research station (28°43'S, 31°53'E, 102 m above sea level) from 2010 to 2013. The CSCHP was established to develop sugarcane cultivars with high cane yield and high sucrose content at 12 months harvest age. The agro-ecological region represents areas with high rainfall, high temperatures, and deep and rich soils that are conducive to high yield. The trials TML10 (planted 2010) and TML11 (planted 2011) included 199 and 198 families, respectively.

The trials were laid out as randomised complete block designs with three replicates per family. Data were collected from 20 stalks randomly chosen from each of the first 20 genotypes per family plot and analysed in the sucrose laboratory for Brix % cane (Brix), BrixDM % cane (BrixDM), Estimable recoverable crystal (ERC) % cane (ERC), Pol % cane (Pol), Purity % (Purity), Fibre % cane (Fibre), and Dry matter % cane (DM) using the standard methods (Shoonees-Muir *et al*., 2009). The Pearson and Spearman rank correlation analyses were done using Proc CORR of the statistical analysis system (SAS institute, 2012).

Results and Discussion

There were similar trends between Pearson and Spearman correlations (Table 1). Only Pearson results are presented. Pearson's correlation measures the strength of a linear relationship between two normally distributed traits (Hauke and Kossowski, 2011). In TML10, ERC had significant (P<0.0001) correlations with Pol (r=0.99), Brix (r=0.92), BrixDM (r=0.54), Purity (r=0.86), DM (r=0.54), and Fibre (r=0.11, P=0.0144). In TML11, ERC had significant (P<0.0001) correlation with Pol (r=0.99), Brix (r=0.86), BrixDM (r=0.53), Purity (r=0.80), DM (r=0.46) and Fibre (r=-0.16, *P*=0.0005). Pol had significant (P<0.0001) correlation with Brix (r=0.96), BrixDM (r=0.59), Purity (r=0.79), DM (r=0.53), Fibre (r=-0.15, P=0.0010) in TML10 and Brix (r=0.92), BrixDM (r=0.60), Purity (r=0.71), DM (r=0.45), Fibre (r=-0.21) in TML11. Brix had significant (*P*<0.0001) correlations with BrixDM (r=0.71), Purity (r=0.58), DM (r=0.44), Fibre (r=-0.27) in TML10 and BrixDM (r=0.74), Purity (r=0.39), DM (r=0.34), Fibre (r=-0.37) in TML11. BrixDM had significant (P<0.0001) correlation with Fibre (r=-0.87), DM (r=-0.32) and Purity (r=0.18) in TML10. In TML11 BrixDM had significant (P<0.0001) correlation with Fibre (r=-0.90), DM (r=-0.37) and non-significant correlation with Purity (r=0.06, P>0.05). Purity had significant (P<0.001) correlation with Fibre (r=0.15) and DM (r=0.55) in TML10 and Fibre (r=0.18), DM (r=0.46) in TML11. Fibre had significant (P<0.0001) correlation with DM (r=0.74) in TML10 and TML11.

The high r-values (0.86-0.99) among Brix, Pol and ERC indicate one of the traits can be used to predict other traits (Figure 1). Brix measured in the field using a hand-held refractometer, a relatively inexpensive method, can be used to predict Pol and ERC. The results suggest that the costs of collecting, transporting and analysing samples for Pol and ERC will be reduced by measuring Brix. Because hand-held refractometer measurements are quick, use less manpower, and are generally less expensive, the sucrose content of all individual genotypes in Mini-Lines trials can be estimated to provide data for determination of within-family genetic variability.

Sucrose content related traits (ERC, Brix, BrixDM and Pol) were negatively correlated with Fibre, suggesting the need to determine optimum trait values between these traits. In sugarcane breeding, high Fibre is associated with lower levels of damage by the African stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (Eldana) (Nuss 1991; Zhou and Lichakane, 2012), further emphasising the need to determine optimum trait values to achieve high sucrose with low Eldana damage. The lower correlation between Brix and Purity (0.39-0.59) suggest poor prediction of crop maturity using hand-held refractometer measurements, particularly in highly variable unselected breeding populations of seedlings. The positive significant correlation between Purity and Fibre could be indicating the indirect association of these traits caused by their increasing values with advancing crop age.

Table 1. Pearson and Spearman phenotypic correlations among sugarcane quality traits measured in the 2010 and 2011 seedling trials in SA.

Trait	ERC	POL	Brix	BrixDM	Purity %	Fibre	DM
				TML10			
ERC		0.99***	0.91***	0.50***	0.85***	-0.07^{ns}	0.53***
POL	0.99***		0.95***	0.55***	0.78***	-0.11*	0.53***
Brix	0.92***	0.96***		0.66***	0.56***	-0.23***	0.45***
BrixDM	0.54***	0.59***	0.71***		0.14**	-0.86***	-0.32***
Purity %	0.86***	0.79***	0.58***	0.18***		0.18***	0.54***
Fibre	-0.11*	-0.15**	-0.27***	-0.87***	0.15***		0.73***
DM	0.54***	0.53***	0.44***	-0.32***	0.55***	0.74***	
				TML11			
ERC		0.99***	0.85***	0.50***	0.79***	-0.16***	0.42***
POL	0.99***		0.92***	0.57***	0.70***	-0.21***	0.41***
Brix	0.86***	0.92***		0.72***	0.39***	-0.36***	0.31***
BrixDM	0.53***	0.60***	0.74***		0.06^{ns}	-0.89***	-0.37***
Purity %	0.80***	0.71***	0.39***	0.06^{ns}		0.17***	0.44***
Fibre	-0.16***	-0.21***	-0.37***	-0.90***	0.18***		0.73***
DM	0.46***	0.45***	0.34***	-0.37***	0.46***	0.74***	

Above diagonal: Spearman, Below diagonal: Pearson. TML – Coastal shorty cycle high potential mini-line, DM – Dry matter, BrixDM – Brix dry matter, Pol – Polarisation, ERC – Estimable recoverable crystal, *significant at P<0.05, ***significant at P<0.01, ***significant at P<0.001

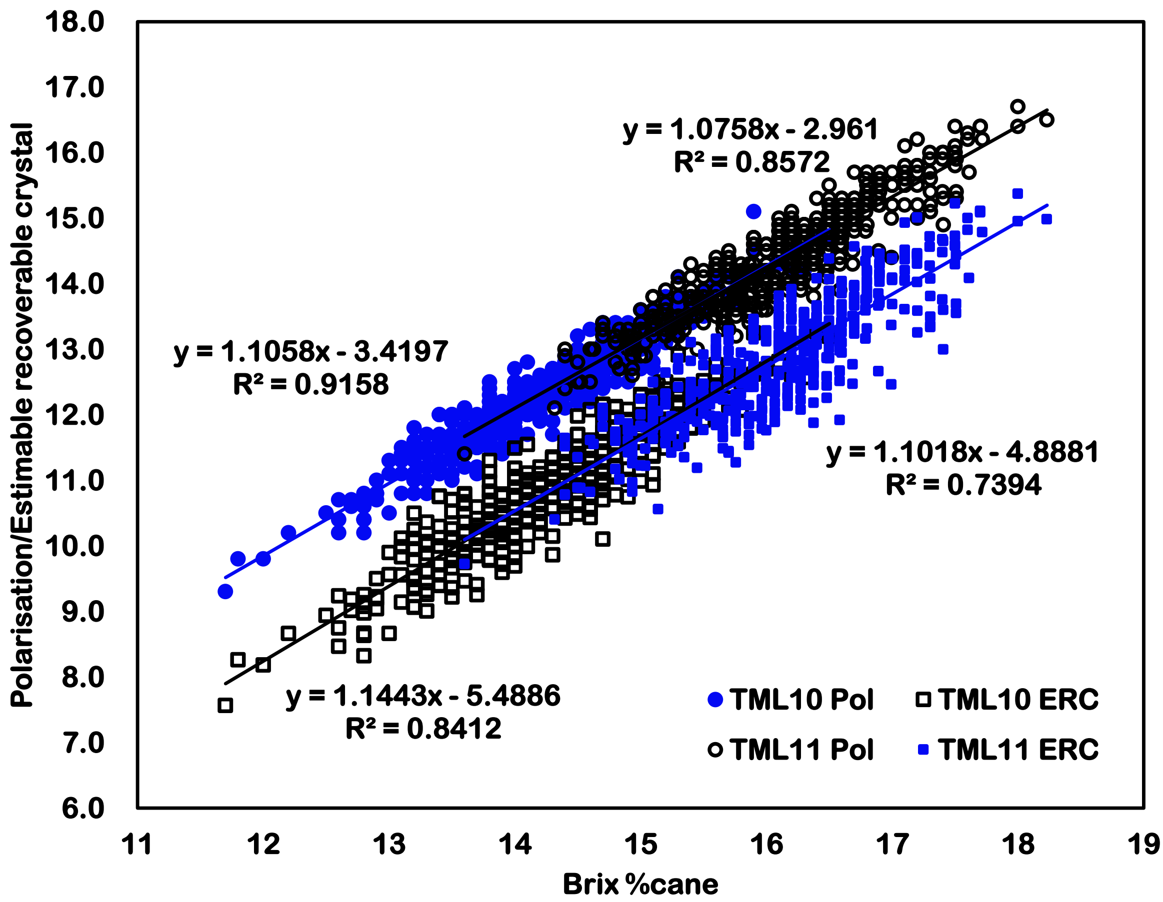

Figure 1. Prediction model for Pol % cane and ERC % cane using Brix % cane.

Conclusion

High correlations among Brix, Pol and ERC suggest that the hand-held refractometer can be used to provide adequate estimates of sucrose content, particularly in early stages of sugarcane breeding, resulting in reduced costs and more data to quantify within family genetic variability. The negative correlation between sucrose traits (Brix, Pol and ERC) and Fibre highlights the complexity of breeding for high sucrose content and low Eldana damage and further emphasises the need for more research to quantify optimum selection rates and trait values for these traits to balance both breeding objectives. The low correlation between Brix and Purity suggest predicting maturity using Brix measured with a hand held refractometer may not be accurate, particularly in highly variable unselected breeding populations. The positive and significant correlation between Purity and Fibre indicates the coincidental association of these traits probably caused by their simultaneous increase with advancing crop age. The increase in purity and fibre could be caused by the distribution or redistribution of carbohydrates as the sugarcane matures.

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