SHORT NON-REFEREED PAPER

# EFFECT OF GENETIC BACKGROUND ON PHENOTYPIC CORRELATIONS IN SUGARCANE BREEDING

SHANDU NM[1,2], ZHOU MM[1,2,3] AND SIBIYA J[2]

*[1]South African Sugarcane Research Institute, P/Bag X02, Mount Edgecombe, 4300, South Africa*
*[2]University of KwaZulu-Natal, P/Bag X01, Scottsville 3209, South Africa*
*[3]University pf the Free State, PO Box 339, Bloemfontein, 9300, South Africa*
*Nqobile.Shandu@sugar.org.za Marvellous.Zhou@sugar.org.za*
*Sibiyaj@ukzn.ac.za*

## Introduction

Understanding the association among traits is of economic importance to sugarcane breeding to advise on the impact of one trait on another during breeding and selection. Phenotypic correlations measure the association between two or more traits caused by the combined effect of genetic and environmental interaction on trait expression (Lynch and Walsh, 1998). While the relationship among traits is known (Brown *et al.,* 1969; Marriotti, 1971; Milligan *et al*., 1994; Mishasha *et al*., 2018), there is limited knowledge on the effect of genetic background on trait interrelationships in sugarcane breeding.

South Africa operates several regional breeding programmes to develop varieties for the different agro-ecological areas. These semi-autonomous breeding programmes develop populations with distinct genetic makeup and characteristics imparting adaptability to these regions. The adaptability is controlled by genetic background that promotes traits suitable for plant growth and development in the agro-ecological regions. For example, the midlands region crops are harvested at 24 months, whereas those for the coastal short cycle are harvested at 12 months. Knowledge on the effects of genetic background on the phenotypic correlation among populations guides breeding strategies. The objectives of this study were to determine phenotypic correlations for yield and quality traits for midlands and coastal short cycle unselected populations, to compare the correlations between breeding programmes and evaluate implications on sugarcane breeding.

## Materials and Methods

Data were collected in stage 1 (mini lines) trials, BML10 planted in 2010 at Bruyns Hill (MHS) and TML11 planted in 2011 at Empangeni research station (CSCH). The trials were laid out as a randomised complete block design with three replications. Data for stalk numbers, height and diameter were collected from the first 20 genotypes in a family plot. Twenty stalk samples per family plot were analysed in the laboratory to determine Brix % cane (Brix), Estimated 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). Phenotypic correlation analysis at the plot and family level were done using the Proc CORR of the statistical analysis system (SAS Institute, 2012).

## Results and Discussion

Cane yield was significantly ($P<0.05$) correlated with stalk number, height and diameter (TML12) and stalk number and height (BML11), indicating that yield components controlling cane yield were specific to regional breeding populations as reported by Zhou (2018). This study showed that stalk populations and height were the major components for long cycle breeding programmes such as BML11, while diameter was significant for short cycle breeding programmes (TML12). Stalk number was significantly correlated with height but negatively correlated with diameter, reflecting the frequently observed numerous tall thin stalks and fewer thick stalks in South African breeding populations. Stalk height was positively correlated with diameter (TML12) and negatively correlated with diameter (BML11), suggesting the importance of tall thick stalks in short cycle crops compared to long cycle crops where all genotypes have the opportunity to achieve maximum stalk height. Sucrose content traits (Brix%, Pol%, ERC%, Purity) were significantly correlated. Fibre% was positively correlated with sucrose traits for BML11 but negatively correlated for TML12, a result suggesting the unique trait combinations that exist among breeding programmes.

Possibly, the requirement for early maturity and high fibre content for resistance to the stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (eldana) accentuates the negative correlations, a requirement not needed in the midlands. The implications of this difference require further research. Stalk number had low correlations with sucrose traits for BML11 but showed highly significant negative correlations with sucrose traits for TML12. These results could be linked to the selection for hardiness in the midlands breeding programmes, where numerous stalks are linked to a higher proportion of the *Spontaneum* genome compared to the coastal short cycle programme where growing conditions are more favourable and *Officinarum* types thrive. Cultivars released in these environments reflect the unique adaptations. Stalk height showed higher correlations with sucrose traits for BML11 but very low values for TML12. Stalk diameter produced high positive correlations with sucrose traits for TML12 but negative correlations for BML11, suggesting the importance of developing sucrose storage space early for early maturing populations compared to 24 month crops in the midlands. Phenotypic correlation trends between genotype plots and family plots showed similar trends.

**Table 1: Family Pearson correlations among yield and quality traits for TML12 (upper diagonal) and BML11 (bottom diagonal).**

| Traits | TCP | Stalks | Height | Diameter | DM | Fibre | Brix | BrixDM | Purity | Pol | ERC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TCP | | 0.62*** | 0.70*** | 0.34*** | -0.11 | 0.06 | -0.17* | -0.12 | -0.11 | -0.16* | -0.15* |
| Stalks | 0.71*** | | 0.24** | -0.42*** | -0.13 | 0.19** | -0.32*** | -0.28*** | -0.29*** | -0.33*** | -0.34*** |
| Height | 0.80*** | 0.41*** | | 0.28*** | 0.06 | 0.11 | -0.05 | -0.09 | 0.02 | -0.03 | -0.02 |
| Diameter | 0.02 | -0.43*** | -0.21* | | 0.04 | -0.22** | 0.26** | 0.26** | 0.26** | 0.28*** | 0.28*** |
| DM | 0.07 | 0.18 | 0.28** | -0.46*** | | 0.53*** | 0.39*** | -0.13 | 0.52*** | 0.46*** | 0.47*** |
| Fibre | 0.04 | 0.22* | 0.24** | -0.51*** | 0.84*** | | -0.58*** | -0.91*** | -0.20** | -0.49*** | -0.46*** |
| Brix | 0.07 | 0.00 | 0.15 | -0.09 | 0.60*** | 0.08 | | 0.86*** | 0.72*** | 0.97*** | 0.95*** |
| BrixDM | 0.00 | -0.20* | -0.14 | 0.42*** | -0.47*** | -0.87*** | 0.42*** | | 0.48*** | 0.79*** | 0.76*** |
| Purity | 0.11 | 0.06 | 0.23** | -0.14 | 0.70*** | 0.37*** | 0.74*** | 0.03 | | 0.85*** | 0.90*** |
| Pol | 0.10 | 0.03 | 0.20* | -0.12 | 0.70*** | 0.21* | 0.96*** | 0.28** | 0.89*** | | 1.00*** |
| ERC | 0.11 | 0.03 | 0.21* | -0.11 | 0.70*** | 0.23** | 0.93*** | 0.24** | 0.94*** | 0.99*** | |

Above diagonal: TML- Coastal shorty cycle high potential mini-line, BML- Bruyns Hill mini-line, TCP- Tons of cane per hectare, DM- Dry matter, BrixDM- Brix dry matter, Pol- Polarisation, ERC- Estimable recoverable crystal, ns = * = P<0.05, ** = P<0.001, *** = P<0.0001

**Table 2: Plot Pearson correlations among yield and quality traits for TML12 (upper diagonal) and BML11 (bottom diagonal).**

| Trait | TCP | Stalks | Height | Diameter | DM | Fibre | Brix | BrixDM | Purity | Pol | ERC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TCP | | 0.61*** | 0.73*** | 0.36*** | -0.02 | 0.11* | -0.15** | -0.15** | 0.00 | -0.11* | -0.09 |
| Stalks | 0.70*** | | 0.24*** | -0.40*** | -0.04 | 0.22*** | -0.29*** | -0.29*** | -0.20 | -0.28*** | -0.28*** |
| Height | 0.80*** | 0.36*** | | 0.31*** | 0.09 | 0.18 | -0.10 | -0.17 | 0.08 | -0.05 | -0.02 |
| Diameter | 0.09 | -0.31*** | -0.11* | | 0.01 | -0.22*** | 0.25*** | 0.27*** | 0.26*** | 0.27*** | 0.28*** |
| DM | 0.15** | 0.19** | 0.30*** | -0.31*** | | 0.55*** | 0.36*** | -0.18 | 0.51*** | 0.43*** | 0.46*** |
| Fibre | 0.07 | 0.17* | 0.21** | -0.31*** | 0.83*** | | -0.58*** | -0.92*** | -0.16 | -0.48*** | -0.44*** |
| Brix | 0.16** | 0.09 | 0.23*** | -0.08 | 0.56*** | 0.00 | | 0.86*** | 0.68*** | 0.97*** | 0.94*** |
| BrixDM | 0.02 | -0.10 | -0.06 | 0.24*** | -0.43*** | -0.86*** | 0.50*** | | 0.43*** | 0.78*** | 0.74*** |
| Purity | 0.14* | 0.06 | 0.23*** | -0.08 | 0.64*** | 0.32*** | 0.66*** | 0.05 | | 0.82*** | 0.88*** |
| Pol | 0.16** | 0.08 | 0.26*** | -0.09 | 0.65*** | 0.15** | 0.94*** | 0.35*** | 0.87*** | | 0.99*** |
| ERC | 0.16** | 0.08 | 0.25*** | -0.08 | 0.65*** | 0.18** | 0.89*** | 0.29*** | 0.93*** | 0.99*** | |

Above diagonal: TML- Coastal shorty cycle high potential mini-line, BML- Bruyns Hill mini line , TCP- Tons of cane per hectare DM- Dry matter, BrixDM- Brix dry matter, Pol- Polarisation, ERC- Estimable recoverable crystal, ns= ,*= P<0.05, **= P<0.001, ***= P<0.0001

## Conclusion

Phenotypic correlations showed the differences in trait adaptation required for the midlands 24 month crop cycles and coastal short 12 month cycle. Generally, high populations of taller stalks were universal to both populations for achieving high cane yield while thicker stalks are important for the coastal short cycle but not the midlands. The high negative effect of fibre content for the coastal short cycle could be a result of high fibre due to breeding for eldana, which is at lower levels of infestation in the midlands.

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