SHORT, NON-REFEREED PAPER

ESTIMATES OF SUGARCANE CULTIVAR GENETIC GAINS FOR THE IRRIGATED REGION OF SOUTH AFRICA

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Abstract

Cultivar genetic gains provide a measure of benefits to growers of sugarcane breeding programmes. The objective of this study was to determine the genetic gains for cane yield, per cent estimated recoverable crystal (ERC%) cane and sugar yield of cultivars grown in the irrigated regions of South Africa. Data for cane yield and ERC% cane and sugar yield were derived from variety trials planted in early and late season at Pongola and Mpumalanga locations. There were significant (P<0.01) cultivar differences for cane and sugar yield and ERC% cane. There were non-significant season effects for cane and sugar yield and non-significant cultivar by season interaction for cane yield. There were significant (P<0.05) season effects for ERC% cane and significant (P<0.01) season by cultivar effects for ERC% cane and sugar yield suggesting seasonal adaptation of cultivars. There were 0.26 t/ha/year cultivar genetic gain for cane yield, 0.03 t/ha/year for sugar yield and 0.06% per year for ERC% cane. Genetic gains by sequence of release were 0.31 t/ha/cultivar for cane yield, 0.09 t/ha/cultivar for sugar yield and 0.06% per cultivar for ERC% cane. Cultivars released after 2000 produced genetic gains equivalent to 6% increase in sugar yield and 9% increase in ERC% cane compared to those released before 1990. ERC% achieved the highest genetic gains while cane yield produced the least. Planting recently released cultivars is expected to increase ERC% cane and sugar yield for the irrigated region.

Keywords: sugarcane, cultivar, genetic gains, early season, late season

Introduction

The cultivar genetic gains highlight the increase in yield and quality derived from plant breeding and the genetic improvements that provide profitability in sugarcane cultivation (Burnquist, 2013). Determining cultivar genetic gains highlights the efficiency of breeding programmes (Edme *et al*., 2005). Cultivar genetic gains measure the effectiveness of several cycles of recurrent selection in sugarcane breeding (Lingle *et al*., 2010). Previous studies on genetic gains in sugarcane breeding (Burnquist, 2013; Burnquist *et al*., 2010) showed larger genetic gains for countries located in the tropics, such as India (50%), Brazil (80%) and Thailand (150%) where flowering is profuse and diverse cross combinations are possible compared to subtropical countries such as South Africa and USA. Since the inception of the irrigated sugarcane breeding programme in South, there has been no study of cultivar genetic gains. The objective of this study was to determine the trends in genetic gains for cane yield, ERC% cane and sugar yield of cultivars released in the irrigated regions of South Africa.

Materials and Methods

Data for cane yield, ERC% cane and sugar yield were collected from advanced variety trial series planted in 1997 to 2014, and harvested in 1998 to 2015. Three trials, FV (Pongola research station) and NNV (Mpumalanga research station) were planted and harvested in the early season, while FV2 (Pongola research station), NPV2 (Pongola off station site) and NTV2 (Mhlati site in Mpumalanga) were harvested mid to late season. Early season trials were harvested from March to May while mid to late season trials were harvested from July to August. Each trial was designed as a randomised complete block design with three replications. The number of genotypes in each trial ranged from 30 to 36, including the cultivars that were used as controls. In each trial, the experimental plot consisted of five rows measuring 8.0 m long and spaced 1.4 m between the rows. The trials were harvested in the plant, first, second and third ratoon crops at 12 months crop age. Data for cultivars only were subjected to analysis of variance (to determine significant effects) and simple linear regression (for trends across cultivars) (Zhou, 2014; Zhou and Gwata, 2016).

Results and Discussion

There were highly significant differences (P=0.0001) among cultivars for cane yield (Table 1) and no significant differences between seasons (P=0.2984) and season by cultivar interaction (P=0.3689) suggesting cultivars shared similar adaptation to early and mid-season. There were highly significant differences (P=0.0001) among cultivars for ERC% cane, significant differences between seasons (P=0.0203) and significant season by cultivar interaction (P=0.0003) suggesting maturity differences among cultivars for early and mid-season. For sugar yield, there were significant differences among cultivars (P=0.003) and season by cultivar interaction (P=0.0017) but non-significant differences between seasons (P=0.5201), suggesting seasonal adaptation largely controlled by ERC% cane. Higher CV% and lower R^2 for yield indicated larger variability of the data compared to ERC% cane.

Table 1. Fixed effects for cane yield, ERC% cane and sugar yield for season by cultivar analysis.

Effect	NDF, DDF	Cane yield (t/ha)		ERC% cane		Sugar yield (t/ha)	
		F value	P value	F value	P value	F value	P value
Season	1,3	1.57	0.2984	20.37	0.0203	0.53	0.5201
Cultivar	19,42	5.28	0.0001	8.75	0.0001	2.77	0.0030
Season x Cultivar	19,42	1.12	0.3689	3.81	0.0003	3.09	0.0017
R^2		0.45		0.51		0.33	
CV%		20.1		15.2		24.9	

When the least square means for cane yield were plotted against cultivars (Figure 1), there was a non-significant (r=0.19; P=0.4342) and 0.31 t/ha/cultivar genetic gains for cane yield indicating limited improvement. There was a non-significant (r=0.44; P=0.0865) and 0.06% per cultivar genetic gains in ERC% cane in the early season and significant (r = 0.65; P = 0.0053) and 0.07% per cultivar genetic gains in the mid-season. The lower gains in the early season suggest potential benefit of using ripeners to enhance ERC% cane during first harvested crops. Recurrent selection (Lingle *et al*., 2010) is required to accelerate gains in early season. For sugar yield, there was non-significant (r=0.45; P=0.0637) and 0.08 t/ha/cultivar genetic gains in the early season while mid-season showed non-significant (r=0.44; P=0.079) and 0.09 t/ha/cultivar genetic gains.

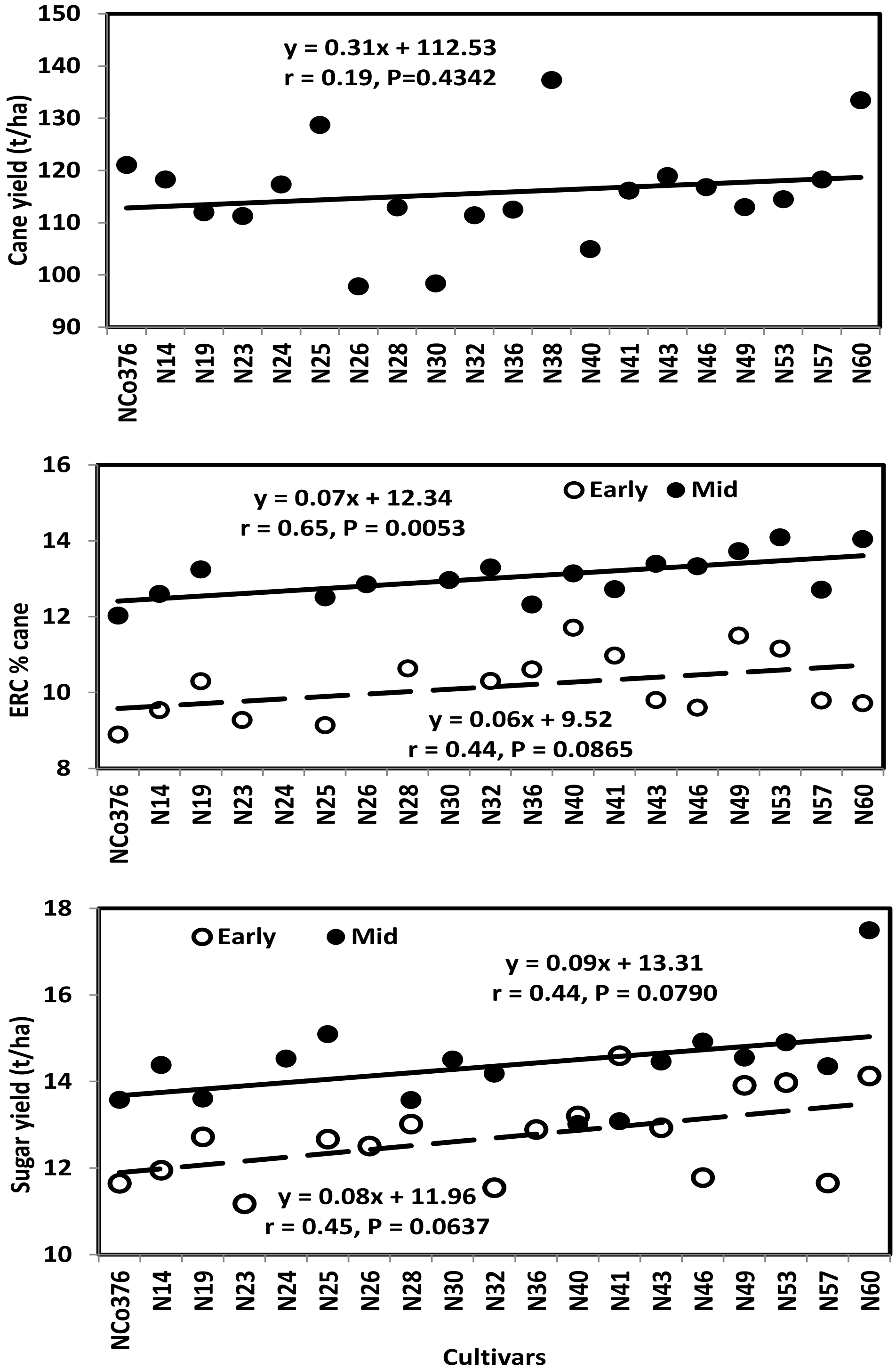

Figure 1. Cane yield, ERC% cane and sugar yield plotted against cultivar.

The highly significant differences among cultivars for cane yield, ERC% cane and sugar yield indicated that cultivars were distinctly different and diverse for these traits. The differences were largest for ERC% cane, followed by cane yield, while sugar yield produced the smallest differences. The large differences for ERC% cane highlight the diverse maturity differences among the cultivars. The lower differences for cane yield compared to ERC% cane highlights the similar yield adaptation of current cultivars for cane yield compared to ERC% cane. Sugar yield, a product of cane yield and ERC% cane, with the lowest cultivar differences highlight the negative association between yield and quality (Jackson, 2005; Milligan *et al*., 1989).

The higher genetic gains for ERC% cane compared to cane and sugar yield for the irrigated cultivars are similar to results reported in Florida, USA (Edme *et al*., 2005). The higher genetic gains are also similar to trends in realised genetic gains (Zhou, 2013) for the irrigated final stage breeding populations. Previous studies (Lingle *et al*., 2010) also demonstrated high genetic gains for ERC% cane achieved by several cycles of recurrent selection in Louisiana, USA. The trends in Figure 1 show higher ERC% cane and sugar yield in mid than early season crops. Thus, mid-season is the optimum time for harvesting sugarcane because it coincides with low rainfall and cooler temperatures during winter months, conditions ideal for sucrose accumulation in sugarcane.

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