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Effect of long-term application of potassium on sugarcane and soil properties in the Herbert River district

G Park[1], BL Schroeder[2], AW Wood[3] and DM Skocaj[4]

[1]*Sugar Research Australia Limited, Ingham, Qld 4850;* gpark@sugarresearch.com.au
[2]*University of Southern Queensland, Toowoomba, Qld 4350*
[3]*Tanglewood Agricultural Services, Millaa Milllaa, Qld 4886*
[4]*Sugar Research Australia Limited, Tully, Qld 4854*

Abstract Excess potassium (K) fertiliser use can have a significant effect on sugar quality and refining costs but offers no benefit to sugarcane crop yield. Potassium fertiliser guidelines are based on soil texture and two measures of soil potassium: readily available or exchangeable K and reserve K. The maximum recommended K rate for the Herbert is 120 kg/ha. A long-term K trial was established on a sandy loam soil at Macknade. High K application rates increased soil exchangeable K levels and resulted in luxury K consumption by the sugarcane plant. This significantly increased juice conductivity and third-leaf K levels. It also resulted in significant reductions in third-leaf values for Ca and Mg.

Key words Potassium, exchangeable K, nitric K, juice conductivity, sugar quality

INTRODUCTION

An average sugarcane crop will remove about 115 kg potassium (K)/ha when the crop is sent to the mill (Calcino *et al*. 2018). Sugarcane plants will luxury feed on K where there is a surplus and this can result in an increased ash content in sugarcane juice and a consequent reduction in the recovery of raw and refined sugar (Jackson *et al*. 2008). Potassium fertiliser recommendations are lower than the average crop removal rate due to the supply of K from weathering of clay minerals (Mengel and Haeder 1973). Potassium fertiliser guidelines for sugarcane production in Australia are based on soil texture and two measures of soil potassium: readily available or exchangeable K and reserve K (Wood *et al*. 2003). The maximum recommended rate for the Herbert sugarcane growing region is 120 kg K/ha.

In August 2000, a long-term small-plot field trial was established on a River Bank soil to validate the K fertilizer guidelines within the SIX EASY STEPS nutrient-management program. River Bank soils are widespread along the Herbert River and former courses of the Herbert River, such as Palm and Trebonne Creeks, and they also occur along Stone River. They are well drained and form in the highest part of the floodplain landscape and are sufficiently old to have developed a distinctive dark organic surface horizon that overlies a yellowish-brown subsoil (Wood *et al*. 2003).

METHOD

A randomized complete-block small-plot experiment with eight replicates was established with four annual K treatments: 0 kg/ha, 85 kg/ha, 170 kg/ha and 255 kg/ha. Potassium was applied as muriate of potash. A single nitrogen rate of 100 kg N/ha was applied annually as urea. No phosphorus fertilizer was required based on a soil test prior to the trial. Plot size was three rows wide by 13 m long. This paper reports on findings from the second crop cycle of this experiment (2009-2018) using sugarcane cultivar Q200⏀.

Soil core samples (0-20, 20-40, 40-60, 60-80 cm depths) were collected in March 2017 (7th ratoon) using a soil corer and jackhammer. Samples were air-dried and ground and were analysed for exchangeable K and nitric K using standard procedures. Third-leaf samples were collected in March 2017. They were dried and ground in preparation for analysis according to standard methodology. Six-stalk samples were collected from the middle row of each plot prior to harvesting and weighing using a weigh-tipper. Juice samples were collected using a small mill and were analysed for CCS and conductivity up until 2015. In later years, SpectraCane™ was used to determine CCS.

RESULTS

Exchangeable K values in the top 80 cm of soil increased with K applied (Figure 1). At the highest rate of K application, the highest levels of exchangeable K were in the 0-20 cm increment. There appears to be no relationship between soil nitric K values and the rate of K applied (compare Figure 1 and Figure 2).

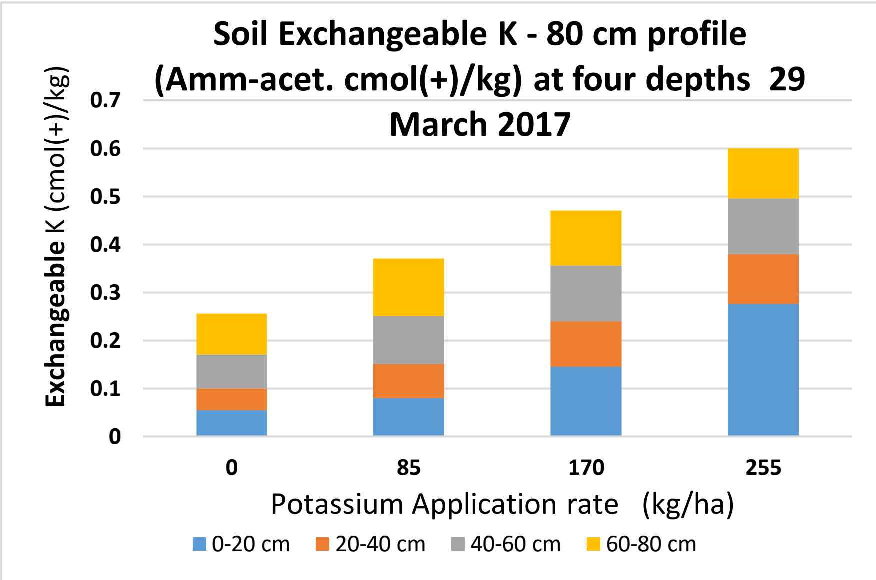

Figure 1. Effect of potassium fertilizer on soil exchangeable K.

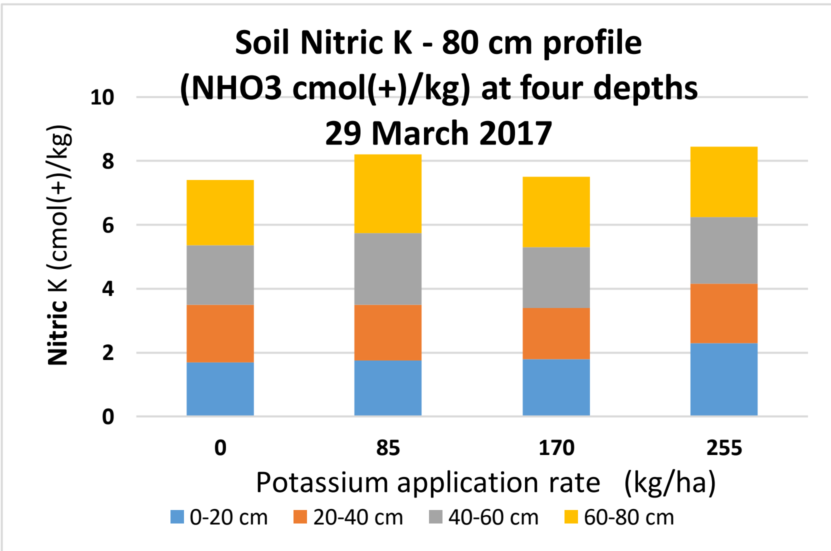

Figure 2. Effect of potassium fertilizer on soil nitric K.

In the 7th ratoon crop, third-leaf K values increased with K applied, whereas Ca and Mg values declined (Table 1). This latter effect may be related to the additional K occupying the cation exchange sites.

Yield data were analysed for each season separately. Cane yield responses to applied K occurred only in the third and fourth ratoon crops (Table 2). However, substantial differences in yield occurred from season to season. No significant differences in CCS values occurred within crops (data not shown here).

Table 1. Effect of potassium fertilizer on third leaf K, Ca and Mg (7th ratoon crop)*.

Potassium applied (kg/ha)	Leaf K (%)	Leaf Ca (%)	Leaf Mg (%)
0	1.3^{C}	0.26^{A}	0.173^{A}
85	1.5^{B}	0.22^{B}	0.143^{B}
170	1.6^{AB}	0.19^{C}	0.135^{BC}
255	1.7^{A}	0.18^{C}	0.128^{C}
Critical value	1.1	0.2	0.08

*Means in a column followed by the same letter are not significantly different (Tukey $p < 0.05$).

Table 2. Effect of potassium fertilizer on cane yield (t/ha)*.

Potassium (kg/ha)	Plant (2010)	2nd ratoon (2012)	3rd ratoon (2013)	4th ratoon (2014)	5th ratoon (2015)	6th ratoon (2016)	7th ratoon (2017)	8th ratoon (2018)
0	78^{A}	70^{A}	69^{B}	73^{B}	93^{A}	74^{A}	101^{A}	71^{A}
85	77^{A}	82^{A}	82^{AB}	84^{AB}	102^{A}	80^{A}	97^{A}	74^{A}
170	88^{A}	87^{A}	85^{A}	79^{AB}	107^{A}	83^{A}	102^{A}	84^{A}
255	90^{A}	87^{A}	92^{A}	93^{A}	113^{A}	83^{A}	109^{A}	84^{A}

*Means in a column followed by the same letter are not significantly different (Tukey $p < 0.05$). First ratoon was damaged in a cyclone.

Juice conductivity values (Table 3) increased with K applied in each crop that was sampled (plant to 5th ratoon). This is consistent with the findings of Jackson *et al*. (2008) who found that conductivity levels increased by 15% per 100 kg/ha of applied K. The conductivity values for the 2010 and 2011 crops tended to be higher than later crops. Rainfall records were higher for 2010, 2011 and 2012 than 2013, 2014 and 2015, and soil K is influenced by moisture and temperature (Wood and Meyer 1986). The low conductivity values for the high rainfall year of 2012 appear to be outliers and inconsistent with the findings of Kingston *et al.* (2009) who found a strong correlation between cumulative rainfall between November and January and leaf K.

Table 3. Effect of potassium fertilizer on juice conductivity (dS/m)*.

Potassium (kg/ha)	Plant (2010)	1st ratoon (2011)	2nd ratoon (2012)	3rd ratoon (2013)	4th ratoon (2014)	5th ratoon (2015)
0	2.2^{B}	1.9^{B}	0.9^{B}	0.9^{C}	0.9^{C}	1.1^{B}
85	2.4^{B}	2.1^{B}	1.1^{B}	1.1^{BC}	1.2^{B}	1.4^{B}
170	3.0^{A}	2.8^{A}	1.3^{AB}	1.3^{AB}	1.3^{B}	1.8^{A}
255	3.2^{A}	3.0^{A}	1.6^{A}	1.6^{A}	1.7^{A}	1.8^{A}

*Means in a column followed by the same letter are not significantly different (Tukey $p < 0.05$).

DISCUSSION AND CONCLUSIONS

Data from long-term K fertiliser trials such as this are of great value for building confidence in the current SIX EASY STEPS K management guidelines. It is only by determining yield responses, soil and plant K over a range of seasonal conditions, with high- and low-yielding crops and variable rainfall events, that critical values can be evaluated.

The data collected from this site show a consistent link between K fertiliser rates, soil exchangeable K and juice conductivity. This justifies the restriction in SIX EASY STEPS K guidelines to minimise the impact on sugar quality.

ACKNOWLEDGEMENTS

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