

SHORT NON-REFEREED PAPER

TOWARDS THE MORE EFFICIENT USE OF FERTILISER POTASSIUM: PREDICTION OF 'SLOWLY-AVAILABLE' POTASSIUM RESERVES IN SOILS

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Abstract

Potassium (K) removals in harvested sugarcane generally range from 100 to 300 kg/ha. Since all K fertiliser is imported, the price is subject to the vicissitudes of the exchange rate. Current annual expenditure on this nutrient in the South African sugar industry is estimated to be in the region of half a billion rand. This investigation deals with the measurement of non-exchangeable ('slowly-available') K reserves in sugarcane soils from South Africa and neighbouring countries. Non-exchangeable K was determined in topsoil samples (n=340) using the boiling nitric acid procedure. Median nitric K was 1.19 cmol_c/kg, with the range being 0 to 17.89 cmol_c/kg. Values were highest in the northern irrigated areas of the South African industry, and in countries to the north, and lowest in the Midlands and coastal areas of South Africa. Data from Australian sugarcane trials as well as from a local sugarcane trial and long-term (25-year) maize trial suggest that for nitric K values above about 2.5 cmol_c/kg, no fertiliser K is required. Since the nitric acid extraction is laborious in terms of routine soil testing, the challenge is to develop reliable predictions of non-exchangeable K using either infra-red spectroscopy or multiple regression techniques based on routinely-measured soil parameters. The potentials of these approaches are considered in the paper.

Keywords: potassium, fertiliser, non-exchangeable K, boiling nitric acid extraction, topsoils

Introduction

Balanced crop nutrition is of cardinal importance in the profitable production of sugarcane. Following the successful establishment of the crop, nutrients of primary concern in ratoon production are N and K. Potassium is taken up in large amounts by the crop, and removals in harvested stalks for high-yielding crops generally range from 100 to 300 kg/ha (Kingston, 2000). Since all K fertiliser is imported, the price is subject to fluctuations in the exchange rate. Current annual expenditure on this nutrient in the South African sugar industry is estimated to be approximately half a billion rand.

Soils of the southern African sugar industries are characterised by considerable variability in terms of their mineralogical, chemical and physical properties. This creates particular challenges for the management of crop nutrition. In terms of K, wide variations in the content of micaceous clays in soils imply significant variability in the 'slowly-available' K reserves

for crop growth (Wood and Schroeder, 1991). The accurate estimation of such reserves is central to the optimisation of the efficiency in K use in production systems.

In this paper, K responses measured in field trials conducted on soils with appreciable 'slowly available' K reserves, are considered. In addition, data on K reserves in soil samples from throughout the sugar-producing areas of southern Africa are reported.

Methodology

Field trials

Data from two field K-response trials are reported in this paper:

- A long-term trial at Bergville (1973-1998) examined maize responses to K on an Avalon soil with 36% clay. Treatments included controls (zero K) and incremental rates of fertiliser K, with the source being potassium chloride. At every harvest, both grain and stover were removed from the trial.
- Sugarcane responses to incremental rates of K (as potassium chloride) were studied in a trial at Komatipoort (Glenrosa soil; 35% clay). The trial was burned prior to cutting, and involved three harvests of successive ratoon crops.

Survey of nitric acid K levels in sugar industry soils

Investigations were carried out on 340 topsoil (0-200 mm) samples from sugarcane fields in six southern African countries. The samples from South Africa (n=237) were collected from fields distributed throughout the sugarcane producing areas. Samples from countries to the north included 61 from Tanzania (TPC Estate), 10 from Mozambique (Maragra Estate), 11 from Malawi (Dwangwa Estate), 11 from Swaziland (Ubombo Estate) and 10 from Zambia (Nanga Estate). Determination of boiling nitric acid K involved 30 minute boiling with 1 N HNO₃ and the determination of K by ICP. Exchangeable K in samples was subtracted from the nitric acid values, and the resultant data referred to hereafter as 'nitric K'.

Results and Discussion

Responses to potassium in field trials

In the Bergville maize trial, where topsoil nitric K was 2.08 cmol_c/kg, no yield response to K was forthcoming for the 25-year duration of the trial. Soil exchangeable K test values and annual K removals are shown in Figure 1a. It is noteworthy that despite substantial K removals in harvests, exchangeable K levels on this site remained essentially constant for the first 20 years of the study. In the Komati trial (nitric K = 2.63 cmol_c/kg), K treatments had no effect on stalk or sucrose yields for the three ratoon crops (average stalk yields for the three ratoons were 119, 157 and 155 t/ha).

A relationship between nitric K values and responsiveness to K in sugarcane field trials was developed in Australia by Haysom (1971). Nitric K levels of >2.5 cmol_c/kg were deemed to be 'very high', with there being no requirement for fertiliser K for high levels of production. Potassium recommendations for sugarcane production in Australia are currently based on both exchangeable and nitric K measurements (Schroeder *et al.*, 2007). The lack of response to K in the field trials included here is essentially consistent with these Australian findings.

Nitric K levels in soils

Median nitric K levels in soils from the various sugar producing areas in South Africa and from estates in countries to the north are shown in Figure 1b. The median for all areas was 1.19 cmol_c/kg, with the range being from 0.27 (Eshowe) to 7.9 cmol_c/kg (Tanzania). With the exception of the Mozambique samples, median values for all irrigated areas were above the 2.5 cmol_c/kg threshold proposed by Haysom (1971).

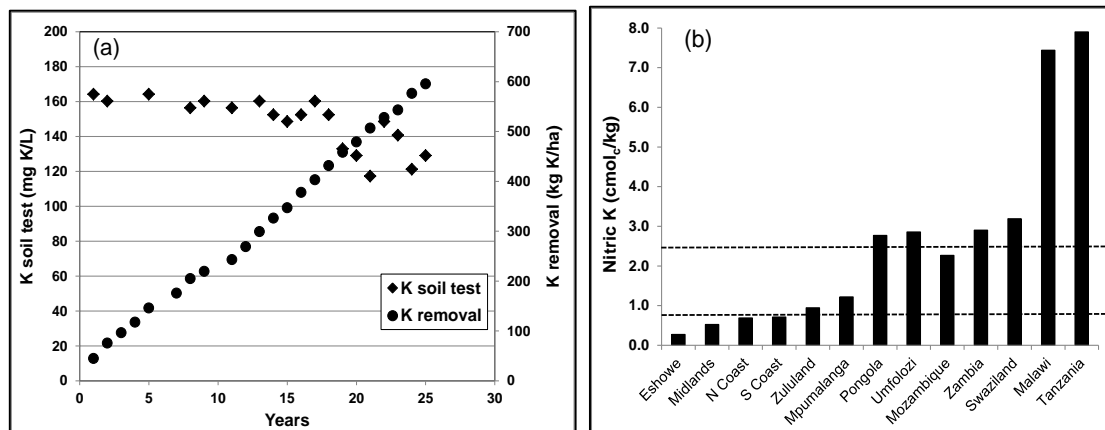


Figure 1. Topsoil exchangeable K and K removals in the harvest in the maize trial at Bergville (a), and median nitric acid extractable K levels in regions of South Africa and in other southern African countries (b). The dotted horizontal lines in (b) indicate the ‘low’ and ‘very high’ levels specified in the Australian studies of Haysom (1971).

Of note, from the point of view of extending advice on K fertiliser requirements, is that within particular areas a wide range in nitric K values was frequently apparent, as reflected in the spread of data for the North Coast (Figure 2a).

Attempts to predict nitric K using mid-infrared (MIR) spectroscopy or multiple regression, based on routinely measured soil properties, met with limited success. The MIR calibration developed (Figure 2b) reflects considerable uncertainty throughout the range of values measured, including at relatively low (<2.5 cmol_c/kg) values, which would be of relevance in terms of adjusting K recommendations. Multiple regression using only South African soils yielded a model with an R² of 40.4% and standard error of prediction of 0.937, based on the parameters extractable Si (0.01 M CaCl₂), volume weight, organic carbon and exchangeable Mg.

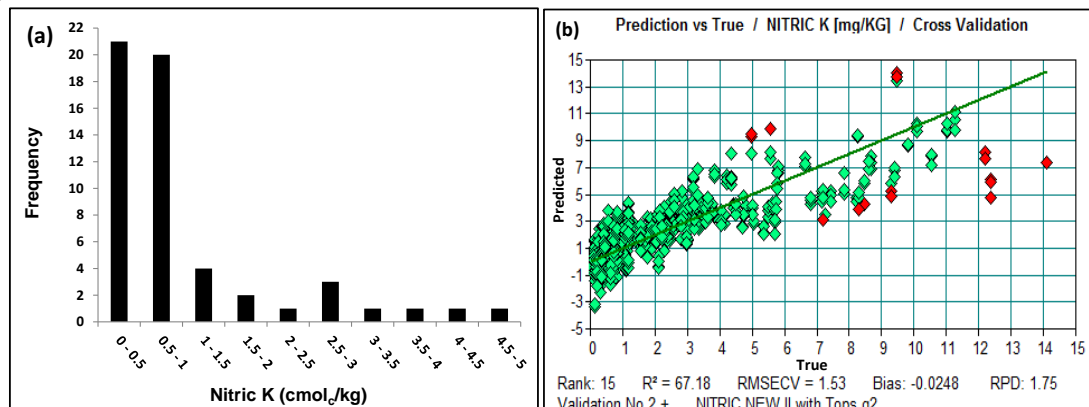


Figure 2. Frequency distribution of nitric K values in samples from the North Coast (a) and mid-infrared prediction of nitric K levels for all topsoils included in the study (b).

Conclusions

Field trial data presented here clearly indicate that, on soils with appreciable non-exchangeable K reserves, crop K requirements may be supplied from these reserves, with there being little or no fertiliser K requirement for periods of many years. The nitric K survey data reflect extremely wide variations in K reserves in sugarcane-producing soils in southern Africa, with the rainfed coastal and midlands areas of South Africa having extremely low reserves, while irrigated areas to the north generally have from high to extremely high reserves. These findings reflect a potential for massive savings in fertiliser K; however, for such savings to be fully appropriated, it is of paramount importance that tests for non-exchangeable K reserves be included in routine soil testing packages in the future.

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