CHANGING FERTILISER PRACTICES IN THE SMALL-SCALE SECTOR OF THE SOUTH AFRICAN SUGAR INDUSTRY: THE ROLE OF EXTENSION

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Abstract

Since 1980, sugarcane production by small-scale growers (SSGs) has increased significantly, and today comprises about 15% of the annual crop in South Africa. Opportunities exist for increasing sugarcane production in the SSG sector through both vertical and horizontal expansion. This paper focuses on current practices with respect to low fertiliser usage in the small-scale sector, the potential for vertical expansion through nutrient replenishment, and the beneficial role that extension can play in achieving this.

Sugarcane crops grown by SSGs in South Africa are generally produced on soils where the levels of nutrients have been depleted, which is in contrast with the soils of large-scale (commercial) farmers, where regular fertiliser application is an accepted management practice. An assessment of records from the Fertiliser Advisory Service of the South African Sugar Association Experiment Station showed that a high proportion (46%) of SSG soil samples are strongly acid (pH <5) and severely deficient in plant available phosphorus, probably because of the high cost of replenishing phosphoric fertilisers. The reasons for a practice that is effectively ‘soil nutrient mining’ by SSGs are explored, and a practical solution to benchmarking and mapping soils for a ‘best fit’ replenishment practice is proposed in the development of a practical tool that can be used in the field by the Extension Officer to circumvent the need for frequent soil analyses in the future.

Keywords: sugarcane, extension, small-scale growers, soil nutrients, soil sampling, soil analysis

Introduction

The international research and development world and local politicians are realising that the exploitation of inherent soil fertility through current farm management practices is threatening food security and the position of economically important agricultural sectors of many sub-Saharan countries (de Jager *et al*., 1998).

There are essentially three groups of sugarcane farmers in South Africa: commercial large-scale growers, farming on titled land of 30 hectares and more, freehold growers farming on titled land, often less than 30 hectares in size, and small-scale growers (SSGs) farming on tribal trust land without ownership. The term ‘small-scale’ is used for land holdings of less than 30 hectares and may include both freehold titled land and tribal land.

The history of SSGs in the South African sugar industry is one of exponential growth, both in numbers and production. The number of SSGs rose from 43 000 in 1992 to 48 000 in 2002, and their contribution to the total crop increased from 10% (1.3 million tons) in 1992 to 15% (3 million tons) in 2002. This figure was as high as 18% in 1997 when the small-scale sector of the industry produced in excess of 4 million tons cane (Anon, 1992/93-2001/02).

Many of the SSGs in KwaZulu-Natal are farming on 'Ngonyama' tribal trust land without freehold title and have, on average, holdings of less than one hectare planted to sugarcane. Two mutually inclusive production restrictions that small-scale farmers most often face are a lack of access to finance and related support, and the depleted nutrient status of their soils. The ability to access finance for production in the form of loans more often than not depends on their capacity to repay these loans, which diminishes when no loan security is offered and low yields are achieved. As a result, there has been reluctance on the part of lending institutions to offer financial support. Coupled with this is the very real problem of ever-increasing demands on family finances away from the agricultural enterprise as the costs of food, fuel, clothing, school fees, medical bills and funerals rise rapidly.

The provision of an effective extension service to the 48 000 SSGs in the industry is critical to the future production and sustainability of this sector. An economically stable small-scale agricultural sector will assist in reducing rural drift and poverty in the KwaZulu-Natal province of South Africa.

The South African sugar industry depends to a large extent on the analysis of soil and leaf samples submitted to the Fertiliser Advisory Service (FAS) of the South African Sugar Association Experiment Station (SASEX) for identifying soil nutrient disorders, and the provision of cost effective fertiliser recommendations to all sugarcane farmers (Meyer, 1998). When the farmer receives FAS results, he/she has the added benefit of being able to call upon the skills and experience of the local Extension Officer (EO) and, if necessary, a SASEX specialist, to assist in the interpretation of the recommendations and the planning of a balanced fertiliser programme.

Improvements in computer technology now enable the EO to access the comprehensive FAS databank, which greatly facilitates the service offered. Since 1980, approximately 10 000 soil samples from SSGs and more than 200 000 samples from the commercial sector have been processed by the FAS.

This paper analyses historical data to identify nutritional factors limiting cane growth, and areas where nutrient deficiencies are likely to occur. The paper identifies opportunities where extension can bring about changes in fertilising practice, and offers a hypothesis and proposal which could in the future reduce the need for regular soil analyses in SSG fields.

Data examination

Nutrient survey

A Nutrient Information Retrieval System (NIRS) was developed by SASEX specifically to capture and store soil and leaf analysis data, and surveys were carried out in which the frequency distribution of important soil and plant nutrients were categorised in stages of sufficiency for the different extension areas (Meyer *et al*., 1989; Meyer, 1998).

The main soil data set for the whole industry is comprised of pH (H_2O) and plant available P, K, Ca and Mg values of about 224 000 soil samples analysed by FAS over the 20-year period from 1980 to 2001, together with information that identifies the extension area, the bioclimatic system and the soil parent material for each area. The soil data set for the SSGs (referred to as the KZN group) was much smaller, and contained about 10 000 samples. This smaller data set was further divided into the main sub-regions of Mpumalanga, KZN (Zululand North, Zululand South, North Coast and Southern Area) and the freehold North

Coast grower group. The KZN North Coast and North Coast freehold data sets were large enough to be benchmarked against the North Coast commercial farmer sector. All three North Coast data sets were in turn subdivided into nine periods of three years each (1980-82, 1983-85, 1986-88, 1989-91, 1992-94, 1995-97, 1998-2000 and 2001-2003), to facilitate the comparison of trends in the respective soil measurements. Analytical methods were the same as those used in a previous survey (Meyer, 1988), as were the class intervals for interpreting soil analyses into various stages of sufficiency.

The mean results for the main SSG sectors in relation to the commercial farmers are summarised in Table 1. The percentage samples rated as strongly acid (pH <5) and deficient in P and K are included in the summary.

Table 1. Comparison of average pH and nutrient content of soil samples from small-scale grower areas in relation to freehold and commercial grower groups.

Area	Main mills	Parent material	No. of samples	pH water	% pH <5	P ppm	K ppm	Ca ppm	Mg ppm	% deficient	
										P	K
Mpumalanga	Malelane, Komati	Basalt, Alluvium	681	6.50	0	22	182	1133	405	24	10
KZN Zululand North	Felixton, Umfolozi, Pongola	Recent sands, Alluvium	255	5.96	7	17	172	911	249	45	27
KZN Zululand South	Amatikulu	TMS (ord)	549	5.5	13	13	94	449	158	59	47
KZN North Coast	Darnall, Maidstone	TMS (ord)	2598	5.18	34	14	113	297	93	58	33
KZN Southern Area	Sezela, Umzimkulu	Granite, TMS (ord)	483	5.44	25	16	129	731	281	44	24
KZN Average	**10 mills**		**4566**	**5.52**	**20**	**16**	**138**	**704**	**237**	**46**	**28**
North Coast (freehold)	3 mills		6352	5.19	25	18	125	349	120	15	31
North Coast (commercial)	3 mills		55851	5.16	33	30	121	565	148	11	27
Commercial farmers	**15 mills**		**213797**	**5.35**	**18**	**33**	**134**	**723**	**194**	**12**	**20**
Soil threshold values (ppm)				>5.5	~	13	112	200	25	~	~

Results

The main findings shown in Table 1 are summarised below:

Soil acidity

- In general, SSG soils in the Mpumalanga area were the least acid, followed by KZN Zululand North and South, KZN Southern Area and KZN North Coast. The proportion of strongly acid soils (pH <5) in KZN varied widely, ranging from 34% on the North Coast to 7% in Zululand North.

- Of interest is that the three North Coast grower groups showed similar mean soil pH values, and the KZN group had the highest concentration of strongly acid soils, closely followed by the commercial and freehold grower groups.
- Since 1990, there has been a marked increase in the rate of soil acidification in most areas, especially on the North Coast. The relative extent of soil acidification for the three North Coast producer groups is shown in Figure 1. Clearly, the KZN group showed the greatest increase in soil acidification, with the proportion of strongly acid soils increasing from about 24% in 1990 to over 60% in 1997. This stabilised thereafter at approximately 30%. The commercial group closely mirrored this trend in acidification, although the rate of soil acidification was markedly lower for the North Coast freehold group.
- The increasing trend in soil acidification is cause for concern and can well influence cane growth:
- by increasing the uptake of toxic ions, such as aluminium and manganese
- through a direct effect of the hydrogen ion concentration on nutrient uptake
- indirectly by affecting major and trace nutrient availability.
- Accelerated acidification of soils under cultivation is most often due to the combined effect of conversion of ammoniated fertilisers to nitric acid, mineralisation of organic matter and leaching of basic cations from the soil.

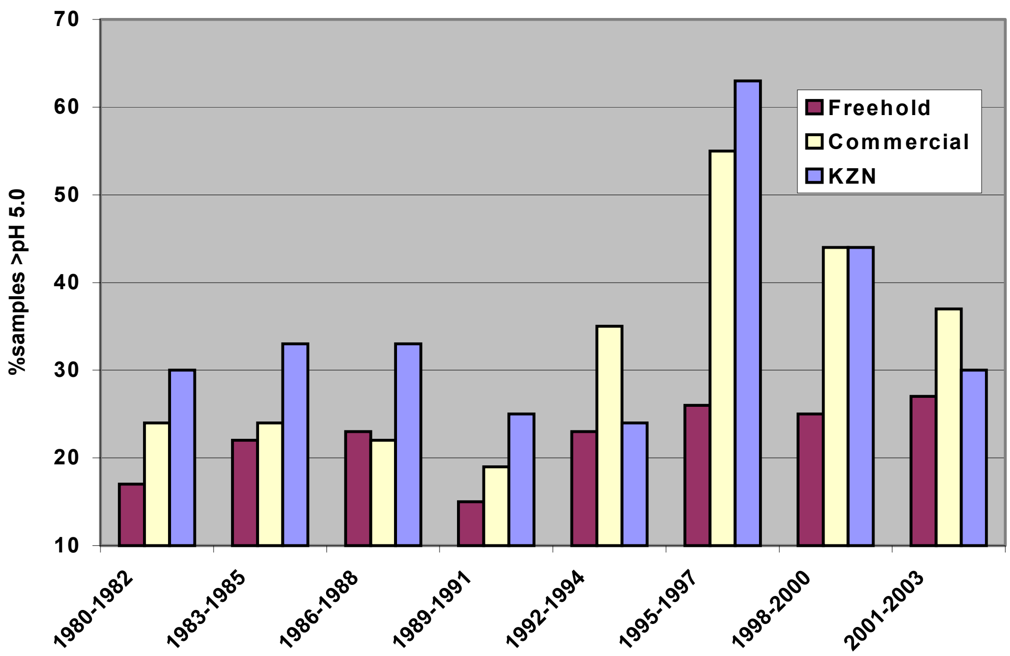

Figure 1. Trends in the development of strongly acid soils in three North Coast grower groups from 1980 to 2003.

Phosphorus availability

- In general, the small-scale KZN areas have a lower P status (mean 16 ppm) than the commercial sector (33 ppm). The KZN Zululand South farmers appear to be the worst off, with 59% of soil samples marginal to deficient in P, closely followed by KZN North Coast with 58% soils poorly supplied with P.
- Soils in the freehold grower areas are in general the best supplied with P, with only 15% of samples recording a low P status, followed by soils in the Mpumalanga area with 22% of the samples low in P.

- Despite the apparently poor P status of the KZN soils, there is evidence of an improvement in P levels over the past three years for the North Coast group of farmers (Figure 2). By contrast, P levels for the North Coast freehold farmers have deteriorated over this period.

Potassium availability

- In general, the soil potassium status of the SSG group compared favourably with that of farmers in the commercial sector. Mean K levels in soils in Mpumalanga (182 ppm) and KZN Zululand North (172 ppm) are a lot higher than the average for the commercial sector (134 ppm).
- The K status of the remaining small-scale grower areas was below the mean for the commercial sector, especially KZN Zululand South (94 ppm). Overall, 47% of the samples submitted from KZN Zululand were deficient in K.
- A comparison of soil K trends since 1980 for the three North Coast farmer sectors indicates a steady improvement in mean soil K levels for the KZN and commercial farmers, whereas the reverse is indicated for the freehold farmers. Trends in all three areas are characterised by a spike between 1991 and 1993 due to the residual build-up of K during drought (Figure 3).

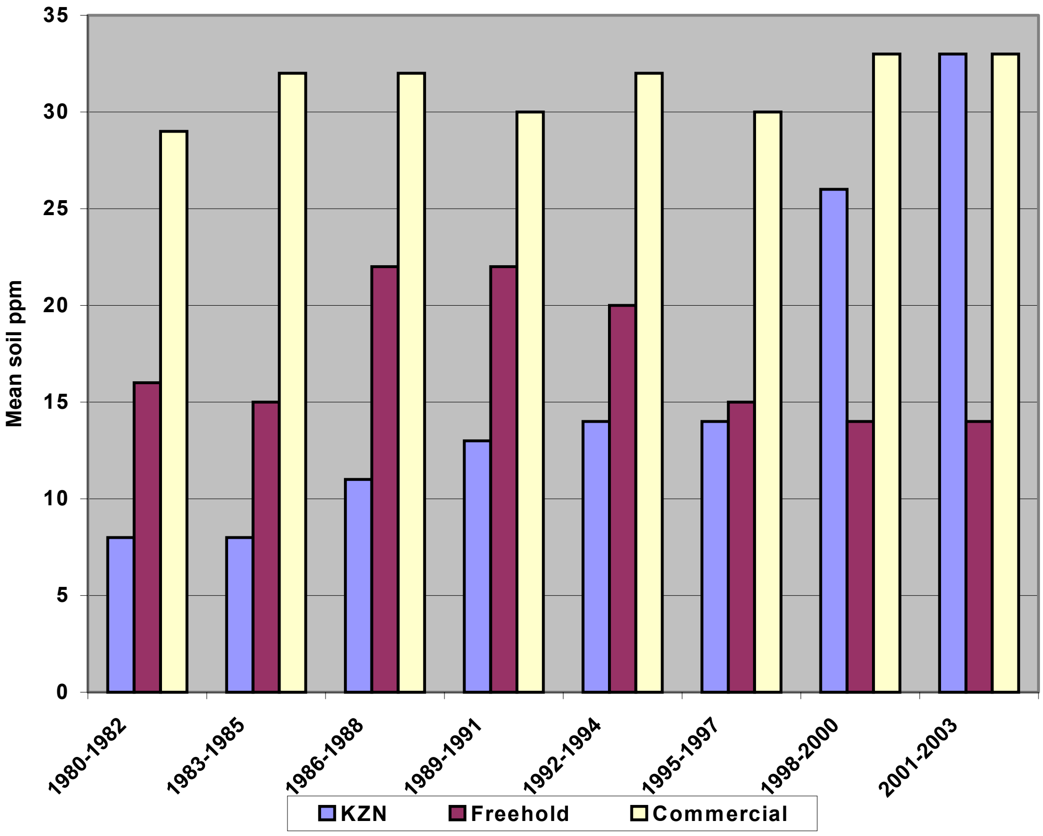

Figure 2. Comparative trends in soil P levels for three North Coast grower groups from 1980 to 2003.

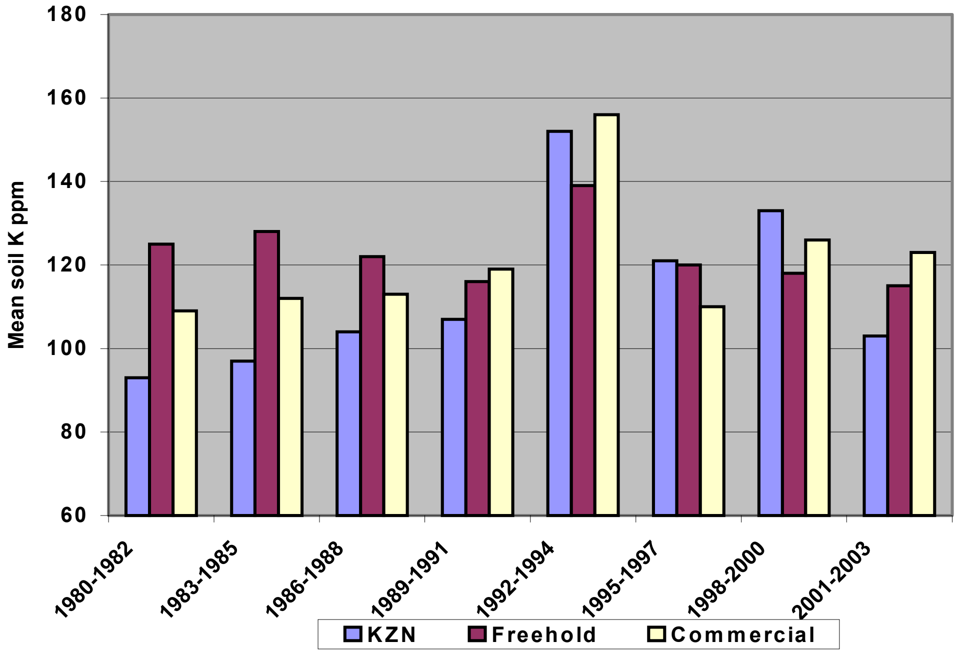

Figure 3. Comparative trends in soil K levels for three North Coast grower groups from 1980 to 2003.

Calcium and magnesium

- About 21% of soil samples from the KZN farmers were deficient in Ca compared with 28% for freehold farmers, and 15% for commercial farmers.
- Of the KZN farmers, the areas showing the highest incidence of Ca deficiency over the period 1980 to 2002 were the North Coast (38%), followed by Zululand South (28%), KZN Southern Area (28%) and Zululand North (14%).
- Although KZN North Coast had the highest frequency of Ca deficiency, the incidence declined from 47% between 1980 and 1982 to just over 12% in 2002 (Figure 4). By comparison, the North Coast commercial and freehold farmers showed an upward trend in Ca deficiency.
- The incidence of Mg deficiency was less than 7% in all areas.

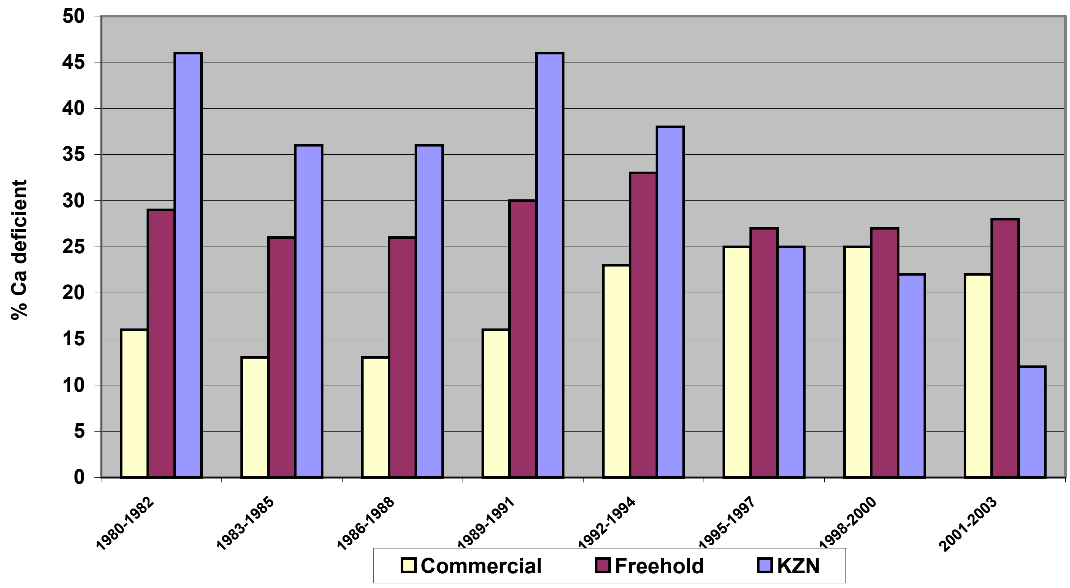

Figure 4. Frequency of soil samples deficient in calcium.

Discussion

The results of the survey have shown clearly that soil acidity, and P and Ca deficiencies are factors that will limit cane growth in the KZN group of farmers, and that a concerted effort by extension staff is required to promote the use of not only soil nutrients but also soil ameliorants.

There needs to be an increase in the number of samples submitted by the small-scale farmers for analysis. If the current production ratio of 85:15% between commercial and small-scale farmers were to be applied to the number of soil samples submitted annually (13 600), then there should be an annual submission of 2 000 soil samples from the SSG sector. The submissions in 2003 were less than half this number.

Based on plant threshold values, the results of soil analyses are deemed to be only 70% accurate in determining the limiting nutrients successfully, and the 30% deficit will limit yields. Although the laboratory can provide very accurate analyses, this will diminish substantially where due attention is not paid to proper sampling methods, and where there is a lack of diligence on the part of the sampler. It is here that problems arise, in that there is often no suitable equipment with which to take samples, and the logistics of delivery and payment to the FAS laboratory are complicated. It is also necessary for the EO to provide the farmer with the results of the analysis and interpret the recommendations.

The submission of a sample for analysis may be seen by some farmers as a grudge purchase, as there is nothing tangible to show for the expenditure, other than an analysis sheet with results and recommendations. Also, where farmers may have the knowledge and skills to apply the recommended nutrients to correct imbalances and thereby maximise production potential, a lack of finance may not allow adequate investment in the forthcoming crop. Discussions with many field workers have revealed that the SSGs are applying far less than the recommended amounts of nutrients, and that this trend is unlikely to change.

Given that historically there has been a poor replant rate by SSGs (<4% annually) and that few soil samples are sent by this sector for laboratory analysis, there is a need to devise a system whereby the SSG would not be required to submit a soil sample to the FAS laboratory for analysis before extension staff can offer a nutrient correction recommendation. Further to this is an urgent need for EOs to be able to provide a 'best fit' on-site recommendation with a high level of confidence.

A review of recent work in Mauritius and Australia confirmed that nitrogen is often applied in excess. N replenishment in South Africa can be carried out successfully by using the soil category benchmarks that are available in the SASEX publication, 'Identification and Management of the Soils of the South African Sugar Industry'. In this manual, Table 6 provides a guide to the nutritional requirements of sugarcane based on soil groups. If this table were to be expanded to include parent materials, a useful decision tree and easy to use field reference guide could be developed.

It is proposed that, in order to use the soil specific guidelines for nutrient replenishment as a reasonable alternative to regular sampling and analysis, a number of permanent reference sites be established where known blocks are sampled on a regular basis to develop a set of benchmark criteria. The popular trend in other sugar industries to use crop removal data as a replenishment tool, would for the South African SSG be inaccurate ([1]personal

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[1] Dr BL Schroeder, Regional Manager and Senior Scientist, Bureau of Sugar Experiment Stations, Australia

communication) and may perpetuate the tendency to replenish nitrogen at a higher level on the better soils and a lesser rate on the poorer soils. In this manner the downward spiral of nutrient utilisation will continue, with increasing environmental degradation and contamination of water sources.

Australia has for more than a decade applied almost double the amount of N fertiliser required to produce the actual sugar yields obtained, and the industry is under increasing pressure on both financial and environmental fronts to improve N fertiliser use efficiency (Thorburn *et al*., 2003).

Similar pressure to conform to recognised practice to reduce environmental degradation and the need to practice low external input sustainable agriculture (LISA) in South Africa is evident. One advantage of current low levels of nutrient application by SSGs is that there is a reduction in the soil organic matter degradation process as described by van Antwerpen *et al.* (2001). In order to maintain productivity, profitability and soil health, N inputs should be closely balanced with N outputs (Thorburn *et al*., 2003).

The role of extension

In 1996, SASEX and the KwaZulu-Natal Department of Agriculture and Environmental Affairs (DAEA) entered into a partnership to provide an appropriate and effective extension service to the SSGs. This service, called the 'Joint Venture', involves the provision by SASEX of five qualified, well-trained extension specialists, with 34 field technicians being supplied by the DAEA. Technology and information developed by SASEX is transferred to the SSGs through the Joint Venture. This flow of technology and information is formalised through Research Development and Extension Committees (RD&ECs) that are based at the 13 sugar mills. These RD&ECs ensure that sugarcane farmers are able to influence both the extension and research programmes, and that there is accountability for these programmes. The committees are also used by SASEX to identify 'gaps' in field staff training, or in the current research programme, with specific reference to the SSGs.

Extension can be successful in promoting soil sampling, and advising on organic/inorganic fertilisers and on soil ameliorants/amendments where finance is limiting. Recent evidence has shown that flyash, a factory waste product, applied at high rates (50 tons/ha +) can be used as a substitute for lime (Dee *et al*., 2002) In addition, the establishment and promotion of buyer groups can lead to more cost-effective fertiliser purchases, and EOs can encourage the formation of these co-operatives. Research trial results are conveyed to SSGs via the extension specialist and the technicians at RD&EC meetings. In this way, research results can be translated into field action.

Conclusions

The survey of the FAS soil sample database has confirmed that the incidence of strongly acid soils, coupled with P and Ca deficiencies, is fairly extensive in the KZN SSG areas. There is evidence that this situation is worsening as the cost of inorganic fertilisers continues to increase, and the financial demands on households goes far beyond the farming enterprise. The amelioration of soil acidity with lime and the application of sufficient amounts of phosphate fertiliser, in particular, to satisfy the plant crop requirement for P is not common, and as a result crop yields are being negatively influenced by continuous soil nutrient mining. The findings suggest that the KZN North Coast and Southern Area are the worst affected. The commercial farmers are not suffering the same degree of soil nutrient depletion as the SSGs, because regular fertiliser applications form part of the commercial sector's management strategy.

The introduction of a decision tree that can be used by EOs as a field tool will go a long way towards alleviating the need for regular soil sampling. This tool will need to be calibrated using data collected from the proposed reference sites, and must instil confidence by maintaining a reasonable degree of accuracy with the existing guidelines.

Extension services have played an important role in encouraging changes and reforming practices among farmers in the past, as shown by the recent trend in amelioration of low P soils. The Joint Venture, in conjunction with the Research Development and Extension Committees, are ideally placed to have a meaningful impact on the adoption of practice change by utilising the communication and technology transfer capacities in place in a highly organised industry.

An increase in cane yields will improve the financial status of the farming families in the small-scale sector, and may lessen the exodus of young men from the rural to the urban areas. Evidence of a sustainable and profitable small-scale sector may reverse the trend of seeking employment in the cities, and keep young people in agriculture.

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