THE SASEX FERTILISER ADVISORY SERVICE: A REVIEW OF 50 YEARS OF SERVICE TO THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

This year, the Experiment Station's Fertiliser Advisory Service (FAS) enters its 50th year of service to the industry. Since it was commissioned in 1954, FAS has achieved recognition as one of the leading agricultural laboratories, not only in South Africa, but also in other cane producing countries. The laboratory provides an efficient and reliable service to growers and research workers, giving cost effective, environmentally friendly fertiliser recommendations based on soil and leaf analysis. It also analyses organic manures and gives advice on water and effluent for irrigation, while keeping pace with advances in modern analytical techniques and instrumentation.

This paper reviews the historical development of FAS since 1954, and highlights technical achievements in terms of the selection and calibration of appropriate soil and leaf testing methods for determining nutrient requirements, advances in the automation of laboratory instrumentation, and the development of soil-specific fertiliser recommendations, nutrient retrieval systems and computer aided decision support programs for more effective fertiliser management. The impact of new challenges from precision agriculture and the rapidly growing soil sustainability school on soil health evaluation and soil management are considered.

Keywords: sugarcane, fertiliser advice, soil fertility, soil testing, leaf analysis

Introduction

In South Africa, as in most other sugarcane growing countries, efficient fertiliser practices have contributed greatly to productivity. The Fertiliser Advisory Service (FAS) of the South African Sugar Association Experiment Station (SASEX) this year enters its 50th year of service to the sugar industry. The FAS has played a major role in providing cost effective recommendations to cane producers, as well as minimising any adverse effect of fertilisers on the environment. The services provided by FAS includes whole cycle N, P and K fertiliser and lime advice based on soil samples taken from pre-plant fields, leaf analysis for checking on the adequacy of fertiliser applications, soil salinity diagnosis, water and effluent analysis to test for suitability for irrigation, analysis of filtercake and poultry litter, and soil textural classification. While the early system of soil and leaf analysis provided a useful guide for determining the nutrient requirement of cane, advances in plant nutrition research over the past three decades have widened the scope and type of recommendations made to cane growers.

This paper reviews the historical development of FAS since 1954, in which four main phases are identified and described.

- Early history, and selection and calibration of appropriate soil and leaf testing methods.
- Advances in improving the reliability of recommendations for major and minor nutrients and lime recommendations.
- Automation of laboratory procedures and the use of rapid, non-destructive techniques for foliar diagnosis.
- Development of fertiliser recommendations, nutrient retrieval systems and computer-aided decision support programs for more effective fertiliser management.

Phase 1: Historical development of FAS

Ever since SASEX was established in 1925, there has been an awareness of soil fertility problems in the sugar industry and the economic importance of correctly fertilising sugarcane. At a field day held at SASEX on 13 November 1933, Mr Alfred Townsend, the doyen of North Coast growers, first suggested that the Experiment Station should employ a trained chemist to analyse grower's soil samples free of charge. He was concerned that fertiliser use by growers took no cognisance of the inherent soil fertility levels of the wide range of soil types that were already under cane production (Beater, 1988). It was not until the widespread, yellow appearance of poorly grown cane observed in the late forties, which was not linked to any known disease, that there was a growing realisation among growers that a central soil and leaf testing facility was long overdue.

Investigations by SASEX staff confirmed that the yellow appearance of the crop was linked to a severe potassium deficiency (du Toit, 1951). Initially, for about two years, staff from the Central Board Cane Testing Service conducted a limited number of soil tests for growers during the off-crop, and SASEX staff prepared the fertiliser recommendations (Beater, 1988).

It was not until October 1954, almost 21 years later, that Mr Townsend's vision of an independent soil/leaf based fertiliser diagnostic service was fulfilled when the South African Sugar Association purchased a property in Briardene to house the new Fertiliser Advisory Service laboratory. The first appointed Advisory Chemist, Mr TAF Sexton, reported that the laboratory could cope with 300 samples per week, and additionally fertiliser, compost and water samples could also be analysed for growers. In its first year of operation nearly 10 000 soil and leaf samples were analysed using a staff complement of 15. Soil measurements included pH, plant available P using dilute sulphuric acid and extractable K, Ca and Mg based on a dilute ammonium acetate procedure (Anon, 1955).

Coupled with the new FAS laboratory, investigations were in progress to develop soil and leaf threshold values and the optimum fertiliser rates to apply on a commercial basis. The establishment of 31 exploratory 3Nx3Px3K factorial trials revealed dramatic economic responses to applied K, of up to 4 t/ha sucrose on many soils (du Toit, 1957). A further outcome of these investigations was that both soil and leaf analyses could predict the likely responses to K and P fertiliser, as well as the economic quantity of fertiliser to apply. Initially a number of soil and leaf procedures were tested and the methods that showed the best correlation with yield responses to applied fertiliser, were retained for advisory purposes. In 1962, the FAS laboratory moved to Mount Edgecombe and became part of SASEX, and it is from there that that the service still operates today.

Early development of N, P and K recommendations for sugarcane (1954 to 1975)

In 1956, a comprehensive series of 53 4Nx2Px3K regional fertiliser trials was established under a wide range of soil and climatic conditions with the objective of more accurately calibrating the soil and leaf methods that were used by FAS at the time (du Toit, 1959). Generally, the results showed economic responses to N and K fertilisers at rates far higher than those in use at the time. Responses to P or K fertiliser treatment were related to the analysis of the soils, and critical or threshold levels of nutrients for optimum growth of cane were established over a wide range of soils (see Table 1). In assessing the reliability of soil threshold values to predict the nutrient requirements of sugarcane, it was concluded that responses to K would have been correctly predicted in 72% of instances and incorrectly in 16%, while predictions for the remaining 12% would have been of doubtful value (du Toit, 1960).

For the first 20 years. N recommendations for ratoon cane were based on using 1.25 kg N per ton expected cane yield. While this was a convenient method for determining the N requirement of sugarcane under irrigated conditions, it often led to excessive use of N for rainfed grown cane because of optimistic yield forecasts by growers. Soil tests for P and K compared the level of the nutrient in the soil with the minimum level needed for optimum cane growth, and the difference was supplied as fertiliser. P recommendations were based on the modified Truog procedure, in which the P is extracted with 0.02N sulphuric acid for 30 minutes (du Toit e*t al*., 1962). The amount of P recommended is the difference between the Truog value and 90 kg P/ha for plant cane or 30 kg P/ha for ratoon cane. Recommendations for K for either plant or ratoon cane were determined in the same manner, being the difference between the 1N ammonium acetate soil test K value and 250 kg K/ha.

The emphasis by FAS on recommending higher rates of N and K and lower applications of P fertiliser, led to some dramatic changes in fertiliser usage between 1952 and 1965 (see Figure 1). K use increased by a factor of 15 from an average of 5 to 75 kg K/ha, and N use increased from 12 to 70 kg N/ha, while P increased only marginally from 14 to 18 kg P/ha. It is no coincidence that average industrial yields improved by 75% from 24 to 42 tc/ha/an over the same period.

Table 1. Soil threshold values currently used by the Fertiliser Advisory Service.

Nutrient	Threshold value
Phosphorus (P)	31 ppm for plant cane 11 ppm for ratoon cane
Potassium (K)	112 ppm - clay content <30% 150 ppm - clay content >30% 225 ppm - clay content >40% 325 ppm - clay content >40% (winter cycle high base status)
Calcium (Ca)	200 ppm
Magnesium (Mg)	25 ppm 75 ppm if Ca <200 ppm
Zinc (Zn)	1.5 ppm - Midlands soil requiring lime 1.0 ppm - clay content >15% 0.5 ppm - clay content <15%
Sulphur (S)	20 ppm
Lime (calcitic or dolomitic)	When Aluminium Saturation Index is >20% (for all varieties except N12) When Aluminium Saturation Index is >40% (for N12 only)

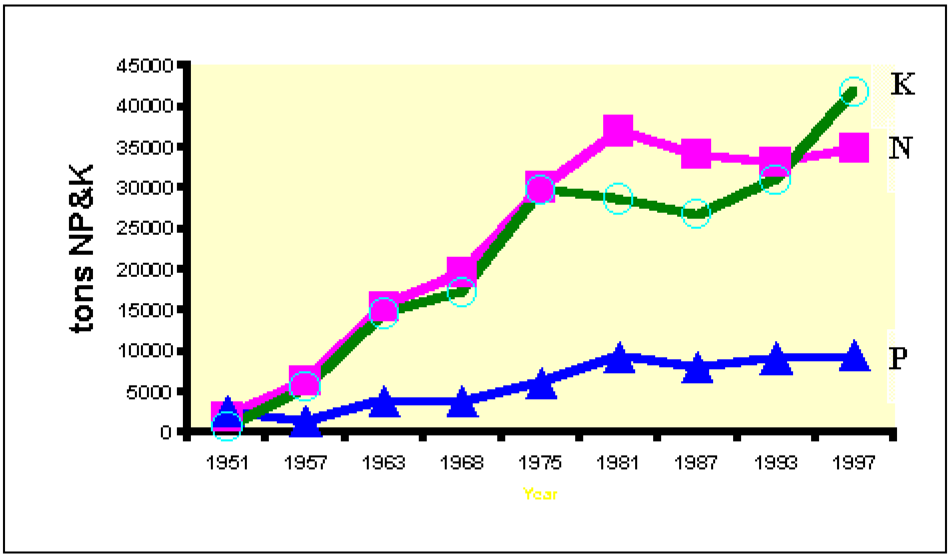

Figure 1. Average amounts of N, P and K (kg/ha) used by the South African sugar industry between 1951 and 1997.

Phase 2: Progress in further improving the basis of nutrient recommendations (1975 to 2003)

Nitrogen

During the early 1970s, N fertiliser recommendations were developed at a time when maximisation of production and short-term economic gain were the key factors driving the industry (du Toit, 1960). N recommendations for ratoon cane were based on expected cane yield, but the actual N usage of 1.90 kg N/t cane far exceeded the recommended FAS rate of 1.25 kg N/t. Little account was taken of the large differences in N mineralising potential that exists between soils, and that resident soil N may in a number of soils play a more important role in sugarcane nutrition than fertiliser N (Wood, 1968). The emphasis was mainly on fertilising the crop, rather than on managing the soil.

Because this method of establishing N requirement led to over-application of N fertiliser, which favoured eldana infestation as well as having an adverse effect on recoverable sucrose, an alternative system of N recommendations for plant and ratoon cane was developed for growers in 1984, using the results of extensive laboratory studies and fertiliser trials (Meyer *et al*., 1983). The system was based on soil form, bioclimatic region and the potential of the soil to release N to the plant. For advisory purposes, an analytical method based on Near Infra-red Reflectance Spectroscopy (NIRS) was pioneered to classify soils into four categories (low, moderate, high and very high) according to their potential to mineralise N from soil organic matter (Meyer *et al*., 1986). The revised N recommendations led to a reduction in N use particularly for cane growing on high to very high N mineralising category soils. Overall, between 1975 and 1999 throughout the industry there has been about a 20% decline in N usage, and N use efficiency now averages about 1.5 kg N/tc compared with a level of over 2 kg N/tc in the Australian sugar industry.

Further nitrogen research has focused on important genotypic differences in N use efficiency between varieties, as demonstrated in trials conducted in Pongola and Mpumalanga. Using the ratio of sucrose yield to N accumulation, varieties may be classified into one of three categories: efficient N use responders, inefficient non-responders and inefficient responders (Schumann *et al*., 1998).

A recent development was the introduction of a rapid soil test method to predict the potential loss of ammonia that could be volatilised from applying urea to a soil. The test permits soils to be classified into low, medium and high ammonia volatilisation risk categories. The results enable either limestone ammonium nitrate (LAN) or ammonium sulphate to be recommended instead of urea fertililiser, for soils that show a high ammonium volatilisation risk (Schumann, 2000).

Phosphorus

While the Truog soil test method was reliable in predicting a likely response to applied P, it did not account for the fate of applied P in the soil, which is a major factor in determining P fertiliser use efficiency. This became important when the industry expanded to the high P-fixing soils in the Natal Midlands. During the late 1970s, laboratory and glasshouse studies on these soils indicated that soils with similar acid extractable P levels but different P sorption characteristics, were likely to have different P requirements (Meyer, 1974). Subsequent field trials confirmed that economic returns were possible from broadcasting P fertiliser in excess of the highest rate recommended by FAS (Meyer and Dicks, 1979). A rapid phosphorus desorption index (PDI) soil test was introduced to supplement the standard soil extraction procedure for Midlands soils (Reeve and Sumner, 1970). Depending on whether the soil is strongly, moderately or weakly P-fixing, the furrow application is increased to 120, 100 or 90 kg P/ha. For moderately and strongly P-fixing soils with Truog P levels below 13 ppm, supplementary broadcast P applications are also now recommended in conjunction with the normal furrow P applications.

Potassium

For many years the K threshold value used by FAS was 112 ppm for all soils, but this was modified in 1982 to allow for differences in soil texture following results from glasshouse trials (Wood and Burrows, 1980) and a re-assessment of other fertiliser trials (Meyer and Wood, 1985). Threshold values of 150 and 225 ppm were introduced for soils with clay contents of 30-40% and >40% respectively. Recent results from K trials in the northern irrigated areas indicated that even 225 ppm was inadequate for a winter cycle crop in heavy textured base saturated vertisols containing a high proportion of K-selective clay minerals (Donaldson *et al*., 1990). Some of the largest responses to applied K were obtained on these soils, and a threshold of 320ppm and the use of a Ca+Mg/K ratio have since been implemented. In addition, a rapid potassium desorption index (KDI) test to screen soils for K fixation has been used on a selective basis. Higher applications of K fertiliser are required for K-fixing soils or where the availability and uptake of K is constrained by high levels of Ca and/or Mg in base saturated soils (ratio (Ca+Mg)/K is greater than 15 for winter cycle cane or 26 for summer cycle cane, or where the release of K may be inhibited by low temperatures in winter and spring (Henry *et al*., 1992).

Other nutrients

Tests to determine the sulphur content in both soil and leaf analyses was made available to growers as an additional routine service. This came about mainly through the results of glasshouse and field studies on a range of soils, which emphasised the importance of S deficiency as a potential factor limiting cane growth. The results indicated that the light grey textured soils derived from granite and Table Mountain Sandstone (now Natal Group Sandstone) parent materials were likely to be the most prone to S deficiency. Threshold values of 20 ppm and 0.13% S are used for interpreting soil and leaf analytical levels respectively (Meyer, 1985).

Although minor element deficiencies are infrequent in the South African sugar industry, zinc and iron deficiencies appear to be continuing problems (du Toit, 1962). A routine soil test using EDTA/ ammonium carbonate as an extractant was developed to predict the Zn requirement of sugarcane (Meyer, 1976). Threshold values of 0.5 and 1.0 ppm are used for diagnosing the Zn status of loamy sands (<15% clay) and clays.

More recently, the spotlight has shifted to silicon because of the recently discovered association between Si assimilation and host-plant resistance to the stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (Keeping and Meyer, 1999). Si now forms part of the standard leaf analysis package offered to growers, which is comprised of nitrogen, phoshorus, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese and silicon. Investigations are in progress to introduce a soil test method for measuring plant available Si.

Lime requirement

Investigations to determine the reasons for the stimulating effects of wattle brushwood ash on cane growth, led to the identification of aluminium toxicity as a growth-limiting factor in the early 1970's (Meyer, 1970). The beneficial effects of the ash were simulated by the application of lime, even where the need for this was not indicated by the soil criteria that were used by FAS at that time. Subsequent research showed that reasons to lime were more closely correlated with Al toxicity, and this led to the development of an exchangeable Al index (EAI) method for determining lime requirement (Moberly and Meyer, 1975).

The criteria for lime requirement of humic soils were further modified in 1992 by supplementing the EAI/clay criteria with an Al:S ratio (Shroeder *et al*., 1993). The sulphate anion was considered to have 'self liming' properties and substantial amounts of organic S can be mineralised from humic soils. Further investigations revealed that the use of an aluminium saturation index (ASI) in conjunction with the Al:S ratio improved the prediction of lime requirement even further (Schroeder *et al*., 1995). Varietal differences in terms of tolerance to Al toxicity have also been identified. A soil ASI threshold value of 40% is now used to determine the lime requirement of N12, whereas 20% is used for all other varieties.

A new recursive calculation method incorporating both lime and gypsum was recently introduced to improve final soil ASI predictions after liming, and to prevent yield losses from over-liming. Recent trial evidence has also indicated the need to increase the soil Ca threshold from 150 to 200 ppm (Schumann *et al*., 1999).

Organic nutrient carriers

While FAS has mainly offered advice for the use of inorganic fertilisers, there has been an increasing demand for advice based on the use of bio-fertilisers such as filtercake, molasses, chicken litter, kraal manure and pig slurries. Poultry litter is potentially the most valuable as it usually contains less than 35% moisture, and at least 60% of the total N and 50% of the total P is considered to be immediately available to the crop. Poultry litter is ideal at planting, and a 5 t/ha application in the furrow can provide sufficient N, P and K for a plant cane crop growing on a humic soil without using additional fertiliser (Moberly and Stevenson, 1971). Filtercake is also frequently applied in the furrow at planting, although it has a considerably higher moisture content than poultry litter, as well as lower total N and K contents, which makes it less attractive as a fertiliser source. It is primarily regarded as a substitute for inorganic P fertiliser (Moberly and Meyer, 1978). A furrow application of 20 t/ha filtercake (at 60% moisture content), will provide approximately 25 kg N, 80 kg P and 16 kg K. On average, 3 tons of fresh filtercake is equivalent in value to one ton of fresh chicken litter.

Phase 3: Automation of laboratory procedures and the use of rapid non-destructive techniques for foliar diagnosis

During the past 25 years, a 'quiet revolution' in analytical methodology has occurred, due to the introduction of sophisticated scientific instruments. Analytical operations have moved away from slow dispensing of liquid samples on a macro to semi and micro scale, making it possible to dispense and analyse very small quantities of liquid very accurately and rapidly. Important milestones in this quiet revolution were the commissioning of NIR and X-ray fluorescence spectrometers in 1983, to analyse leaf samples directly without having to use time consuming acid digestion procedures (Wood *et al*., 1985). This world-first for sugarcane was followed by further applications of NIR to improve N use efficiency of sugarcane by matching crop N requirement to soil N mineralising potential and plant N status, both properties determined by NIR (Meyer, 1989).

These improved laboratory operations have enabled sample throughput to be increased from 300 samples per week prior to 1960 to 300 samples per day, using nine laboratory staff compared with the 15 staff used prior to 1960. This streamlining in analytical operations represents a 700% increase in productivity per laboratory analyst.

Other important developments have included:

1986 New soil test to predict phosphorus fixation (PDI) in Midlands soils.
1987 New soil tests for zinc and sulphur.
1988 NIR based soil tests developed to rapidly assess soil organic matter, clay and N mineralisation potential.
1989 Computerised advice to ameliorate soil salinity/sodicity problems.
1989 Provision of DRIS indices with each leaf analysis.
1990 Water quality assessment for irrigation.
1992 Introduction of Al saturation index soil test for lime requirement.
1995 Advice on the use of organic sources of N, P and K such as filtercake, chicken litter and vinasse.
1996 XRF PW2400 Spectrometer used for the rapid analysis of major and minor nutrients in leaf samples, not only from sugarcane, but also from fruit crops such as coffee, tea, citrus, macadamias and various species of commercial forest trees.
1997 Anthos Reader 2010 introduced as a filter photometer designed to measure the light absorbance of samples in micro-plates. Reading eight wells simultaneously, the system is able to read a micro-plate within five seconds.
1998 The Spectra AA 220 FS auto-dilutor and dispenser has replaced the traditional atomic absorption spectrophotometer. The new system not only saves time and improves sample throughput, but also reduces running costs, as more samples can be determined in less time.
1999 New laboratory test to predict potential ammonia volatilisation losses from surface-applied urea fertiliser.
2000 Tecan Genesis Diluting Instrument is widely used for application in clinical diagnostics. It comprises four sample pick-up probes with a work area that can handle 320 samples and any number of reagents.
2001 A new recursive Pascal program used to recommend lime rates was incorporated into the main whole cycle fertiliser programme to save costs from over-liming.
2002 A continuous model exponential Fourier function describing the concentration of leaf N in relation to crop age and season was used to develop new threshold values for making diagnoses at any month of the year, such as during continuous fertigation, provided the crop is not stressed.
2003 Calibration of X-ray spectrometer for leaf Si analysis.

Phase 4: Information development and transfer

Whole cycle recommendations

During the first 20 years of FAS operation, considerable historical data from soil and leaf analyses, fertiliser recommendations and crop performance had accumulated, and as a result FAS was able to introduce whole cycle fertiliser advice in 1973. This provided growers with fertiliser recommen-dations for cane covering a plant crop andfour succeeding ratoons, referred to as a 'whole crop cycle' (Wood, 1987). Each recommendation was based on the chemical analysis of a representative pre-plant soil sample taken after the previous crop had been ploughed out. The computer at SASEX was programmed to evaluate the analytical data using available soil threshold values as well as a set of tables from which the crop nutrient requirement could be determined.

With the introduction of whole cycle advice, the need for taking soil samples after each harvest largely fell away. Initially this led to a decline in the numbers of samples sent to FAS, from 16 000 in 1974, to 12 000 samples in 1975. Nonetheless, the number of grower samples analysed gradually increased, and by 1983 had reached a peak of 25 000 (see Figure 2). With the introduction of the 'user pay entity'(UPE) in the following year, sample throughput again declined. The drought between 1993 and 1995 also contributed to the decline in numbers of grower soil and leaf samples, and since 1997 there has been a slow recovery, although the 19 063 soil and leaf samples analysed in 2002/03 was still well below the 25 000 samples processed in 1983.

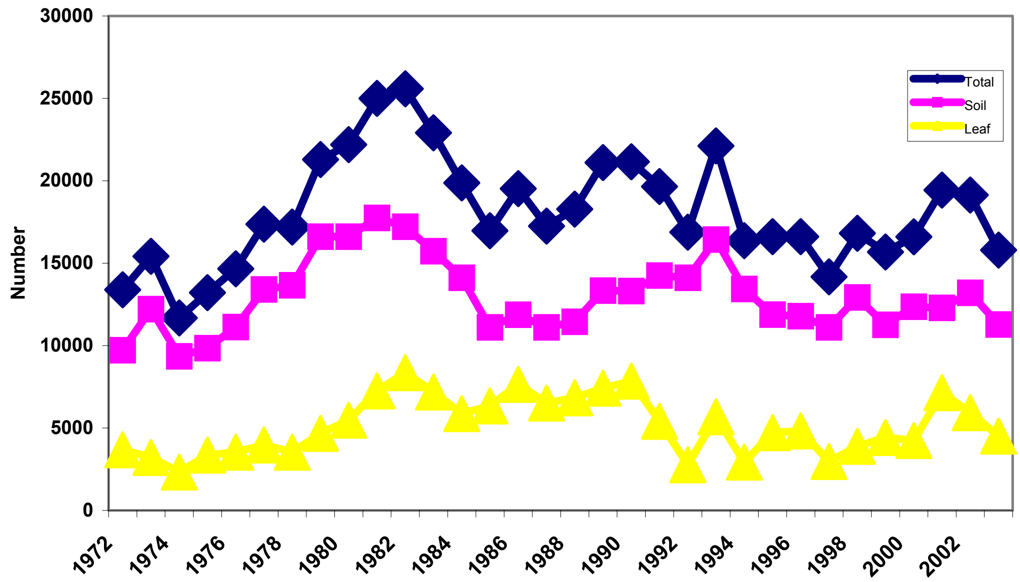

Figure 2. Trends in grower soil and leaf samples analysed by the Fertiliser Advisory Service since 1972.

Identifying long term fertility trends

Some idea of the scope of the work done by the FAS can be obtained from the fact that files are maintained for about 2000 individual commercial farms and about 500 small-scale growers. These represent a large portion of the 430 000 hectares under cane in South Africa. Since the change to computerized recommendations in 1980, a database has been compiled from the analyses of more than 250 000 soil and 90 000 leaf samples that were submitted by these growers over a period. A specially developed program, the Nutrient Information Retrieval System (NIRS) has yielded valuable information on changes in nutrient availability for different extension areas, bio-climatic regions, soil parent materials and cane varieties (Meyer *et al*., 1989). A significant trend towards increased acidification of soils derived from basement granite and Natal Group Sandstone parent materials has occurred in the rainfed coastal regions. This contrasts with the observed increase in soil alkalinity in the irrigated areas of Mpumalanga. There has been a steady build-up of soil potassium and phosphorus in many areas, suggesting over-application of these nutrients. Results of a survey of paired cultivated and virgin sites also revealed accelerated acidification of soils under cultivation (van Antwerpen and Meyer, 1996).

Development of computer-aided support systems

Following many years of research by SASEX staff, FAS provides growers with recommendations that are based on sound economic principles that ensure the best returns on their investment in fertilisers. The principle of maximum economic yield per hectare was already adopted in 1960 (du Toit, 1960) and in the late seventies the emphasis shifted to relating recommendations to maximum return on fertiliser investment using marginal return curves (Thompson, 1980). In 1992 collaborative work developed a computer programme (Kynoman) to evaluate the consequences of under- or over-fertilisation and choice of fertiliser carrier (Prins *et al*., 1993). Provision was made for risk scenarios that offered the grower a range of strategies to suit individual circumstances. Using the cost/price ratio of fertiliser to sucrose, there was generally good agreement with FAS recommendations. However significant differences in N recommendations were found when certain risk scenarios were used, particularly in areas with mean rainfall below 900mm.

More recently a Windows-based modular utility program was developed by SASEX for use by Extension Officers (Anon, 2000) The modules assist in choosing the most cost-effective carrier, timing and placement for N fertiliser; determine lime requirement; assess the economics of trashing versus burning; determine the most cost-effective fertiliser mix; classify irrigation water quality; and assess the nature and extent of salinity and sodicity in soils.

Transfer of technology

Since the inception of FAS, Extension Officers (EOs) have played a crucial role in assisting growers with the interpretation of analyses and planning of a balanced fertiliser programme. Improvements in computer programs now enable EOs to access the comprehensive FAS database, which greatly facilitates the effectiveness of the service. Where regular sampling has been carried out for a number of years, it is possible to follow nutrient trends in specific fields and/or homogenous areas. This information makes it possible for the grower to rationalise his fertiliser programme, and also provides SASEX with new directions for future research work.

Other examples of information transfer that have helped to promote the use of FAS include:

- Emphasising the importance of soil testing, cane nutrition and fertiliser management at grower meetings.
- Over 200 publications dealing with cane nutrition and fertiliser management outcomes during the period 1970-2004 alone.
- Numerous articles in the Link dealing with cane nutrition and fertiliser management.
- Eighteen SASEX Information Sheets on cane nutrition and related fertiliser management topics.
- Development of a soil and leaf sample preparation laboratory in Mpumalanga, from where an overnight courier service dispatches samples to FAS.

- Provision of numerous sample collection bins around the industry.
- New soil and leaf analysis recommendation report formats (2002), including introduction of specific fertiliser mixture recommendations for selected extension areas.

Discussion

There can be little doubt that the advantages of soil and leaf testing are considerable, and that over the past 50 years FAS has had a substantial impact on yield productivity and efficient fertiliser usage in the sugar industry (Chadwick, 1997). Since 1954, yield output in the industry has more than doubled, and whilst new varieties have undoubtedly had a large impact, the improvement could not have come about without eliminating nutrient deficiency in sugar cane and overcoming Al toxicity in areas with acidic soils. The average saving to the industry on nitrogen alone (of 0.4 kg N/t cane) resulting from improved recommendations introduced 20 years ago, total about R50 million per annum. The impact of FAS has also assisted in restricting fertiliser expenditure to around R12 per ton cane, which on an industry-wide basis translates to about R350 million per annum; in areas where SASEX advice is not heeded, current fertiliser expenditure is up to R24 per ton. This implies that overall fertiliser expenditure in the industry could have been a lot higher and closer to R600 million per annum had the industry not invested in the research to establish soil and leaf threshold values and optimum fertiliser levels for sugar cane.

Soil type and fertiliser management can have an important impact on the chemical composition and quality of cane juice. Nutrient deficiency and excess mat both result in reduced sucrose contents; excessive nutrient uptake can influence the exhaustibility of final molasses, as well as the colour and ash content of raw sugars. Crop nutrition may also influence the presence of non-sucrose constituents such as soluble high molecular weight polysaccharides, which can interfere with the processing of raw sugar. Given the impact of N, P and K fertilisation (as well as liming) on cane quality, there is even greater need for growers to use soil and leaf analyses through FAS in order to maximise RV production (Meyer, 2001). The more efficient use of N and other nutrients is also particularly important as growers become more aware of environmental issues.

The road ahead for FAS

The ability of FAS to operate as a self-sufficient user pays entity is highly dependent on an acceptable yearly throughput of samples. As well serving the South African sugarcane industry, FAS analyses soil and leaf samples for a range of other crops, and also receives sugarcane-related samples from Australia and a number of African countries. While FAS has met its financial obligations very well in recent years, sample numbers from growers have not reached the desired targets that were set in the 1998 five year plan, despite a vigorous campaign to market FAS services to the industry. In terms of the road ahead, beyond gaining more business the most important challenge will be to increase sample turnover and to reduce sample analysis cost through improved automation of laboratory equipment.

There are a number of growth opportunities for FAS in terms of vertical and horizontal expansion including:

- Making FAS more accessible to the >50 000 small-scale growers in South Africa, many of whom may feel unable to afford the cost of the routine soil analysis provided by FAS. If such growers were made aware of the potential returns from correct fertilisation, the potential increase in sugar production could be enormous.
- Increasing the range of soil tests to include determination of a 'soil health index' assist growers in preventing or reversing soil degradation. This may include certain biological tests, including determination of microbial biomass and estimating the dominant nematode species.

- Modifying recommendations to include the use of trashing, organic amendments and green manures.
- Modification of lime recommendations in order to take into account of low pH soils that do not contain toxic levels of aluminium.
- Introduction of a Geographical Information System (GIS) to enable FAS to offer an additional service providing soil maps showing the spatial variability of nutrients, to meet the growing trend towards precision agriculture or site-specific management.
- Use of X-ray fluorescence and NIR techniques for leaf analysis of a range of crops, including tea, coffee, forest species, macadamias, bananas and turf grass.
- Development of a more effective marketing strategy to promote the use of FAS services for sugar cane and other crops in the SADEC countries and beyond.

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