

THE SASEX FERTILISER ADVISORY SERVICE: OVER 40 YEARS' SERVICE TO THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

In South Africa, as in most other sugarcane growing countries, efficient fertiliser practices have contributed greatly to sugarcane productivity. The South African Sugar Association Experiment Station (SASEX) Fertiliser Advisory Service (FAS), which has been operating for more than 40 years, has played a major role in providing cost effective recommendations to cane producers and in minimising the adverse effects of fertilisers on the environment. The FAS offers the grower and miller-cum-planter a comprehensive range of services, including whole cycle fertiliser advice based on soil samples taken from pre-plant fields, leaf analysis for checking on the adequacy of fertiliser applications, water and effluent analysis to test for suitability for irrigation, analysis of filtercake and poultry litter, salinity/sodicity tests and soil textural classification. The historical development of the FAS is reviewed, the advances that have been made in soil and leaf methodology are described, and the scope of fertiliser and salinity management advice is discussed. Examples are given of how the FAS database has been used in planning fertiliser strategies and monitoring soil fertility trends.

Introduction

Fertiliser management for sugarcane is characterised by large inputs of nitrogen, phosphorus and potassium fertilisers, which can amount to 20% of total production costs. In the 1995-96 season the South African sugar industry spent R180 million on fertiliser (Chadwick, 1997). In past seasons with favourable conditions, growers have tended to over-apply fertiliser to capitalise on the good crop. However, over-application of fertiliser is wasteful, and can cause pollution and a reduction in sucrose content, while under-application can lead to losses in crop and sucrose yields. In both cases profitability could be affected. The cost of soil sample analysis and the accompanying fertiliser recommendations for a plant and four ratoon crops is negligible in relation to the total cost of fertiliser applied over a whole crop cycle. Many producers do not, however, fully appreciate the substantial benefits to be gained from soil and leaf analysis.

The South African Sugar Association Experiment Station (SASEX) has operated a Fertiliser Advisory Service (FAS) for more than 40 years. From the outset fertiliser recommendations were based primarily on chemical analysis of the soil, but leaf

analyses have subsequently formed an integral part of the advisory system. While the early system of soil and leaf analysis provided a useful guide for determining the nutrient requirements of cane, advances in plant nutrition research during the past four decades have widened the scope and type of recommendations given to cane growers. This paper is a review of the historical development of the FAS since its inception in 1952. Advances in nutritional advice, the main benefits of soil and leaf analysis to the grower and the researcher, and the impact on fertiliser use, are highlighted.

Fertiliser advice prior to the FAS

During the first 70 years of cane production, the South African sugar industry lacked a rational solution to the problem of how to optimise crop nutrition, but from 1920 onwards a more scientific approach began to develop. Formal fertiliser trials conducted independently by staff of the German Potash Syndicate and the newly established Experiment Station (1925), showed economic responses to P applied as single superphosphate (Dodds and Fowlie, 1931; Lintner, 1935), but responses to N and K were not apparent. By 1936, marked responses to N fertiliser applications were being obtained, particularly in ratoon cane (Watson, 1938). At that time growers were advised to use 600-800 kg single superphosphate per hectare in the furrow at planting, and to top-dress ratoon cane with 250 to 400 kg sulphate of ammonia per hectare. No cognisance was taken of the inherent soil fertility differences among the wide range of soils already under cane production. The outbreak of war in 1939 severely curtailed further experimental work.

The first 20 years of FAS (1954-1974)

The need for the industry to have a fertiliser advisory service laboratory initially arose from the concern of growers regarding the widespread, yellow appearance of the crop that was often linked to growth failure. In 1950, potassium deficiency was identified as a growth limiting factor (du Toit, 1951) and 31 exploratory 3³NPK factorial trials were established. Throughout the industry, the trials confirmed that dramatic responses to applied potassium could be obtained on many soils. Furthermore, it was shown that soil and leaf analyses could be used to predict likely crop responses to K and P fertilisers as well as the economic quantity of fertiliser to apply. Initially a number of

soil and leaf analytical procedures were tested and the data correlated with yield responses from these trials. The test extractants that showed the best correlations with responses to applied P (0,02N H₂SO₄) and K fertiliser (1N NH₄OAc) were selected for advisory purposes (du Toit, 1957).

These developments led to the establishment of the FAS which, in 1952, formulated advice only upon receipt of analyses carried out by a number of mill laboratories. From 1954 onwards, the service was run entirely by SASEX from a new laboratory that was established at Briardene, near Durban. In its first year, nearly 10 000 soil and leaf samples were analysed by a staff complement of 15. Soil measurements included pH and plant available P, K, Ca and Mg. No attempt was made to measure the remaining major nutrients (N and S) and the minor elements (Zn, Cu, B, Mn and Fe).

In 1956, a comprehensive series (53) of 4x2x3 NPK factorial regional fertiliser trials was established under a wide range of soil and climatic conditions, with the objective of calibrating the soil and leaf methods used by the FAS at the time. Generally the results showed economic responses to N and K at rates far higher than those in use at the time (du Toit, 1960a). Responses to P or K fertiliser treatments were related to the analysis of the soils, and threshold levels of nutrients for optimum growth of cane were established for a wide range of soils (Table 1). In 1962, the laboratory was moved to SASEX, and it is from here that the service still operates today.

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

The next 20 years (1975-1995)

Development of whole crop cycle recommendations

During the first 20 years, considerable historical data from soil and leaf analyses, fertiliser recommendations and crop performances had accumulated and, as a result, the FAS was able to introduce whole cycle fertiliser advice in 1975. This provided recommendations for a plant crop and four succeeding ratoons, referred to as a 'whole crop cycle'. 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 analytical data based on available soil threshold values and a set of tables. Crop nutrient requirements were shown on an advice sheet that was sent to the grower, with a copy being forwarded to his extension officer (Figure 2). The approximate cost of the fertiliser application recommended was included on the advice sheet.

With the introduction of whole cycle advice, the need for taking soil samples after each harvest largely fell away. This led to a decline in the annual numbers of samples sent to the FAS, from 16 000 in 1974 to 12 000 samples in 1975. Nonetheless, the number of grower samples analysed gradually increased, and in 1983 reached a peak of 25 000. With the introduction of the 'user pay entity' (UPE) in the following year, sample throughput again declined and has since been on a downward trend. The drought between 1993 and 1995 also contributed to the decline in numbers of soil and leaf samples.

Table 1
Soil threshold values currently used by FAS.

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)	150 ppm 100 ppm (Recent Sands only)
Magnesium (Mg)	25 ppm
Zinc (Zn)	1,5 ppm - Midlands soil requiring lime 1,0 ppm - clay content >15% 0,5 ppm - clay content <15%
Sulphur (S)	15 ppm
Lime	When Aluminium Saturation Index >20% (for all varieties except N12) When Aluminium Saturation Index >40% (for variety N12 only)

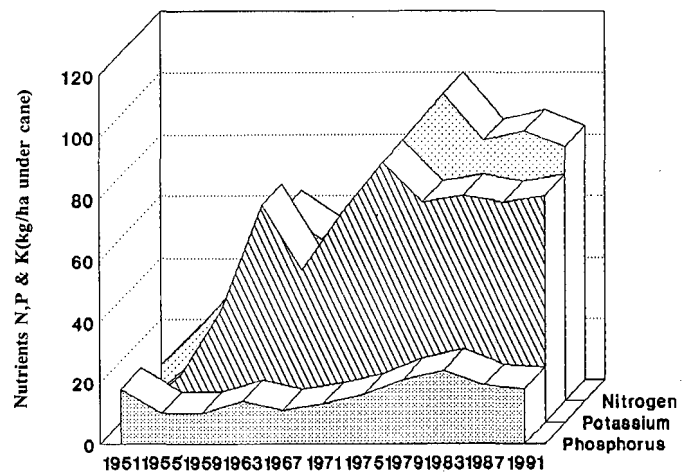


Figure 1. Average amounts of NPK used (kg/ha) by the South African sugar industry between 1951 and 1991.

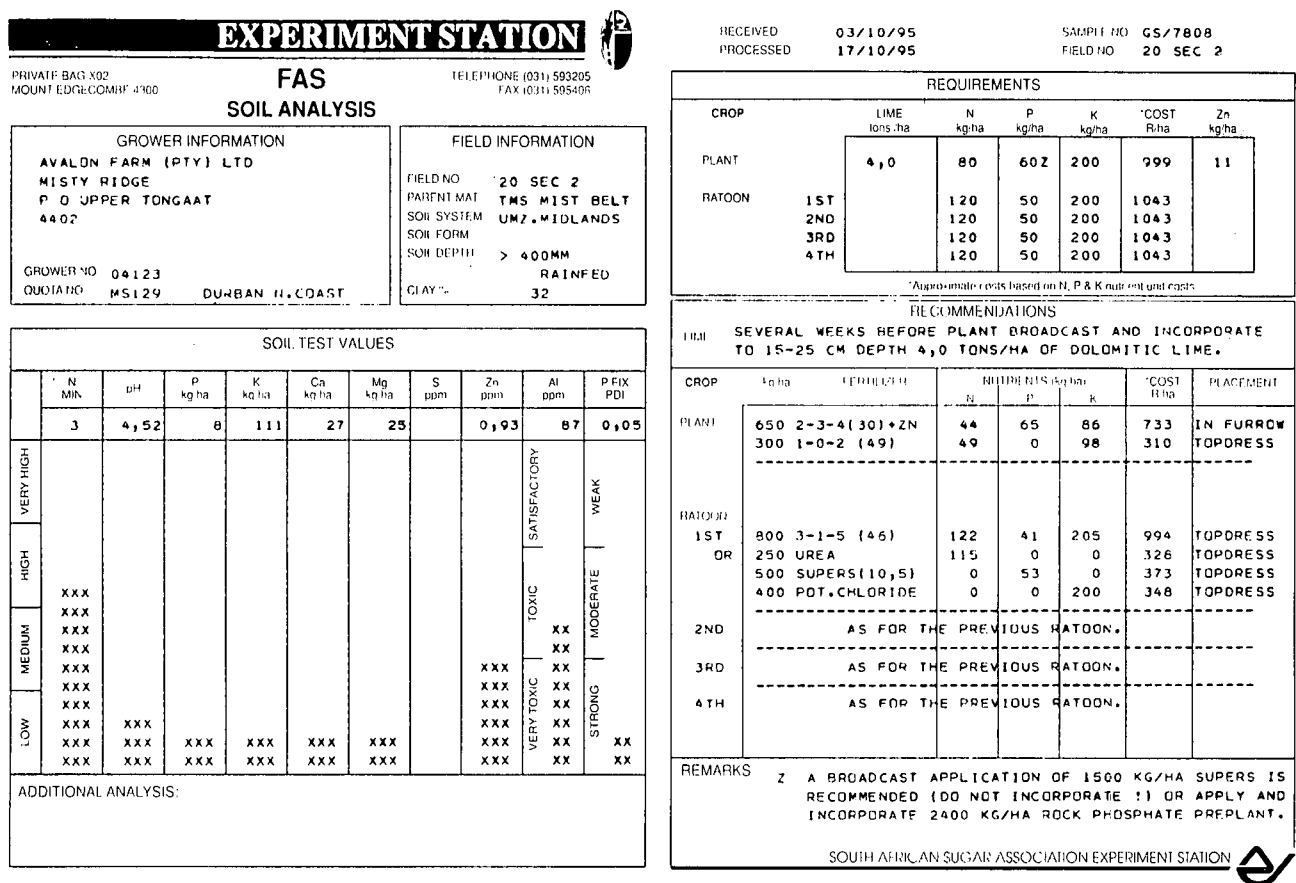


Figure 2. Example of computerised soil analysis and recommendation sheet used by the FAS.

Nitrogen

The industry was initially driven by maximisation of production and short term economic gain, and the FAS N fertiliser recommendations were developed to accommodate this objective. Nitrogen recommendations for ratoon cane were based on expected cane yield, but the actual N usage of 1,90 kg N/ton cane far exceeded the recommended FAS amount of 1,25 kg N/ton. Little account was taken of the large differences in N mineralising potential that existed between soils, and that residual soil N may in a number of soils play a more important role for sugarcane nutrition than fertiliser N (Wood, 1968). The emphasis was mainly on fertilising the crop rather than on managing the mineralisation potential of the soil and taking this into account when making fertiliser recommendations. Because this method of establishing N requirement generally led to over-application of N fertiliser, 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). For advisory purposes, an analytical method based on near infra-red reflectance spectroscopy (NIRS) was developed 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; Meyer, 1989). In general the revised N recommendations led to a reduction in N use, particularly for cane growing on high to very high N mineralising category soils.

Potassium

For many years, the threshold value used by the 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 fertiliser trials (Meyer and Wood, 1985). K threshold levels of 150 and 225 ppm were introduced for soils with clay contents of 30-40%, and >40% respectively. Results from recent K trials in the northern irrigated areas indicated that even 225 ppm was too low for a winter cycle crop in heavy textured, base saturated vertisols containing a high proportion of K-selective clay minerals. Some of the largest responses to applied K were obtained on these soils and a threshold of 320 ppm has 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 (Donaldson *et al.*, 1990).

Phosphorus

The difference between the measured amount of P in the soil and the amount needed for optimum cane growth is used to determine the P fertiliser requirement. Prior to 1980, P recommendations were based on the modified Truog procedure in which the P is extracted with 0,02 N sulphuric acid for 30 minutes (du Toit, 1963). 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. This procedure was reliable in predicting a likely response to P but did not allow for the applied P to react with 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 KwaZulu-Natal midlands. Laboratory and glasshouse studies with 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 the FAS (Meyer and Dicks, 1979). As a result, all soils from the midlands with less than 31 ppm Troug extractable P are tested for P fixing capacity, using a rapid phosphorus desorption index (PDI) screening test (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 respectively. For medium and high P fixing soils with Troug P levels below 13 ppm, supplementary broadcast P applications are recommended in conjunction with the normal furrow P applications.

Lime requirement

Other characteristics of the highly weathered soils in the KwaZulu-Natal midlands are nutritional problems associated with Zn deficiency (du Toit, 1961), Al toxicity and Si deficiency (Bishop, 1967). Investigations to determine the reasons for the stimulating effects of wattle brushwood ash on cane growth (Meyer, 1970), led to the identification of Al toxicity as a growth limiting factor. The beneficial effects of the ash were simulated by the application of lime, even where the need for this was not indicated by the FAS criteria based on pH, and exchangeable Ca and Mg levels. A modified exchangeable Al index (EAI) proved effective in establishing the degree of Al toxicity in soil. The relationship between the EAI and clay content was used on a routine basis for predicting the toxic effects of Al, and the lime requirements of acid soils. Soils with EAI/clay ratios in excess of 3.5 responded to liming (Moberly and Meyer, 1975).

The criteria for lime requirement of humic soils was modified in 1992 by supplementing the EAI/clay criteria with an Al:S ratio (Schroeder *et al.*, 1993). The sulphate anion is considered to have 'self liming' properties, and substantial amounts of mineral S may occur in humic soils. For diagnostic purposes soils with Al:S ratios of two or higher are expected to respond to liming. 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. Varietal differences in terms of tolerance to Al toxicity have also been identified. A soil ASI threshold value of 40% is used to determine the lime requirement of N12, compared with 20% for all other varieties (Schroeder *et al.*, 1995).

Using organic nutrient carriers

While the FAS has mainly offered advice in terms of both straights and fertiliser mixtures, there has been an increasing demand for advice based on the use of biofertilisers such as

chicken litter, filtercake, 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 (Moberly *et al.*, 1971). Five tons/ha in the furrow can provide sufficient N, P and K for a plant crop growing on a humic soil without using additional fertiliser. This provides a saving of R200-300/hectare to the grower at 1996 prices. Similar savings may be obtained for fertilising ratoon cane with poultry litter.

Filtercake is also frequently applied in the furrow at planting although it has a moisture content considerably higher than that of poultry litter, and 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 tons filtercake (at 60% moisture content) per hectare will provide approximately 25 kg N, 80 kg P and 16 kg K. On average three tons of fresh filtercake is equivalent in value to one ton of fresh chicken litter.

Economics of fertiliser usage

Although the principle of maximum economic yield per hectare was emphasised by du Toit (1960b), it was only in the late seventies that the concept of maximum return on fertiliser investment using marginal return curves, was applied to fertiliser recommendations for sugarcane (Thompson, 1980). The assessment showed that, between 1970 and 1980, there was very little change in the ratio between the value of a ton of cane and the cost of a ton of fertiliser, and essentially the two approaches produced similar recommendations for N, P and K. However, since 1980 the ratio has become less favourable, requiring 11 instead of 8 tons of A pool cane to cover the cost of one ton of fertiliser.

With an increasing squeeze on profit margins and the likelihood that output value/input price ratios will be more volatile, it may be expected that economic optima for N, P and K will be more vulnerable to such changes. The KYNO-CANE computer program was recently developed using the FAS soil norms to more accurately quantify the consequences of economic changes on optimal nutrient recommendations (Prins *et al.*, 1997). SASEX is developing the CANEMAN model, which will enable growers to evaluate the economic consequences of different fertiliser strategies under various risk scenarios.

Improved fertiliser management through leaf analysis

Foliar diagnosis has been used to great advantage in determining the nutrient status of sugarcane and is widely accepted as a means of improving the effectiveness of fertiliser use. With the introduction of X-ray fluorescence and NIR (Wood *et al.*, 1985), leaf analysis has become more accessible as a diagnostic tool. It compares favourably with soil analysis in correlating with fertiliser responses and provides a useful check on the uptake of fertilisers already applied. A disadvantage is that it is often

carried out too late and the results can only be used for adjusting the fertiliser programme for the next crop. However, investigations with the Diagnosis and Recommendation Integrated System (DRIS) (Meyer, 1981), in which nutrient indices derived from ratios between nutrients rather than nutrient percentages in the leaf, have indicated that this system can help to expedite corrective fertiliser treatment of the crop that has been sampled. Since nutrient ratios vary less than nutrient percentages as the crop ages, diagnosis on irrigated cane can be made at two months, compared with four months using the conventional approach. In fertiliser management, foliar diagnosis has an important advantage over soil analysis in that it is the only means of assessing the efficacy of fertiliser applications, or detecting the effects of N losses due to volatilisation, leaching or denitrification.

Leaf analysis has been useful in identifying the reasons for yield declines in past research projects. These include the Upper Tongaat syndrome (Thompson, 1985) in which Zn and P deficiencies were identified as limiting factors, the weak sands project (Thompson, 1983) in which sulphur deficiency was prominent, the low leaf/high soil K problem in the lowveld (Donaldson *et al.*, 1990), acid chlorosis as a result of Fe deficiency induced by Mn toxicity and a suspected boron deficiency in Malawi. More recently a suspected compaction problem on a large estate in the lowveld was linked to a high incidence of leaf P deficiency as identified by foliar diagnosis.

Monitoring long term fertility trends

Since the industry wide nutrient survey conducted in 1970 (Meyer *et al.*, 1971), little use had been made of historical analytical data until the computerisation of FAS recommendations in 1980. In 1988, a programme referred to as NIRS (Nutrient Information Retrieval System) was developed to make meaningful comparisons of nutrient trends between the various extension areas (Meyer *et al.*, 1989). Currently, analyses from more than 200 000 soil and 75 000 leaf samples are stored in the FAS database (Table 2). Since 1980-82 there has been a steady decline in average leaf N and P levels, which is partly attributed to the increased use of varieties N12 and N14, which are both known to be less efficient in N and P uptake than NCo376. Other factors include reductions in N and P usage due to the eldana epidemic and the recent drought. The highest frequency of samples having a N deficiency occurred in south Zululand (36%), P deficiency occurred in the northern midlands (32%), K deficiency in Mapumalanga (24%), and Zn deficiency among the north coast small scale growers (18%).

An important observation from the soil database assessment is the rapid acidification that has occurred in the light textured soils since 1980-82. Results of a survey of paired cultivated and virgin sites also revealed accelerated acidification of soils under cultivation (van Antwerpen and Meyer, 1996).

Planning cost effective fertiliser strategies

On receiving the FAS results, growers have the option of calling upon the skills and experience of the local Extension Officer (EO) and a SASEX specialist to assist in the interpretation and planning of a balanced fertiliser programme. Improvements in computer programs now enable the EO to access the comprehensive FAS database, which greatly facilitates the service offered. Where regular sampling has been carried out for a number of years, it is possible to trace nutrient trends in specific fields and over homogeneous areas. Not only does this information make it possible for the grower to rationalise his fertiliser programme by reducing the number of mixtures that need to be used, but it also provides SASEX with directions for future research work. The following examples illustrate the impact that FAS has made in effecting savings in fertiliser costs at the grower and industrial level:

Midlands grower

Between 1985 and 1990 a large estate in the midlands progressively reduced fertiliser application from an average of 173 to 106 kg N/ha, with an apparent improvement in sucrose production. To date the saving in fertiliser cost has amounted to several million Rand (Figure 3).

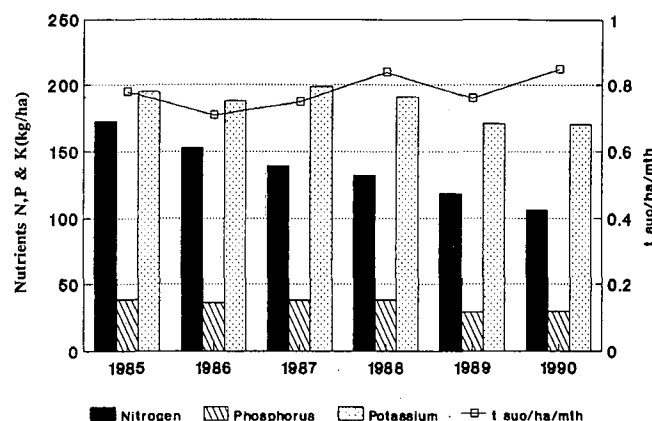


Figure 3. Effect of reduction in N use on sucrose for a grower in the midlands.

Miller-cum-planter on the north coast

Following the recent two-year drought the miller needed to know whether there was sufficient residual nitrogen present in the soil to reduce N fertiliser expenditure on an estate covering 7 154 hectares. Selected fields were sampled and residual N levels were determined in relation to N mineralisation categories. Recommended reductions as great as 50 kg N/ha were based on residual N levels and mineralisation potential. In addition, reductions in P and K requirements were made on soil samples previously submitted to the FAS. The rationalised programme that was prepared for over 500 fields resulted in a saving of R450 000 for the season.

Table 2
Example of leaf analysis report for the Umfolozi area.

REGIONAL EXTENSION CROP NUTRITION REPORT							
LEAF ANALYSIS ASSESSMENT							
No. 5							
EXTENSION AREA: UMFOLOZI				EXTENSION OFFICER: MR TL CULVERWELL			
NUTRIENT	PERIOD	No. of SAMPLES	MEAN (%)	PERCENTAGE OF TOTAL			
				DEFICIENT	MARGINAL	ADEQUATE	HIGH
NITROGEN	1980-1982	46	1.94	<1.6	1.6-1.8	1.8-2.7	>2.7
	1983-1985	225	1.85	13	13	73	0
	1986-1988	290	1.85	12	26	59	0
	1988-1990	162	1.75	16	24	57	0
	1990-1993	493	1.74	38	22	41	0
	1993-1995	286	1.75	34	25	41	0
	1993-1995	286	1.75	23	31	47	0
	AVG (TREND)		250	1.81	23	24	53
PHOSPHORUS	1980-1982	46	0.21	<0.17	0.17-0.19	0.20-0.30	>0.30
	1983-1985	225	0.21	8	28	60	2
	1986-1988	290	0.20	8	25	63	1
	1988-1990	162	0.19	15	38	43	0
	1990-1993	493	0.19	29	26	45	0
	1993-1995	286	0.20	29	26	45	0
	1993-1995	286	0.20	13	26	61	3
	AVG (TREND)		250	0.20	17	28	53
POTASSIUM	1980-1982	46	1.14	<0.86	0.86-1.05	1.05-1.50	>1.50
	1983-1985	225	1.27	6	34	55	2
	1986-1988	290	1.17	3	13	67	14
	1988-1990	162	1.14	14	21	48	13
	1990-1993	493	1.31	13	21	60	6
	1993-1995	286	1.33	3	12	63	21
	1993-1995	286	1.33	8	18	51	24
	AVG (TREND)		250	1.23	8	20	57
CALCIUM	1980-1982	46	0.33	<0.15	0.15-0.20	0.20-0.40	>0.40
	1983-1985	258	0.28	0	0	84	15
	1986-1988	293	0.29	0	15	78	4
	1988-1990	162	0.28	3	11	76	7
	1990-1993	493	0.22	1	10	81	8
	1993-1995	286	0.23	7	36	55	2
	1993-1995	286	0.23	5	18	76	1
	AVG (TREND)		256	0.27	3	15	75
MAGNESIUM	1980-1982	46	0.29	<0.10	0.10-0.20	0.20-0.40	>0.40
	1983-1985	258	0.23	0	0	67	32
	1986-1988	293	0.24	0	4	91	2
	1988-1990	162	0.23	0	5	85	8
	1990-1993	493	0.19	0	27	73	0
	1993-1995	286	0.20	0	69	31	0
	1993-1995	286	0.20	0	42	58	0
	AVG (TREND)		256	0.23	0	25	68
SULPHUR	1980-1982	0	0.00	<0.10	0.10-0.15	0.15-0.30	>0.30
	1983-1985	60	0.17	0	0	0	0
	1986-1988	289	0.18	0	35	64	0
	1988-1990	153	0.17	1	34	62	0
	1990-1993	491	0.19	0	22	78	0
	1993-1995	243	0.20	0	4	96	0
	1993-1995	243	0.20	0	0	100	0
	AVG (TREND)		247	0.18	0	19	80
ZINC	1980-1982	10	22	<12	12-15	15-25	>25
	1983-1985	59	17	0	0	100	0
	1986-1988	284	18	11	25	61	0
	1988-1990	153	17	9	24	61	3
	1990-1993	491	15	11	20	64	5
	1993-1995	243	15	26	32	41	1
	1993-1995	243	15	14	21	64	1
	AVG (TREND)		207	17	12	20	65

COMMENTS: There has been a steady increase in the incidence of N deficiency from 13% in 1980-82 to 23% in 1993-95. The incidence of P deficiency has also increased from 8 to 13%. K and S levels have improved over the 15 year period. The incidence of Zn deficiency has increased from 0 to 14% in 1993-95.

Industry as a whole

Fifteen years ago N use was excessive (1,9 kg N/ton cane), but the combined efforts of the FAS and the extension service has led to a current average usage of 1,5 kg N/ton cane. The saving of approximately 0,4 kg N/ton cane translates into an industry saving of between R20 and R25 million per annum.

Future developments, 2000 and beyond

There can be little doubt that the advantages of soil and leaf testing are considerable, and that over the past 40 years the FAS has had a substantial impact on efficient fertiliser usage and the type of fertiliser used in the sugar industry. The more efficient use of N is particularly important environmentally. Environmental issues are playing an increasingly important part in the USA and Europe in influencing nutrient management strategies. Countries such as Holland and parts of the USA have introduced legislation governing the use of fertilisers and agricultural chemicals so that off-farm exports can be subject to penalties. Whether this happens in our industry or not, it is clear that the FAS is well placed to advise growers on avoiding excess nutrient usage.

Due to rapidly increasing fertiliser prices and uncertainty about the effects of deregulation on the price of cane, providing computer-based decision support models for minimising risk in fertiliser management will become an important area of involvement for FAS and extension specialists. Investigations combining the FAS database with the Field Record System (FRS) and Geographic Information System (GIS) will also in future play an important role in relating field productivity to fertility trends (Hellman *et al.*, 1995). A trend that is emerging in the USA and Europe is towards site specific management, where Global Positioning System (GPS) controlled fertiliser applicators can vary the amount of fertiliser applied to a field according to soil test results. The FAS will also be well placed to advise growers when this technology becomes available to the sugar industry.

With the recently acquired new generation X-ray spectrometer, the range of elements that can now be analysed in leaf samples has increased to include elements such as aluminium, silicon and chloride in addition to a number of trace elements. Advances in NIR research have also enabled the rapid determination of soil organic matter and this could be used as a basis in determining a 'soil sustainability index'. Quantifying the distribution of leaf N pools such as nitrate-N, amino-N, soluble and structural proteins could be another potential application of NIR in the next decade. As NIR spectra have been used to determine canopy nitrogen and carbon in a number of forest sites by remote sensing from NASA's Airborne Imaging Spectrophotometer, there is also the exciting prospect that laboratory based NIR calibrations may one day become a necessity for interpreting the nitrogen status of a cane field using satellite imagery (Meyer, 1996).

Given the many and substantial benefits from using FAS, all sugarcane producers should heed its mission, which "... undertakes to promote the competitiveness of the South African sugar industry by providing an efficient analytical and cost effective fertiliser advisory service that will optimise sucrose production for our stakeholders."

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