UNIVERSITY OF SOUTHERN QUEENSLAND

CANEGROWERS ROCKY POINT

HECK GROUP

Sugar Research Australia

SOIL-SPECIFIC NUTRIENT MANAGEMENT GUIDELINES

FOR SUGARCANE PRODUCTION IN THE ROCKY POINT DISTRICT

AUTHORS:
Bernard Schroeder[1], John Panitz[2], Sebastien Garcia-Cuenca[3],
Victor Schwenke[4] and Gavin Rodman[5]

[1]University of Southern Queensland, Toowoomba; [2]Sugar Research Australia, Bundaberg; [3]Sugar Research Australia, Condong;
[4]Rocky Point Canegrowers, Rocky Point; [5]Sugar Research Australia, Meringa

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This publication has been developed as an informative guide for sugarcane growers and agronomists. It is not intended for regulatory use and or as a baseline for the development of regulatory frameworks in the Rocky Point district. Importantly, these guidelines are currently being validated through a series of grower led field trials anticipated to run for a full crop cycle or at least 5 years from publication date.

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FOREWORD

Rocky Point has a long history of growing and milling sugarcane and is best known for being the smallest milling district in Queensland. However, in recent years the local area and industry have been under increasing pressure from nearby urban and industrial development. As a result, it is fair to say that the rest of the industry has heard or talked more about our slow death rather than our dedication to improvement, diversification and our desire to keep farming sugarcane in the most sustainable and profitable way.

We have had to adapt and adopt new practices to maximise our profitability. Most of the Rocky Point district is farmed using controlled traffic and green cane harvesting. Some of the trash is retained in the paddock and legumes are planted as break crops on 'fallow' ground.

Looking forward, one of the most important improvements for us is how we manage our fertiliser programs. In line with the rest of the industry, we want to match the nutrients we buy and apply to our farms to what our soils and crops actually require. We may be small in area, but we have very diverse soils with different characteristics and needs, and therefore we need soil-specific nutrient management guidelines.

We are grateful to Sugar Research Australia (SRA), the University of Southern Queensland (USQ), Rocky Point CANEGROWERS and the Rocky Point Mill, that have all worked with us to develop these guidelines. These will undoubtedly assist Rocky Point growers to understand and manage their soils and nutrients in more precise, profitable and sustainable ways and allow us to continue to improve our practices.

Josh Keith

Ben Spann

ABOUT THE AUTHORS

Dr Bernard Schroeder is Professor (Farming Systems) at USQ. He has been involved in RD&E associated with various aspects of soil fertility and crop nutrition for more than 35 years. He has a sound understanding of the sugarcane production systems and in-depth knowledge of issues affecting sugarcane productivity, profitability and environment. A major part of his work has been aimed at fine-tuning the nutrient requirements for the Australian sugar industry and the development of the SIX EASY STEPS ® nutrient management program for sugarcane. This work has usually been in collaboration with other agricultural scientists, particularly within SRA, BSES and SRDC funded projects. He is the author/co-author of a large number of publications, both technical and more industry focused.

John Panitz is a Principal Technician with SRA based at Bundaberg. He has close to 40 years' working experience in an RD&E environment. John is one of the inaugural members of the SIX EASY STEPS development and delivery team. Currently he is a member of a research team that has a focus on crop nutrition, soil health, farming systems and production management. John brings with him a wealth of practical and technical experience and has the ability to communicate effectively across the full spectrum of people in the sugar industry. He is the author/co-author of several publications, both technical and more industry focused.

Sebastien Garcia-Cuenca is the SRA Regional Coordinator for New South Wales (NSW) and Rocky Point. He has over 12 years' experience in agricultural extension and development as well as environmental management and remediation. He has delivered and contributed to acid sulfate soils, nutrient cycles and soil health, water and effluent management projects. He has worked closely with the sugar, horticulture, and dairy as well as mining industries. Prior to this period, he worked as a qualified horticulturalist on farms in New South Wales, Queensland and Western Australia.

Victor Schwenke is the Productivity Officer for Rocky Point CANEGROWERS. He has served the industry for over 45 years, working for the Productivity and Pest and Disease Boards as well as BSES. Over the years, Victor's work focussed on pest and disease inspection, variety propagation and advice and general extension services. He has contributed to numerous research and development projects in the fields of agronomy trials, Fiji disease, water quality monitoring, soil and land capability assessment, acid sulfate soils monitoring and management. Victor continues to farm in the district.

Gavin Rodman is the Adoption Officer for Nutrient Management with SRA based at Meringa. Gavin grew up on a sugarcane farm in the Babinda district of North Queensland and studied environmental science and business at university. He is involved in delivering SIX EASY STEPS short courses across the industry and working with growers to bridge the water quality science gap through the Cane to Creek Project.

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- Josh Keith and Ben Spann for initiating this project in the Rocky Point district, and for their continued support and encouragement.
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- Dr Andrew Wood for reviewing the draft version of the booklet and his constructive comments. We also acknowledge the large contribution Andrew has made in developing the SIX EASY STEPS program, establishing the nutrient management guidelines and encouraging the use of soil properties to guide nutrient inputs.
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- Canegrowers in the Rocky Point district, including the Heck Group, who kindly allowed access to their farms, collection of soil samples and digging of the soil pits.

The soil-specific guidelines in this publication are based on outcomes from various projects that originally received funding, individually or severally, from Sugar Research and Development Corporation (SRDC), BSES Limited, the Cooperative Research Centre for Sustainable Sugar Production, and the Queensland and Australian Governments. The specific information relating to the Rocky Point soils and management practices are the result of direct and in-kind funding and support from SRA and USQ.

INTRODUCTION

This booklet deals with soils of the Rocky Point district in South East Queensland and describes the appropriate nutrient management guidelines for sugarcane production in the area. The district extends from the coastline adjacent to Jacobs Well in the east to the Albert River in the west, and from the Logan River in the north to the Pimpama River and Pimpama/Coomera residential area in the south. A soils map for this area is included as a useful reference for readers of this booklet.

This booklet, and similar booklets developed for various sugarcane production areas, describe the basic principles of soil management and presents nutrient guidelines for the major cane growing soils. The soil-specific nutrient management guidelines for sugarcane grown at Rocky Point are based on a methodology developed within a former SRDC-funded project (Improved nutrient management in the Australian sugar industry).

Our philosophy is that knowledge of soils should form the basis for making management decisions on-farm. Not only does soil type influence decisions on which sugarcane cultivar to plant and how much fertiliser to apply, but it also has an impact on the choice of tillage practices, planting techniques, drainage and irrigation requirements, and harvest scheduling.

A major objective of this publication is to help growers integrate their knowledge of different soils. This includes the appearance of soils, their occurrence in the landscape, their properties and how they should be managed. Soil-specific guidelines as presented in this booklet represent a much more precise way of managing fertiliser inputs than the traditional "one size fits all" approach. It provides a benchmark against which soils and soil analyses can be compared. However, it is not intended as a substitute for on-farm soil and leaf testing. Ideally each block on the farm should be sampled every crop cycle for both soil and leaf analyses. A system of record keeping should also be implemented which records nutrient inputs, changes in soil fertility, and crop productivity and profitability.

This philosophy is particularly appropriate for the current circumstances in the Australian sugar industry. The escalating costs of fertiliser, the need to reduce production costs and mounting environmental pressures demand responsible soil and nutrient management. The guidelines in this booklet are aimed at providing best-practice soil and nutrient management for Rocky Point cane growers. Use of these will not only maintain or improve crop yields and soil fertility, but will also provide opportunities for cost reductions whilst enhancing sustainability and delivering positive environmental outcomes by minimising possible off-site nutrient movement.


CASTROL

1. INTRODUCTION TO ROCKY POINT SOILS AND THEIR PROPERTIES

Sugarcane in the Rocky Point district is grown on a relatively small group of soils. However, their properties still reflect a range of soil forming factors that include climate, parent material, topography and the action of organisms. The types of parent material in the area have a marked influence on the soils, their mineralogy, texture and nutrient status. In addition, weathering, erosion, depositional processes and cropping continue to contribute to the physical, chemical and biological properties of soils in this relatively low-lying area.

Soil formation and distribution

The Rocky Point sugarcane district is divided into two main zones, namely Rocky Point and Alberton (Table 3.1).

The Rocky Point zone covers a larger area in the central and south east section of the mill area. It consists of soils that are mainly derived from sedimentary, alluvial and/or marine origins. The soils closer to the coast can be sandy in nature due to their formation on previous beach ridges (e.g. Beach Sands), but can also have considerable clay and organic C contents due to depositional processes that have occurred in hollows and depressions (e.g. Marine Mud). The soils away from the coast i.e. Black Sands, Sandy Loams and Peats are often associated with sand and clay ridges and hollows formed by previous watercourses. Soils with mottled and greyish blue clay subsoils (Peaty Clays and Heavy Black Clays) are found in depressions and in the lowest positions in the landscape.

The Alberton zone covers a smaller area in the northwest section of the mill area south of the Logan River. It comprises relatively well-drained loam and clay loam soils on terrace plains and old and active levee sites. While Old Alluvial soils are found on undulating river terraces associated with the Logan River, Young Alluvials are often found adjacent to the Albert River. Clays and heavy clays occupy positions on previous river flood plains.

Position in the landscape

Because of the interactive effect of the soil-forming factors, the existence of soils with specific characteristics is predictable in the landscape. Soils differ according to their position in the landscape and due to the interaction between topography, geology and climate. For example, a typical sequence of soils on weathered alluvial or sedimentary material consists of soils with different coloured subsoils. Red clay or clay loam subsoils are often found on upper and/or well-drained slopes, yellow clay or clay loam subsoils lower down, grey and mottled subsoils on lower slope, and blue/grey clays in the lowest positions in the landscape.

Soil field properties

In recognising the existence of a range of soil types, it is possible to classify them according to complex scientific systems. However, recognition of basic soil field properties such as colour, texture, structure, depth and position in the landscape enables the separation of soils into 'user-friendly' soil types. Soil type used in combination with soil chemical properties (from soil tests) will enable growers and their advisors to make informed decisions about appropriate nutrient management strategies on-farm.

Colour

The colour of soil is determined by the amount of organic matter present, iron oxide levels and the degree of aeration/moisture content. Dark coloured soils have more organic matter than lighter-coloured soils. Well-drained soils have red or brown colours whereas poorer drainage is indicated by paler colours ranging from yellow, grading through to grey, light grey and even blue in very poorly drained soils.

Bleached horizons (containing little organic matter or iron) with mottles are indicative of seasonal saturation and intense leaching. The mottles form around larger soil pores and root channels where there is some oxygen. The colours referred to in this booklet relate to soils that are moist.

Soil texture

This is an important soil property as it affects soil structure (see below), the capacity of soil to hold air and water, the amount and availability of nutrients, and many chemical properties. Management issues such as workability, trafficability, erodibility and root development are also associated with soil texture.

Soil texture is a measure of the relative proportions of the various sized soil particles present. While the largest particles include gravel and sand, the smallest particles are referred to as clay. Silt particles are moderate in size. Soils are classified as sand, loam or clay depending on the proportions of these basic components. Clay particles, with their large surface area and negative charge, are the most reactive constituents of the soil. They give soils the ability to store positively charged nutrients such as potassium, sodium, calcium and magnesium. The fine pores between the clay particles also allow them to store large volumes of water. Actual texture (particle size distribution) can be determined in the laboratory. Alternatively, soil texture can be estimated in the field using the guidelines provided in Appendix 2.

Structure

Structure is the natural aggregation of the soil particles (sand, silt and clay) and organic matter into units called peds (aggregates). These peds can differ markedly in terms of size, shape and level of stability. Their presence in soil affects the way soils behave, the growth of plants and the way we manage the soil. For instance, while some structure is essential to enable soil stability and good water-holding characteristics, large and strong structural units in the soil can prevent root penetration and negatively affect tillage operations.

Soil horizons

Soils develop different horizons or layers in their vertical sections. Horizon development varies with the type of parent material, organic matter, and the influence of water through leaching/flooding. Each horizon has characteristics which relate to soil colour, texture and structure that distinguish it from the horizons above and below it. Farming activities mix the surface horizons, which we refer to as topsoil. Material below this is referred to as subsoil. In the Rocky Point cane producing soils the top 20 cm is generally considered mixed topsoil and the 40 – 60 cm depth increment is usually well within the subsoil.

Chemical properties

Clay particles and soil organic matter are largely responsible for the chemical properties of soils due to their reactivity and their small particle size which results in a large surface area.

Cation exchange capacity

Cation exchange capacity (CEC) refers to the amount of negative charge on clay and organic matter particles that attracts positively charged chemicals called cations. The most common cations in soil are calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}) and aluminium (Al^{3+}). As these cations are held electrostatically, they are not easily leached but can be exchanged for other cations enabling plants to have access to them. Soils in the wetter tropical areas generally have lower CECs than soils in cooler or drier areas as they are more highly weathered. As they become more acid due to ongoing leaching their CECs are commonly reduced. The CEC of soils in this booklet is defined as the effective cation exchange capacity (ECEC) which is the sum of the exchangeable cations (K^{+}, Ca^{2+}, Mg^{2+}, Na^{+}, Al^{3+} and H^{+}) as

measured in the laboratory. The ECEC in the Rocky Point district is classified as very low (less than 2 meq/100g), low (2 - 4 meq/100g), medium (4 - 8 meq/100g), high (8 - 16 meq/100g) or very high (> 16 meq/100g).

Organic Matter

Soil organic matter is derived from the breakdown of plant and animal matter. It also has the ability to attract nutrients and has a greater cation exchange capacity than a similar mass of clay. Dark colour and good structure are indicators of high organic matter. Organic matter, measured as organic carbon %, improves soil structure and is a source of nitrogen (N), phosphorus (P), sulfur (S) and trace elements. There is no optimum level of organic matter, but it is best to maintain it at the highest possible level. The organic matter content of a soil is determined by the balance between inputs of organic matter forming material and the breakdown (mineralisation) of the existing stabilised soil organic matter (humus). Green harvested sugarcane contributes about 10-15 t/ha in trash and 3 t/ha in roots per year, but 80% of this is lost by decomposition in the first year. In soils with low clay content, organic matter is the chief store for exchangeable cations. Organic matter is a major source of nitrogen which is released by mineralisation. The potential amount of nitrogen released from specific soils can be estimated using a nitrogen mineralisation index. This index is used to guide nitrogen fertiliser recommendations.

As mentioned earlier, building organic matter levels is difficult. Within the Rocky Point district, relatively high organic carbon values are associated with some strongly acid soils in bottom land positions. Breakdown of organic matter is enhanced by cultivation. Trash conservation following green cane harvesting and the use of fallow green manure crops are the major ways organic matter can be added to soil in sugarcane farming systems. Other methods of maintaining soil organic matter include reducing tillage operations, preventing soil erosion and use of imported organic matter sources such as mill mud, mud/ash and bagasse.

Acidity and soil pH

Acidity in soils is caused by excessive hydrogen (H) and aluminium (Al) ions on the cation exchange sites. Acidity is expressed in terms of pH: pH values less than 7 are acidic whilst those more than 7 are alkaline. Soil tests commonly include two measures of acidity: pH in water (pH_{water}) and pH in calcium chloride solution (pH_{CaCl_2}). In this booklet we only consider pH in water. Soil pH values greater than 5.5 are desirable for sugarcane growth in the Rocky Point district, where soils are naturally acidic. Strongly acid soils also occur in positions in the landscape that are characterised by acid sulfate conditions. Under acidic conditions, aluminium is present in its soluble form and is toxic to most plants. Fortunately, Australian sugarcane cultivars are fairly tolerant of high levels of exchangeable aluminium. However, this does not apply to legume crops which may be grown as fallow crops. Consequently, regular additions of lime are essential particularly if legume crops are going to be part of a farming system on acid soils. Soybeans require pH values greater than 5.5. Increased acidity (lower pH) is associated with reduced availability of N, P and S, while micro-nutrients such as copper (Cu) and zinc (Zn) will become more available. Ameliorating excessive soil acidity is also important from a soil health perspective.

Low pH may reduce the CEC of some soils and causes the soil CEC to be dominated by the acidic cations H^+ and Al^{3+}. This reduces the storage capacity for nutrients such as Ca, Mg and K and can be critical particularly on sandy soils with low CEC. Soil acidification is a natural process which is accelerated by the leaching of nitrate from nitrogen fertilisers and the removal of cane to the mill. Regular use of liming materials will reduce soil acidity, neutralise applied acidity arising from nitrogen fertiliser use and

replace calcium and magnesium (if using Mag lime or dolomite) withdrawn in the harvested crop.

Flocculation / dispersion

Clay particles can remain suspended in water or they can flocculate and settle. Soils with their CEC dominated by calcium, magnesium and aluminium ions flocculate well and do not disperse easily in water. However, sodium dominated soils with an exchangeable sodium percentage (ESP) greater than 5% are unstable when wet and disperse. Clays that disperse readily fill-up pore spaces and reduce permeability to both air and water.

Sodicity and salinity

Sodic subsoils restrict rooting depth, reduce soil water availability to roots and may increase susceptibility to surface erosion. Salinity is an issue for sugarcane grown on coastal and marine plains, and inland areas where water tables are above 0.5 m, causing salt accumulation in mid and lower landscape positions.

Plant nutrition

Plants require 16 elements for optimum growth. Carbon (C), hydrogen (H) and oxygen (O) are supplied from air and water. The other mineral elements can be divided into three groups: macronutrients [(nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S) and magnesium (Mg)) which are required in relatively large amounts (20 – 200 kg/ha), micronutrients [iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), manganese (Mn), boron (B), and for some plants sodium (Na)] which are required in small amounts (less than 10 kg/ha/crop). Silicon (Si), which is considered beneficial for plant growth, is required in fairly large quantities. All of these nutrients are naturally available in soils. Some soils are able to supply more of a particular nutrient than other soils. Fertilisers and soil ameliorants are used to supplement these supplies of nutrients and prevent the mining of nutrients stored in our soils.

Nitrogen (N)

Past research suggests that a crop of sugarcane requires about 1.4 kg N/tonne cane up to 100 tonnes cane per hectare and 1.0 kg N/ha thereafter. In order to achieve sustainable crop production, maximum use must be made of all the available nitrogen sources within the nitrogen cycle (Figure 1.1). To do this it is important to have an understanding of the transformations of nitrogen from one form to another.

Mineralisation of organic matter to ammonium and nitrate is on-going and the amount released depends on the amount of organic matter and microbial activity. The rate of mineralisation is also dependent on temperature and moisture and will therefore vary through the year according to climatic conditions. However, irrespective of the actual rate of mineralisation, this nitrogen is available for plant uptake and should be taken into account when nitrogen requirements are calculated. Nitrate levels fluctuate considerably in the soil. They rise substantially after cultivation in some soils (those high in organic matter) and after fertilisation. They are reduced by crop removal and after heavy rainfall (by leaching and runoff) and waterlogging (denitrification). Ammonium-N is subject to volatilisation, a loss process often associated with urea applied to the surface of a trash blanket. More detail is provided on these processes in Figure 1.1.

As it is important to minimise nitrogen losses, the following strategies are suggested:

- Apply nitrogen according to the specific requirements of different soils based on their N mineralisation index (as shown in Chapter 2).
- Reduce nitrogen losses from leaching, runoff and denitrification by splitting applications of nitrogen and avoiding applications just before or during the wet season.

- Reduce the potential for denitrification by improving drainage and placing fertiliser in the cane row where waterlogging is less likely.
- Reduce the potential for ammonia volatilisation when urea is applied to the surface of a trash blanket by delaying application until a cane canopy has developed.
- Apply urea below the soil surface to reduce losses by volatilisation. Be aware that this could however increase the risk of loss by dentirification if waterlogging occurs.

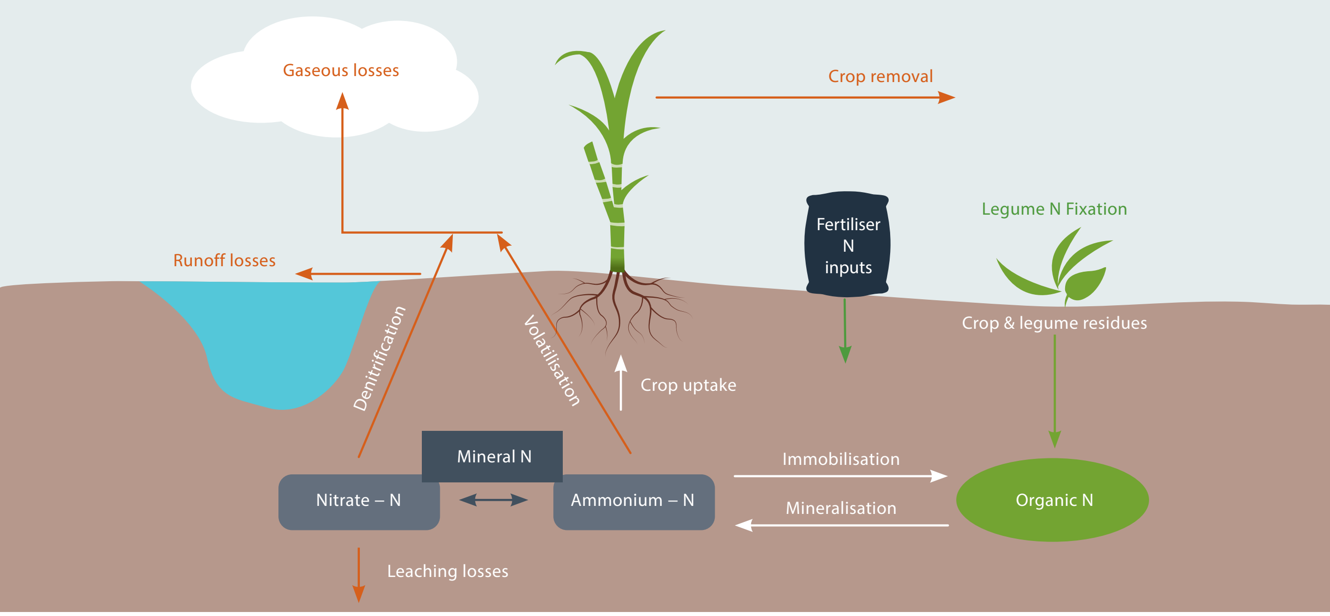
Phosphorus (P)

Phosphorus cycles between the various forms in soil (Figure 1.2), with some forms being more readily available than others. In some soils with high clay and/or organic matter content, phosphorus is held tightly onto soil particle surfaces by a process called phosphorus sorption. More phosphorus fertiliser needs to be applied when phosphorus is strongly 'sorbed' as it is relatively unavailable to plants. A soil test known as the Phosphorus Buffer Index (PBI), is available to measure how strongly different soils sorb added phosphorus.

Potassium (K)

Sugarcane needs potassium in relatively large quantities mainly for the maintenance of water balance. On average 150 kg K/ha is removed each year in the cane harvested and sent to the mill. Plants luxury feed on potassium where surplus is available. Potassium is present in several distinct forms within soils. A schematic diagram of the potassium cycle is shown in Figure 1.3.

F.1.1 SCHEMATIC DIAGRAM OF THE NITROGEN CYCLE



Lattice K is part of the clay structure and in some soils can represent a major part of the total K in soil and provides a source of plant available potassium. Slowly available non-exchangeable K exists in some potassium minerals and this can also act as a source of exchangeable and solution K (plant available forms). Potassium losses are possible with leaching of exchangeable and soil solution K particularly from sandy soils. Erosion also results in losses of lattice and non-exchangeable K reserves.

Calcium (Ca)

Calcium is essential for cane growth and for cell wall development. It is taken up as positively charged cations from the soil solution. Soil calcium held by the cation exchange capacity is supplemented by additions of liming materials and gypsum. A cane crop removes about 30 kg Ca/ha/year but when applying lime, considerably more calcium than this is applied because of the need to control soil acidity.

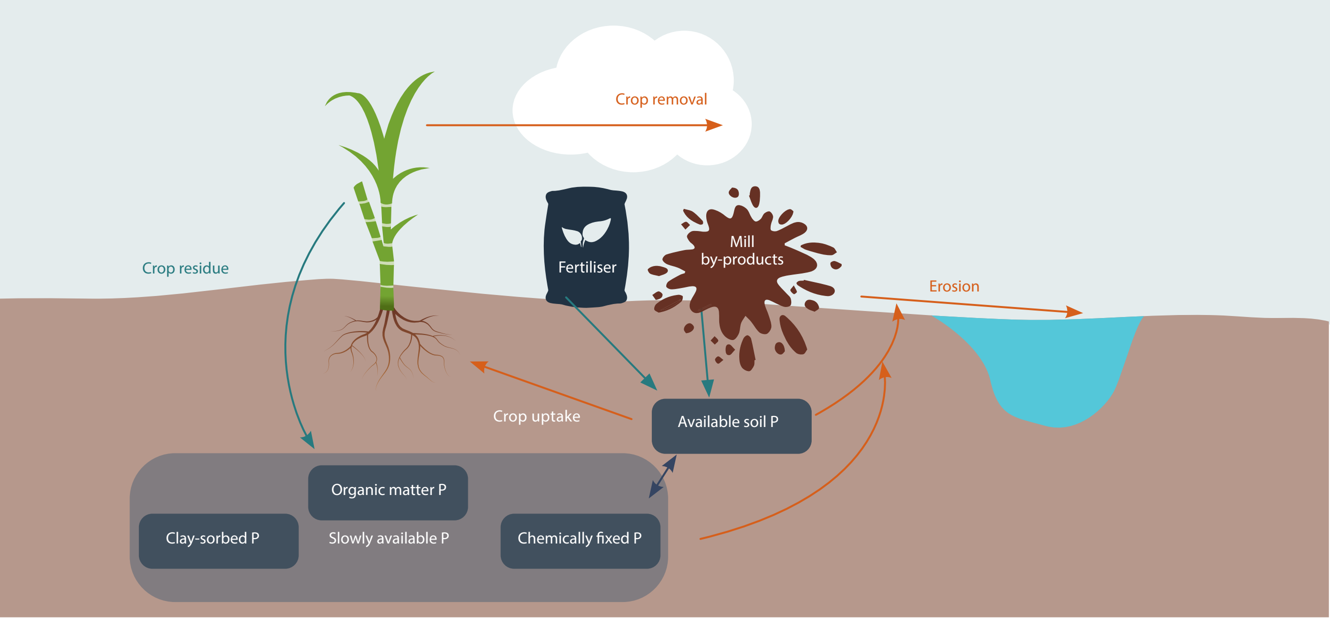
Magnesium (Mg)

Magnesium is essential for plant photosynthesis, as it is the main mineral constituent of chlorophyll. Like calcium, it is taken up from the soil solution and from the cation exchange sites. The total magnesium uptake by sugarcane crops is similar to calcium.

Sodium (Na)

Sodium is required in very small amounts for the maintenance of plant water balance. It is stored on the cation exchange sites and can be taken up from the soil solution by plants. Sodium is readily supplied from rainfall, particularly in coastal areas. It can have a detrimental effect on soil structure even at low levels (ESP of around 5%) and at higher levels (ESP above 15%) can restrict plant growth and root development.

F.1.2 SOIL PHOSPHORUS CYCLE



Sulfur (S)

Sugarcane requires sulfur in relatively large amounts of about 25 kg S/ha/year, which is used for plant structure and growth. Plants take up sulfur as sulfate which is more mobile in soils than phosphate and is therefore subject to leaching. Consequently, fertiliser applications may need to supply more than that harvested in the crop. The main store of sulfur in soils is organic matter. The release of sulfur from the mineralisation of soil organic matter should be allowed for when developing fertiliser recommendations. Other natural sources of sulfur are rainfall and irrigation.

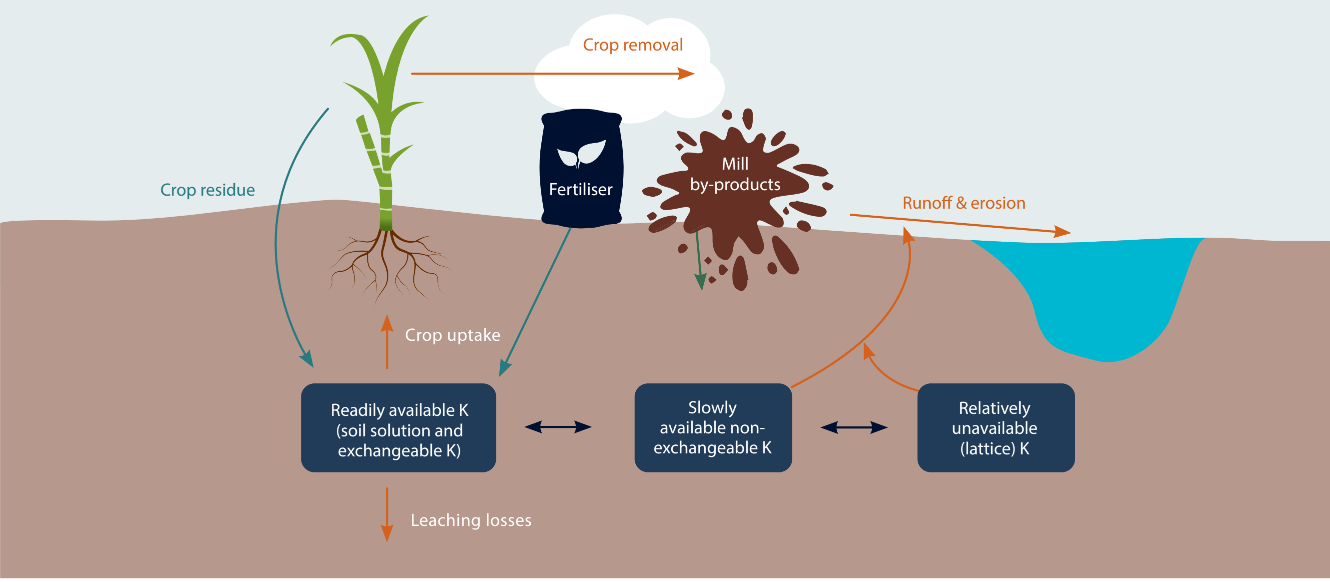
Micro-nutrients

Micronutrients are taken up by cane in much smaller quantities than the nutrients already mentioned and are generally regulators of plant growth. Both copper (Cu) and zinc (Zn) have been shown to be deficient in some sugar industry soils, particularly low organic matter sandy soils, whereas iron (Fe) and manganese (Mn) are usually well supplied. Little is known about the status of molybdenum (Mo) and boron (B) in Rocky Point soils.

Silicon

Deficiencies of silicon (Si) have been detected in some of the other Queensland sugarcane areas, particularly in very sandy soils on sedimentary rocks.

F.1.3 SOIL POTASSIUM CYCLE



2. PRINCIPLES FOR DETERMINING NUTRIENT MANAGEMENT GUIDELINES

When developing nutrient management guidelines for the different soil types in the Rocky Point district the following factors were considered:

- Crop yield potential
- Nutrients removed in the harvested crop
- Nutrients returned to the soil in trash, fallow crops and mill by-products
- Nutrients released by the mineralisation of soil organic matter
- Nutrients released by the weathering of soil minerals
- Nutrients fixed (held tightly) on soil particle surfaces
- Soil acidity
- Critical levels of nutrients as determined by soil analyses
- The balance and interactions of different nutrients, particularly those on the cation exchange sites
- The risk of nutrient loss processes occurring.

A wide range of soil physical and chemical properties were used to assist this process. Data were obtained from the analyses of samples collected from the soil reference sites and were used to produce the bar graphs for each soil type in Chapter 3. They include:

- Soil particle size distribution, particularly clay % (soil texture)
- Soil organic carbon % (a measure of organic matter)
- Nitrogen mineralisation index (a measure of the amount of N released from the breakdown of soil organic matter)
- Soil pH (a measure of soil acidity)
- Cation exchange capacity (CEC)
- Exchangeable K, Ca, Mg and Na (cations held on the soil CEC)
- Nitric K (a crude measure of K reserves)
- Exchangeable sodium percentage or ESP (the % of the CEC occupied by sodium)
- Exchange acidity (a measure of acidic cations held on the CEC)
- Acid saturation (% of the CEC occupied by acidic cations)
- BSES and Colwell P (indices of available phosphorus)
- Phosphorus Buffer Index – PBI (a measure of the degree to which added P is held onto soil particle surfaces and, therefore, unavailable for plant uptake)
- Sulfur, copper and zinc.

Nitrogen

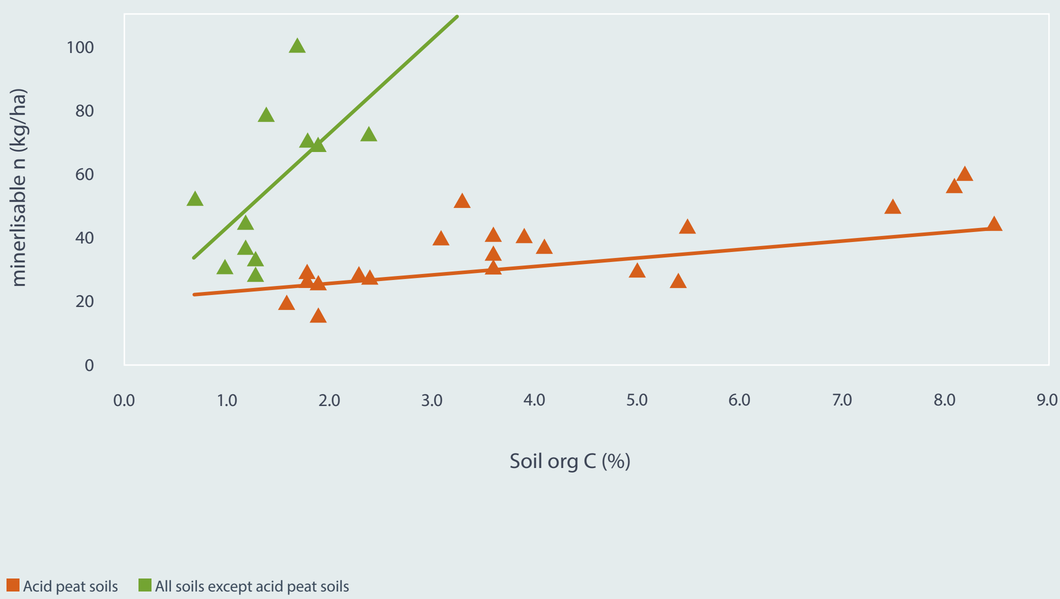
Nitrogen guidelines are based on a combination of district yield potential and soil N mineralisation index. The district yield potential is determined from the best possible yield averaged over all soil types within a district and is defined as the estimated highest average annual district cane yield (tonnes cane/ha) multiplied by a factor of 1.2. The district yield potential for Rocky Point is 120 tonnes cane/ha (estimated highest average annual yield of 100 tonnes cane/ha multiplied by 1.2). This concept of district yield potential recognises differences in the ability of districts and regions to produce cane. For example, the Burdekin region with its fertile soils, higher temperatures and access to water, has a higher yield potential than many other districts.

The district yield potential is used to establish the base N application rate according to an estimate, previously developed by CSIRO scientists. Accordingly, 1.4 kg N per tonne of cane is required up to a cane yield of 100 tonnes/ha and 1 kg N per tonne of cane/ha thereafter. With this approach however, inputs are adjusted according to the N mineralisation index, which is based on soil organic carbon (C) percentage and is related to soil colour. Generally, the darker the soil, the more organic matter is present. In the Queensland industry, from Maryborough north, seven N mineralisation index categories are recognised based on corresponding soil organic carbon classes. In Rocky Point a larger range of organic carbon values occur in two broad soil groups that are defined by soil pH and organic carbon values.

One group consists of organic carbon values similar to those found north of Rocky Point (0 to ≥2.4% C) with corresponding comparable N mineralisation values. These soils usually have organic carbon values less than 3% and pH values above five. The other group contains the acid peat soils (predominantly acid sulfate or potentially acid sulfate soils) with much higher soil organic carbon values (up to about 10%). In this booklet we refer to acid sulfate/potentially acid sulfate soils as those containing organic carbon >2%, pH <5.5 and S>200 mg/kg. These are similar to the soils found in New South Wales (Figure 2.1). Nitrogen mineralisation in this group of soils appears to be inhibited by low pH values and the amounts of N mineralised are lower than expected for the levels of organic matter.

F.2.1

MINERALISED N PLOTTED AGAINST SOIL ORGANIC C FOR ACID PEAT SOILS (SHOWN IN RED) AND ALL OTHER SOILS (SHOWN IN GREEN) IN THE NSW SUGARCANE INDUSTRY. SIMILAR RELATIONSHIPS WOULD OCCUR WITHIN THE TWO GROUPS OF SOILS AT ROCKY POINT.



The use of N mineralised from the soil organic matter (according to the N mineralisation index) results in a set of guidelines for N fertiliser inputs as shown in Tables 2.1 and 2.2. Whilst Table 2.1 refers to all soils except the "acid peat soils", Table 2.2 is relevant to the acid peat soils.

After determining the appropriate N application rate in this way, further discounting is required to recognise the contributions of other sources of N. These sources include N from legume fallow crops, harvested legume crops and application of mill by-products.

TABLE 2.1 - N MINERALISATION INDEX AND SUGGESTED NITROGEN RATES FOR REPLANT AND RATOON CROPS, AND PLANT CANE FOLLOWING A BARE OR GRASS FALLOW ON ALL SOILS EXCEPT ACID PEAT SOILS.

N MINERALISATION INDEX	ORGANIC CARBON (%)	CROP	N RATE (kg/ha)
VL	<0.40	Plough-out replant / ratoons	160
		Plant cane following a bare or grass fallow	140
L	0.41 – 0.80	Plough-out replant / ratoons	150
		Plant cane following a bare or grass fallow	130
ML	0.81 – 1.20	Plough-out replant / ratoons	140
		Plant cane following a bare or grass fallow	120
M	1.21 – 1.60	Plough-out replant / ratoons	130
		Plant cane following a bare or grass fallow	110
MH	1.61 – 2.00	Plough-out replant / ratoons	120
		Plant cane following a bare or grass fallow	100
H	2.01 – 2.40	Plough-out replant / ratoons	110
		Plant cane following a bare or grass fallow	90
VH	>2.40	Plough-out replant / ratoons	100
		Plant cane following a bare or grass fallow	80

TABLE 2.2 – N MINERALISATION INDEX AND NITROGEN RATES FOR REPLANT AND RATOON CROPS, AND PLANT CANE FOLLOWING A BARE OR GRASS FALLOWS ON ACID PEAT SOILS

N MINERALISATION INDEX	ORGANIC CARBON (%)	CROP	N RATE (kg/ha)
L	<3.0	Plough-out replant / ratoons	160
		Plant cane following a bare or grass fallow	140
M	3.0 – 6.0	Plough-out replant / ratoons	150
		Plant cane following a bare or grass fallow	130
H	> 6.0	Plough-out replant / ratoons	140
		Plant cane following a bare or grass fallow	120

Determining N application rates for sugarcane following legume fallows

Unlike N held in soil organic matter, legume N is usually immediately available for plant uptake and should be treated the same way as fertiliser N for the purposes of calculating N requirement. However, in acid sulfate soils mineralisation of N from legume residues may be retarded in the same way as mineralisation of soil organic matter. Information published by scientists working in the Sugar Yield Decline Joint Venture has provided details on how to estimate the amount of legume N being returned to the soil from a legume crop. The amount of N available to the succeeding sugarcane crop will be dependent on the type of legume, how well it was grown and whether the grain was harvested. A summary of the calculations for various legume fallows is shown in Table 2.3. This information can be used to adjust the amount of N fertiliser required for the different soils following different legume fallows. The values shown in BOLD in Table 2.3 are used as examples in Table 2.4.

TABLE 2.3 - CALCULATION OF N CONTRIBUTION FROM FALLOW LEGUME CROPS AS SUPPLIED BY THE SUGAR YIELD DECLINE JOINT VENTURE

LEGUME CROP	FALLOW CROP DRY MASS (t/ha)	N (%)	TOTAL N CONTRIBUTION (kg N/ha)	N CONTRIBUTION IF GRAIN HARVESTED (kg N/ha)
Soybean	8	3.5	360	120
	6		270	90
	4		180	60
	2		90	30
Peanut*	8	3.0	n/a	125
	6			100
	4			65
	2			25
Cowpea	8	2.8	290	100
	6		220	75
	4		145	50
	2		70	25
Lablab	8	2.3	240	80
	6		180	60
	4		120	40
	2		60	20

* MJ Bell, 2007

TABLE 2.4 - EFFECT OF FALLOW MANAGEMENT ON N REQUIREMENT FOR ALL SOILS EXCEPT ACID PEATS

CROP	N MINERALISATION INDEX						
	VL	L	ML	M	MH	H	VH
	NITROGEN APPLICATION RATE (kg N/ha)						
Replant crops	160	150	140	130	120	110	100
Ratoon crops	160	150	140	130	120	110	100
Plant cane after a grass/bare fallow	140	130	120	110	100	90	80
Plant cane after a poor legume crop (e.g. 2 t/ha cowpea green manure: N rate minus 70 kg N/ha)	90	80	70	60	50	40	30
Plant cane after a good legume crop (e.g. 6 t/ha soybean: N rate minus 270 kg N/ha)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Plant cane after a good legume crop harvested for grain (e.g.6 t/ha soybean: N rate minus 90 kg N/ha)	70	60	50	40	30	20	10
First ratoon after a good legume crop*	160	150	140	130	120	110	100
Second ratoon after a good legume crop	160	150	140	130	120	110	100

* Data from the Yield Decline Joint Venture and other field trials suggest that N applied to the first ratoon sugarcane crop after a good legume crop can possibly be reduced. The reduction in N applied will depend on several factors which include legume residue management, soil type, climate and tillage practices.

TABLE 2.5 - EFFECT OF FALLOW MANAGEMENT ON N REQUIREMENT FOR ACID PEATS

CROP	N MINERALISATION INDEX		
	L	M	H
	NITROGEN APPLICATION RATE (kg N/ha)		
Replant crops	160	150	140
Ratoon crops	160	150	140
Plant cane after a grass/bare fallow	140	130	120
Plant cane after a poor legume crop (e.g. 2 t/ha cowpea green manure: N rate minus 40[1] kg N/ha)	120	110	100
Plant cane after a good legume crop (e.g. 6 t/ha soybean: N rate minus 160[1] kg N/ha)	Nil	Nil	Nil
Plant cane after a good legume crop harvested for grain (e.g.6 t/ha soybean: N rate minus 50[1] kg N/ha)	110	100	90
First ratoon after a good legume crop*	160	150	140
Second ratoon after a good legume crop	160	150	140

* Data from the Sugar Yield Decline Joint Venture and other field trials suggest that N applied to the first ratoon sugarcane crop after a good legume crop can possibly be reduced. The reduction in N applied will depend on several factors which include legume residue management, soil type, climate and tillage practices.

[1] Estimated discounts. Mineralisation of N from legume residues may be reduced in acid sulfate / acid peat soils. Please discuss any planned and reductions to compensate for contributions from legume break crops with your advisor / extension officer.

TABLE 2.6 - DISCOUNTS TO N APPLICATION RATES DUE TO N CONTRIBUTION FROM MILL MUD

PRODUCT	APPLICATION RATE (Wet t/ha)	DISCOUNT TO N APPLICATION RATE (kg N/ha)		
		Year 1	Year 2	Year 3
Mill mud	100	50	25	0
	150	80	40	20

Modifying N application rates for sugarcane where mill by-products have been used

The amount of N applied needs to be discounted for up to three years after application of mill by-products. The amount of N to be subtracted from N application rates following the use of mill mud is shown in Table 2.6.

Phosphorus

Two techniques are used to decide how much P fertiliser is needed. Firstly a BSES P critical level is used to determine the quantity of P fertiliser required. This is then modified by the soil's ability to fix added P (P sorption), which determines how much of the fertiliser P will be available to the crop. The P sorption class of each soil is based on the Phosphorus Buffer Index (PBI) which is measured in the laboratory (Table 2.7). If PBI values are not available, P sorption can be estimated from the clay % and organic carbon content of a particular soil (Table 2.8).

Clay % is not given on most soil tests but can be estimated from a soil texture determination. If that is not available then an estimate of texture can be made from the cation exchange capacity of the soil as shown in Table 2.9.

TABLE 2.7 - P SORPTION CLASSES BASED ON PBI

P SORPTION CLASS	PBI
Low	< 140
Moderate	140 – 280
High	> 280

TABLE 2.8 - P SORPTION CLASSES BASED ON ORG C (%) AND TEXTURE CLASS

ORG C (%)	SAND (<24% CLAY)	LOAM (24-36% CLAY)	CLAY (>36% CLAY)
< 0.60 %	Low	Low	Moderate
0.61 – 1.20 %	Low	Moderate	Moderate
1.21 – 1.80 %	Moderate	Moderate	High
> 1.80%	High	High	High

TABLE 2.9 - ESTIMATE OF SOIL TEXTURE CLASS FROM CEC

CEC (meq/100g)	TEXTURE CLASS
< 4.0	Sand
4.1 – 8.0	Loam
> 8.0	Clay

Currently, some older sugarcane areas do not require any P fertiliser due to their long history of P fertilisation. New land, on the other hand, is often deficient in available P with BSES P values less than 5 and requires P fertiliser in the first crop cycle (Table 2.10).

P application rates should be reduced where mill mud has been applied, as it is a source of P (Table 2.11).

TABLE 2.10 - PHOSPHORUS GUIDELINES FOR OLD AND NEW LAND

BSES P IN SOIL TEST (mg/kg)	P SORPTION CLASS	PHOSPHORUS APPLICATION (kg P/ha)	
> 60	All	Nil P for at least 2 crop cycles	
50 – 60	All	Nil P for 1 crop cycle	
		PLANT	RATOON
40 – 50	Low	20	0
	Moderate	20	5
	High	20	10
30 – 40	Low	20	10
	Moderate	20	15
	High	20	20
20 – 30	Low	20	10
	Moderate	20	20
	High	30	25
10 – 20	Low	30	15
	Moderate	30	20
	High	40	30
5 -10	Low	30	20
	Moderate	40	30
	High	50	40
< 5	Low	40	20
	Moderate	60	30
	High	80	40

TABLE 2.11 - PHOSPHORUS CONTRIBUTION FROM MILL MUD APPLICATION

PRODUCT	APPLICATION RATE (Wet t/ha)	P APPLICATION GUIDELINE
Mill mud	100	Apply nil P for one crop cycle
	150	Apply nil P for two crop cycles

Potassium

Potassium fertiliser guidelines are based on two measures of soil K: readily available or exchangeable K (potassium in the soil solution and on the CEC) and reserve or Nitric K (slowly available, non-exchangeable potassium).

The maximum recommended K rate for Rocky Point cane fields is 120 kg K/ha which is slightly less than the amount of K removed in the harvested sugarcane crop when trash is retained. This upper limit on K applied is to avoid luxury consumption of K by the crop (resulting in reduced juice quality) and leaching losses on low CEC soils. It is justified by the relatively high K reserves on some soils that slowly become available. Hence, a plant crop following a fallow requires less K than replant or ratoon crops.

Soil-critical levels for exchangeable K are dependent on clay content. Soils are therefore assigned into one of three textural classes: sand (<24% clay); loam (24 – 36% clay); and clay (>36% clay). Based on this approach, potassium fertiliser guidelines are shown in Table 2.12.

Discounts should be made where mill by-products have been used, because they are sources of K (Table 2.13).

TABLE 2.12 - POTASSIUM FERTILISER GUIDELINES

POTASSIUM APPLICATION RATES FOR PLANT CANE (kg K/ha)						
Nitric K (meq/100g)	Exchangeable K (meq/100g)					
	< 0.20	0.20 – 0.25	0.26 – 0.30	0.31 – 0.35	0.36 – 0.40	> 0.40
< 0.70	100 (sand)	80 (sand)	50 (sand)	50 (sand)	Nil (sand)	Nil
	120 (loam)	100 (loam)	80 (loam)	50 (loam)	Nil(loam)	
	120 (clay)	120 (clay)	100 (clay)	80 (clay)	50 (clay)	
> 0.70	80 (sand)	50 (sand)	Nil (sand)	Nil (sand)	Nil (sand)	
	100 (loam)	80 (loam)	50 (loam)	Nil (loam)	Nil (loam)	
	100 (clay)	100 (clay)	80 (clay)	50 (clay)	Nil (clay)	
POTASSIUM APPLICATION RATES FOR REPLANT AND RATOON CANE (Kg K/ha)						
Nitric K (meq/100g)	Exchangeable K (meq/100g)					
	< 0.26	0.26 – 0.30	0.31 – 0.35	0.36 – 0.40	0.41 – 0.45	> 0.45
< 0.70	120 (sand)	100 (sand)	80 (sand)	50 (sand)	Nil (sand)	Nil
	120 (loam)	100 (loam)	100 (loam)	80 (loam)	50 (loam)	
	120 (clay)	100 (clay)	100 (clay)	100 (clay)	80 (clay)	
> 0.70	100 (sand)	80 (sand)	50 (sand)	Nil (sand)	Nil (sand)	
	100 (loam)	100 (loam)	80 (loam)	50 (loam)	Nil (loam)	
	100 (clay)	100 (clay)	100 (clay)	80 (clay)	50 (clay)	

TABLE 2.13 - DISCOUNTS TO K APPLICATION RATES DUE TO K CONTRIBUTION FROM MILL MUD

PRODUCT	APPLICATION RATE (Wet t/ha)	DISCOUNT TO K APPLICATION RATE (kg/ha)	
		Year 1	Year 2
Mill mud	100	25	0
	150	40	0

Sulfur

As the mineralisation of soil organic matter provides a source of sulfur, S fertiliser guidelines are based on the N mineralisation index. Soils are placed in one of three N mineralisation classes. Soil sulfate critical values are then used to calculate S fertiliser rates (Table 2.14). Discounts should be made where mill by-products have been used, because they supply S (Table 2.15).

TABLE 2.14 - SULFUR FERTILISER GUIDELINES (kg S/ha) FOR PLANT AND RATOON CROPS

SULFATE-S (mg/kg)	SULFUR APPLICATION RATES (kg/ha)			
	ALL SOILS EXCEPT ACID PEAT SOILS	ACID PEAT SOILS		
	SULFUR APPLICATION (KG S/HA) BASED ON N MINERALISATION CATEGORIES			
	VL – L	L	M	H
< 5	25	25	20	15
5 - 10	15	15	10	5
11 - 15	10	10	5	0
> 15	0	0	0	0

TABLE 2.15 - DISCOUNTS TO S APPLICATION RATES DUE TO S CONTRIBUTION FROM MILL MUD

PRODUCT	APPLICATION RATE (Wet t/ha)	DISCOUNT TO SULFUR APPLICATION RATE (kg S/ha)		
		Year 1	Year 2	Year 3
Mill mud	100	5	5	5
	150	10	10	10

Lime

Lime is used to neutralise soil acidity and to supply calcium. Soils are constantly being acidified through the use of N fertiliser, removal of nutrients in the harvested crop and by leaching of nitrate. Maintenance applications of about 2 tonnes lime/ha each crop cycle are needed to neutralise this effect. The more N fertiliser used, the greater is the lime requirement. In addition, some forms of N fertiliser acidify more than others (ammonium sulfate acidifies more than urea which acidifies more than calcium ammonium nitrate). Some soil tests include liming estimates to a target pH of 5.5, 6.0 and 6.5. The liming estimate aimed at a soil pH of 5.5 should be used where available, otherwise the guidelines in Table 2.16 can be used. Lime is recommended when soil pH falls below 5.5 (Table 2.16) and when exchangeable Ca is below the critical value of 1.5 me% (Table 2.17). Discounts are necessary where mill by-products have been applied (Table 2.18).

TABLE 2.16 - Ag LIME GUIDELINES FOR ACID SOILS (WHEN PH_{WATER} <5.5)

CEC (meq/100g)	LIME APPLICATION (tonnes/ha)
< 4.0	1.25
4.0 - 8.0	2.5
8.0 – 16.0	4
> 16.0	5

TABLE 2.17 - AG LIME GUIDELINES BASED ON EXCHANGEABLE Ca

SOIL Ca (meq/100g)	SUGGESTED LIME APPLICATION (tonnes/ha)
< 0.2	4.0
0.2 – 0.4	3.5
0.4 – 0.6	3.0
0.6 – 0.8	2.5
0.8 – 1.2	2.0
1.2 – 1.6	1.5
1.6 – 2.0	1.0
> 2.0	0

TABLE 2.18 - DISCOUNT TO CALCIUM APPLICATION RATE DUE TO CONTRIBUTION FROM MILL MUD

PRODUCT	APPLICATION RATE (Wet t/ha)	DISCOUNT TO CALCIUM APPLICATION RATE (kg Ca/ha)		
		Year 1	Year 2	Year 3
Mill mud	100	5	5	5
	150	10	10	10

Magnesium

Magnesium guidelines are based on soil critical levels for exchangeable magnesium (Table 2.19). Whilst a Mg level of 10-20% of CEC is desirable, levels of over 50% of CEC can occur on some soils. This may affect soil physical properties, making the soils prone to hard-setting and possibly causing germination difficulties. However, subsequent sugarcane growth does not appear to be affected, provided all nutrients are above their critical levels and soil pH is above 5.5. Magnesium guidelines following mill mud application are shown in Table 2.20.

TABLE 2.19 - MAGNESIUM GUIDELINES FOR PLANT CROPS

SOIL Mg (meq/100g)	< 0.05	0.06-0.10	0.11-0.15	0.16-0.20	0.21-0.25	> 0.25
Mg RATE (kg/ha)	150	125	100	75	50	0

TABLE 2.20 – GUIDELINES FOR MAGNESIUM WHEN MILL MUD HAS BEEN APPLIED

PRODUCT	APPLICATION RATE (Wet t/ha)	MAGNESIUM GUIDELINE WHEN MILL MUD HAS BEEN APPLIED
Mill mud	100 – 150	Apply nil Mg for one crop cycle

Sodium

Sodium does not need to be applied to sugarcane but needs to be reduced when the exchangeable sodium percentage (ESP) is above 5% of the CEC in the topsoil. Where this occurs it is suggested that subsoil samples be collected to determine ESP in the soil profile and specialist advice be sought on possible remedial activities. Gypsum is the normal ameliorant for sodic soils because it is relatively soluble. However, lime is an alternative in acidic soils. Rates of application are dependent on ESP values. Guidelines are provided in Table 2.21.

TABLE 2.21 - GYPSUM REQUIREMENT FOR SODIC SOILS

ESP (%)	GYPSUM RATE (tonnes/ha)
< 5	0
5 – 10	2
10 -15	4
> 15	6

Micronutrients

Copper and zinc guidelines are based on previously established soil-critical values (Table 2.22). The HCl zinc test is appropriate for acidic soils in north Queensland. The DTPA soil test should be used if soil pH is greater than 6.5. In this booklet, only DTPA results have been reported. Copper and zinc are most often required on low CEC and very sandy soils. Leaf analysis is a suitable method for determining the micronutrient status of crops. Heavy applications of ag lime may induce deficiencies when micronutrient levels are marginal. This is particularly relevant to zinc.

TABLE 2.22 - COPPER AND ZINC GUIDELINES

MICRONUTRIENT	SOIL TEST VALUE	SUGGESTED APPLICATION RATE
DTPA soil test		
Copper	< 0.2 mg Cu/kg	10 kg Cu/ha once per crop cycle
Zinc	< 0.3 mg Zn/kg	10 kg Zn/ha once per crop cycle
HCl zinc test		
Zinc	< 0.6 mg Zn/kg	10 kg Zn/ha once per crop cycle

Silicon

Two soil tests are appropriate for assessing silicon deficiencies. These are based on calcium chloride extractable Si and dilute sulfuric acid extractable Si. The latter is sometimes referred to as BSES-Si. Ameliorants are only required if both of the Si test values are low (Table 2.23). Leaf analysis is appropriate for assessing whether crops have been able to take up adequate amounts of Si.

TABLE 2.23 - SILICON GUIDELINES FOR PLANT CANE

	Si (BSES/Sulfuric acid)		Si ($CaCl_2$)	SUGGESTED APPLICATION RATE
Si (mg/kg)	< 70	and	< 10	Calcium silicate @ 4 t/ha or Cement @ 3t/ha or Mill mud/ash @ 150 wet t/ha

3. DESCRIPTION OF ROCKY POINT SOILS AND GUIDELINES FOR THEIR MANAGEMENT

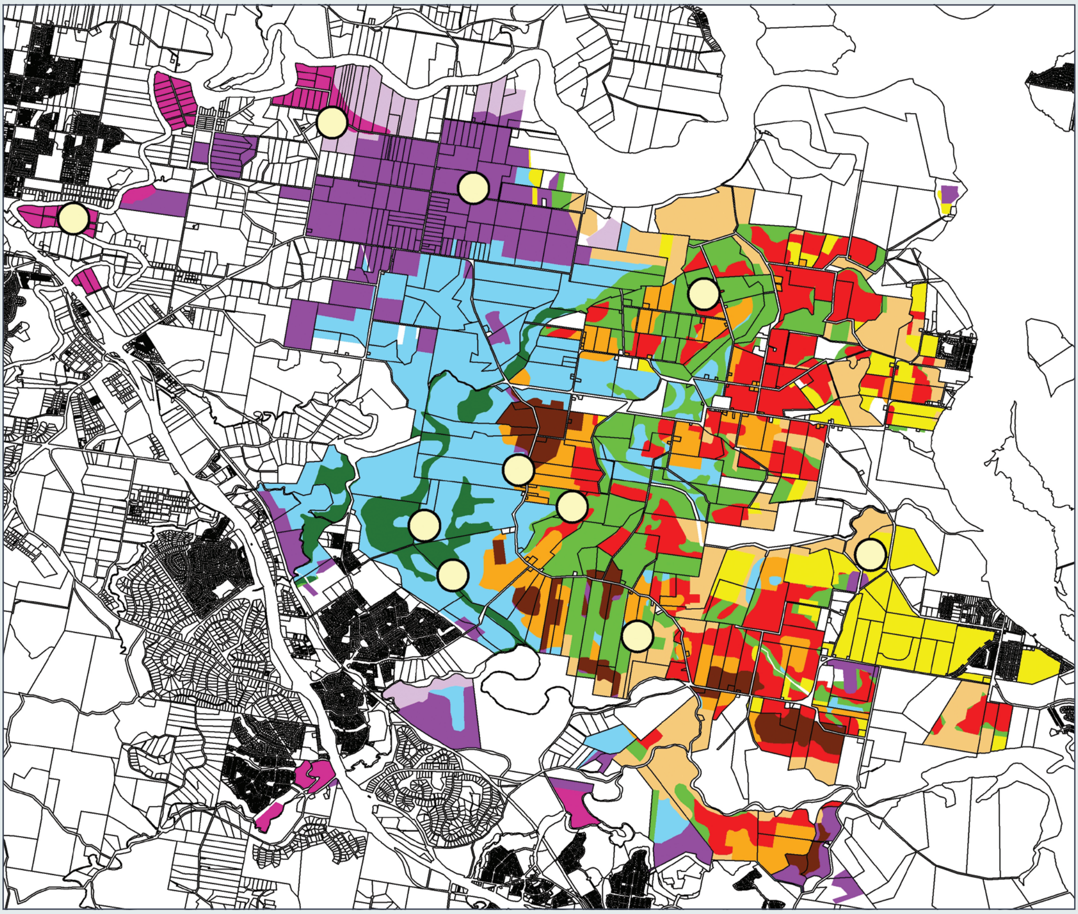
This chapter presents information on the location, appearance, properties and management requirements of the major sugarcane producing soils for the Rocky Point district. A summary of the soil types and their brief descriptions are shown in Table 3.1.

TABLE 3.1 - ROCKY POINT SUGARCANE PRODUCING SOILS.

ZONE	LOCAL NAME	GROUP	BRIEF DESCRIPTION	PAGE
Rocky Point	Beach Sand	Sand	A sandy topsoil overlying a grey sandy subsoil	36
	Black Sand	Sand	Black to dark brown sandy topsoil over a mottled grey sandy loam	38
	Sandy Loam	Sand	A grey sandy loam topsoil over a mottled clay loam subsoil	40
	Peaty Clay	Peat	Grey to dark grey brown, strongly acidic clay soils with shallow topsoils	42
	Sandy Peat	Peat	Brown clay loam over a light grey sandy loam subsoil with yellow mottles	44
	Marine Mud	Clay	A dark brown clay over a sticky light grey clay	46
	Heavy Black Clay	Clay	Heavy black clay topsoil, over a mottled clay loam subsoil	48
Alberton	Young Alluvial	Loam	Dark grey/brown clay topsoil overlying a grey clay subsoil with orange/yellow mottles	50
	Old Alluvial	Clay	Grey clay topsoil grading into a uniformly brown subsoil	52
	Clay	Clay	Shallow brown topsoil overlying a yellow/grey subsoil that transitions into a mottled light grey heavy clay	54

F.3.1

SOIL CLASSES FOR THE ROCKY POINT DISTRICT



LEGEND

Soil pit

Rocky Point soils

- Beach Sand
- Black Sand
- Sandy Loam
- Peaty Clay
- Sandy Peat
- Marine Mud
- Heavy Black Clay
- Young Alluvial
- Old Alluvial
- Clay
- Salty

Author: Livia Faria Defeo
Date: 27.08.2020

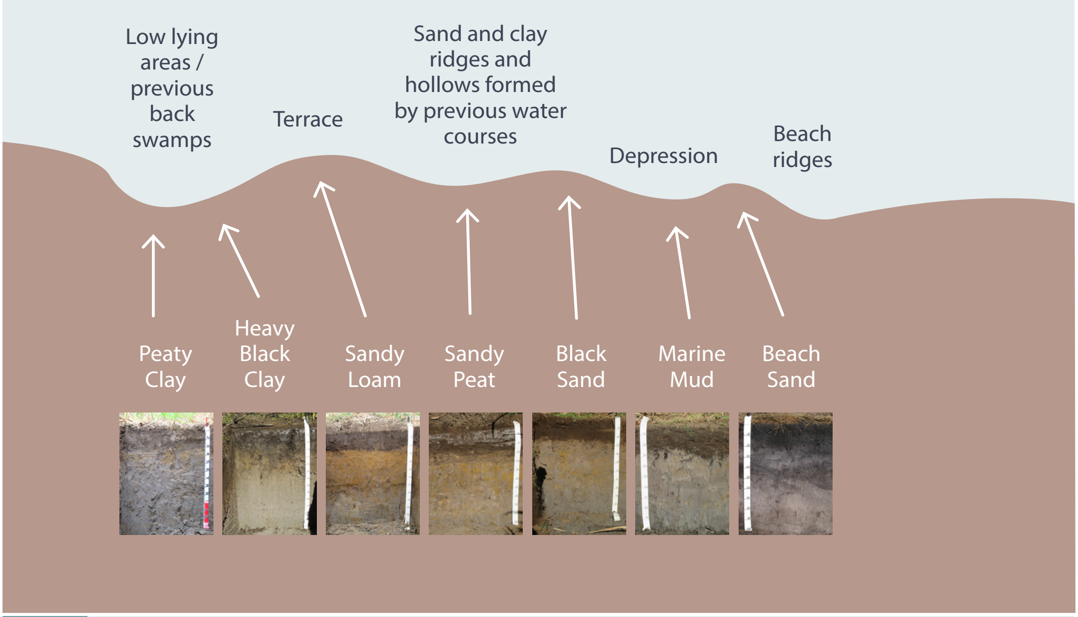
0 0.5 1 2 3 4 Kilometers

N

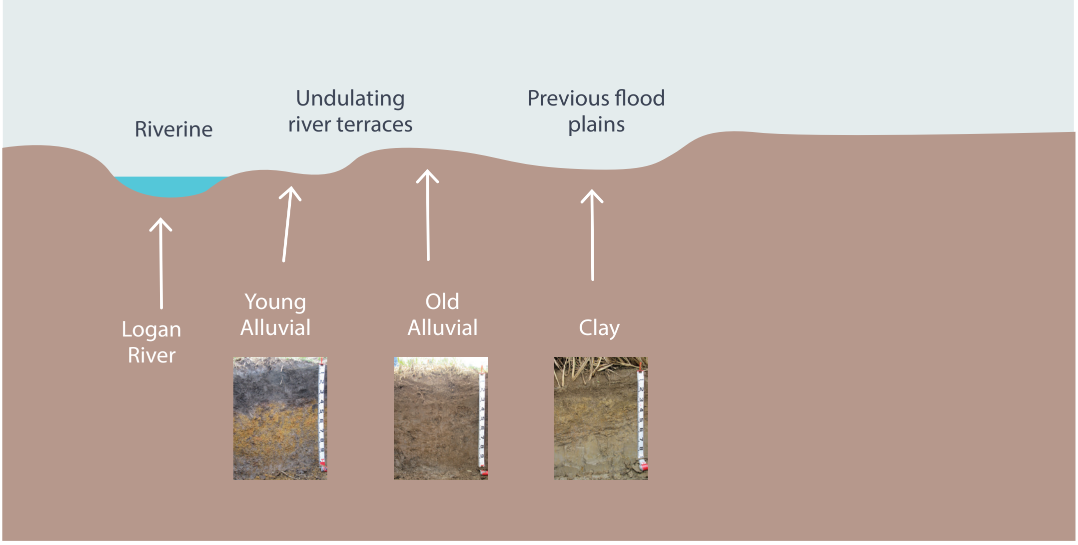
Location of soils

Each soil is found in a particular part of the landscape. Two landscape sections covering different parts of the Rocky Point district are shown in Figures 3.2 and 3.3. They illustrate where each soil type occurs and its relationship to the river systems, other soils and different topographic features.

F.3.2 TYPICAL LANDSCAPE IN THE ROCKY POINT ZONE



F.3.3 TYPICAL ALBERTON LANDSCAPE



Soil reference sites

Ten soil reference sites representative of the major soil groups were established and are listed in Table 3.1. Two geographic zones were identified, Rocky Point and Alberton, where soil pits were excavated for describing field appearance of each soil type. Representative topsoil (0 – 20 cm) and subsoil (40 – 60 cm) samples were collected from the surrounding cane area. These samples were analysed in laboratories for a range of chemical and physical properties.

In the rest of this chapter, information on the occurrence, formation, field appearance and chemical and physical properties of these 10 soils is provided in a two-page format. Bar graphs are used to represent the soil analytical data on a scale from very low to very high for each reference site and for the median values for all reference site soils. Guidelines are given for the management of nutrient applications, tillage, water and environmental risks. Nutrient management guidelines are provided for different crop classes, such as fallow plant and ratoons. However specific nutrient guidelines following the use of legume crops and mill by-products are not included and readers need to refer to the information in Chapter 2. The nutrient management guidelines are for the reference sites. They are only intended to be used as a guide for nutrient inputs when recent soil and/or leaf tests are not available for specific blocks.

BEACH SAND

ZONE: Rocky Point
GROUP: Sand
BRIEF DESCRIPTION: Sandy topsoil overlying a grey sandy subsoil

Occurrence:

These sandy soils are former beach lines in the lowest part of the Rocky Point landscape.

Formation:

These soils are remnants of previous beaches or sandy estuarine banks.

Field appearance:

Relatively deep dark topsoils overlying remnants of bleached A2 horizons. Subsoils are deep grey to light grey with some yellow mottles at depth.

Physical properties:

Beach Sands are extremely permeable within the usual rooting zone to about one meter. Water holding capacity is low, because of their sandy nature. However, there is some evidence of restricted drainage at depth.

Chemical properties:

These soils have relatively low pH values in both top and subsoils. Organic matter content is variable and largely dependent on the history of mill mud applications. Low Organic C values occur where mill mud has not been applied. The sandy subsoils have a poor nutrient status. The relatively low CEC also reflects the sandy nature of these soils. The cation exchange complex of the topsoil is dominated by calcium. Potassium reserves in these soils are low. Phosphorus and micronutrient concentrations are dependent on previous mill mud applications to these fields. The very low PBIs indicate a risk of phosphorus losses to ground water.

Tillage and water management:

Sandy soils have few limitations for cultivation as they are easily tilled and produce good seed beds. These soils have low water holding capacity and are usually most productive in wetter years. Green cane trash blanketing is recommended for these soils to conserve moisture and retain organic matter.

Environmental risk management:

These soils are prone to leaching and subsoils can become waterlogged in wet years. To reduce loss of nitrogen and potassium, split applications can be considered. There is a risk of phosphorus losses due to low PBI values. Offsite movement of suspended sediments may occur in the absence of grassed headlands.

(Below left) Beach Sand profile.
(Below right) Beach Sand in the Rocky Point district.

F.3.4

REFERENCE SITE AND MEDIAN ANALYSIS DATA

TABLE 3.1 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	2.0	125	130	0	100	25	0	0
RATOON	0	0	150	0	120	25	0	0

BLACK SAND

ZONE: Rocky Point
GROUP: Sand
BRIEF DESCRIPTION: Black to dark brown sandy topsoil over a mottled grey sandy loam

Occurrence:

Black sands occur in low lying areas with restricted drainage.

Formation:

Black sands are developed from alluvial deposits and accumulation of organic matter in localised depressions.

Field appearance:

Topsoils are black to dark brown sands to sandy loams. Subsoils are grey with yellow mottles that become less apparent at depth.

Physical properties:

Drainage of these soils is restricted due to the low position in the landscape. Plant-available water capacity is low due to the sandy nature of the topsoil and the waterlogged nature of the subsoil.

Chemical properties:

These soils are moderately fertile and this is reflected in the CEC and organic matter content. They have acidic topsoils with increasing pH to depth. Lime application is required to adjust pH and to address Ca deficiency. The organic carbon, N mineralisation index and sulfur values of the topsoil are high. Potassium reserves and exchangeable potassium values are moderate. Topsoils have high P-sorbing capacities. BSES P varies according to past fertiliser history, however at the reference site these values were quite low.

Tillage and water management:

Drainage is advisable where possible to reduce the effects of waterlogging. Green cane trash blanketing and the application of organic amendments can improve soil structure, tilth, soil porosity and plant-available water capacity. Plant-available water capacity is low. Laser grading of these soils is recommended to minimise water ponding.

Environmental risk management:

Loss of nitrogen by denitrification can occur during periods of excessive rainfall or waterlogging. To reduce this risk, mound planting should be considered and fertiliser applications should be split.

(Below left)Black Sand profile.
(Below right) Black Sand in the Rocky Point district.

F.3.5 REFERENCE SITE AND MEDIAN ANALYSIS DATA

TABLE 3.2 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	2.5	0	90	40	0	0	0	0
RATOON	0	0	100	30	80	0	0	0

SANDY LOAM

ZONE: Rocky Point
GROUP: Sand
BRIEF DESCRIPTION: Grey sandy loam topsoil over a mottled clay loam subsoil

Occurrence:

Sandy Loams occur mid landscape on gentle slopes.

Formation:

Sandy loams have developed on relatively fine-grained alluvial material deposited from ancient water courses.

Field appearance:

Soil profiles show three distinct layers, with topsoils being grey to dark brown and subsoils ranging from predominately yellow to light grey at depth. The occurrence of mottles decreases with depth indicating wet conditions in this zone.

Physical properties:

These soils are imperfectly drained at depth. These relatively deep loamy topsoils can be quite productive, as indicated by productivity reports.

Chemical properties:

These soils have a moderate to high fertility status and have high nutrient retention due to moderate CEC and organic matter content. They are slightly acid to neutral at depth. Although potassium reserves are relatively high, exchangeable potassium values can be low. Topsoils have low P-sorbing capacities, with BSES P varying according to past fertiliser history. Sulfur values are usually low.

Tillage and water management:

Green cane trash blanketing and the application of organic amendments can improve soil structure, tilth, soil porosity and plant-available water capacity. Plant-available water capacity is low. Laser grading may be necessary in situations where ponding occurs.

Environmental risk management:

Although environmental risks are not likely, normal BMP practices are still recommended.

(Below left) Sandy Loam profile.
(Below right) Sandy Loam in the Rocky Point district.

F.3.6 REFERENCE SITE AND MEDIAN ANALYSIS DATA

TABLE 3.3 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	0	0	120	0	100	15	0	0
RATOON	0	0	140	0	100	15	0	0

PEATY CLAY

ZONE: Rocky Point
GROUP: Peat
BRIEF DESCRIPTION: Grey to dark grey brown, strongly acidic clay soils with shallow topsoils - these are acid sulfate or potentially acid sulfate soils

Occurrence:

Peaty Clay soils occur in drainage depressions and the lowest sections of the landscape.

Formation:

These soils are formed from alluvial deposits comprised of clay and silt deposits. The dark organic topsoil reflects the accumulation of organic matter in swampy areas.

Field appearance:

Topsoils are moderate to strongly structured dark grey brown clays with limited depth. Subsoils are heavy clays with yellow mottles nearer the surface, but are predominately grey to blue-grey at depth.

Physical properties:

These soils are poorly drained, because of their position in the landscape. Rooting depths are shallow and the water table is generally close to the surface. Water logging and/or flooding often limits productivity in wet years.

Chemical properties:

Soil pH values are low. Lime is required to raise the pH to above 5. The cation exchange capacity and organic matter levels are high. The phosphorus status of these soils can vary depending on previous nutrient management strategies. The PBI values indicate moderate to high P-sorbing capacity. Potassium reserves are high and immediately available potassium is usually adequate.

Exchangeable calcium and magnesium are also generally high. Sulfur levels are very high in these soils. Silicon levels are high. Some micronutrients such as zinc and copper can be close to critical values, but no widescale deficiencies are reported. Elevated soil sodicity may occur due to position in the landscape. The acidic and sodic properties necessitate the application of both lime and gypsum to ameliorate the soil.

Tillage and water management:

Flood hazard, poor drainage and high water tables/ shallow rooting depth are the main limitations to cropping on these peaty clays. They have a moderate to good water-holding capacity. Laser grading in conjunction with drainage is recommended where possible. Establishing mole drains is an option to improve subsoil drainage. However care must be taken to not disturb acid sulfate soils.

Environmental risk management:

The surface of peat soils is close to the potential acid sulfate layer so deep soil disturbance should be minimised. Construction and maintenance of drains will generally require liming. These soils are prone to flooding. Growers can reduce denitrification risk by planting and fertilising into mounds.

In the interspace, most water movement occurs as surface drainage. There is a slight potential for off-site movement of suspended sediment down compacted traffic lanes following high intensity rainfall events. Grassed headlands will help keep sediment out of drainage lines.

(Below left) Peaty Clay profile.
(Below right) Peaty Clay in the Rocky Point district.

F.3.7 REFERENCE SITE AND MEDIAN ANALYSIS DATA

TABLE 3.4 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	5	2	140	30	0	0	0	0
RATOON	0	0	160	20	0	0	0	0

* As there is a requirement for both lime and gypsum, these need to be rationalised. Gypsum is not required if lime is used. Consult your advisor.

SANDY PEAT

ZONE: Rocky Point
GROUP: Peat
BRIEF DESCRIPTION: Brown clay loam over a light grey sandy loam subsoil with yellow mottles

Occurrence:

Sandy Peat soils occur on gently sloping plains, drainage depressions and lower slopes of rises.

Formation:

These soils are developed on deep alluvial material.

Field appearance:

Topsoils are shallow brown clay loams. Subsoils are light grey sandy loams, with a predominance of yellow mottles decreasing with depth as the clay content increases.

Physical properties:

These soils are imperfectly drained, but topsoils can become hard when dry.

Chemical properties:

These soils have a moderate to high fertility status. Soil organic carbon and N mineralisation potential are moderate. They have slightly acidic topsoils becoming more acidic at depth. Topsoil CEC values are moderate to high as are potassium reserves. Exchangeable K values are moderate, as are P-sorbing capacities. BSES P varies according to past fertiliser history. Sulfur values and micronutrients are usually high.

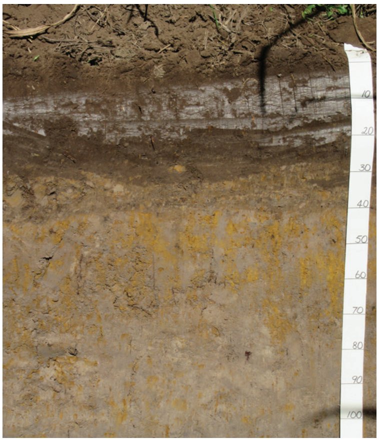
Tillage and water management:

Green cane trash blanketing and the application of organic amendments can improve soil structure, tilth, soil porosity and plant-available water capacity. Plant-available water capacity is moderate. Laser grading of these soils is recommended to minimise water ponding.

Environmental risk management:

Apart from extreme wet weather events, the risk of loss of nitrogen by denitrification is low. In line with BMPs, mound planting should be considered. Due to the moderate P sorbing capacity, relatively low P concentration and position in the landscape there is little risk of off-site movement of sediment and phosphate.

(Below left) Sandy Peat profile.
(Below right) Sandy Peat in the Rocky Point district.



F.3.8 REFERENCE SITE AND MEDIAN ANALYSIS DATA

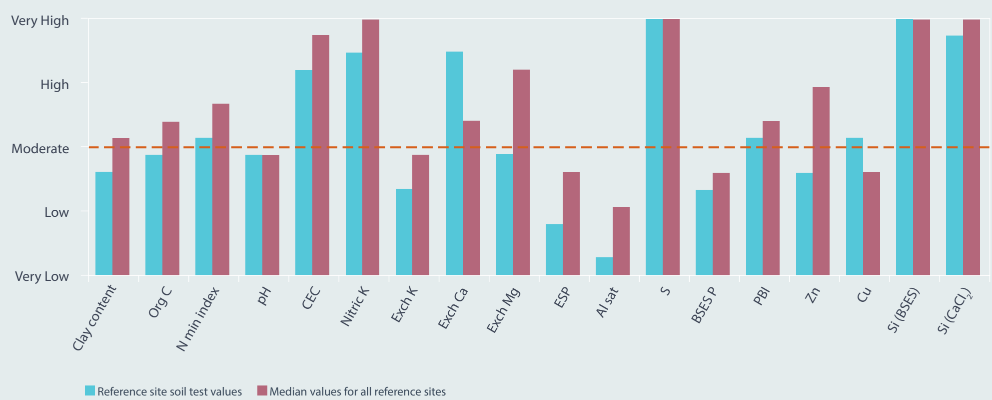


TABLE 3.5 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	0	0	100	20	80	0	0	0
RATOON	0	0	120	20	100	0	0	0

MARINE MUD

ZONE: Rocky Point
GROUP: Clay
BRIEF DESCRIPTION: Dark brown clay over a sticky light grey clay - these are acid sulfate or potentially acid sulfate soils

Occurrence:

Marine Muds occur low in the landscape in hollows and depressions.

Formation:

These soils are developed on deep fine-grained alluvial material that has been subject to ancient marine and riverine influences.

Field appearance:

Topsoils are dark brown clays abruptly overlying heavy, sticky grey clays. Occurrence of some localised orange to yellow mottles to depth.

Physical properties:

Due to their position at the bottom of the landscape, these subsoils are wet for most of the year. The sodic nature of the clay in the subsoil prevents structural development and root growth.

Chemical properties:

Although the topsoils are relatively fertile, the potential acid sulfate and sodic nature of the subsoil and the position in the landscape affects the overall productivity. The mineralisation of the high organic carbon is hampered by low pH and hence N availability is reduced. The CEC values, sulfur, potassium reserves and exchangeable postassium are all high to very high. The acidic and sodic properties necessitate the application of both lime and gypsum to ameliorate the soil. Topsoils have very high P-sorbing capacities and BSES P varies according to past fertiliser history. Monitoring of micronutrients is needed because they can be low.

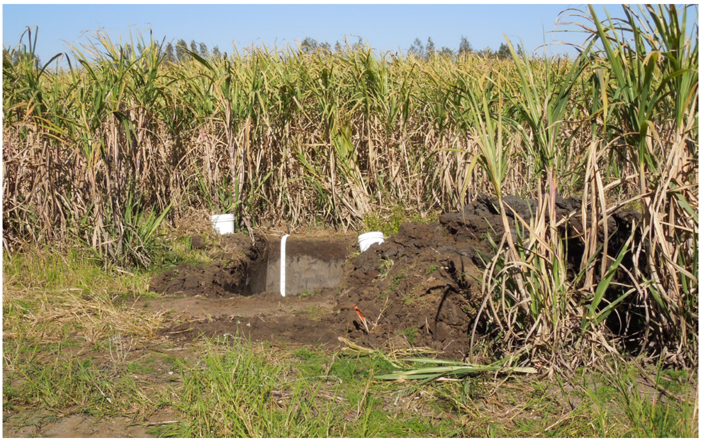
Tillage and water management:

Drainage of these soils is difficult because of their position in the landscape. However, mole drains could be useful in some circumstances. As these are acid sulfate soils or potential acid sulfate soils caution is required with any earthworks that expose the subsoils. Green cane trash blanketing in combination with lime and/or gypsum may improve soil structure, tilth and soil porosity. Laser grading of these soils is recommended in combination with raised beds to reduce waterlogging. If possible, headlands on the bottom end of cane blocks should be lower than the rest of the paddock.

Environmental risk management:

Denitrification is the most likely N loss pathway in these soils due to frequent periods of waterlogging. To reduce this risk, planting into raised beds should be considered. Due to the low P sorbing capacity of the topsoil and proximity to watercourses, there is a risk of off-site movement of sediment and phosphate. Plan fertiliser application for when dry conditions are forecast.

(Below left) Marine Mud profile.
(Below right) Marine Mud in the Rocky Point district.



F.3.9

REFERENCE SITE AND MEDIAN ANALYSIS DATA

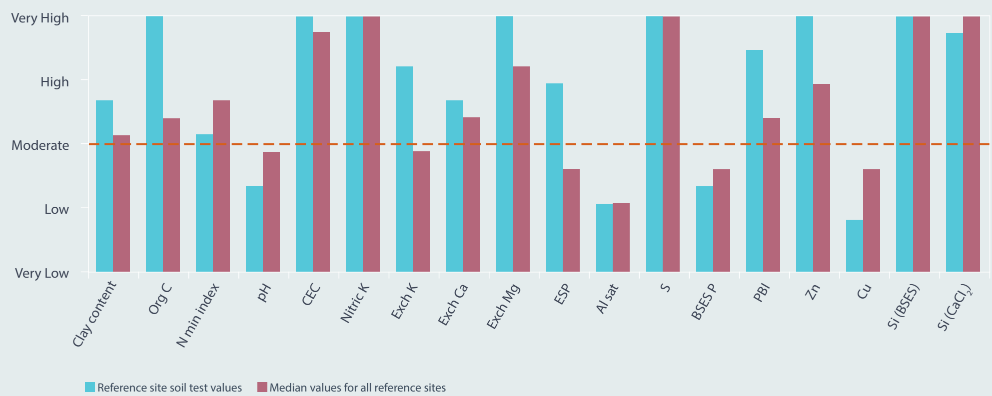


TABLE 3.6 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	5	4	130	30	0	0	10	0
RATOON	0	0	150	25	0	0	0	0

* As there is a requirement for both lime and gypsum, these need to be rationalised. Gypsum is not required if lime is used. Consult your advisor.

HEAVY BLACK CLAY

ZONE: Rocky Point
GROUP: Clay
BRIEF DESCRIPTION: Black heavy clay topsoil, over a mottled clay loam subsoil

Occurrence:

Heavy Black Clays occur away from the coast on previous flood plains.

Formation:

These soils developed on fine-grained sedimentary material on remnant flood plains.

Field appearance:

Topsoils are black/dark brown clays grading into yellow grey brown clay loam that overlay mottled grey clay subsoils.

Physical properties:

Heavy Black Clays are imperfectly drained. They become very hard when dry without the appearance of deep cracks.

Chemical properties:

These soils have a relatively high fertility, with very high CEC values that reflect the clay and organic matter contents. They are slightly acid and do not require lime or dolomite due to high calcium and magnesium values. As the potassium reserves and exchangeable potassium values are high, potassium applications will probably not be needed in the medium term. Due to elevated sodium values, sodic conditions may occur, necessitating the use of gypsum. This amelioration will also contribute to improved soil structure. Topsoils have moderate P-sorbing capacities and BSES P could vary according to past fertiliser history. Sulfur and silicon values are high.

Tillage and water management:

The moisture held within these soils reflects weather conditions. Following rainfall, they become quite wet and dry relatively quickly and set hard. Green cane trash blanketing and the application of organic amendments can improve soil structure, tilth, soil porosity and plant-available water capacity. Laser grading is recommended to reduce water ponding in hollows.

Environmental risk management:

Loss of nitrogen by denitrification can occur during periods of excessive rainfall. Planting into preformed beds should be considered to optimise growing conditions and reduce risk of denitrification.

(Below left) Heavy Black Clay profile.
(Below right) Heavy Black Clay in the Rocky Point district.

F.3.10 REFERENCE SITE AND MEDIAN ANALYSIS DATA

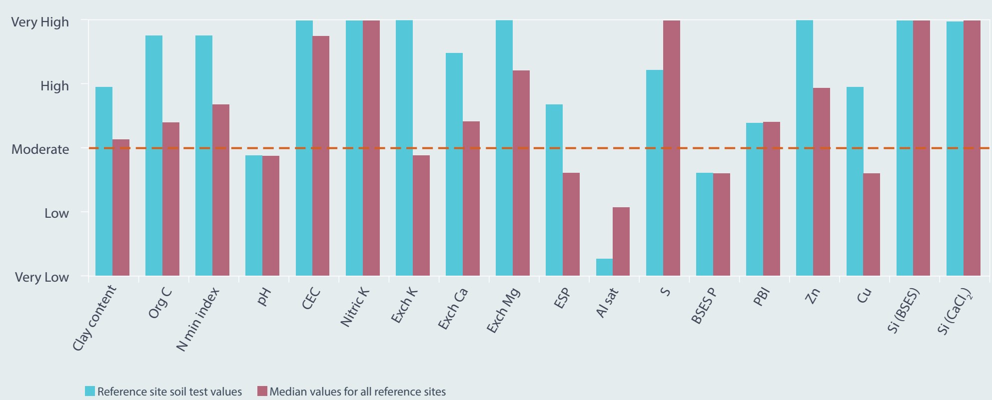


TABLE 3.7 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	2	0	80	20	0	0	0	0
RATOON	0	0	100	15	0	0	0	0

YOUNG ALLUVIAL

ZONE: Alberton
GROUP: Loam
BRIEF DESCRIPTION: Dark grey/brown clay topsoil overlying a grey clay subsoil with orange/yellow mottles

Occurrence:

Young Alluvial soils of the Alberton zone occur adjacent to the Albert River.

Formation:

Young Alluvial soils formed from recently deposited material.

Field appearance:

Topsoils are deep dark grey/brown clays. Deep subsoils are light grey with striking orange/yellow mottles.

Physical properties:

These soils are relatively well drained. Plant available water capacity is generally high.

Chemical properties:

These soils have a high fertility status and CEC due to the high clay and organic matter content. They are acid and need relatively high amounts of lime to adjust pH. The potassium reserves and exchangeable potassium values are high. Although BSES P values in the topsoils are high, phosphorus is still required due to the very high P-sorbing capacity of these soils. Sulfur values are high. Monitoring of micronutrients is needed.

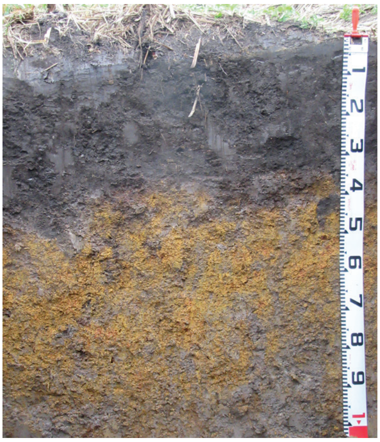
Tillage and water management:

Green cane trash blanketing and the application of organic amendments can improve soil structure, tilth, soil porosity and plant-available water capacity. Plant-available water capacity is moderate. Laser grading is recommended to reduce water ponding in hollows.

Environmental risk management:

Loss of nitrogen by leaching can occur during periods of excessive rainfall.

(Top left) Young Alluvial profile
(Bottom left) Young Alluvial in the Alberton area



F.3.11 REFERENCE SITE AND MEDIAN ANALYSIS DATA

TABLE 3.8 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	5	0	80	30	0	0	10	0
RATOON	0	0	100	20	0	0	0	0

OLD ALLUVIAL

ZONE: Alberton
GROUP: Clay
BRIEF DESCRIPTION: Grey clay topsoil grading into a uniformly brown subsoil

Occurrence:

Old Alluvials occur on undulating river terraces.

Formation:

Old Alluvials have formed with time from material deposited during flood events.

Field appearance:

Topsoils are grey/brown clay loams. Subsoils are uniformly dark brown silty clays, that can be quite deep.

Physical properties:

These soils are relatively well drained. Plant available water is quite high.

Chemical properties:

These soils have high fertility status and have high nutrient retention due to high CEC values and moderately high organic matter contents. They are slightly acid and non-sodic. The potassium reserves and exchangeable potassium values tend to be high. Topsoils have moderate to low P-sorbing capacities. The high BSES P values reflect deposition of up-stream material. Sulfur values are usually high. Micronutrients and silicon are generally well supplied.

Tillage and water management:

Green cane trash blanketing and the application of organic amendments can improve soil structure, tilth, soil porosity and plant-available water capacity. Laser grading of these soils is recommended to minimise water ponding.

Environmental risk management:

Nitrogen losses may occur during flood events, particularly if these occur soon after N application. Monitoring of forecast weather for planned fertiliser application is recommended. As these soils are found adjacent to water courses, there is a risk of phosphorus losses due to the relatively low P-sorbing capacities and high BSES P values.

(Below left) Old Alluvial profile
(Below left) Old Alluvial in the Alberton area

F.3.12

REFERENCE SITE AND MEDIAN ANALYSIS DATA

TABLE 3.9 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	0	0	100	0	0	0	0	0
RATOON	0	0	120	0	50	0	0	0

CLAY

ZONE: Alberton
GROUP: Clay
BRIEF DESCRIPTION: Shallow brown topsoil overlying a yellow/grey subsoil that transitions into a mottled light grey heavy clay

Occurrence:

Clay soils occur away from the coast on previous river flood plains.

Formation:

These soils developed on fine-grained sedimentary material on remnant flood plains.

Field appearance:

Topsoils are shallow brown clays overlying yellow/grey subsoils that transitions into mottled light grey heavy clays. Although the soils are quite deep, root penetration into the subsoil is restricted.

Physical properties:

Clays have shallow top soils. They are imperfectly drained, leading to relatively low plant available water capacity.

Chemical properties:

These soils have a relatively low fertility status, with moderate CEC values and organic matter contents. They are moderately acid and likely to be sodic, hence requiring lime and gypsum for amelioration. Potassium reserves and exchangeable Potassium values are low. Topsoils have moderate P-sorbing capacities and BSES P may vary according to past fertiliser history. Sulfur values are moderate. Monitoring of micronutrients is recommended. Silicon values are satisfactory.

Tillage and water management:

Drainage is advisable to reduce the effects of waterlogging in the shallow topsoil. Planting into raised beds is therefore recommended. Green cane trash blanketing and the application of organic amendments can improve soil structure, tilth, soil porosity and plant-available water capacity. Plant-available water capacity can be limited by the shallow topsoil. Laser grading of these soils is recommended to minimise water ponding.

Environmental risk management:

Loss of nitrogen by denitrification can occur during periods of excessive rainfall or waterlogging. Planting into raised beds will reduce this risk.

(Below left) Clay profile
(Below left) Clay in the Alberton area

F.3.13 REFERENCE SITE AND MEDIAN ANALYSIS DATA

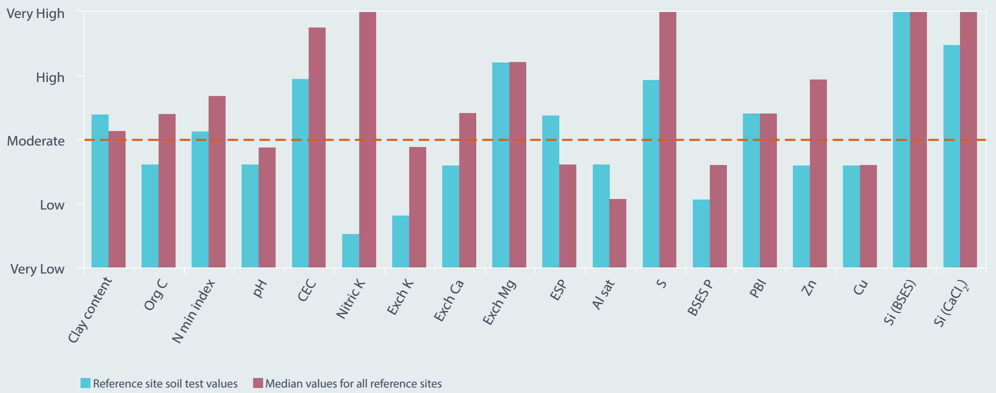


TABLE 3.10 – NUTRIENT MANAGEMENT GUIDELINES BASED ON THE REFERENCE SITE DATA:

CROP SITUATION	Lime (t/ha)	Mg (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S kg/ha)	Cu (kg/ha)	Zn (kg/ha)
FALLOW PLANT	1.5	2	110	20	120	0	0	0
RATOON	0	0	130	20	120	0	0	0

* As there is a requirement for both lime and gypsum, these need to be rationalised. Gypsum is not required if lime is used. Consult your advisor.

4. NUTRIENT REQUIREMENTS FOR SPECIFIC BLOCKS OF SUGARCANE

The guidelines for managing nutrient inputs according to soil type (Chapter 3) should be refined for specific blocks of cane by making use of some important tools such as soil testing, leaf analysis, and the SIX EASY STEPS nutrient management tools.

Soil testing

Soil testing provides useful information about the chemical (and some physical) properties of a soil and serves as a basis for determining specific nutrient inputs for a particular block of sugarcane. There are four important steps involved in this process. Each of these needs to be carried out with care to ensure meaningful results.

1. Sample collection

Collect soil samples according to the guidelines provided in Appendix 3.

2. Sample analysis

Submit samples to a reputable laboratory for analysis.

3. Interpretation of results and calculating nutrient inputs

Ensure sound interpretation of the results and appropriate fertiliser recommendations by having an understanding of the basic process and getting advice from accredited advisor/s.

4. Fertiliser applications

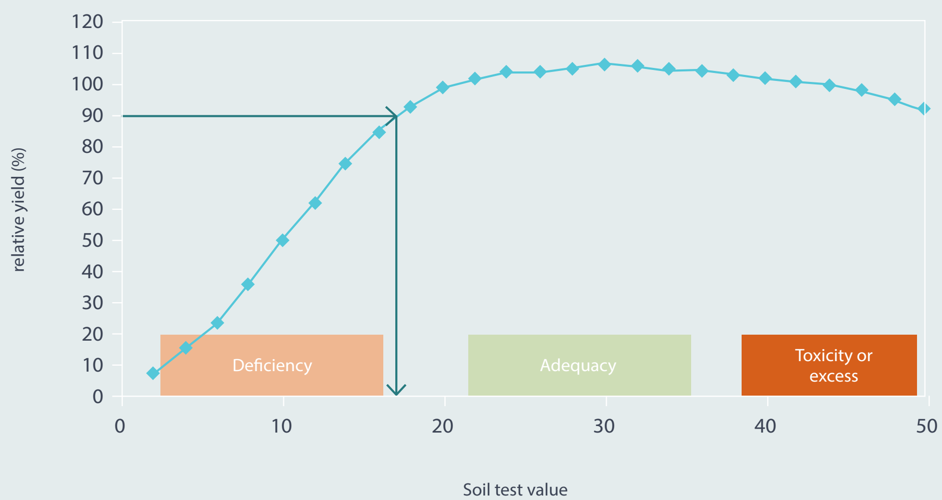
Apply fertilisers at the appropriate rates and keep records of nutrient inputs.

Interpretation of soil test values

With the exception of N, soil tests are interpreted by comparing the actual soil analysis data with established critical values. As shown in Figure 4.1, a critical value for a particular nutrient is that soil test value above which any further yield response to the applied nutrient is unlikely.

Soil test results therefore indicate those nutrients which are present in adequate quantities (and are readily available to the crop),

F.4.1 AN EXAMPLE OF A NUTRIENT RESPONSE CURVE FOR SUGARCANE



F.4.2 EXAMPLE OF A SOIL TEST REPORT FROM A COMMERCIAL LABORATORY.

SOIL TEST REPORT		
TRADING NAME: SMITH & JONES	FARM NO. 1234	BLOCK NO.12A
LOCATION: ROCKY POINT	GPS LATITUDE:	GPS LONGITUDE:
CONTACT NAME: JOE SMITH	PHONE:	ADVISER:
SAMPLE NUMBER: 021216799	SAMPLE TYPE: SOIL	DEPTH: 0-20 cm
SAMPLING DATE: 12 DECEMBER	CROP: SUGARCANE	STAGE: FALLOW

ANALYTE / ASSAY	VALUE	LOW	< OPTIMUM	SATISFACTORY	> OPTIMUM
pH (1:5 water)	5.5			■	
Electr. Conduct dS/m	0.07	■			
Organic Carbon (%)	1.3			■	
Sulfur (MCP) mg/kg	27			■	
Phosphorus (BSES) mg/kg	22		■		
Potassium (Nitric K) me%	0.20	■			
Potassium (Amm-acet.) me%	0.15	■			
Calcium (Amm-acet) me%	1.6		■		
Magnesium (Amm-acet) me%	3.2			■	
Aluminium (KCl) me%	3.1			■	
Sodium (Amm-acet) me%	0.74			■	
Copper (DTPA) mg/kg	0.37			■	
Zinc (DTPA) mg/kg	0.61			■	
Zinc (HCl) mg/kg	0.7			■	
Manganese (DTPA) mg/kg	77.0			■	
Silicon (CaCl2) mg/kg	33			■	
Silicon (BSES) mg/kg	230			■	
Cation Exch. Cap. (CEC) me%	8.76			■	
Aluminium saturation %	35.0				■
Sodium % of cations (ESP)	8.5				■
Phosphorus Buffer Index (PBI)	260			■	
Colour (Munsell)	Brown				
Texture	Clay				

and those nutrients which are lacking (and need to be applied). As indicated in Chapter 2, nitrogen requirement is based on the yield potential for the district and the N mineralisation index, which depends on the organic carbon content (%) of the soil. Actual soil test values are interpreted by using the information provided in Chapter 2.

An example of a soil test report (Figure 4.2) shows the numerical soil test values from a commercial laboratory (column 2) and a representation of these values within the range from low (deficient) to optimum. These values are used to assess the amount of each nutrient required by the crop for optimum production.

Appropriate nutrient inputs for this soil test report are calculated as follows (using the guidelines in Chapter 2 or the summarised SIX EASY STEPS nutrient management guidelines that are available from the SRA website.

sugarresearch.com.au/growers-and-millers/nutrient-management/

Lime requirement of 1.5 t/ha is based on the exchangeable calcium (Ca) value of 1.6 meg/100g and the lime requirement determined from Table 2.17.

Gypsum requirement is determined using Table 2.21. The ESP% from the soil test report is 8.5, which indicates moderate sodicity. To ameliorate the soil, an application of gypsum at 2 t/ha is required.

The application of ameliorants in this case should be rationalised to a single application of gypsum at 2 t/ha, as this will address soil sodicity and Ca deficiency.

Applications of magnesium and/or a silica product are not required in this example, as soil test values for magnesium, silicon (BSES) and silicon ($CaCl_2$) are all above respective critical values, as shown in Tables 2.19 and 2.23 respectively.

Nitrogen (N) requirement for a plant crop following a bare or grass fallow is 110 kg N/ha, because Organic Carbon% is 1.3 and the N mineralisation index is Moderate. Refer to Table 2.1. For subsequent ratoon crops, the N application rate is 130 kg N/ha. This application rate is also appropriate for replant cane and ratoon cane after replant. When a legume crop has been grown during fallow and/or mill by-products have been applied N application rates should be discounted to take into account N contributions from these sources. Refer to Tables 2.3 and 2.6.

Phosphorus (P) requirement for plant cane is 20 kg P/ha because the BSES P value is 22 mg/kg and the P sorption class is Moderate as indicated by a PBI of 260 (Tables 2.7 and 2.10). Maintenance dressings of P at a rate of 20 kg P/ha are also required in subsequent ratoon crops in this example.

Potassium (K) requirement is 120 kg K/ha for plant cane, because the Nitric K value of 0.2 is less than 0.7 meq/100g, the texture is described as a clay and an exchangeable K value of 0.15 meq/100mg. For each ratoon crop, 120 kg K/ha is the required application rate.

Soil test values for sulfur, copper and zinc are all below their respective critical values, so there is no requirement for these nutrients (Tables 2.14 and 2.22).

A summary of the nutrient requirement for the entire crop cycle in this example (Plant crop following a bare fallow and three successive ratoons) is as follows:

Crop	Lime (t/ha)	Gypsum (t/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Plant cane	1.5	2	110	20	120	0	0	0
Ratoon crops	0	0	130	20	120	0	0	0

Leaf analysis

Leaf sampling offers an appropriate means of checking on the adequacy of fertiliser recommendations and nutrient inputs to a block of sugarcane. It allows adjustment of fertiliser rates in the subsequent crop (or in the current crop if the cane was young enough at the time of sampling). It also allows possible nutrient problems associated with 'poor cane' to be identified and is an important tool for monitoring nutrient trends at different scales (cane block, farm and region). Leaf sampling instructions are supplied in Appendix 4.

Leaf analysis results are interpreted according to the third leaf critical values shown in Table 4.1. It should be noted that third leaf N values decrease as the season progresses.

TABLE 4.1 - THIRD LEAF NUTRIENT CRITICAL VALUES FOR SUGARCANE

NUTRIENT	MONTH OF SAMPLING	THIRD LEAF CRITICAL NUTRIENT VALUE
N	November to mid-January	1.9 %
	Mid-January to February	1.8 %
	March to May	1.7 %
P	November to May	0.19%
K		1.1 %
Ca		0.2 %
Mg		0.08 %
S		0.13 %
Cu		2 mg/kg
Zn		15 mg/kg
Mn		15 mg/kg
Si		0.55 %

F.4.3

THE SIX EASY STEPS FRAMEWORK SHOWING THE SIX STEPS AND THE UNDERLYING CYCLICAL LEARNING AND CONTINUOUS IMPROVEMENT STRATEGY.

Logical steps within the SIX EASY STEPS program	
STEP	Description
1	Knowing and understanding our soils
2	Understanding and managing nutrient processes and losses
3	Soil testing regularly
4	Adopting soil-specific nutrient management guidelines
5	Checking on the adequacy of nutrient inputs
6	Interpreting trends and modifying inputs

SIX EASY STEPS nutrient management package

SIX EASY STEPS is a comprehensive, integrated and science-based nutrient management program developed for and with the Australian sugar industry. It is recognised as the basis for nutrient best management practice (BMP) in sugarcane production in Queensland and New South Wales. It consists of six higher level and logical steps (Figure 4.3). These steps provide a structured framework and a basis for cyclical learning and continuous improvement in nutrient management. As the program aims at sustainability, it focuses on productivity, profitability and environmental aspects that cover on-farm soil fertility or off-farm effects. Importantly, it promotes and endorses balanced nutrition by recognising differences in soil type and properties, and considering all essential nutrients for sugarcane production.

The SIX EASY STEPS program may be used by growers and/or their advisors for determining nutrient inputs on-farm, and by researchers and extension specialists for RD&E and adoption purposes. STEPS 1 and 2 bring together knowledge of the farm/area, the occurrence of different soil types, positions in the landscape and opportunities/challenges for improving nutrient management. STEPS 3 and 4 are used for interpreting soil test results from accredited laboratories with sets of district-specific SIX EASY STEPS nutrient management guidelines. STEPS 5 and 6 enable expansion of the system to include a range of options for further fine-tuning of nutrient management options. These include refinements for specific circumstances, when new information becomes available and/or to meet an individual grower's needs and appetite for risk.

The SIX EASY STEPS program is supported by a range of publications such as this booklet, information sheets, sets of district-specific nutrient managements guidelines, an on-line nutrient management requirement calculator (SIX EASY STEPS NutriCalc™) and grower-orientated short-courses. Further information may be found on the SRA website.

sugarresearch.com.au/growers-and-millers/nutrient-management/

5. CONCLUDING REMARKS

Soils are complex physical, chemical and biological systems. They are arguably the most important natural resource on the farm, and store and release nutrients for crop growth. The amount and rate of release of nutrients from different soils and the reactions between soils and fertilisers need to be taken into account when developing and implementing nutrient guidelines. Farmers have an excellent understanding of the different soil types occurring on their farms. They appreciate and consider these processes and interactions on an ongoing basis. They also recognise that different management practices are appropriate for different soils and circumstances. The information presented in this booklet is intended to reinforce this local soil knowledge and provide an easily understood system for soil, crop and nutrient management.

Our philosophy focuses on the management of different soils to enhance their ability to store and supply a wide range of nutrients to the crop. It emphasises the importance of improving levels of soil organic matter and has the long term goal of improving soil fertility through the enhancement of natural soil processes and nutrient cycles. In particular, it recognises the following:

- Lime is recommended for the amelioration of soil acidity even though many soils are well supplied with calcium.
- Our nutrient management guidelines take into account the release of N, P and S in the soil through the mineralisation of soil organic matter.
- Although our N guidelines are lower than previous recommendations, they are aimed at ensuring sustainability – profitable sugarcane and sugar production in combination with environmental responsibility.
- We recognise that soils differ in their capacity to sorb added P fertiliser and render it less available to sugarcane crops. We therefore interpret the standard BSES P tests values in combination with PBI values.
- Our K guidelines take into account differences in soil texture. They also use so-called Nitric K soil test values to separate soils with higher and lower amounts of K reserves. The guidelines ensure that K applications do not contribute to excessive crop removal not over-exploitation of K reserves.
- Balanced nutrition ensures that nutrients are applied when needed and are neither over- nor under-applied. Our philosophy aims to prevent one, or a restricted number of nutrients, being applied at the expense of others.

We hope that this booklet will improve local awareness and understanding of different soils in the Rocky Point district, particularly in relation to managing for sustainable sugarcane production. While growers can use the guidelines directly for their different soils, the booklet also explains the ways in which the nutrient management guidelines have been derived so that growers can make informed judgements on how to manage their soils. It also provides guidelines for interpreting soil and leaf analyses. We hope this will encourage growers to make greater use of these important nutrient management tools.

APPENDIX 1.
GUIDELINES FOR THE BANDED APPLICATION OF MILL MUD

Information contained in this appendix is based on estimates only and therefore should only be used as guidelines. Further research is required to refine these recommendations.

Below: Typical nutrient content of mill mud and estimated available nutrients when applied at 50 t/ha as a band on the row.

MILL MUD	50 t/ha	ESTIMATED AVAILABLE NUTRIENTS (kg/ha)		
Nutrients	Typical nutrient content (kg/ha)	1st crop	2nd crop	3rd and 4th crop
Nitrogen	140	25	15	0
Phosphorus	140	Sufficient	Sufficient	Sufficient
Potassium	40	0	0	0
Sulfur	15	0	0	0
Calcium (0.7 t/ha lime)	240	Sufficient	Sufficient	Sufficient

APPENDIX 2.
HOW TO DETERMINE SOIL TEXTURE

The texture of a soil is defined as the relative proportions of sand, silt and clay particles in the soil. In the laboratory, the particle size distribution is determined by measuring the percentages of each of these particles in a particular soil. In the field, the field texture grade of a soil (sand, sandy loam, loam, clay loam, silty clay loam, clay, etc) can be estimated by observing the behaviour of a small handful of soil, moistened with enough water to ensure that a ball (bolus) can be formed with kneading and then pressed between thumb and forefinger to produce a ribbon. The texture is determined by noting certain characteristics of the moistened soil and comparing the length of this ribbon (mm) with the ranges indicated in the following table.

(Above left) Forming the ball (bolus) of soil. (Above right) Pressing the soil into a ribbon.

SIMPLIFIED GUIDE TO DETERMINING SOIL TEXTURE.

CHARACTERISTICS OF THE SOIL BOLUS AND RIBBON	LENGTH OF THE RIBBON (mm)	TEXTURAL GRADE	APPROXIMATE CLAY %
Sandy feel, no coherence with single grains sticking to fingers	Nil	Sand	0 - 10
Sandy feel, slight coherence, with discolouration of fingers	5-15	Loamy sand	5 - 15
Sandy feel, slight coherence	15-25	Sandy loam	10 - 20
Spongy, greasy feel, with coherence, but no obvious sandiness of silkiness.	25	Loam	10 - 24
Smooth, silky feel, with distinct coherence	25	Silt loam	10 – 24
Sandy feel but with distinct coherence	25-40	Sandy clay loam	20 – 30
Smooth feel with strong coherence and no obvious sand grains	40-50	Clay loam	25 – 40
Smooth, silky feel with distinct coherence	40-50	Silty clay loam	25 - 40
Easily moulded with sandy feel	50-75	Sandy clay	25 - 50
Easily moulded with smooth and silky feel	50-75	Light clay / silty clay	35 - 45
Easily moulded (like plasticine), smooth feel, but with resistance to shearing.	+75	Medium / heavy clay	> 45

APPENDIX 3.
HOW TO COLLECT A SOIL SAMPLE

Soil tests in the laboratory are carried out on a 10 g sample which is taken from about 500 g of soil submitted to the laboratory. Usually this 500 g sample is a sub-sample of about 10 kg of soil which ideally should be sampled from a block of cane (average 2 hectare area) which contains about 6 000 tonnes of soil in the plough layer.

The ten grams of soil analysed in the laboratory is a sub-sample of the soil sample collected in the field and represents around 1.6 parts per billion. In view of this it is extremely important that a soil sample is representative of the volume of soil from which it is collected. This is achieved by collecting adequate soil from the block being sampled using a standard procedure.

Soil sampling procedure

- Determine the area that is to be sampled. Ensure that the area (or block) being sampled does not exceed 2 or 3 hectares and that it is relatively uniform in soil type. In large blocks consider taking multiple samples and if a block consists of more than one distinct soil types sample each separately. Avoid sampling areas that differ in terms of crop growth or where large amounts of mill mud or other ameliorants have been dumped. Again, sample such areas separately if necessary.
- Sampling is traditionally undertaken using an auger (either a turning auger or a soil coring tube) to a depth of 20 cm.
- At least 10 or 12 'augerings' should be collected from the area, using a zig-zag or grid pattern. The basic principle is that more 'augerings' are better than less.

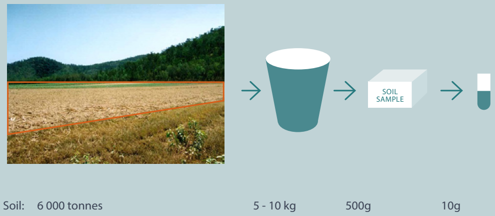
Alternative soil sampling use electrical conductivity (EC) generated maps to guide sample collection points. This enables in-field variability to be taken into account. It also enables in-field zones to be samples separately. This approach provides the basis for variable rate applications of ameliorants and, potentially, nutrients.

Geo-referencing soil samples will facilitate better monitoring of soil fertility over time. It will allow soil sampling at the same location each time and overcome problems that arise with changes to block numbers or block configuration.

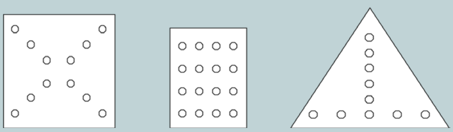
Consider the following when soil sampling:

- While there is some debate as to where soil samples should be taken in relation to the cane row or inter-row, we suggest that all samples be taken from the shoulder of the cane row, approximately mid-way between the centre of the cane row and the centre of the inter-row. By following this rule, you will avoid sampling the highly compacted centre of the inter-space where there are likely to be fewer roots. You will also avoid sampling the centre of the cane row where you are likely to encounter the cane stool and/or residual fertiliser.
- If possible, take soil samples in the last ratoon crop just after harvest. You should then have sufficient time to apply lime and/or soil ameliorants to the fallow, well before planting.
- All sub-samples should be collected in a good-quality plastic bag or a clean plastic bucket to form a single composite sample. After collection, the soil should be mixed thoroughly to ensure uniformity of the sample.

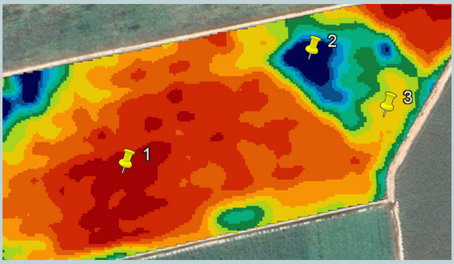
F.A3.1 HOW TO TAKE A SOIL SAMPLE



F.A3.2 SOME SUGGESTED SAMPLING PATTERNS WITHIN CANE BLOCKS OF DIFFERENT SHAPES.



F.A3.3 AN EC MAP WITH THREE SOIL SAMPLING SITES SELECTED AND INDICATED BY YELLOW PIN MARKERS.



- Preferably the complete sample should be dispatched to a reputable laboratory for analysis. If the sample is too cumbersome, however, a portion (500g- 1kg) should be sub-sampled for analysis. Ideally this should occur after air-drying and initial sieving. However, such facilities are not always available.
- Supply as many details as possible on a label and on the sample bag itself to ensure that the sample can be easily identified, and that meaningful interpretation of the results is possible.

Remember: Care should be taken to ensure that the sample is not contaminated. Cleanliness is most important. Always ensure that the auger is cleaned between sampling different blocks, that any buckets used are clean and that new plastic bags are used. Do not use a soil sampler or shovel made from galvanised iron or a bucket with a galvanised handle if the soil is to be hand-mixed, otherwise zinc contamination could occur.

APPENDIX 4.
HOW TO COLLECT A LEAF SAMPLE

To ensure meaningful interpretation of the analysis results, make sure that the following guidelines are adhered to:

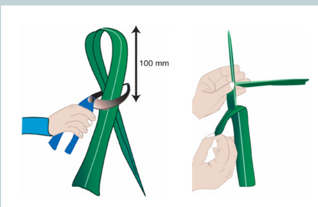
- Cane is sampled during the prescribed leaf-sampling season (December to April).
- Cane is the correct age (3 - 7 months) at the time of sampling.
- Cane has been growing vigorously during the month prior to sampling.
- Cane is not affected by moisture stress at the time of sampling.
- Cane is also unaffected by any other factors, such as disease, insect damage, etc.
- Six weeks has passed since fertiliser applications.

It is important that leaves are sampled correctly and that all the details requested by the testing laboratory are supplied as accurately as possible. This will enable meaningful interpretation of the analysis results.

F.A4.1 STEP 1

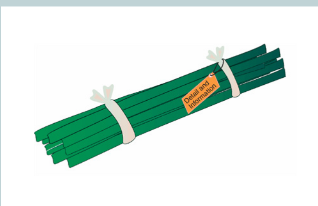
- Select leaves from stalks of average height.
- Sample the third leaf from the top of the stalk (as shown on the diagram). Counting from the top of the plant, the first leaf is the one that is more than half-unrolled. The third leaf usually corresponds to the top visible dewlap.
- Collect 30 - 40 leaves at random from across the entire block of sugarcane being sampled.

STEP 2



- Fold the leaves in half (top to base) and cut a 100 – 150 mm length from these folded leaves (giving a total 200-300 mm section of each leaf). Retain these middle 200 – 300 mm sections of the leaf blades and discard the remaining top and bottom sections.
- Strip out & discard the midrib from each 200 – 300 mm section.

STEP 3



- Bundle the leaf strips together and attach a label with sample details.
- Place the sample in a cool environment (polystyrene cooler) until it can be dried in an oven (at about 60°C) or in a dry well-ventilated area.
- Once the sample is dry, place it in a clean paper bag or envelope, and send it to a reputable laboratory for analysis.

FURTHER READING

The material covered in this booklet includes information drawn from various sources. This expertise and knowledge is gratefully acknowledged, particularly in relation to the following publications and/or reports. The list also provides details of some further reading options.

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GLOSSARY

ACID SATURATION
The proportion of the soil cation exchange capacity (CEC) occupied by the acidic cations aluminium and hydrogen. It appears on soil tests as aluminium saturation. Low acid saturation is desirable so that more of the CEC is available for storing nutrient cations.

ACID SULFATE SOILS (ASS) Soils and sediments that contain sulphides capable of oxidising and producing sulfuric acid. These soils become problematic when they are exposed to air by construction of drains or other earthworks. Under such conditions, the sulphide components of the iron compounds oxidise to sulfuric acid and produce actual acid sulfate soils with pH <4. In the saturated or reduced state, these soils remain unaltered and have normal pHs mainly in the range of 5.5 to 7.5. These soils are referred to as potential acid sulfate soils.

In this booklet we refer to acid sulfate/potentially acid sulfate soils as those containing organic carbon >2%, pH <5.5 and S>200 mg/kg.

ACIDIC CATIONS
Positively charged ions of aluminium and hydrogen that give the soil CEC an acid reaction. Aluminium and hydrogen are always present in large quantities in the soil but they are only present on the CEC and in the soil solution if the soil pH is below 5.3.

ACIDIFICATION
The process whereby soils become acidic over time as a result of the soil parent material, the addition of nitrogen to the soil by either fertiliser or legumes, and/or the leaching of nutrients from the soil by rainfall.

AEROBIC
Soil conditions in which there is plenty of oxygen; these conditions are suitable for plant roots and those soil organisms that carry out processes beneficial to plant nutrition and soil structure. Best in well-drained, well-structured soils.

ALKALINE SOIL
Soil with a pH above 7. Soils in the Burdekin district tend to be alkaline; in the rest of the Australian industry, soils are mostly acidic.

ALLUVIAL
Soils derived from recent stream deposits. These soils dominate flood plains.

AMELIORANT
A soil improver. A substance added to soil to improve the growing conditions for plant roots. A soil ameliorant e.g. gypsum, lime or mill by-products, improves the structure and/or nutritional level of the soil.

AMMONIA (NH_3)
A gas formed under conditions of denitrification which results in a loss of nitrogen to the atmosphere.

AMMONIUM (NH_4^+)
One of the two forms of nitrogen which plants can use for growth, the other being nitrate (NO_3^-).

ANAEROBIC In the absence of free oxygen and where reducing processes predominate. This condition generally occurs in poorly-drained or waterlogged soils where water has replaced the air resulting in a bluey-grey coloured soil. Denitrification by certain soil organisms occurs under waterlogged, anaerobic conditions.

ANION
Negatively charged ion such as nitrate, phosphate, sulfate and chloride. See IONS.

BASE SATURATION
The percentage of the CEC occupied by the basic cations Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}. If all the exchangeable bases total 100%, there is no exchangeable acidity.

BALANCED NUTRITION
The supply to a crop of adequate amounts of all the essential nutrients and silicon to meet crop demand. Over supply or under supply of one or more nutrients may be detrimental to crop yields, profitability or environmental stewardship.

BSES-P
A measure of soil phosphorus which is readily available for sugarcane growth in acid soils.

CATION
Positively charged ions that are held on to the negatively charged sites on the soil CEC. The major cations are calcium, potassium, magnesium and sodium, hydrogen and ammonium. See ANION, EXCHANGEABLE CATIONS and IONS.

CATION EXCHANGE CAPACITY (CEC)
An indication of the soil's nutrient-holding capacity. The sum of total exchangeable cations (Ca^{2+}, Mg^{+}, K^{+}, Na^{+}, Al^{3+}). A measure of the soil's capacity to hold and exchange cations. CEC measurements are often made with a buffer solution at a particular pH value. If this pH differs from the natural pH of the soil, the measurement will not reflect the true CEC under normal conditions. CEC is a major factor affecting soil structure, nutrient availability, soil pH and the soil's response to fertiliser. The value of the CEC is dependent on the amount and type of clay and on the amount of humus. The higher the clay content of the soil, the higher the CEC and the lower the leaching susceptibility of the soil. CEC is expressed as milli-equivalents per 100 grams of soil (meq%). Also see EFFECTIVE CEC.

CLAY MINERALS
The basic building blocks of clay. They are made from weathered minerals in rocks and aluminium and silicate layers as well as oxides and hydroxides.

COLOUR
Soil colour refers to the colour of the soil when it is moist. A simple system of everyday terms is used in this booklet. Soil scientists use a more complicated system in which the colour is matched to a series of standard colours (Munsell Soil Colour Chart).

COMPACTION
A reduction in pore space in soil (meaning less air space and poorer infiltration rates) caused by machinery traffic and inappropriate tillage.

CONTROLLED RELEASE FERTILISER
A fertiliser that releases nutrients slower than conventional inorganic fertilisers. Nutrient release from controlled release fertilisers (only soil temperature affects nutrient release) is usually more predictable than from slow release fertilisers.
See SLOW RELEASE FERTILISER.

CRITICAL LEVEL
The value for a nutrient in either a soil or leaf test above which a yield response is unlikely to occur when that nutrient is applied.

DEFICIENCY
A nutrient level below the critical level. In extreme cases, a deficiency is reflected by plant symptoms such as leaf colour.

DENITRIFICATION
One of the main ways nitrogen in fertiliser is lost. The process involves conversion of the nitrate form of nitrogen fertiliser to nitrous oxide gas and nitrogen gas which are lost to the atmosphere. Occurs in anaerobic, waterlogged conditions and is caused by certain bacteria in the soil.

DISSOLVED INORGANIC NITROGEN (DIN)
DIN is comprised of nitrate-N, nitrite-N and ammonium-N. These forms of nitrogen are readily available for algal growth which can cause degradation of coral reefs. Anthropogenic sources of DIN include fertiliser runoff from sugarcane paddocks.

DISTRICT YIELD POTENTIAL (DYP) DYP is determined from best possible yield averaged over all soil types within a district. It is defined as estimated highest average annual district yield (tonnes cane/ha) over a specified time period multiplied by a factor of 1.2. This enables recognition of differences in the ability of districts to produce cane.

DTPA
Chemical used in soil analysis to extract micro-nutrients from the soil.

DOLOMITE ($CaMg(CO_3)_2$)
A mixture of calcium and magnesium carbonates. Contains about 14% calcium and 8% to 10% magnesium. Suitable for correcting magnesium deficiency.

DUNDER
A liquid by-product of ethanol production and a rich source of potassium. Used as a fertiliser on sugarcane farms in some regions of the Australian sugar industry. Also known as vinasse or stillage in some countries.

DUPLEX SOILS
A soil with a relatively permeable topsoil abruptly overlying a very slowly permeable subsoil.

EFFECTIVE CEC (ECEC)
The effective cation exchange capacity of a soil. The amount of cation charges that a soil can hold at the pH of the soil. Effective CEC = sum of the exchangeable cations (Ca^{2+}, Mg^{+}, K^{+}, Na^{+}) + exchangeable acidity (Al^{3+})). The ECEC measurement is made at the natural soil pH. See CATION EXCHANGE CAPACITY.

ELECTRICAL CONDUCTIVITY
A measure of the amount of soluble salt compounds in the soil solution. Soluble salts are present in small amounts in all fertile soils, but excessive quantities are undesirable as plant growth suffers. Units are decisiemens/metre (dS/m), numerically equal to the old units millisiemens/centimetre (mS/cm) and the even older units millimho/centimetre (mmho/cm).

ENHANCED EFFICIENCY FERTILISER (EEF)
Fertiliser products that can reduce nutrient losses while increasing nutrient availability for the plant or the crop. Can either slow the release of nutrients for uptake or delay the conversion of nutrients to other forms that may be more susceptible to losses. EEFs include slow and controlled release fertilisers, ammonium stabilisers, urease inhibitors and phosphate management products.

EXCHANGEABLE ACIDITY
A measure of the amount of acid cations, aluminium (Al^{3+}) and hydrogen (H^{+}), occupied on the CEC.

EXCHANGEABLE CATIONS
Positively charged ions including calcium, magnesium, potassium, sodium and aluminium that are held on negatively charged soil particles.

EXCHANGEABLE POTASSIUM
(K(amm-acet); K(exch))
Potassium that is readily available to the growing crop. Exchangeable K is loosely held by soil organic matter and clays. Two other forms of potassium in the soil are slowly available K (K(nitric)), and unavailable potassium, which is found in minerals and which the plant cannot use.

EXCHANGEABLE SODIUM PERCENTAGE (ESP)
The percent of the cation exchange capacity (CEC) occupied by exchangeable sodium. Also called sodium percent of cations. A high ESP reading indicates crop production problems: 5 – 15% indicates some breakdown of soil structure; above 15% indicates severe structural deterioration in most soils.

GREEN CANE TRASH BLANKET

Green cane trash blanket (GCTB). The layer of sugarcane residues covering the ground after harvest of the crop which had not previously been burnt. Amounts to approximately 10 – 15 t/ha. Approximately 80% of the trash blanket is lost by decomposition per year.

GREENHOUSE GAS

Gases including carbon dioxide, methane and nitrous oxide which absorb incident and reflected radiation from the sun and re-radiate this heat into the atmosphere thereby warming Earth's atmosphere.

GREEN MANURE

Plants grown for incorporation into the soil to improve soil fertility and organic matter. Legumes can also provide nitrogen to the soil by converting inert atmospheric nitrogen to plant-available nitrogen.

GYPSUM ($CaSO_4.2H_2O$)

Calcium sulfate. A naturally mined substance, and a by-product of fertiliser manufacture. Used to reduce soil swelling and dispersion and for improving soil structure. Useful for overcoming poor growth in problem soils such as soda patches or hard setting soils. Gypsum does not alter the soil pH level.

HORIZON

A layer of soil roughly parallel to the land surface, which is distinct from the layers either above it or below it. Differences are based on colour, texture, structure or some other soil property.

HUMUS

The stable, black organic matter in soils (distinct from decomposing trash) which is the end-product of the decomposition of animal and vegetable matter. Humus can no longer be recognised as individual components. The compounds that make up humus are able to resist further decomposition and, therefore, accumulate in the soil.

IMMOBILISATION

Also called demineralisation, the opposite of mineralisation. The conversion of inorganic compounds to organic compounds by micro-organisms or plants, by which it is prevented from being accessible to plants. Occurs when nitrate (NO_3-) and/or ammonium-N (NH_4+) in the soil is used by microbes. Can occur during the initial breakdown of crop residues. Immobilisation causes a temporary unavailability of mineral nitrogen in the soil for plants to utilise.

LEACHING

Washing soluble nutrients and suspended clay particles downwards through the soil profile with rainwater or irrigation water and out of the root zone.

LIME/LIMING MATERIAL

A material with a high level of calcium which is effective in neutralising soil acidity. Usually refers to calcium carbonate (agricultural lime or earth lime) but also includes hydrated lime and burnt lime, and sometimes, dolomitic limestone. Other products may produce a "liming action" by increasing soil pH.

LUXURY FEEDING

The process whereby sugarcane takes up some nutrients in excess of the levels required for sound growth, for no extra benefit to the plant. It can lead to poor nutrient use efficiency and increased ash and colour in sugarcane juice. Sugarcane "luxury feeds" on nitrogen and potassium.

meq%

Milli-equivalents per cent: The quantity of some nutrients in the soil is expressed in this unit. Conversion: 1 meq% K= 390 ppm; 1 meq% Ca = 200 ppm; 1 meq% Mg = 120 ppm; 1 meq% Na = 230 ppm.

mg/kg

Milligrams per kilogram. The quantity of some nutrients in the soil is expressed in this unit. Equivalent to parts per million (ppm).

MICRO-NUTRIENTS
Essential plant nutrients required in small or trace amounts – zinc, copper, iron, manganese, molybdenum, boron and chlorine.

MICRO-ORGANISMS
Microscopic organisms including soil bacteria, fungi, protozoans, yeast, moulds, viruses and algae that recycle nutrients making them available for plant growth. Also includes pathogenic organisms that have an adverse effect on plant growth. Also called microbes. Are less than 0.2 mm.

MILL MUD
The residual mud and fibre filtered from the raw juice after lime addition and juice clarification in rotary vacuum filters. Mud is comprised mainly of water, fibre, mud solids from soil and natural impurities in the sugarcane. Filter mud % sugarcane is approximately 7%. Also called filter mud, filter cake or sugarcane press mud.

MINERALISATION
The process whereby nutrients, particularly nitrogen, phosphorus and sulfur, are released from the breakdown of humus (stabilised organic matter) by soil microbes, becoming available for plant growth in the inorganic form. For nitrogen, the ammonium form (NH_4^+) is produced which is subsequently converted to nitrate (NO_3^-) through the microbial process of nitrification.

MOTTLES
Patches of lighter or darker colour in soils often indicating the effects of poor drainage.

MOUND PLANTING
As a counter to wet soil conditions, growers in high rainfall areas sometimes plant into pre-formed raised drills or beds. The sett is planted above the surrounding soil level thus keeping the sett out of saturated soil. Also called bed planting.

NITRATE (NO_3^-)
One of the two forms of nitrogen which plants can use for growth, the other being ammonium (NH_4^+). Nitrogen → ammonium (NH_4^+) → nitrite (NO_2^-) → nitrate (NO_3^-).

Nitric K.
Potassium extracted from a soil sample with the use of strong nitric acid. It is a crude measure of the slowly available, non-exchangeable (reserve) potassium in the soil. The higher the value, the greater the potassium reserve in the clay minerals.

NITRIFICATION
The conversion of ammonium-N (NH_4^+) in soils to nitrite-N (NO_2^-) followed by the conversion of the nitrite to nitrate-N (NO_3^-) by certain nitrifying bacteria such as Nitrosomonas and Nitrobacter.

NITRIFICATION INHIBITOR
Also called ammonium stabiliser. Substance that inhibits the biological conversion of the ammonium ion (NH_4^+) to nitrite (NO_2^-) which slows the production of nitrate (NO_3^-). It does this by controlling the population of Nitrosomonas and other bacteria. Ammonium is attached to the soil due to its positive charge. Nitrate which has a negative charge is weakly attracted to soil and is prone to leaching and denitrification. These inhibitors can help reduce losses of N in soil that would otherwise be used by crops.

NITRITE (NO_2^-)
Compound formed in one of the stages of the conversion of nitrogen fertiliser: nitrogen → ammonium (NH_4^+) → nitrite (NO_2^-) → nitrate (NO_3^-). Sugarcane uses the ammonium and nitrate forms, not nitrite.

NITROGEN (N)

One of 16 nutrients essential for growth of plants. Present in all living cells. Present in organic matter and as nitrogen gas (N), nitrite (NO_2^-), nitrous oxide (N_2O), ammonia (NH_3), ammonium (NH_4^+) and nitrate (NO_3^-). Only the last two forms can be used by plants from the soil.

NITROGEN CYCLE

The continuous cycling of nitrogen and nitrogen compounds in nature between the atmosphere, the soil, and plants and animals.

NITROGEN FIXATION

The process whereby atmospheric nitrogen is converted to ammonia. This process must occur before the atmospheric nitrogen can be used by plants. The most widely known example is the association between Rhizobium bacteria in the nodules on legume roots. Industrial nitrogen fixation produces manufactured nitrogen fertiliser.

NITROUS OXIDE (N_2O)

Laughing gas. A product of denitrification resulting in nitrogen loss. Has approximately 310 times the greenhouse gas potential of carbon dioxide.

NITROGEN USE EFFICIENCY (NUE)

A measure of crop production per unit of nitrogen fertiliser input. In this manual, NUE = cane yield (t/ha) ÷ nitrogen applied (kg N/ha).

ORGANIC AMENDMENT

The addition of material high in organic matter which has the potential to improve soil condition and fertility. Examples are mill mud and mud-ash, compost, manures, sugarcane residues and fallow crop residues.

ORGANIC CARBON

A measure of the organic matter content of the soil. The carbon content of organic matter is relatively constant and comprises about 60 % of soil organic matter. Soils have low organic carbon if below 1%; soils greater than 4% are peaty and tend to indicate poor drainage where decomposition of the organic matter is slow. The terms total organic carbon, soil organic carbon and organic carbon are the same.

ORGANIC FERTILISER

Organic material that supplies plant nutrients when added to the soil. Must be decomposed by micro-organisms to make the nutrients available for plant growth.

ORGANIC MATTER

Consists of plant residues, soil organisms and animal remains. Composed of three pools: living biomass of micro-organisms; fresh and partially decomposed residues (the active fraction); the decomposed and highly stable organic material. Undecomposed surface litter is normally not included as a component of soil organic matter. Contains all the essential plant nutrients, particularly nitrogen, phosphorus and sulfur, which are slowly available for plant growth. Acts as a reservoir of plant nutrients, helps conserve moisture, improves the physical structure of the soil and provides a favourable environment for soil micro-organisms. Organic matter (%) may be estimated as 1.72 x organic carbon (%).

PARENT MATERIAL

Material (rock or alluvium) from which soils have formed.

pH

A measure of acidity or alkalinity (of the soil, water etc.) on a scale of 0 (extreme acidity) to 14 (extreme alkalinity). Pure water has a pH of 7. The scale is logarithmic: a change of one unit on the scale represents a 10-fold change in pH. pH is short for the Latin term “potentia hydrogenii” and means hydrogen ion concentration.

PEAT
A dark soil consisting of partially decomposed organic matter.

PEDS
Aggregates of soil particles.

PERMEABILITY
The ability of soil to drain water through the profile. It is dependent on pore space, which is reduced by compaction.

PHOSPHORUS BUFFERING INDEX (PBI)
A measure of the degree to which added phosphorus is held tightly onto soil particle surfaces and is unavailable for plant uptake.

POTENTIAL ACID SULFATE SOIL
Soil that contains sulphides that have the potential to generate sulfuric acid if disturbed (drained, excavated etc.) and exposed to air.
See ACID SULFATE SOILS.

P-SORPTION
The process by which phosphorus is held tightly onto soil particle surfaces and rendered relatively unavailable for plant uptake.

PYRITE
An iron sulphide mineral often found in tidal swamps and brackish sediments. If submerged, these soils are relatively harmless. However, when exposed through falling water levels the pyrite will oxidise to jarosite, which forms highly acidifying acid sulfate soil.

RUNOFF
The draining away of water and substances (e.g. soil, phosphorus attached to soil, dissolved nitrogen) carried in the water from the surface of an area of land. May cause erosion. When runoff water carries nutrients, it may contribute to water quality decline and reduce farm profitability.

SALINE SOIL
A non-alkali soil containing an excessive level of salt in the soil water, restricting plant growth. The salt is soluble and may be leached out.

SILT
Soil particles which together with sand, clay and organic matter are the main constituents of soil. Derived from eroded rocks, silt is intermediate in size between sand and clay. Individual silt particles are so small they are difficult or impossible to see, in the size range 0.002 mm to 0.05 mm.

SIX EASY STEPS
An integrated nutrient management tool that enables the adoption of on-farm best-practice nutrient management. It is aimed at sustainable and balanced nutrition of sugarcane. It consists of (1) Knowing and understanding your soils; (2) Understanding and managing nutrient processes and losses; (3) Soil testing regularly; (4) Adopting soil-specific nutrient management guidelines; (5) Checking on the adequacy of nutrient inputs, and (6) Keeping good records and modifying nutrient inputs when necessary. The recommended SIX EASY STEPS nutrient rates are recognised by Government and industry as being the most appropriate for the Australian sugar industry.

SODIC SOIL
Soil in which high levels of exchangeable sodium are attached to the clay particles, causing breakdown of the soil structure and poor plant growth. Soda patches are areas containing sodic soil. Such soils have a poor structure, disperse easily and are prone to erosion. Generally, a sodic soil is regarded as having an exchangeable sodium percentage 15% or greater.
See EXCHANGEABLE SODIUM PERCENTAGE (ESP).

SODIUM (Na)
Excessive levels cause plant nutritional and soil structural problems. Very soluble in water. Part of common or table salt (sodium chloride), it contributes to electrical conductivity along with chloride.
See ELECTRICAL CONDUCTIVITY.

SOIL HEALTH
The physical, chemical and biological components that make up a living soil, how they interact with one another and how they interact to sustain production. A healthy soil has properties that promote the health of plants, animals and humans while maintaining environmental quality.

SPLIT APPLICATION
Fertiliser applied to a crop two or more times during its seasonal growth.

STOOL SPLITTING
The use of a coulter to slice a thin line through sugarcane stools along the length of the row. Fertiliser is dropped into the shallow slot (about 7 cm to 10 cm deep) via a hollow tyne directly behind the coulter. A following press wheel closes the slot to prevent volatilisation loss of nitrogen.

SUBSOIL
Soil below the cultivated zone commonly sampled at 40-60cm depth.

SUBSURFACE-APPLIED FERTILISER
Fertiliser buried in bands in the soil. With suitable equipment, fertiliser can be subsurface-applied through a green trash blanket.

SURFACE-APPLIED FERTILISER
Fertiliser applied in bands or as a broadcast application either on top of the green or burnt trash blanket or on the soil surface.

TEXTURE
A soil property that depends on the relative proportions of coarse sand (2-0.2mm), fine sand (0.2-0.02mm), silt (0.02-0.002mm) and clay (<0.002) but may be modified by organic matter or type of clay minerals.

TOPSOIL
The cultivated zone of soil commonly sampled at 0-20cm depth.

UREA ($CO(NH_2)_2$)
A white, crystalline solid containing 46% nitrogen that is widely applied as a fertiliser.

UREASE
A naturally-occurring enzyme which converts urea to ammonia.

UREASE INHIBITOR
A substance which inhibits hydrolytic action on urea by urease enzyme. A urease inhibitor results in less urea nitrogen lost by ammonia volatilisation or leaching of nitrate. The efficiency of urea and urea-containing fertilisers is increased while adverse environmental impacts of nitrogen loss are reduced.

VOLATILISATION
The loss of nitrogen to the atmosphere when surface-applied urea or products containing urea are converted to ammonia gas.

WATERLOGGED
A soil which is saturated with water, displacing air to the point where there is insufficient oxygen for full root activity and plant growth. See ANAEROBIC.


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Sugar Research Australia Limited
ABN 16 163 670 068

Brisbane Office 50 Meiers Road Indooroopilly QLD 4068 Australia
Postal Address PO Box 86 Indooroopilly QLD 4068 Australia

T 07 3331 3333
E sra@sugarresearch.com.au
sugarresearch.com.au