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SOIL REFERENCE BOOKLET FOR THE HERBERT DISTRICT

Soil Specific Management Guidelines for Sugarcane Production

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and Bob Stewart

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Disclaimer

The nutrient management guidelines for different soils in this publication are based on generalised management conditions across each soil type and provide general advice only. They may not apply to the specific soil conditons on your farm. If you would like to adjust the guidelines to the situation on your farm, we strongly recommend that you take soil and leaf tests from each cane block and seek professional advice. The authors and publishers of this booklet do not assume any responsibility or liability for any loss or damage which may result from the use of the information contained herein.

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Introduction

In 1985 a booklet entitled *Nutrition and Fertilizing of Sugarcane in the Herbert Valley* was distributed to all Herbert cane growers by the CSR Technical Field Department. This described the basic principles of soil management and presented nutrient guidelines for three groups of Herbert soils based on the early findings of the Herbert cane soil mapping programme. After a further eighteen years, using the additional information that has been gathered, we are now in a position to provide guidelines for 24 different soils used for sugarcane growing that have been identified in the Herbert River District.

Our philosophy is that soils should form the basis for making management decisions on farm. Not only does soil type influence decisions on what variety 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: namely what they look like, where they occur, their properties and how they should be managed. Soil-specific guidelines as presented in this booklet represent a much more precise way of managing inputs such as fertiliser rather than the current "one size fits all" approach. It provides a benchmark against which soils and soil analyses from your farm 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 analysis and a system of record keeping implemented which records nutrient inputs, changes in soil fertility and crop productivity and profitability.

This philosophy is particularly appropriate for the current situation of the sugar industry. The continuing low sugar prices and the need to reduce production costs together with mounting environmental pressures demand demonstration of responsible soil and nutrient management. The guidelines in this booklet are aimed at providing best practice soil and nutrient management for Herbert growers that will not only maintain or improve crop yields and soil fertility but will also provide opportunities for cost reduction whilst enhancing sustainability and delivering better environmental outcomes.

CHAPTER 2

Glossary of technical terms

It is inevitable that specialist and technical words have to be used in this publication. To assist those not familiar with some of the words used we have included a list of technical terms, known as a glossary. This can be used as a reference source whilst reading the book.

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

Acid saturation: The proportion of the soil 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 volcanic: Soils formed from rock that has a high proportion of acidic minerals and fine sand. Acid volcanic rocks dominate the eastern part of the Cardwell Range.

Alluvial: Soils derived from recent stream deposits. These soils dominate floodplains.

Ameliorant: A substance added to soil that slowly improves its nutrient status and physical properties, usually beyond a single crop cycle, such as lime, mill by-products and rock phosphate.

Amino nitrogen: A form of nitrogen found in sugarcane juice that can enhance colour in sugar. It is caused by excessive amounts of nitrogen available from the soil.

Anions: Negatively charged ions. The major anions for sugarcane nutrition are nitrate, phosphate and sulphate.

Cations: Positively charged ions. The major ones for sugarcane nutrition are calcium, potassium, magnesium and sodium. These cations are held on negatively charged sites on the soil CEC and can be accessed by plants.

CEC (cation exchange capacity): A measure of a soil's capacity to store and exchange cations. The value of the CEC is dependent on the amount and type of clay and on the amount of humus. Measurement expressed as milli-equivalents per 100 grams of soil (me%) or, in scientific publications, as centimoles of positive charge per kilogram ($cmol(+)kg^{-1}$).

Chemically-fixed phosphorus: Phosphorus can react with chemical compounds in the soil solution and precipitate as insoluble phosphates that plants cannot extract.

Clay minerals: The basic building blocks of clay. They are made from the weathered minerals in rocks and include aluminium and silicate layers as well as oxides and hydroxides. (A mineral is a naturally occurring substance that has a definite chemical composition and an ordered structure).

Colluvial fan: Sediment accumulated at the base of hills which has moved downslope. For example the material on hill slopes surrounding the Herbert Valley on which the Red and Grey Sands have formed.

Colour: Soil colour refers to the colour of the soil when it is moist. A simple system using everyday terms is used in this booklet. Soil scientists use a more complicated system requiring the colour to be matched against a book of standard colours (Munsell Soil Colour Chart).

Compaction: A reduction in pore space in soil (meaning less air space and poorer drainage rates) caused by trafficking and inappropriate tillage.

Critical level: The value for a nutrient in either a soil or leaf test above which an economic yield response is unlikely to occur when that nutrient is applied.

Decomposition: The breakdown of a complex substance to something simpler. The process can be caused by weathering, chemical change (e.g. increased acidification) or biological action.

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

Denitrification: The conversion of the nitrate form of nitrogen to a gas. It occurs under waterlogged conditions in the presence of organic matter and suitable bacteria.

DTPA: Chemical used in soil analysis to extract micronutrients from the soil.

ESP (exchangeable sodium percentage): The percentage of the CEC occupied by sodium. ESP in the topsoil of more than 6% is undesirable as soil structure breaks down.

Exchangeable nutrients: Essential nutrients present as cations that are associated with the soil CEC and can exchange freely. The nutrients involved are calcium, potassium, magnesium and sodium.

Flocculation: The grouping of clay particles which is an essential pre-requisite for the formation of good soil structure.

Granite: Igneous rock formed at depth and characterised by coarse minerals.

Horizon: A layer of soil roughly parallel to the land surface which is distinct from the layers above and/or below it based on colour, texture, structure or some other property. Surface horizons do not occur in agricultural soil because they are usually mixed by cultivation.

Humus: Stabilised soil organic matter, distinct from decomposing trash.

Lattice K: Potassium which forms part of the clay mineral structure, distinct from exchangeable or soluble potassium. It is not readily available for plant use, but can become available through weathering (see nitric K).

Leaching: The downward movement of water through the soil and the accompanied movement of soluble nutrients and suspended clay particles.

Luxury consumption: Plants absorb nutrients selectively but also passively as they take up water. Where surplus nutrient is available in the soil solution, particularly soluble nutrients like nitrate, ammonium and potassium, plants can take up more than they need, which can lead to poor use efficiency and possible undesirable consequences such as increased ash and colour in juice.

Massive: A non-sandy soil with no apparent structure. Such soils are very lumpy, difficult to cultivate and set hard when dry.

Median: The middle number in a group of numbers. The median for the list of numbers 4, 5, 8, 20 and 27 is 8. It is different from the mean or average which is the sum of all numbers divided by the number in the list = (4+5+8+20+27)/5 = 12.8. The median is a better predictor of representative soil properties as it is not influenced by extreme values.

Micronutrient: An essential nutrient that is required in very small quantities, <10 kg/ha/year.

Mineralisation: The breakdown of humus (stabilised organic matter) and release of nutrients especially nitrogen, sulphur and phosphorus.

Mottles: Patches of darker colour in soils, indicating the effects of poor drainage.

New land: Land in its first crop cycle of sugarcane.

Nitric K: Potassium extracted with the use of strong nitric acid. It is a crude measure of non-exchangeable potassium; the higher the value the greater the potassium reserve in the clay minerals.

Non-exchangeable potassium: Potassium held within clay minerals which becomes available slowly.

Old land: Land in its second or later crop cycle of sugarcane.

Organic matter: Carbon compounds in the soil derived from plant matter. Organic matter is composed of carbon, hydrogen and oxygen and contains significant amounts of nitrogen, phosphorus and sulphur.

Peds: Aggregates of soil, usually only found in undisturbed soil.

Permeability: The ability of soil to drain water. It is dependent on pore space which is reduced by compaction.

pH: The scale that is used to measure acidity and alkalinity. A pH of 7 is neutral, less than 7 is acidic, greater than 7 is alkaline.

Photosynthesis: The process that maintains life on earth. Carbon dioxide and water are combined by green plants in the presence of sunlight to make carbohydrates and oxygen.

Prior streams: Former water courses that have been filled in by coarse sediments and no longer function as streams. Soils developed on them are usually quite distinct from surrounding soils.

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

Sodic soil: Soils having high exchangeable sodium levels (see ESP). Such soils have a poor structure, disperse easily and are prone to erosion.

Soil structure: The arrangement of soil particles into aggregates and the pore spaces between them.

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

Subsoil: Soil below the cultivated zone, commonly sampled at 40 – 60 cm depth.

Topography: The shape of the landscape, including height of hills, general slope and position of drainage lines.

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

Toxicity: A high level of nutrient that causes plant injury and/or reduction in growth.

Volatilisation: The loss from soil of nutrients in a gaseous form. The main concern is the loss of urea as ammonia gas when urea is applied to the soil surface. Losses of up to 60 kg N/ha have been measured.

Water holding capacity: The quantity of water a soil can hold after drainage and which can be extracted by plants.

Waterlogging: The saturation of soil with water so that all air is excluded (anaerobic). Under these conditions denitrification can occur.

Weathering: The decomposition of minerals into different sized particles and other minerals; caused by carbon dioxide, water and biological processes.

Yield potential: The best yield that could be expected in a field situation in a particular year. It is determined from the average best block yields occurring over a number of seasons and across all soils. For the Herbert district the block yield potential is estimated to be 120 tonnes cane per hectare.

CHAPTER 3

Introduction to Herbert soils and their properties

A large number of markedly different soils are found in the Herbert district. An understanding of their differences, at both the district and farm levels, will ensure that nutrient management reflects this diversity and enables profitable and sustainable sugarcane production in the region.

Soils are composed of mineral particles of varying sizes which are derived from fragments of rock and clay minerals mixed with organic matter. They are complex, natural bodies and are products of the interaction of the original soil forming material (parent material) and other factors such as climate, topography, drainage and the presence of plants, animals and microbes.

Soil formation and distribution

Most Herbert Valley soils have formed on alluvial deposits from the Herbert River and its tributaries. The Herbert River has changed its course a number of times over the last few thousand years which has resulted in a complex soil pattern, with sandier soils generally found closest to the river along its levees and progressively finer textured soils away from the river. This is because sand particles, being bigger, tend to settle-out first when rivers break their banks. Silt and clay particles, being smaller, tend to be transported further away from the river when flooding occurs. Some soils have formed on fairly sandy deposits which have infilled old stream channels known as prior streams. These are particularly obvious in the Lannercost area where narrow sand ridges, following old stream channels, wind for many kilometres across the landscape. Similar but broader deposits occur in the Abergowrie and Stone River areas. Around the edges of the valley, at the foot of the hillslopes, colluvial fans have formed. Most of these are composed of coarse granitic material as the main rock type is granite. However in the eastern part of the Cardwell Range, adjacent to the Ripple Creek and Seymour areas, acid volcanic rocks occur which give rise to a much finer colluvium and hence a different set of soils containing more fine sand and silt. Recent beach sands are present along the coastline. They follow old shorelines as sediment from the Herbert River has gradually extended the coastline out to sea. Recent marine mud deposits also occur here and support mangrove vegetation. A few of these areas have been drained for growing sugarcane and form soils with high clay contents.

Soil field properties

In recognizing 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 'grower-friendly' soil types. Soil type used in combination with soil chemical properties (from soil tests) will enable growers and their advisers to make informed decisions about appropriate nutrient management strategies on-farm.

Colour
The colour of soil is determined by its moisture content, the amount of organic matter present, iron oxide levels and the degree of aeration. Dark coloured soils have more organic matter than lighter-coloured soils. Well-drained soils have red 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 are for moist soils.

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

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, with silt particles being moderately sized. 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, 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, field texture can be estimated in the field using the guidelines provided in Appendix 1.

Structure
Structure is the natural aggregation of the soil particles (sand, silt and clay) and organic matter into units called peds which can differ markedly in terms of size, shape and level of stability. Their presence in soil affects the ways soils behave, the growth of plants and the manner in which 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 soil parent material and the influence of leaching, organic matter, flooding and drainage potential. Each horizon has attributes of colour, texture and structure that distinguish it from the horizons above and below it. Farming activities mix together the surface horizons, which we refer to as topsoil. Material below this is referred to as subsoil. In the Herbert cane producing soils the top 20cm is generally considered mixed topsoil and the 40-60cm depth increment is well within the subsoil.

Position in the landscape
Because of the interactive effect of the soil-forming factors, the existence of soils with specific characteristics is predicable in the landscape. Soils differ according to their position in the landscape. For instance in the Herbert, red or brown well-drained soils

are found in upslope positions, while poorly drained heavy clays are often found at the lowest point in the landscape.

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), magnesium (Mg), potassium (K), sodium (Na) and aluminium (Al). 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 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 are classified as low (less than 3 me%), medium (3 – 6 me%) or high (more than 6 me%).

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. Soils in the Herbert have organic matter contents of up to 4%. Organic matter, usually measured as organic carbon %, improves soil structure and is a source of nitrogen (N), phosphorus (P), sulphur (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 inputs about 10-15 t/ha in trash and 3 t/ha in roots per year, but 80% percent of this is lost by decomposition in the first year. In soils with low clay contents, organic matter is the chief store for exchangeable cations. Organic matter is a major source of N which is released by mineralisation (the process in which organic matter is broken down into its mineral components). The N mineralisation potential provides an index of the amount of N released from specific soils and is used to guide nitrogen fertiliser recommendations.

As indicated above, building organic matter levels is difficult in tropical soils due to rapid decomposition rates. Breakdown of organic matter is enhanced by cultivation. Trash conservation following green cane harvesting and the use of fallow crops are the major ways organic matter can be added to the soil. 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, mill ash and bagasse.

Acidity and soil pH
Acidity in soils is caused by excessive hydrogen and aluminium 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. On soil tests, two measures of acidity are commonly given: pH in water (pH_{water}) and pH in calcium chloride solution (pH_{CaCl2}). In this booklet we only consider pH in water. Soils with pH greater than 5.5 are desirable for plant growth in the Herbert as concentrations of aluminium, which is more soluble at low pH and toxic to many plants, are minimised above pH 5.5. Increased acidity (lower pH) causes reduced availability of N, K, Ca, Mg, P and S, while micro-nutrients such as copper (Cu) and zinc (Zn) become more available. Under acidic conditions, Al is present in its soluble form and is toxic to most plants but particularly to legume crops. Consequently regular additions of lime are essential if legume crops are going to be part of a farming system on acid soils. Fortunately, Australian sugarcane varieties are fairly tolerant to high levels of Al. Low pH can reduce the already low CEC of tropical soils and cause the soil CEC to be dominated by the acidic cations hydrogen (H) and aluminium (Al). This reduces the storage capacity for nutrients such as Ca, Mg and K sometimes by more than a half. This can be critical particularly on sandy soils with low CEC. Soil acidification is a natural process which is made worse by the use of 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 Ca and Mg (if using Mag lime or dolomite) withdrawn in the harvested crop.

Flocculation
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 6% are unstable when wet and disperse. Clays that disperse readily, fill up pore spaces and reduce permeability to both air and water.

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 two groups: macronutrients (nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S) and magnesium (Mg)) which are required in relatively large amounts (20 – 200 kg/ha), and micronutrients (iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), manganese (Mn), boron (B), silicon (Si) and for some plants sodium (Na)) which are required in small amounts (less than 10 kg/ha/crop). 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 soil nutrients and to prevent the mining of nutrients stored in our soils.

Nitrogen *(N)*
CSIRO 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/tonne thereafter. In order to achieve sustainable crop production, maximum use must be made of all the available N sources within the N cycle (Figure 3.1). To do this it is important to have an understanding of the transformations of N 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. This N 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). More detail is provided on these processes in Figure 3.1.

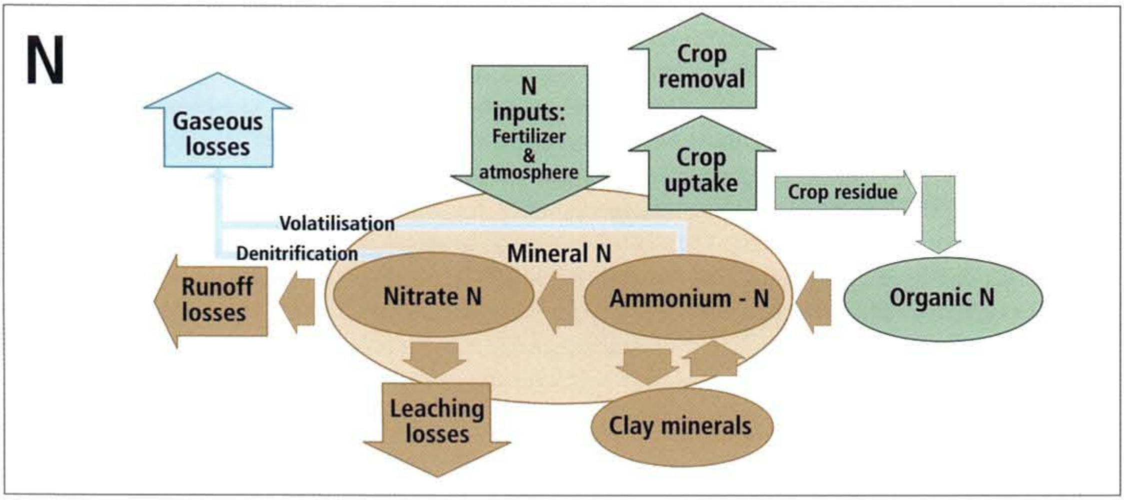


Figure 3.1. A schematic diagram of the nitrogen cycle.

Ammonium-N is subject to volatilisation, a loss often associated with urea applied to the surface of a trash blanket. As it is important to minimise each of these losses, the following strategies are suggested:

- Determine soil organic matter mineralisation capacity and apply nitrogen according to the specific requirements of different soils (as shown in Chapter 4).
- Reduce nitrogen losses by leaching, runoff or denitrification by splitting applications of nitrogen, which is the usual practice in plant cane.
- Reduce the potential for denitrification by improving drainage and placing fertiliser on the cane row where it is less likely to be waterlogged.
- 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. Applying the urea below the soil surface removes the possibility of losses by volatilisation but could increase the risk of loss by denitrification if waterlogging occurs. Surface application of a mixture of urea and ammonium sulphate can reduce the risk of loss by volatilisation as the ammonium sulphate is acidic. Conversely the application of urea and muriate of potash can increase the potential for volatilisation as the potash is alkaline.

Phosphorus *(P)*

Phosphorus cycles between the various forms in soil (Figure 3.2), with some forms being more readily available than others. In some soils with high clay and/or organic matter contents, phosphorus is held tightly onto soil particle surfaces by a process called P sorption. More P fertiliser needs to be applied when P is strongly 'sorbed' as this P is relatively unavailable to plants.

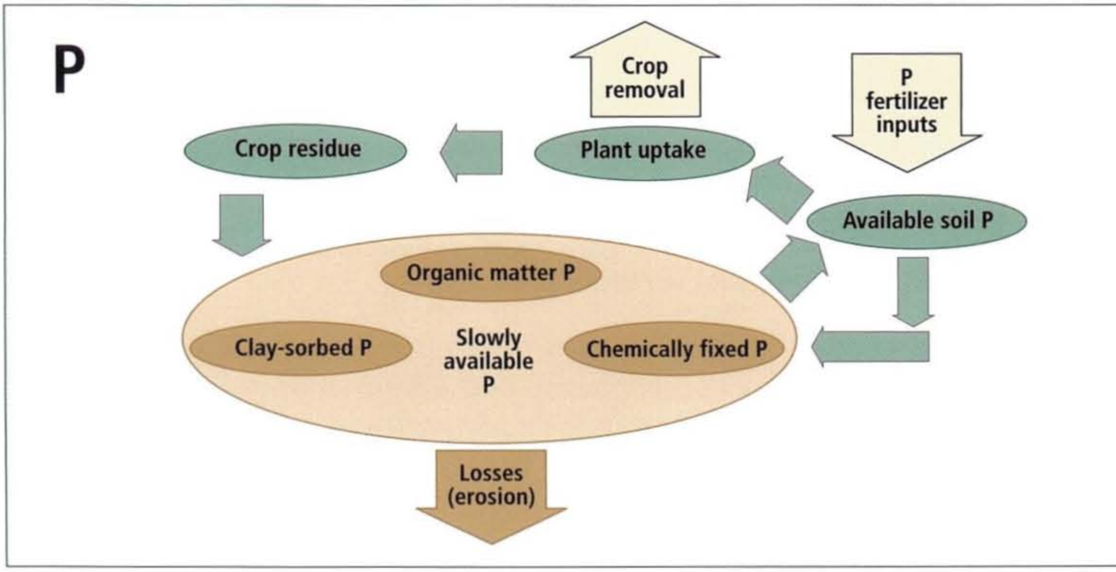


Figure 3.2. Soil phosphorus cycle.

Potassium *(K)*

Sugarcane needs potassium in large quantities mainly for the maintenance of water balance. On average, around 115 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 a number of distinct forms within soils. A schematic diagram of the potassium cycle is shown in Figure 3.3.

Lattice K is part of the clay structure and represents over 90% of the total K in the soil. This breaks down into the slowly available non-exchangeable form of K, which in turn

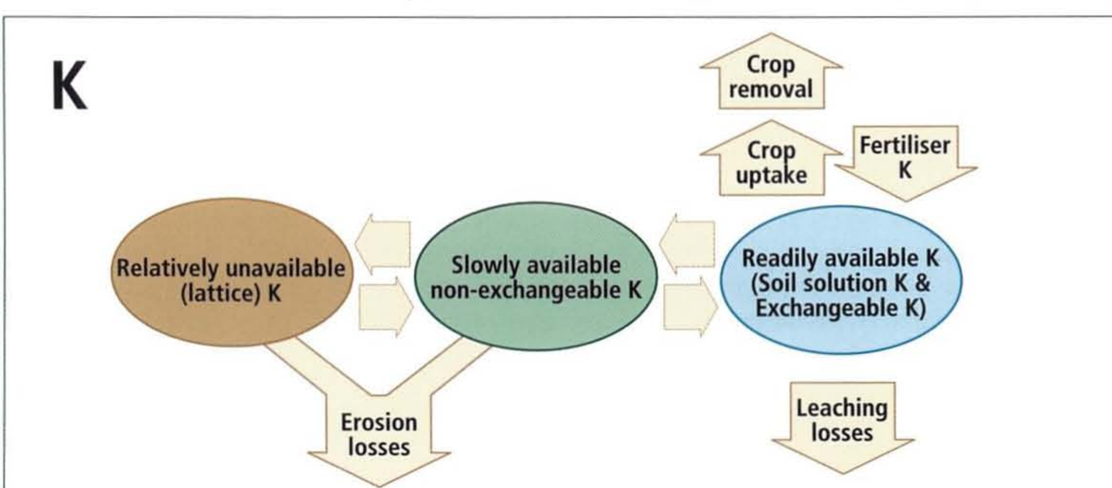


Figure 3.3. Soil potassium cycle

acts as a source of exchangeable and solution K (plant available forms). This is why the amount of K applied as fertilizer is always less than that removed in the harvested crop. Potassium losses are possible with leaching of exchangeable and soil solution K, particularly from sandy soils, and by erosion which 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 a positively charged cation from the soil solution. Soil reserves of Ca, which are held on the CEC, are supplemented by additions of liming materials and by gypsum. A cane crop removes around 30 kg Ca/ha/year but when applying lime, considerably more Ca 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 CEC. Whilst total uptake is similar to calcium, the level of Mg on the CEC should ideally be about 20% that of Ca.

Sodium *(Na)*

Sodium is required in very small amounts for the maintenance of plant water balance. It is taken up from the soil solution and stored on the CEC. It 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 6%) and at higher levels (ESP above 20%) can restrict plant growth.

Sulphur *(S)*

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

Micronutrients

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 Herbert soils, particularly low organic matter sandy soils, whereas iron (Fe) and manganese (Mn) are well supplied. Little is known about the status of molybdenum (Mo) and boron (B) in Herbert River soils. No deficiencies of silicon (Si) have so far been detected in the Herbert through leaf analysis although soil Si levels tend to be relatively low in very sandy soils.

Principles for determining nutrient management guidelines

When developing nutrient management guidelines for the different soil types in the Herbert the following factors were taken into account:

1. Crop yield potential
2. Nutrients removed in the harvested crop
3. Nutrients returned to the soil in trash, fallow crops and mill by-products
4. Nutrients released by the mineralisation of soil organic matter
5. Nutrients released by the weathering of soil minerals
6. Nutrients fixed (held tightly) on soil particle surfaces
7. Soil acidity
8. Critical levels of nutrients as determined by soil analysis
9. The balance and interactions of different nutrients, particularly those on the soil CEC
10. The chances of nutrient loss processes occurring

The following soil physical and chemical properties were used to assist this process. Median values for all these properties were calculated from an extensive soil analysis database compiled for Herbert soils over the past 20 years. This was used to produce the bar graphs and soil test values for each soil type in Chapter 5.

- 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 nitrogen 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)
- 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 P (index of available phosphorus)
- Phosphorus sorption (the degree to which added P is held tightly onto soil particle surfaces and unavailable for plant uptake)
- Sulphur
- Copper and zinc

Nitrogen
It has been estimated that sugarcane requires 1.4 kg N for every tonne of cane growth up to a yield of 100 tonnes/ha and 1.0 kg N/tonne for each additional tonne/ha above 100 t/ha. The yield potential for the Herbert River district, which is defined as the highest

block yields averaged across all soils and over a number of seasons, is estimated to be 120 tonnes cane/hectare. Thus to achieve this generalised potential yield a crop requires 160 kg N/ha. In order to calculate how much N fertiliser the crop requires on specific soil types we need to take into account how much of the 160 kg N required by the crop can be supplied from other sources such as from soil organic matter. This is done by using soil organic carbon levels to place the soil type in an N mineralisation category, which assigns a recommended N rate by discounting what the soil is capable of providing from the original 160 kg N/ha value. Further discounting is required to recognise the N contributions from legume-based fallows and any applications of mill by-products (Table 4.1).

Table 4.1. N mineralisation index and suggested nitrogen rates

N mineralisation index	Organic carbon (%)	Suggested N rate for ratoons (kg/ha)
VL	<0.4	160
L	0.4-0.8	150
ML	0.8-1.2	140
M	1.2-1.6	130
MH	1.6-2.0	120
H	2.0-2.4	110
VH	>2.4	100

< denotes less than; > denotes greater than

Effect of fallow management on N mineralisation index and suggested N rates (kg/ha)

	VL	L	ML	M	MH	H	VH
Replant cane and ratoon after replant	160	150	140	130	120	110	100
Plant cane after grass/bare/poor legume fallow	140	130	120	110	100	90	80
Ratoon after grass/bare/poor legume fallow	160	150	140	130	120	110	100
Plant cane after good soybean/cowpea fallow	80	70	60	50	40	30	20
First ratoon after good soybean/cowpea fallow	110	100	90	80	70	60	50
Second ratoon after good soybean/cowpea fallow	160	150	140	130	120	110	100

Modifications to suggested N rates where mill by-products have been used:

- **Mill mud** applied at 200 – 250 wet t/ha. Subtract 100 kg N/ha from plant, 50 kg N/ha from 1st ratoon, and 25 kg N/ha from 2nd ratoon
- **Mud/ash mixture** applied at 200 –250 wet t/ha. Subtract 60 kg N/ha from plant, 30 kg N/ha from 1st ratoon, 15 kg N/ha from 2nd ratoon
- **Mill ash only** – no change.

Phosphorus

Two techniques are used to decide how much P fertiliser is required. Firstly a BSES 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 a particular soil can be measured in the laboratory but is not reported in soil tests. It can be estimated from the clay % and organic matter content of a particular soil (Table 4.2). Clay % is not given on most soil tests but can be estimated from a soil texture determination (see Appendix 1).

Table 4.2. P sorption classes

Organic carbon (%)	<24% clay	24-36% clay	>36% clay
<0.6	low	low	moderate
0.6 – 1.2	low	moderate	moderate
1.2 – 1.8	moderate	high	high
>1.8	high	high	high

(< denotes less than; > denotes greater than)

Many of the older sugarcane areas of the Herbert do not require any P fertiliser due to their long history of excessive P fertilisation. New land on the other hand is nearly always deficient in available P and requires additional P fertiliser in the first crop cycle (Table 4.3). As with nitrogen, discounts should be made where mill by-products have been used.

Table 4.3 Phosphorus guidelines for old and new land

Old land

BSES P in soil test (mg/kg)	P sorption class	Suggested phosphorus application (kg/ha)	
>60	All	Nil P for at least 2 crop cycles	
40 – 60	All	Nil P for 1 crop cycle	
		Plant	**Ratoon**
20 – 40	Low	10	0
	Moderate	20	0
	High	30	0
10 – 20	Low	10	10
	Moderate	20	20
	High	30	30
<10	Low	20	20
	Moderate	40	30
	High	60	40

***New land** (first crop cycle)*

	P sorption class	Plant	Ratoon
	Low	40	20
	Moderate	60	30
	High	80	40

(< denotes less than; > denotes greater than)

Modifications to suggested P rates where mill by-products have been used:

- **Mill mud** applied at 200-250 wet t/ha. Apply nil P for at least 2 crop cycles.
- **Mud/ash mixture** applied at 200-250 wet t/ha. Apply nil P for at least 2 crop cycles.
- **Mill ash** only. Apply nil P for at least one crop cycle.

Sulphur

Since the main supply of sulphur in Herbert soils is from the mineralisation of soil organic matter, sulphur fertilising guidelines are based on the nitrogen mineralisation index. For sulphur it is sufficient to assign soils into one of three N mineralisation classes and then use a soil sulphate critical level (Table 4.4). Discounts should be made where mill by-products have been used.

Table 4.4. Sulphur fertiliser guidelines for plant and ratoon crops in the Herbert (kg S/ha)

SO_4 S (mg/kg)	N min VL-L	N min ML-M	N min MH-H
<5	25	20	15
5-10	15	10	5
10-15	10	5	0
>15	0	0	0

< denotes less than; > denotes greater than

Modifications to suggested S rates where mill by-products have been used

- **Mill mud** applied at 200-250 wet t/ha. Subtract 15 kg S/ha on first 3 crops.
- **Mud/ash mixture** applied at 200-250 wet t/ha. Subtract 15 kg S/ha on first 2 crops.
- **Mill ash** only. Nil effect.

Potassium

Potassium fertiliser guidelines are based on two measures of soil potassium: readily available or exchangeable K (the potassium in the soil solution and on the CEC) and reserve or nitric K (the slowly available, non-exchangeable potassium). Most soils in the Herbert, apart from very sandy soils, have relatively high nitric K levels and consequently have the potential to release K slowly but steadily into the soil solution from non-exchangeable reserves.

The maximum recommended K rate for the Herbert is 120 kg K/ha which is similar to the amount of K removed in the harvested sugarcane crop when trash is retained. This limit on K applied is to avoid luxury consumption of K by the crop (resulting in reduced juice quality) and losses by leaching on low CEC sandy soils. It is justified by the relatively high K reserves on most soils which slowly but continuously becomes available. Hence fallow plant requires less K than replant or ratoons.

Soil critical levels for exchangeable K are dependent on clay content and soils are assigned into one of three textural classes. Potassium fertiliser recommendations can then be derived (Table 4.5). As for N and P, discounts should be made where mill by-products have been used.

Table 4.5. Potassium fertiliser guidelines for the Herbert

Soils with low K reserves (nitric K ≤ 0.7 me%)							
Low clay soils (<24% clay)							
Exch. K (me%)	<0.18	0.18 – 0.21	0.21 – 0.24	0.24 – 0.27	0.27 – 0.36	0.36 – 0.39	>0.39
Plant	120	100	80	60	40	0	0
Ratoon	120	120	120	100	100	100	0
Moderate clay soils (24 –36% clay)							
Exch. K (me%)	<0.21	0.21 – 0.24	0.24 – 0.27	0.27 – 0.30	0.30 – 0.39	0.39 – 0.42	>0.42
Plant	120	100	80	60	40	0	0
Ratoon	120	120	120	100	100	100	0
High clay soils (>36% clay)							
Exch. K (me%)	<0.24	0.24 – 0.27	0.27 – 0.30	0.30 – 0.33	0.33 – 0.42	0.42 – 0.45	>0.45
Plant	120	100	80	60	40	0	0
Ratoon	120	120	120	100	100	100	0
Soils with high K reserves (nitric K > 0.7 me%)							
Low clay soils (<24% clay)							
Exch K (me%)	<0.18	0.18– 0.21	0.21– 0.24	0.24 – 0.33	0.33 – 0.36	0.36 – 0.39	>0.39
Plant	100	80	60	40	40	0	0
Ratoon	100	100	100	80	60	40	0
Moderate clay soils (24 –36% clay)							
Exch K (me%)	<0.21	0.21 – 0.24	0.24 – 0.27	0.27 – 0.33	0.33 – 0.39	0.39 – 0.42	>0.42
Plant	100	80	60	40	40	0	0
Ratoon	100	100	100	80	60	40	0
High clay soils (>36% clay)							
Exch K (me%)	<0.24	0.24 – 0.27	0.27 – 0.30	0.30 – 0.33	0.33 – 0.42	0.42 – 0.45	>0.45
Plant	100	80	60	40	40	0	0
Ratoon	100	100	100	80	60	40	0

< denotes less than; > denotes greater than

Modifications to suggested K rates where mill by-products have been used:

- **Mill mud** applied at 200-250 wet t/ha. Subtract 50 kg K/ha on first crop.
- **Mud/ash mixture** applied at 200-250 wet t/ha. Apply nil K on first 2 crops.
- **Mill ash** only. Apply nil K for at least one crop cycle.

Lime

Lime is used to neutralise soil acidity and to supply calcium. Soils are constantly being acidified through the use of nitrogen fertilisers and through the removal of nutrients in the harvested crop. On average a maintenance application of about 2 tonnes lime/ha each crop cycle is needed to neutralise this effect. The more N fertiliser used, the greater is the lime requirement. In addition, some forms of nitrogen fertiliser are more acidifying than others (ammonium sulphate more than urea more than calcium ammonium nitrate). In our guidelines for the Herbert, lime is recommended either when median soil pH falls below 5.5 or when exchangeable Ca is below 1.5 me%. On most soils, lime is required to neutralise soil acidity as the average pH over all Herbert soils is less than 5. However some sandy soils, particularly in the Stone River and Ingham Line areas have a soil pH above 5.5 but have very low exchangeable Ca levels. These soils also typically have low CECs, often below 1.5 me%. It is impossible to achieve the desired exchangeable Ca level of 1.5 me% on these soils. The only way that plant growth can be optimised (with sufficient Ca) is to maintain a supply of free calcium (unreacted lime) in the soil. More lime is needed on a high CEC clay soil than on a low CEC sandy soil to achieve an equivalent rise in soil pH. For the Herbert, three rates of lime application are suggested (Table 4.6). Discounts are again necessary where mill by-products have been used.

In situations where soil pH is very low (pH less than 4.5) it is preferable to increase pH gradually rather than to apply a very high rate of lime to achieve an immediate rise in soil pH to 5.5. Continued applications of lime each crop cycle above the maintenance application, until the target soil pH is reached, is better for both economic and agronomic reasons.

Table 4.6. Pulverised lime guidelines for acid soils (when pH_{water} <5.5) or for soils with low exchangeable Ca (<1.5 me%)

Soil CEC (me%)	Suggested lime application (tonnes/ha)
<3.0	2.5
3.0 - 6.0	4
>6.0	5

Modifications to suggested lime rates where mill by-products have been used

- **Mill mud** applied at 200-250 wet t/ha. Subtract 2.5 t/ha pulverised lime.
- **Mud/ash mixture** applied at 200-250 wet t/ha. Subtract 2.5 t/ha pulverised lime.
- **Mill ash** only. Subtract 2.5 t/ha pulverised lime.

Magnesium

Magnesium guidelines are based on soil critical levels for exchangeable magnesium (Table 4.7). Whilst a magnesium 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, but does not appear to affect plant growth provided all nutrients are above their critical levels and soil pH is above 5.5.

Table 4.7. Magnesium guidelines for plant crops (kg Mg/ha) for various soil exchangeable Mg levels.

Exch Mg (me%)	<0.05	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	>0.25
Magnesium application (kg Mg/ha)	150	125	100	75	50	0

Sodium

Sodium does not need to be applied but needs to be managed when it occurs at levels of above 6% of the CEC in the topsoil. Gypsum is the normal ameliorant for sodic soils because it is soluble but lime is an alternative on acidic soils. Rates of application are dependant on soil CEC and on exchangeable sodium percentage (ESP).

Micronutrients

Copper and zinc guidelines are based on soil critical levels and these nutrients are generally required on sandy soils. Leaf analysis is the preferred method of diagnosing whether micro-nutrient applications are required. Heavy applications of lime may induce deficiencies, particularly of zinc, when micronutrient levels are marginal.

For copper and zinc using the DTPA soil test:

Copper	soil test value <0.2 ppm	apply 10 kg Cu/ha once per crop cycle
Zinc	soil test value <0.3 ppm	apply 10 kg Zn/ha once per crop cycle

For zinc using the BSES zinc test:

Zinc	soil test value <0.6 ppm	apply 10 kg Zn/ha once per crop cycle

Silicon

Leaf analysis is the preferred method of diagnosing whether silicon applications are required. No deficiencies have been detected in the Herbert through leaf analysis.

There are two soil tests for silicon: $CaCl_2$ silicon and H_2SO_4 silicon. Using both soil tests together:

If $CaCl_2$ silicon is less than 10 mg/kg and H_2SO_4 silicon less than 70 mg/kg, then a response to silicon is likely.

To rectify a silicon deficiency, an application of 1.25 t/ha cement or 200-250 wet tonnes/ha of mill ash or mud/ash mixture is suggested.

CHAPTER 5

Description of Herbert sugarcane soils and guidelines for their management.

This chapter presents information on the location, appearance, properties and management requirements for 24 different soil types identified in the cane lands of the Herbert River District.

Herbert soil survey

Detailed mapping of Herbert sugarcane soils began in 1981 and is still continuing. Over 50,000 hectares of cane land have been mapped to a scale of 1:5,000. Each year between September and December, our two soil surveyors, Ron Rutherford and Sam Pennisi, walk over every cane block in a 2000 – 2500 hectare area augering holes to a depth of around 60cm. From this they are able to map the distribution of soils across the landscape and draw boundaries around each soil type. So far they have identified 24 different soils. Many soil types can occur on one farm and the soil pattern is sometimes so complex that up to four soil types can occur in one block. In this situation you will most probably decide on a major soil type in each block and manage it accordingly.

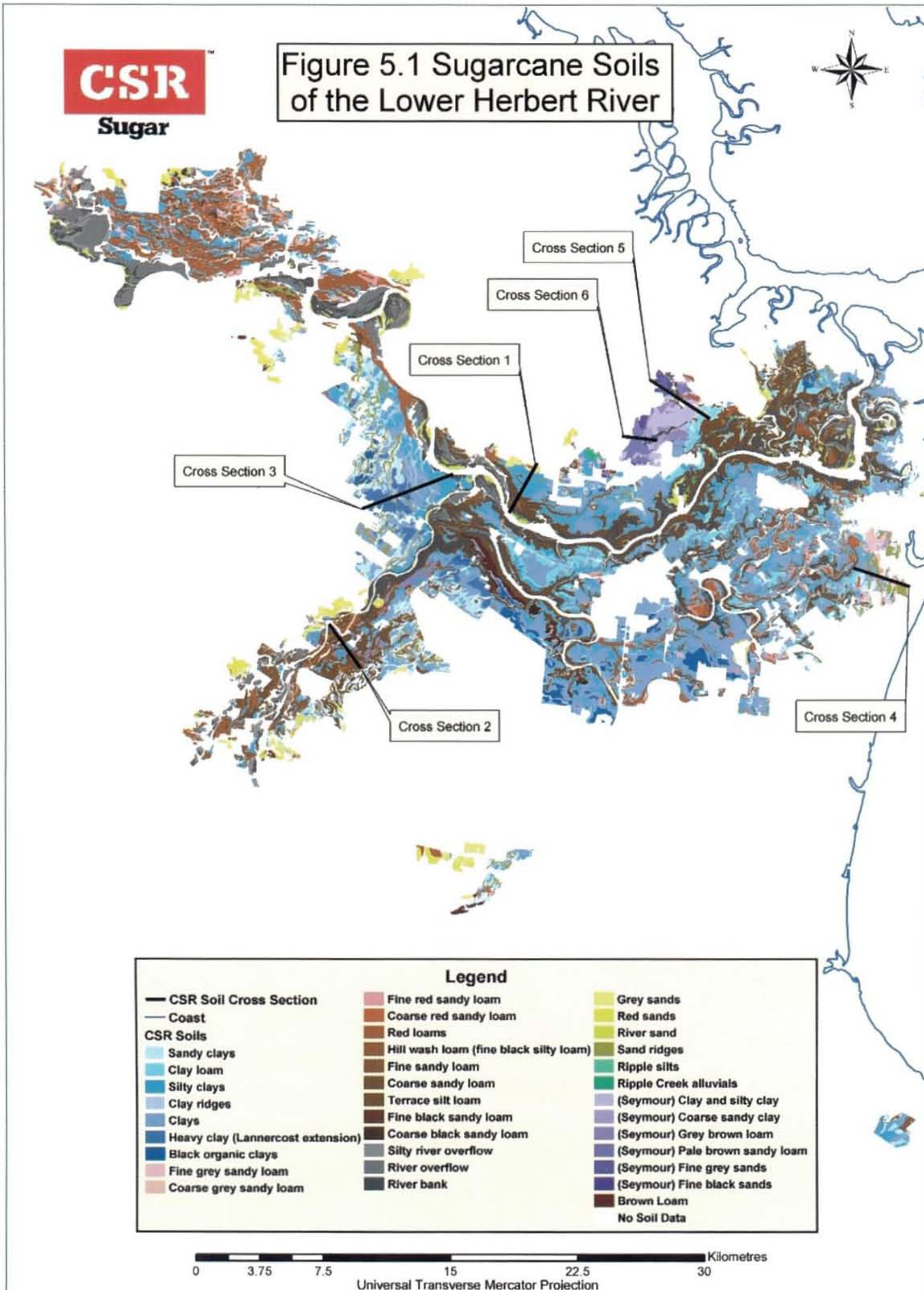
Soils are distinguished according to their colour and texture in both topsoil and subsoil as well as their drainage and position in the landscape. Some of these distinguishing features are used to name each soil type, which is intended to assist with soil identification and the use of soil names by growers.

In the year following the mapping of an area, around 60 sites considered representative of the different soil types are sampled for both topsoil (0-20 cm) and subsoil (40-60 cm). These samples are analysed for a range of chemical and physical properties and the results are stored in a large soil database which now contains data for more than 1200 sites. Median soil test values for each soil have been derived from this database.

The soil mapping data are stored in the Herbert Resource Information Centre's (HRIC) geographic information system. Soil maps for farms can be obtained through Herbert Cane Productivity Services Ltd (HCPSL), apart from those in the Ingham Line area which have not yet been mapped.

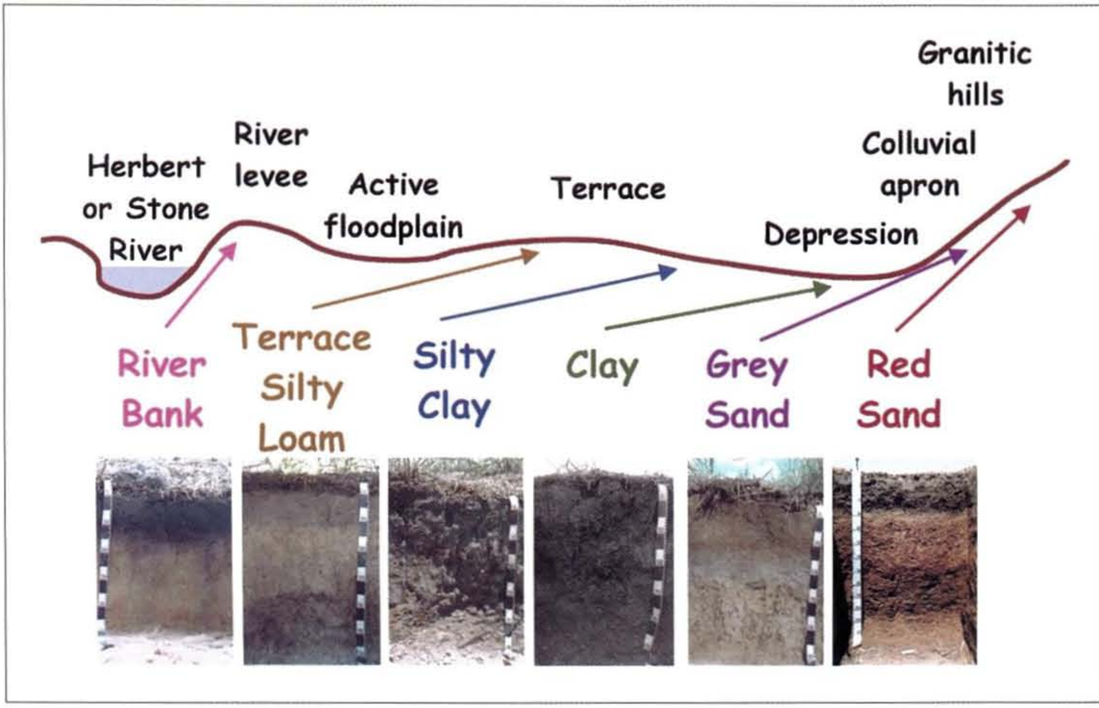
Location of different soils

Each soil is found in a particular part of the landscape. Six cross sections covering different parts of the Herbert landscape are shown on the following pages and illustrate where each soil occurs and its relationship to the river system, different topographic features and the surrounding hills. The approximate locations of these cross sections are shown in Figure 5.1.

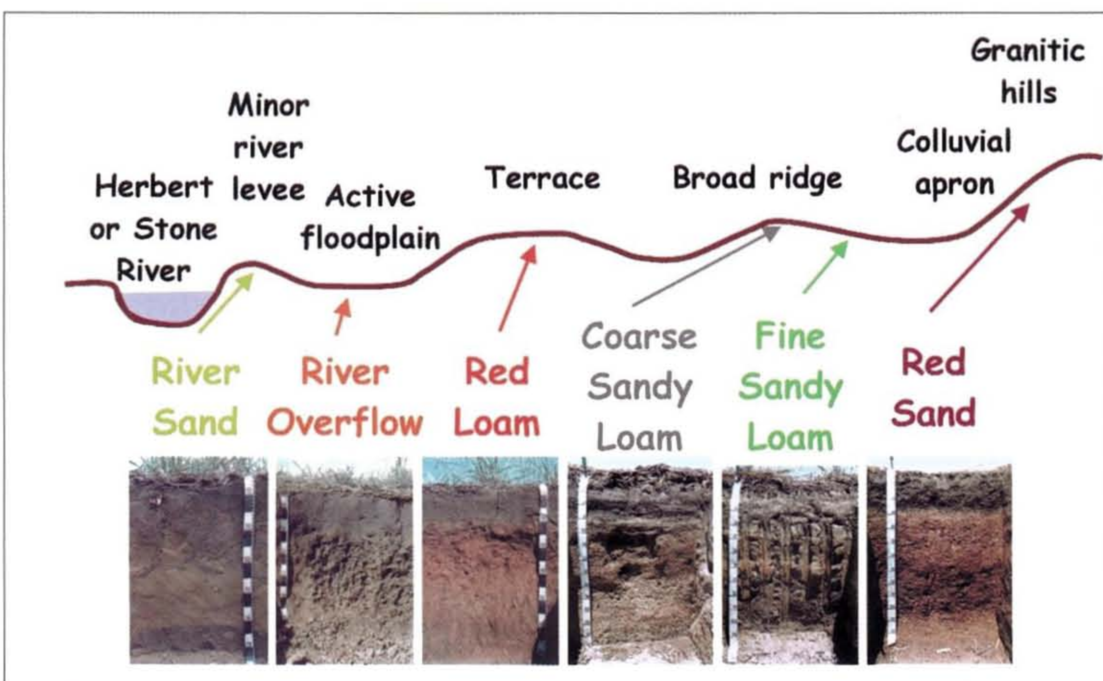


CSR
Sugar
Figure 5.1 Sugarcane Soils of the Lower Herbert River
Cross Section 5
Cross Section 6
Cross Section 1
Cross Section 3
Cross Section 2
Cross Section 4
Legend
CSR Soil Cross Section
Coast
CSR Soils
Sandy clays
Clay loam
Silty clays
Clay ridges
Clays
Heavy clay (Lannercost extension)
Black organic clays
Fine grey sandy loam
Coarse grey sandy loam
Fine red sandy loam
Coarse red sandy loam
Red loams
Hill wash loam (fine black silty loam)
Fine sandy loam
Coarse sandy loam
Terrace silt loam
Fine black sandy loam
Coarse black sandy loam
Silty river overflow
River overflow
River bank
Grey sands
Red sands
River sand
Sand ridges
Ripple silts
Ripple Creek alluvials
(Seymour) Clay and silty clay
(Seymour) Coarse sandy clay
(Seymour) Grey brown loam
(Seymour) Pale brown sandy loam
(Seymour) Fine grey sands
(Seymour) Fine black sands
Brown Loam
No Soil Data
Kilometres
0
3.75
7.5
15
22.5
30
Universal Transverse Mercator Projection
Geocentric Datum of Australia 1994 Zone 55

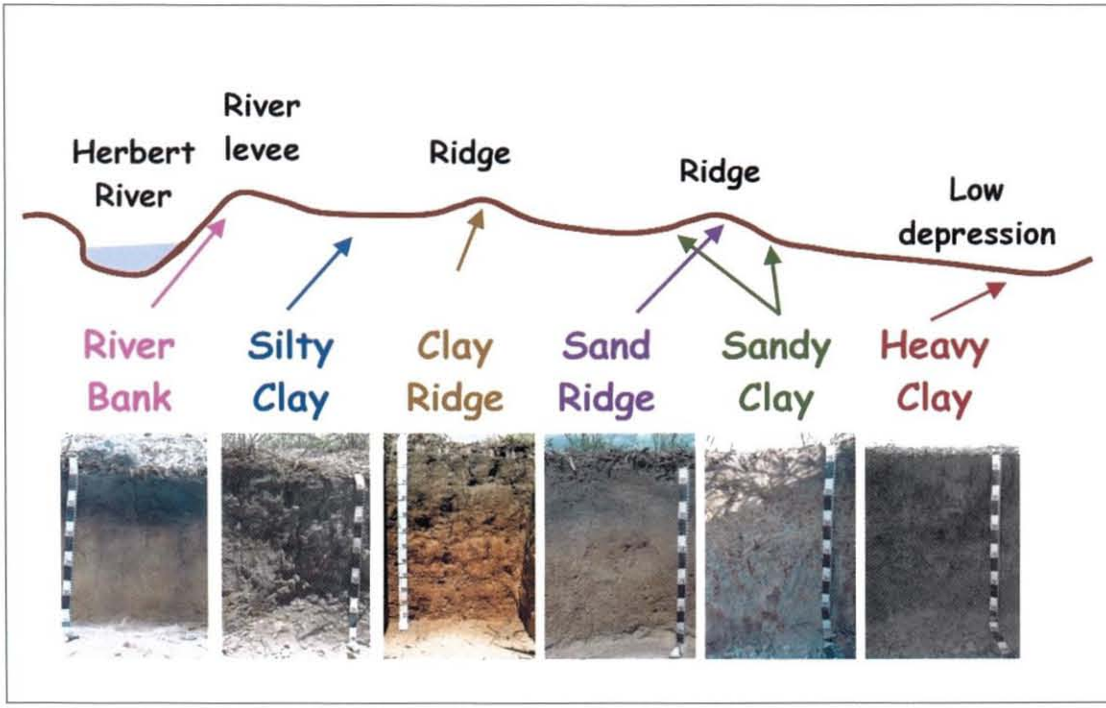
Cross Section 1: Soils close to the Lower Herbert and Stone Rivers



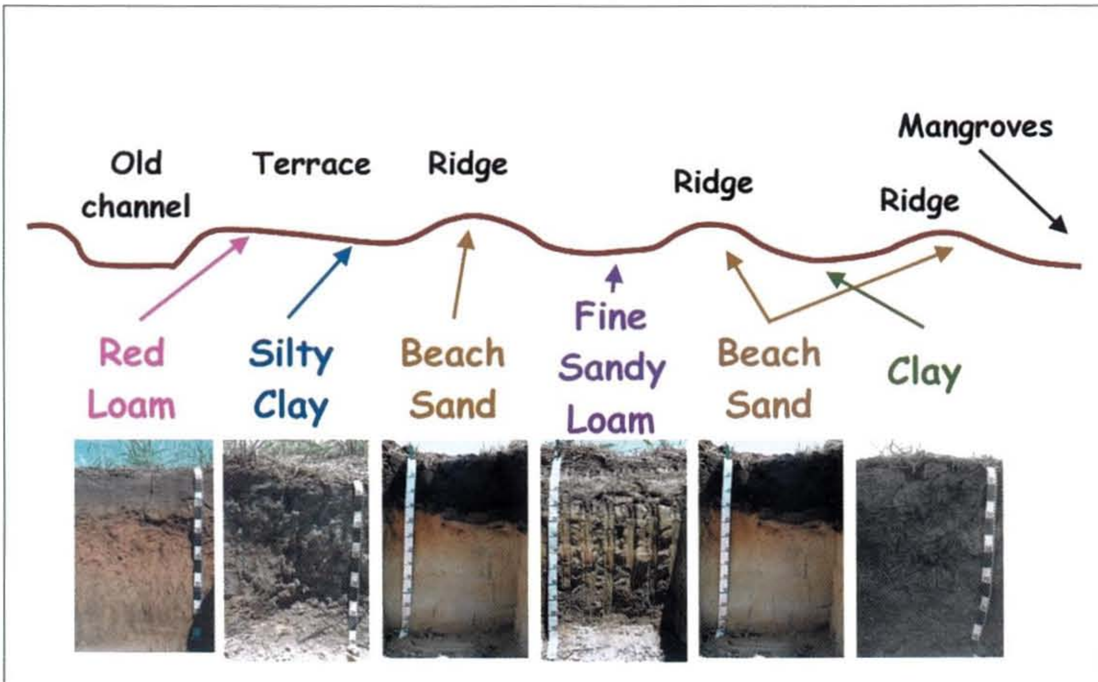
Cross Section 2: Soils close to the Upper Herbert and Stone Rivers



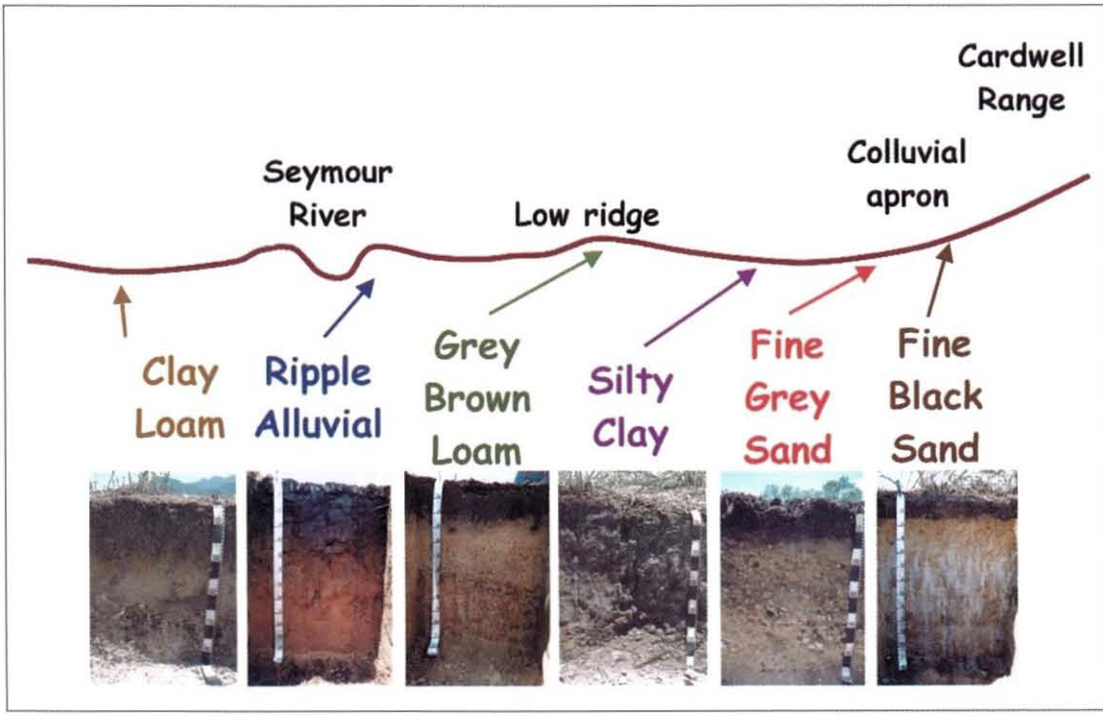
Cross Section 3: Soils in the Lannercost area



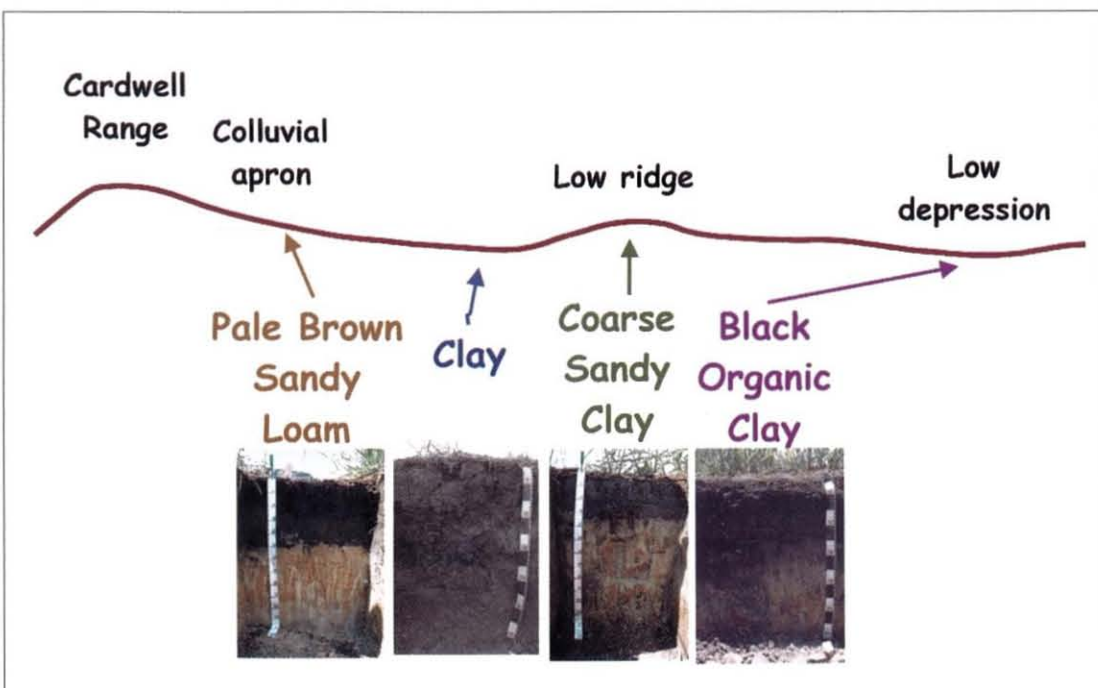
Cross Section 4: Soils in the coastal Four Mile area



Cross Section 5: Soils in the northern Seymour area



Cross Section 6: Soils in the southern Seymour area



Soil groups

The 24 soils can be grouped into seven broad categories based on their position in the landscape and how they have formed. These groups are:

1. Soils on recent alluvium close to the Herbert and Stone rivers affected by floods
   - River Sand
   - River Bank
   - River Overflow
2. Soils on terraces above the Herbert and Stone Rivers
   - Terrace Silty Loam (lower Herbert only)
   - Red Loam (upper Herbert and Stone only)
3. Clay soils in the lowest parts of the landscape
   - Silty Clay
   - Clay
   - Heavy Clay
   - Black Organic Clay
   - Clay Loam
4. Sandy soils formed on raised deposits following old stream channels
   - Sand Ridge
   - Clay Ridge
   - Sandy Clay
   - Coarse Sandy Loam
   - Fine Sandy Loam
5. Hillslope soils
   - Red Sand
   - Grey Sand
6. Seymour soils on acid volcanic parent material
   - Fine Black Sand
   - Fine Grey Sand
   - Pale Brown Sandy Loam
   - Grey Brown Loam
   - Coarse Sandy Clay
   - Ripple Alluvial
7. Beach ridge soils
   - Beach Sand Ridge

Soils in each of these seven groups have similar parent materials, are found next to each other in the landscape, have similar properties and thus have similar management requirements. Initially we intended to provide management guidelines at soil group level only. However opinion at grower meetings strongly favoured the presentation of management guidelines for all 24 soil types. Thus guidelines for all 24 soil types are given on the following pages. The soils are listed in alphabetical order.

For each soil type, information is presented on its occurrence, formation, field appearance and distinguishing features from similar but related soils. Chemical and physical properties are summarised and a bar graph is used to show how median soil test values, calculated from the soil analytical database, relate to desirable levels. Guidelines are given on the management of nutrient applications, tillage, water and environmental risks. Nutrient management guidelines are given for different crop situations such as fallow plant, replant and ratoons. However specific nutrient guidelines following the use of legume fallows and sugar mill by-products are not included and readers need to refer to Appendix 4 for this information. The nutrient management guidelines are intended to be used when a recent soil and/or leaf test is not available for a particular block.

Beach Sand Ridge

Occurrence: These soils occur as broad, black sand ridges close to the coastline in the Macknade, Lucinda, Halifax, Taylor's Beach and Four Mile areas. It is a minor soil occupying around 1% of the area under sugarcane.

Formation: These relatively young soils have formed on old beach ridges and sand dunes that once formed the coastline. Sediment from the Herbert River has subsequently extended the coastline beyond these features.

Beach Sand Ridge soil profile

Beach Sand Ridge soil in the Four Mile area

Field appearance:

These are young soils always occurring on high ridges. Profiles are always very sandy and well drained. They have a deep black loamy sand topsoil overlying a pale yellowish brown or almost white sandy subsoil.

Similar soils:

Sand Ridge soils occur on much narrower ridges and have a lower sand content and less organic matter in the topsoil.

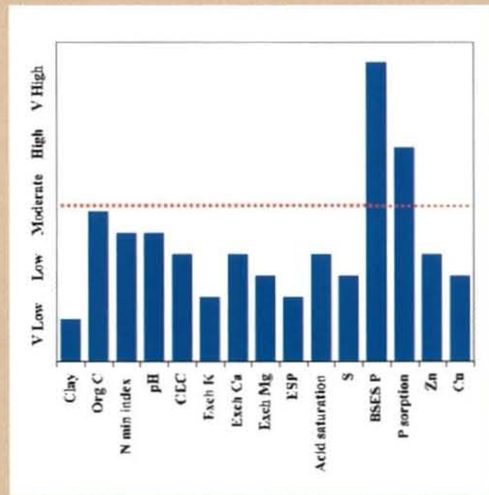
Coarse Sandy Loam soils are not as sandy, do not have such black topsoils, and have a wider range of subsoil colours ranging from red to grey.

Chemical properties:

These soils have a low nutrient status due to their extremely sandy texture but their high organic matter content is responsible for them being more fertile than some of the other sandy soils in the Herbert. Topsoils have moderate organic carbon levels and a low CEC. Exchangeable potassium is deficient in all profiles, calcium in >25% and magnesium in 50% of profiles. Acidic cations occupy 25% of total CEC. Sulphur deficiency occurs in >80% of profiles sampled, copper is deficient in >50% profiles and zinc in about 20% of profiles sampled. Median BSES phosphorus levels are very high with <40% of sites sampled requiring phosphorus. However, soils which need P require greater than replacement amounts of P fertiliser to satisfy crop requirements as they sorb P strongly.

Median soil test values for topsoils

Clay (%)	7.6
Organic C (%)	1.56
N mineralisation index	Moderate
pH (water)	5.23
CEC (me%)	2.29
Exch potassium (me%)	0.11
Exch calcium (me%)	1.25
Exch magnesium (me%)	0.26
Exch sodium (me%)	0.03
Exch sodium percentage (ESP)	1.31
Exch acidity (me%)	0.64
Acid saturation (%)	27.9
Sulphur (mg/kg)	5.0
BSES P (mg/kg)	75.0
P sorption	High
Zinc (mg/kg)	0.51
Copper (mg/kg)	0.16



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	110	40	0	120	10	50	10	0
Replant	2.5	130	40	0	120	10	50	10	0
Ratoon	0	130	20	0	120	10	0	0	0

Physical properties:

These well drained, very sandy soils have a low water holding capacity and are prone to drought but are easy to cultivate at all moisture contents. High leaching rates are likely.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter. Implements like rotary hoes are not required as these soils do not set hard. Laser levelling is not recommended as these soils are naturally very well drained and removal of their topsoil would severely reduce their productivity. Supplementary irrigation is essential to avoid stool death in dry periods.

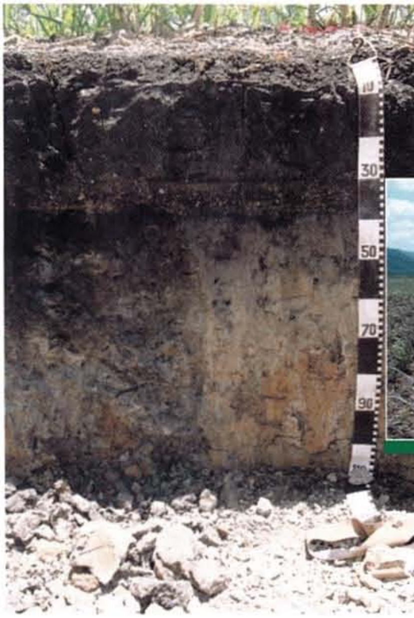
Environmental risk management:

Trash blanketing is essential for retaining moisture, increasing soil organic matter and CEC and for protecting the soil against erosion. The main environmental risk is leaching as these soils are very permeable. Split applications of fertiliser should be considered as well as growing fallow crops to protect the soil from erosion and to retain nutrients during the wet season.

Black Organic Clay

Occurrence: This soil occurs in low-lying, swampy depressions and backswamps throughout the lower Herbert but particularly in the Seymour, Macknade, Lannercost and Pomona areas. It is a minor soil type occupying around 1% of the cane area. It usually occurs adjacent to Clay soils but lower down in the landscape.

Formation: These soils have formed on heavy textured alluvium in depressions under conditions of poor drainage. During floods the finest clay and silt particles are deposited in these areas and organic matter accumulates to produce the black topsoils.



Black Organic Clay soils in the Seymour

Black Organic Clay soil profile

Field appearance: Profiles have deep, black, organic topsoils with an excellent structure. These overlie poorly drained, pale coloured, mottled subsoils.

Similar soils:

Clay soils have slightly lower clay content, less organic matter in the topsoil and a less well developed surface structure.

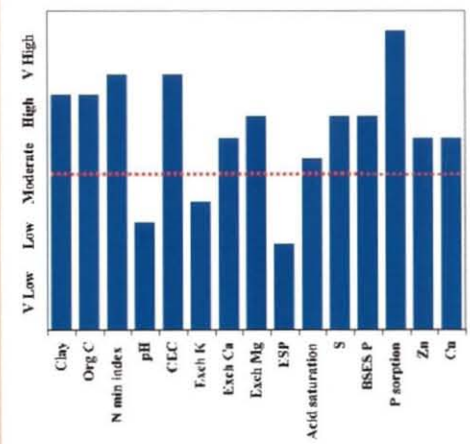
Heavy Clay soils are not so black in colour, have more clay, more surface cracking and a weaker surface structure.

Chemical properties:

These soils have high nitrogen reserves and a high nutrient storage capacity. Topsoils are high in organic matter and have a moderately high CEC. Lime is needed as soil pH is around 5.0 and acidic cations occupy over 40% of the CEC. Exchangeable potassium is moderately supplied and no calcium or magnesium deficiency occurs. There is no evidence of sulphur or micronutrient deficiencies. Phosphorus levels are usually adequate with only 30% of profiles requiring some phosphorus. Since these soils sorb phosphorus fertiliser strongly, where P is needed they require greater than replacement amounts of P fertiliser to satisfy crop requirements.

Median soil test values for topsoils

Clay (%)	42.7
Organic C (%)	2.32
N mineralisation index	High
pH (water)	5.00
CEC (me%)	10.12
Exch potassium (me%)	0.30
Exch calcium (me%)	3.15
Exch magnesium (me%)	2.01
Exch sodium (me%)	0.24
Exch sodium percentage (ESP)	2.37
Exch acidity (me%)	4.42
Acid saturation (%)	43.7
Sulphur (mg/kg)	23.5
BSES P (mg/kg)	52.0
P sorption	Very high
Zinc (mg/kg)	1.65
Copper (mg/kg)	0.73



Nutrient management guidelines

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	5	90	80	0	60	0	0	0	0
Replant	5	110	80	0	100	0	0	0	0
Ratoon	0	110	40	0	100	0	0	0	0

Physical properties:

These soils are characterised by a high organic matter content and excellent surface structure. They have high water tables and poor drainage, consequently profiles are usually wet thus imposing limitations on both tillage and harvesting operations.

Tillage and water management:

These soils occur in swampy depressions and are very difficult to drain. It is inadvisable to open up wetland areas containing these soils for sugarcane cultivation unless an obvious drainage outlet exists. Due to their wetness and high clay content there is a very restricted window of opportunity for tillage and traffic. In very wet years harvesting may be impossible. Their high organic matter and excellent surface structure means that these soils recover better from compaction than other heavy soils in the Herbert.

Environmental risk management:

Loss of nitrogen by denitrification is a major risk due to the common occurrence of waterlogging in these soils. Mounding of cane, surface application of nitrogen fertiliser and split fertiliser applications would help to limit these losses.

Clay

Occurrence: This is one of the major soil types in the Herbert River District occupying around 12% of the cane area. It occurs widely in flat or very gently sloping areas away from the river in the lowest part of the landscape. Clay soils are found extensively in the Hawkins Creek and Lannercost areas and occur adjacent to Silty Clay soils lower down in the landscape.

Formation: These soils have formed under conditions of poor drainage in the lowest part of the landscape where the finest clay particles are deposited. Organic matter also accumulates under such conditions.

Clay soil profile

Clay soils near Ripple Creek

Field appearance: Profiles are dark in colour with massive or weakly structured dark greyish brown silty clay loam topsoils overlying paler coloured, mottled, coarse structured, grey clay subsoils. Surface cracks are common in dry weather.

Similar soils:

Clay Loam soils have a more well developed topsoil structure and better profile drainage.

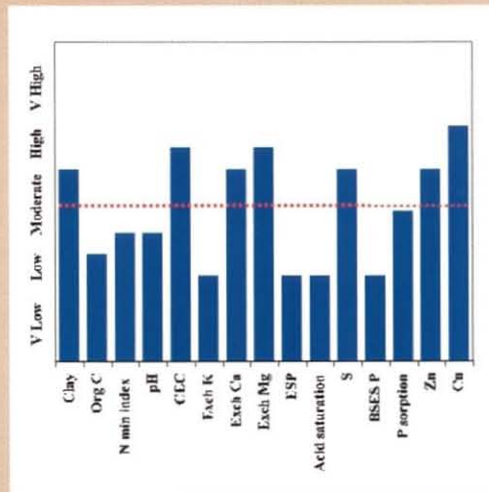
Heavy Clay soils have higher clay content particularly in the topsoil and also larger surface cracks in dry weather.

Chemical properties:

These soils have a moderately high chemical fertility. Topsoils have moderate organic matter content and a moderate CEC. Soil pH is around 5.1 and acidic cations occupy around 20% of the CEC. Whilst exchangeable potassium is low in about 70% of profiles sampled, calcium and magnesium are not deficient in any profiles. Sulphur is adequate in nearly all samples and there is no evidence of micronutrient deficiencies. Median BSES P levels are 24 mg/kg in the topsoil and around 60% of profiles require some phosphorus. About 30% of these soils have sodic subsoils and these occur mainly in the drier parts of the district to the south of Ingham.

Median soil test values for topsoils

Clay (%)	32.9
Organic C (%)	1.10
N mineralisation index	Moderately low
pH (water)	5.12
CEC (me%)	7.43
Exch potassium (me%)	0.20
Exch calcium (me%)	3.01
Exch magnesium (me%)	2.14
Exch sodium (me%)	0.15
Exch sodium percentage (ESP)	2.02
Exch acidity (me%)	1.51
Acid saturation (%)	20.3
Sulphur (mg/kg)	17.0
BSES P (mg/kg)	24.0
P sorption	Moderate
Zinc (mg/kg)	1.48
Copper (mg/kg)	1.27



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	5	120	60	20	100	0	0	0	0
Replant	5	140	60	20	100	0	0	0	0
Ratoon	0	140	30	0	100	0	0	0	0

Physical properties:

These poorly drained soils have seasonally high water tables. The high silt content and high magnesium and sodium levels in some profiles cause them to be massive and hard setting.

Tillage and water management:

They have a restricted moisture range for both tillage and trafficability and are often compacted due to harvesting operations occurring when soils are too wet. The presence of shrink-swell clays assists recovery from compaction. Soil ameliorants such as mill ash improve friability and water holding capacity particularly where soils are sodic. Laser levelling is essential for improving surface drainage and for reducing the incidence of waterlogging. Cross drains may also be beneficial.

Environmental risk management:

Loss of nitrogen by denitrification is a constant risk. Strategies to reduce these losses include mounding of cane, application of nitrogen fertiliser to the surface of the mound and split application of fertiliser.

Clay Loam

Occurrence: These soils occur mainly in the lower Herbert around Ripple Creek and Macknade and occupy around 5% of the cane area. They occur on flat or very gently sloping areas away from the Herbert River in the lowest part of the landscape. They are commonly covered with water during major floods and occur in association with Terrace Silty Loam soils but lower down in the landscape.

Formation: These soils have formed on heavy textured alluvium under conditions of poor drainage in the lowest part of the landscape where the finest clay particles are deposited. Organic matter also accumulates under such conditions.

Clay Loam soils in the Ripple Creek area

Clay Loam soil profile

Field appearance: Profiles have deep, dark, organic silty clay loam topsoils which are friable and well structured. They overlie paler coloured, mottled, coarse structured, grey silty clay loam subsoils. Surface cracks are not so common in these soils.

Similar soils:

Clay soils have a higher clay content and a poorer, more massive structure which results in bigger lumps when cultivated.

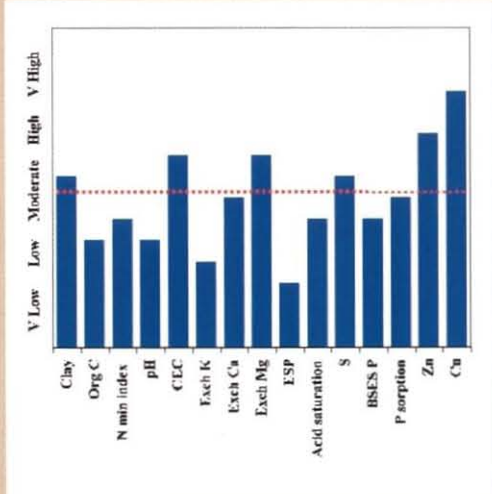
Silty Clay soils are also more massive, lower in organic matter content and have paler coloured topsoils.

Chemical properties:

These soils have moderate chemical fertility. Topsoils are moderately low in organic matter and have a moderate CEC. Soils are very acid with pH of around 4.8 and acidic cations occupying more than 30% of the CEC. Calcium and magnesium are not deficient but potassium is low in about 70% of profiles sampled. There is no evidence of sulphur or micronutrient deficiencies. Median BSES P levels are 31 mg/kg in the topsoil and around 60% of profiles require some phosphorus.

Median soil test values for topsoils

Clay (%)	31.1
Organic C (%)	1.03
N mineralisation index	Moderately low
pH (water)	4.84
CEC (me%)	6.97
Exch potassium (me%)	0.20
Exch calcium (me%)	2.28
Exch magnesium (me%)	1.80
Exch sodium (me%)	0.12
Exch sodium percentage (ESP)	1.72
Exch acidity (me%)	2.28
Acid saturation (%)	32.7
Sulphur (mg/kg)	16.0
BSES P (mg/kg)	31.2
P sorption	Moderate
Zinc (mg/kg)	2.21
Copper (mg/kg)	1.31



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	5	120	60	20	100	0	0	0	0
Replant	5	140	60	20	100	0	0	0	0
Ratoon	0	140	30	0	100	0	0	0	0

Physical properties:

These poorly drained soils have seasonally high water tables. Consequently profiles are usually wet thus imposing limitations on both tillage and harvesting operations.

Tillage and water management:

They have a restricted moisture range for both tillage and trafficability and are prone to compaction due to their high silt content. Compaction of these soils is common due to harvesting operations occurring when soils are too wet. Soil ameliorants such as mill ash improve friability and water holding capacity. Laser levelling is essential for improving surface drainage and for reducing the incidence of waterlogging. Headland compaction may also need to be alleviated for better infield drainage.

Environmental risk management:

Loss of nitrogen by denitrification is a constant risk. Strategies to reduce these losses include mounding of cane, application of nitrogen fertiliser to the surface of the mound and split application of fertiliser.

Clay Ridge

Occurrence: These soils occur as broad, winding ridges following old prior stream channels which occur in the Lannercost area between Stone River and Long Pocket. They grade into sand ridges away from the Herbert River and into Red Loams close to the River. It is a minor soil occupying less than 1% of the area under sugarcane.

Formation: These soils have formed on sandy channel infill deposits following old prior stream channels and contain a reasonable amount of silt and clay. The infill deposits become much sandier away from the Herbert River.

Clay Ridge soil in Lannercost

Clay Ridge soil profile

Field appearance: These soils always occur on a ridge. Profiles are well drained and have a dark brown loam topsoil overlying a bright yellowish brown, gritty sandy clay loam subsoil.

Similar soils:

Sand Ridge soils occur on narrower ridges and have more coarse sand and less silt and clay in the profile. They have paler colours in the subsoil.

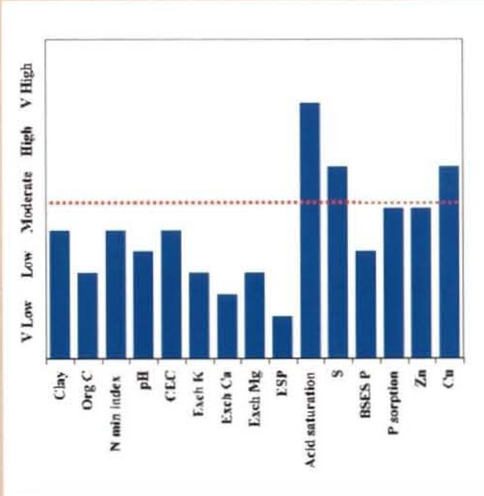
Red Loam soils have similar topsoil textures but more clay in the subsoil. They do not occur on such pronounced ridges and have much redder colours in the subsoil.

Chemical properties:

Topsoils are moderately low in organic matter and the whole profile is very acidic with a pH below 4.6. They have a moderate CEC but acidic cations commonly occupy over 70% of the CEC. Consequently all exchangeable nutrients occur at low levels. Exchangeable potassium is deficient in nearly all profiles and calcium and magnesium are deficient in >60% of profiles. Sulphur is adequate in most profiles sampled as are copper and zinc. Most soils are well supplied with phosphorus.

Median soil test values for topsoils

Clay (%)	22.3
Organic C (%)	0.82
N mineralisation index	Moderately low
pH (water)	4.52
CEC (me%)	3.06
Exch potassium (me%)	0.19
Exch calcium (me%)	0.42
Exch magnesium (me%)	0.22
Exch sodium (me%)	0.03
Exch sodium percentage (ESP)	0.98
Exch acidity (me%)	2.20
Acid saturation (%)	71.9
Sulphur (mg/kg)	20.1
BSES P (mg/kg)	30.0
P sorption	Moderate
Zinc (mg/kg)	0.88
Copper (mg/kg)	0.71



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	4	120	60	20	80	0	50	0	0
Replant	4	140	60	20	100	0	50	0	0
Ratoon	0	140	30	0	100	0	0	0	0

Physical properties:

These well drained soils have a moderate water holding capacity and are reasonably easy to cultivate. They have few restrictions to root development.

Tillage and water management:

Intensive tillage is not normally required unless the soils are badly compacted. Tillage should be minimised to conserve moisture and organic matter. Soil compaction can be a problem as these soils are favoured for harvesting in wet conditions and care needs to be taken in avoiding tillage and traffic when soils are too wet. Laser levelling is unlikely to be necessary as soils are well drained and have a good natural slope.

Environmental risk management:

Trash blanketing is beneficial for retaining moisture, increasing soil organic matter and CEC and for protecting the soil against erosion. The main environmental risk is leaching. Split applications of fertiliser should be considered as well as growing fallow crops to protect the soil from erosion and to retain nutrients during the wet season.

Coarse Sandy Clay

Occurrence: These soils occur in four small areas in the Seymour on gently sloping lower slopes below the sandy colluvial fan deposits. It is a very minor soil occupying less than 1% of the area under sugarcane.

Formation: These soils have formed in a similar way to the Grey Brown Loams except that the channel infill deposits are derived from both acid volcanic and granitic material. Profiles contain more coarse sand and gravel than other soils in the Seymour. The grey, mottled subsoil indicates a seasonally high water table.

Coarse Sandy Clay soils in the Seymour

Coarse Sandy Clay soil profile

Field appearance: Profiles commonly have dark brown to grey brown, loamy topsoils abruptly overlying light brownish grey, clay loam subsoils. Strong mottling occurs in the subsoil and angular coarse sand and gravel occur throughout the profile.

Similar soils:

Grey Brown Loam soils have paler topsoils, more mottling and concretions in the subsoil and much less coarse sand.

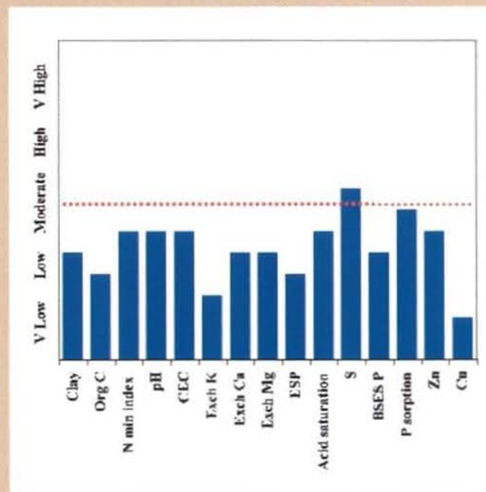
Clay Loam soils have deeper topsoils, paler coloured subsoils indicating poorer drainage and much less coarse sand and gravel.

Chemical properties:

These soils are not very fertile due to a moderately low organic matter content and low CEC. Topsoil pH averages 5.1 and acidic cations occupy around 35% of total CEC. Calcium and magnesium are low but not deficient whilst potassium is deficient in all profiles sampled. There is no evidence of sulphur or zinc deficiency but copper is deficient in all profiles. Most soils are well supplied with phosphorus.

Median soil test values for topsoils

Clay (%)	18.9
Organic C (%)	0.94
N mineralisation index	Moderately low
pH (water)	5.05
CEC (me%)	2.93
Exch potassium (me%)	0.15
Exch calcium (me%)	1.34
Exch magnesium (me%)	0.39
Exch sodium (me%)	0.06
Exch sodium percentage (ESP)	2.05
Exch acidity (me%)	0.99
Acid saturation (%)	33.8
Sulphur (mg/kg)	14.6
BSES P (mg/kg)	30.0
P sorption	Moderate
Zinc (mg/kg)	0.74
Copper (mg/kg)	0.10



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	120	60	20	100	0	0	10	0
Replant	2.5	140	60	20	100	0	0	10	0
Ratoon	0	140	30	0	100	0	0	0	0

Physical properties:

These soils have a high coarse sand content compared with other Seymour soils and are imperfectly to poorly drained. They remain wet for longer than other coarse sandy soils as they are usually underlain by a clay layer and have a high seasonal water table.

Tillage and water management:

They have a restricted moisture range for both tillage and trafficability. Compaction of these soils is common due to harvesting operations occurring when soils are too wet. Laser levelling is recommended for improving surface drainage and for reducing the incidence of waterlogging.

Environmental risk management:

Trash blanketing is beneficial for increasing soil organic matter and CEC and for protecting the soil from erosion. There is a moderate risk of denitrification and split applications of fertiliser would be appropriate, particularly for late cut blocks.

Coarse Sandy Loam

Occurrence: These soils occur on the crests and upper slopes of broad sandy deposits mainly in the upper parts of the sugarcane area. They grade into Fine Sandy Loams lower down the slope. They are particularly extensive in the Abergowrie and Stone River areas. They occupy around 5% of the area which has been mapped.

Formation: These soils have formed on broad expanses of sandy material that have been deposited in and around old prior stream channels. Soils overlying the prior streams are reddish brown in colour and grade into yellowish brown and greyish brown versions down the slope.

Coarse Sandy Loam landscape in Stone River

Coarse Sandy Loam soil profile

Field appearance: Profiles are commonly well drained and have a dark brown coarse sandy loam topsoil overlying a coarse sandy loam or coarse sandy clay loam subsoil which can range in colour from reddish brown to yellowish brown or to greyish brown.

Similar soils:

Sand Ridge soils have a similar texture but occur on narrow winding ridges and occupy much smaller areas.

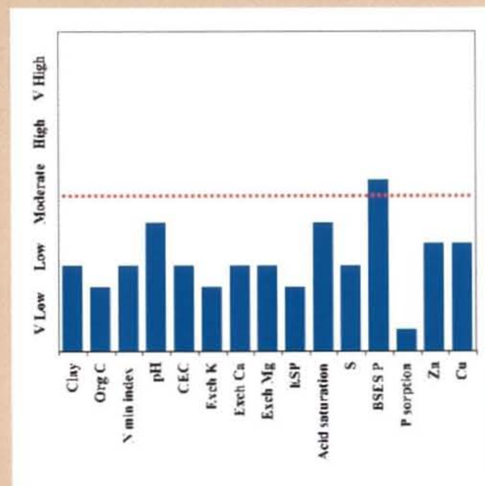
Fine Sandy Loam soils occur lower down in the landscape and are not so well drained. They have much less coarse sand and more fine sand and have paler colours.

Chemical properties:

These soils have low nutrient status due to their low organic matter and CEC. Exchangeable potassium is deficient in all profiles, calcium in >30% and magnesium in >50% of profiles. Acidic cations occupy more than 30% of total CEC. Sulphur deficiency occurs in about 60% of profiles sampled. Copper is deficient in >40% profiles and zinc in about 20% of profiles sampled. Mean BSES phosphorus levels are adequate to high in some profiles although around 50% of sites sampled require some phosphorus.

Median soil test values for topsoils

Clay (%)	15.1
Organic C (%)	0.67
N mineralisation index	Low
pH (water)	5.13
CEC (me%)	1.69
Exch potassium (me%)	0.14
Exch calcium (me%)	0.76
Exch magnesium (me%)	0.24
Exch sodium (me%)	0.03
Exch sodium percentage (ESP)	1.78
Exch acidity (me%)	0.52
Acid saturation (%)	30.8
Sulphur (mg/kg)	5.5
BSES P (mg/kg)	44.5
P sorption	Very low
Zinc (mg/kg)	0.51
Copper (mg/kg)	0.21



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	130	40	10	120	15	50	10	10
Replant	2.5	150	40	10	120	15	50	10	10
Ratoon	0	150	20	10	120	15	0	0	0

Physical properties:

These well drained, very sandy soils are prone to drought as they have a low water holding capacity. They are also prone to leaching but are easy to cultivate at all moisture contents.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter. Implements like rotary hoes do not need to be used. Excessive tillage will deplete the already low levels of soil organic matter. Laser levelling is not recommended as these soils have shallow topsoils which if removed can severely reduce their productivity. Good responses to supplementary irrigation can be expected.

Environmental risk management:

Trash blanketing is essential for retaining moisture, increasing soil organic matter and CEC, and for protecting the soil against erosion. The main environmental risk is leaching and split applications of fertiliser should be considered as well as growing fallow crops to protect the soil from erosion and to retain nutrients during the wet season.

Fine Black Sand

Occurrence: These distinctive black soils occur on the lower slopes of alluvial or colluvial fans in the Seymour and in eastern Hawkins Creek, close to the Cardwell Range where there are acid volcanic rocks. The high proportion of fine sand in these soils originates from the fine sandy acid volcanic parent material. It is a minor soil occupying less than 1% of the area under sugarcane.

Formation: These soils have formed on fine sandy colluvial or alluvial fans. The dark organic topsoil indicates organic matter accumulation. This and the pale coloured subsoil may have formed as a result of the wet conditions caused by continuous seepage from the adjacent hills.

Fine Black Sand soils in the Seymour

Fine Black Sand soil profile

Field appearance: Profiles commonly have deep, moderately structured, black, fine sandy loam topsoils abruptly overlying very pale coloured, almost white fine sandy loam subsoils. Rounded river gravels occur in some profiles.

Similar soils:

Fine Grey Sand soils have similar pale coloured, fine sandy subsoils but have much less organic matter in the topsoil and consequently greyer colours.

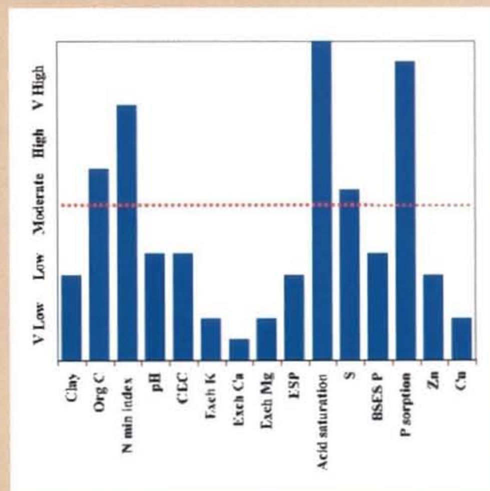
Pale Brown Sandy Loam soils have lighter coloured topsoils containing less organic matter.

Chemical properties:

Although these soils are well supplied with nitrogen and sulphur due to a high organic matter content they are deficient in most other nutrients due to a very low CEC and losses of nutrients through leaching. Topsoil pH averages 4.7 and acidic cations occupy more than 70% of the total CEC. Exchangeable calcium, magnesium and potassium are deficient in nearly all profiles sampled. Copper and zinc are also deficient in most profiles. Most soils are well supplied with phosphorus but since these soils sorb phosphorus fertiliser strongly, where P is needed they require greater than replacement amounts of P fertiliser to satisfy crop requirements.

Median soil test values for topsoils

Clay (%)	13.0
Organic C (%)	1.88
N mineralisation index	High
pH (water)	4.70
CEC (me%)	2.16
Exch potassium (me%)	0.08
Exch calcium (me%)	0.14
Exch magnesium (me%)	0.06
Exch sodium (me%)	0.05
Exch sodium percentage (ESP)	2.31
Exch acidity (me%)	1.83
Acid saturation (%)	84.7
Sulphur (mg/kg)	15.7
BSES P (mg/kg)	30.0
P sorption	Very high
Zinc (mg/kg)	0.33
Copper (mg/kg)	0.08



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	90	80	30	120	0	125	10	10
Replant	2.5	110	80	30	120	0	125	10	10
Ratoon	0	110	40	0	120	0	0	0	0

Physical properties:

These fine sandy soils have relatively high plant available water content due to their high organic matter. However they are prone to leaching. Profiles often remain wet well into the dry season due to constant seepage of water from the surrounding hills.

Tillage and water management:

Despite their sandy texture these soils are often wet due to seepage. It is important that the surface horizons are given sufficient time to dry out prior to tillage or harvesting operations to avoid soil damage and compaction. Tillage should be kept to a minimum in order to conserve organic matter and the use of rotary hoes should be avoided. Springs and seeps can be drained using slotted underground pipes provided there is a suitable outfall.

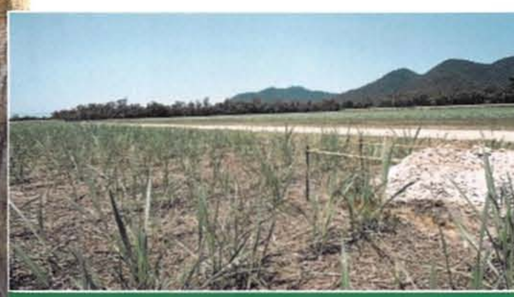
Environmental risk management:

These soils are highly permeable and the risk of leaching is high. Split applications of fertiliser would be appropriate as would the growth of fallow crops for retaining nutrients during the wet season. There is a moderately high risk of denitrification, given the high organic matter level, particularly for late cut blocks.

Fine Grey Sand

Occurrence: These soils occur in association with Fine Black Sands on the lower slopes of alluvial or colluvial fans in the Seymour and in eastern Hawkins Creek, close to the Cardwell Range where there are acid volcanic rocks. The high proportion of fine sand in these soils originates from the fine sandy acid volcanic parent material. It is a minor soil occupying less than 1% of the area under sugarcane.

Formation: These soils have formed on fine sandy material derived from acid volcanic rocks. The pale colours are the result of the constant seepage of water from the adjacent hills and the continuous wet conditions.



Fine Grey Sand soils in the Seymour

Fine Grey Sand soil profile

Field appearance: Profiles commonly have shallow, dark brown loam topsoils abruptly overlying pale coloured loam subsoils with abundant mottling just below the organic topsoil.

Similar soils:

Fine Black Sand soils have deeper, blacker topsoils and similar pale coloured but sandier subsoils.

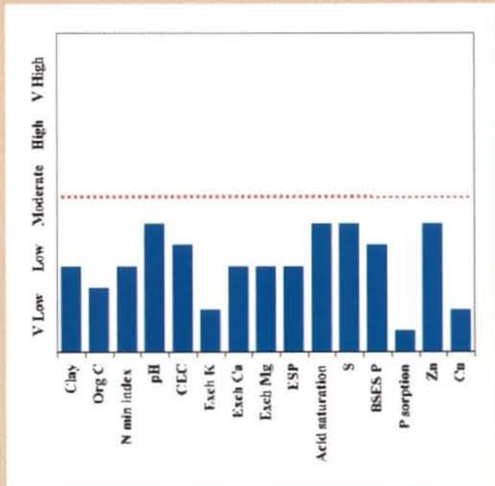
Pale Brown Sandy Loam soils have deeper, darker coloured topsoils and fewer signs of restricted drainage in the subsoil.

Chemical properties:

These soils have low natural fertility and need to be carefully managed for sugarcane production. They are low in organic matter and are very low in other nutrients due to a very low CEC and losses of nutrients through leaching. Topsoil pH averages 5.1 and acidic cations occupy around 40% of total CEC. Exchangeable calcium, magnesium and potassium are deficient in nearly all profiles sampled as is available copper and zinc. Sulphur is deficient in 25% of profiles sampled. Most soils are moderately well supplied with phosphorus.

Median soil test values for topsoils

Clay (%)	13.0
Organic C (%)	0.67
N mineralisation index	Low
pH (water)	5.10
CEC (me%)	2.03
Exch potassium (me%)	0.08
Exch calcium (me%)	0.98
Exch magnesium (me%)	0.21
Exch sodium (me%)	0.06
Exch sodium percentage (ESP)	2.96
Exch acidity (me%)	0.70
Acid saturation (%)	34.5
Sulphur (mg/kg)	10.1
BSES P (mg/kg)	30.0
P sorption	Very low
Zinc (mg/kg)	0.67
Copper (mg/kg)	0.07



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	130	40	10	120	0	50	10	10
Replant	2.5	150	40	10	120	0	50	10	10
Ratoon	0	150	20	0	120	0	0	0	0

Physical properties:

These fine sandy soils are prone to leaching. However profiles often remain wet well into the dry season due to constant seepage of water from the surrounding hills.

Tillage and water management:

Despite their sandy texture these soils are often wet due to seepage. It is important that the surface horizons are given sufficient time to dry out prior to tillage or harvesting operations to avoid soil damage and compaction. Tillage should be kept to a minimum in order to conserve organic matter and the use of rotary hoes should be avoided. Springs and seeps can be drained using slotted underground pipes provided there is a suitable outfall. Laser levelling would also improve surface drainage and reduce the incidence of waterlogging.

Environmental risk management:

Trash blanketing is beneficial for increasing soil organic matter and CEC and for protecting the soil from erosion. These soils are permeable with a moderate risk of leaching. Split applications of fertiliser would be appropriate as would the growth of fallow crops for retaining nutrients during the wet season. There is a moderately high risk of denitrification, particularly for late cut blocks, due to the wet conditions.

Fine Sandy Loam

Occurrence: These soils occur on the middle and lower slopes of broad sandy deposits mainly in the upper parts of the sugarcane area. They grade into Coarse Sandy Loams higher up the slope. They are particularly extensive in the Abergowrie and Stone River areas. They occupy around 5% of the area which has been mapped.

Formation: These soils have formed on the lower slopes of broad expanses of sandy material that have been deposited in and around old prior stream channels. They have formed under conditions of restricted drainage and have greyish colours and mottling in the subsoil.

Fine Sandy Loam landscape in Stone River

Fine Sandy Loam soil profile

Field appearance: Profiles are commonly imperfectly drained and have a dark greyish brown fine sandy loam topsoil overlying a pale yellowish brown to grey brown fine sandy clay loam to fine sandy clay subsoil with common rusty mottles.

Similar soils:

Coarse Sandy Loam soils occur higher up in the landscape and have better drainage. They have more coarse sand, less fine sand and have brighter reddish or brownish colours.

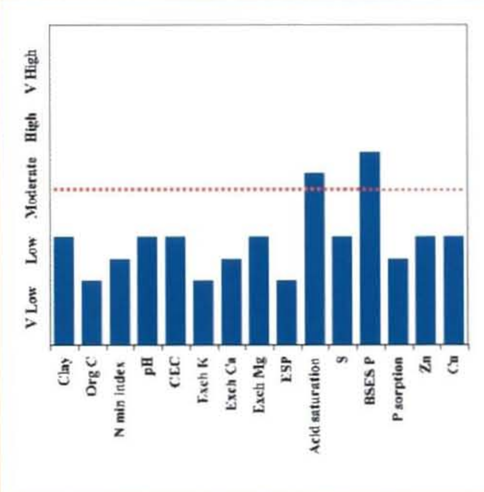
Sandy Clay soils occur in a similar position in the landscape but usually adjacent to narrow sand ridges. They are paler in colour with more coarse sand and less fine sand in the profile.

Chemical properties:

These soils have a low nutrient status due to their low organic matter and low CEC. Exchangeable potassium is deficient in over 80% of profiles, calcium in 30% and magnesium in 38% of profiles. Acidic cations occupy more than 40% of total CEC. Sulphur deficiency occurs in about 40% of profiles sampled. Copper is deficient in about 30% of profiles and zinc in around 25% of profiles sampled. Mean BSES phosphorus levels are adequate in most profiles with around 35% of sites sampled requiring some phosphorus. Some profiles have sodic subsoils and these occur principally in the drier parts of the district.

Median soil test values for topsoils

Clay (%)	17.3
Organic C (%)	0.69
N mineralisation index	Low
pH (water)	4.89
CEC (me%)	2.28
Exch potassium (me%)	0.14
Exch calcium (me%)	0.80
Exch magnesium (me%)	0.32
Exch sodium (me%)	0.03
Exch sodium percentage (ESP)	1.32
Exch acidity (me%)	0.99
Acid saturation (%)	43.4
Sulphur (mg/kg)	7.0
BSES P (mg/kg)	50.9
P sorption	Low
Zinc (mg/kg)	0.58
Copper (mg/kg)	0.30



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	130	40	10	100	15	0	0	0
Replant	2.5	150	40	10	100	15	0	0	0
Ratoon	0	150	20	10	100	15	0	0	0

Physical properties:

These imperfectly drained soils have seasonally high water tables and may remain wet due to seepage along the boundary between the Coarse Sandy Loams and these finer textured soils. They are commonly poorly structured with massive, hard setting topsoils. This is particularly evident where they are sodic.

Tillage and water management:

Their hard setting surface and vulnerability to compaction make a good tilth difficult to achieve although green cane trash blanketing has improved soil structure. Tillage should be kept to a minimum to conserve moisture and organic matter and rotary hoes should be used with care. Laser levelling is essential for improving surface drainage and slotted underground pipes are useful for draining springs and seeps.

Environmental risk management:

Trash blanketing is essential for retaining moisture, increasing soil organic matter and CEC and for protecting the soil against erosion. The main environmental risk is denitrification, particularly for late cut blocks. Split applications of fertiliser should be considered as well as growing fallow crops for protecting the soil from erosion and to retain nutrients during the wet season. Exposure of the subsoil in drain construction or in laser levelling increases the risk of subsoil erosion (gullying) due to the dispersive nature of some of these soils.

Grey Brown Loam

Occurrence: These soils occur on broad east-west trending ridges in the Seymour and in Hawkins Creek near the north eastern part of the Cardwell Range. The high proportion of fine sand in these soils originates from the fine sandy acid volcanic parent material. They are a minor soil occupying less than 1% of the area under sugarcane.

Formation: These soils have formed on channel infill deposits derived from acid volcanic material which occurs in broad, low ridges across the landscape. The grey colours and mottling in the subsoil are indicative of a seasonally high water table.

Grey Brown Loams in the Seymour

Grey Brown Loam soil profile

Field appearance: Profiles commonly have shallow, weakly structured, dark brown, loamy topsoils abruptly overlying greyish brown clay loam subsoils. Abundant mottles and hard concretions occur in the subsoil.

Similar soils:

Pale Brown Sandy Loam soils have deeper and darker topsoils and more fine sand, particularly in the subsoil.

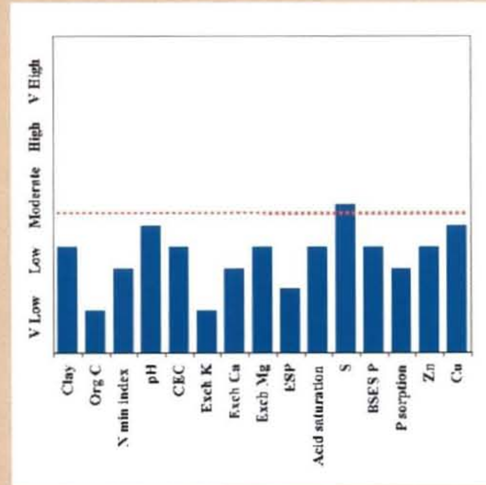
Fine Grey Sand soils have shallower topsoils and paler coloured subsoils indicating poorer drainage.

Chemical properties:

These soils are not very fertile due to low organic matter content and low CEC. Topsoil pH averages 5.0 and acidic cations occupy around 25% of total CEC. Exchangeable calcium is low and is deficient in 60% of profiles whilst potassium is deficient in all profiles sampled. Copper and zinc are deficient in around 40% of profiles. Most soils are well supplied with phosphorus but sulphur is low in some profiles.

Median soil test values for topsoils

Clay (%)	19.2
Organic C (%)	0.56
N mineralisation index	Low
pH (water)	5.04
CEC (me%)	2.09
Exch potassium (me%)	0.10
Exch calcium (me%)	0.95
Exch magnesium (me%)	0.42
Exch sodium (me%)	0.04
Exch sodium percentage (ESP)	1.91
Exch acidity (me%)	0.58
Acid saturation (%)	27.8
Sulphur (mg/kg)	12.5
BSES P (mg/kg)	30.0
P sorption	Low
Zinc (mg/kg)	0.50
Copper (mg/kg)	0.31



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	130	40	10	120	10	0	10	10
Replant	2.5	150	40	10	120	10	0	10	10
Ratoon	0	150	20	0	120	10	0	0	0

Physical properties:

These soils are high in fine sand and silt and are imperfectly to poorly drained due to seasonally high water tables. They are reasonably easy to cultivate, however they compact easily due to their high fine sand and silt content.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter and rotary hoes should only be used when soils are badly compacted. Care needs to be taken in avoiding tillage and traffic when soils are moist or wet as they are easily compacted. Whilst soil drainage is better than Silty Clays, laser levelling is beneficial for improving surface drainage and for reducing the impact of waterlogging. Headland compaction may also need to be alleviated for better infield drainage.

Environmental risk management:

Trash blanketing is beneficial for increasing soil organic matter and CEC and for protecting the soil from erosion. There is a moderate risk of denitrification and split applications of fertiliser would be appropriate, particularly for late cut blocks.

Grey Sand

Occurrence: These pale coloured coarse sandy soils occur in association with Red Sand soils on fans of weathered granitic material along hill slopes around the edge of the Herbert sugarcane area. The Red Sands have formed on the well drained upper slopes and the Grey Sands on the more poorly drained lower slopes. It is a minor soil occupying around 2% of the area under sugarcane.

Formation: These soils have formed on colluvial granitic material under conditions of restricted drainage. Seepage through the profile is also responsible for the pale coloured subsoil and the occurrence of iron and manganese mottles and concretions.

Grey Sand soils in the Stone River area

Grey Sand soil profile

Field appearance: Profiles commonly have grey brown coarse sandy loam topsoils overlying pale grey, mottled, gritty coarse sandy loam or sandy clay loam subsoils. Hard iron and manganese concretions commonly occur and are often partially cemented together.

Similar soils:

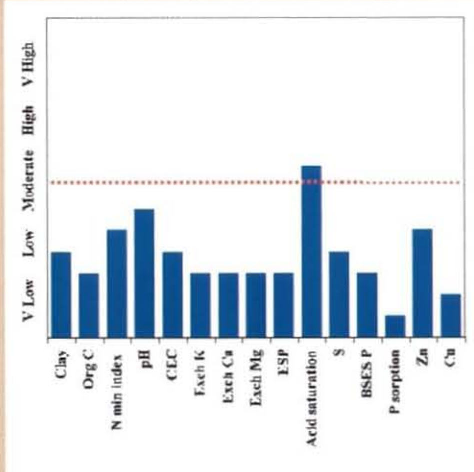
Sandy Clay soils have similar grey, mottled profiles but have less coarse sand and more clay, particularly in the subsoil.

Chemical properties:

These soils have low nutrient status due to their low organic matter, low CEC and losses of nutrients through leaching. CEC is very low and all exchangeable nutrients occur at very low levels. Topsoil pH averages 5.1 and acidic cations occupy more than 40% of total CEC. Exchangeable potassium is deficient in all profiles sampled, calcium is deficient in >40% of profiles and magnesium in >60% of profiles. Sulphur is also deficient in about 60% of profiles sampled. Copper is deficient in >80% profiles and zinc in about 30% of profiles sampled. Mean BSES phosphorus levels are low and all sites sampled require phosphorus.

Median soil test values for topsoils

Clay (%)	15.2
Organic C (%)	0.62
N mineralisation index	Low
pH (water)	5.10
CEC (me%)	1.52
Exch potassium (me%)	0.11
Exch calcium (me%)	0.54
Exch magnesium (me%)	0.16
Exch sodium (me%)	0.03
Exch sodium percentage (ESP)	1.97
Exch acidity (me%)	0.68
Acid saturation (%)	44.7
Sulphur (mg/kg)	5.9
BSES P (mg/kg)	18.0
P sorption	Very low
Zinc (mg/kg)	0.41
Copper (mg/kg)	0.10



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	140	40	10	120	15	75	10	10
Replant	2.5	160	40	10	120	15	75	10	10
Ratoon	0	160	20	10	120	15	0	0	0

Physical properties:

These coarse sandy soils are susceptible to drought as they have a low plant available water capacity and are prone to leaching. Profiles often remain wet well into the dry season due to seepage from the surrounding hills.

Tillage and water management:

Despite their sandy texture these soils are often wet due to seepage. It is important that the surface horizons are given sufficient time to dry out prior to tillage or harvesting operations to avoid soil damage and compaction. Tillage should be kept to a minimum in order to conserve organic matter. Springs and seeps can be drained using slotted underground pipes provided there is a suitable outfall.

Environmental risk management:

Trash blanketing is beneficial for increasing soil organic matter and CEC and for protecting the soil from erosion. These soils are highly permeable and the risk of leaching is high. Split applications of fertiliser would be appropriate as would the growth of fallow crops for retaining nutrients during the wet season. There is a moderately high risk of denitrification, particularly for late cut blocks.

Heavy Clay

Occurrence: This is the heaviest textured soil type in the Herbert River District. It occurs only in Lannercost and Lannercost Extension and is found in very flat, low-lying areas close to Lannercost Creek. It is a minor soil type occupying around 1% of the total cane area. It usually occurs adjacent to Clay soils but lower in the landscape.

Formation: These soils have formed under swampy conditions in the lowest part of the landscape where the finest clay particles have been deposited. Organic matter also accumulates under such conditions.

Heavy Clay soils near Lannercost Creek

Heavy Clay soil profile

Field appearance: Profiles are dark in colour with dark greyish brown clay topsoils overlying paler, mottled, coarse structured, grey clay subsoils. Structure is strongly blocky at the surface and lenticular below. Wide surface cracks are common in dry weather.

Similar soils:

Clay soils have less clay, less cracking and a weaker structure in the topsoil.

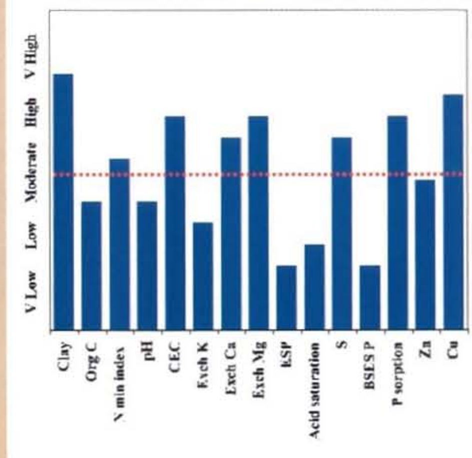
Black Organic Clay soils have more organic matter, blacker colours, a stronger structure but less cracking in the topsoil.

Chemical properties:

These soils have moderately high chemical fertility with high nitrogen reserves and a high nutrient storage capacity. Topsoils have moderate organic matter content and a moderately high CEC. Soil pH is 5.1 and acidic cations occupy around 20% of the CEC. Whilst exchangeable potassium is low in almost all profiles, there is no calcium or magnesium deficiency. There is no evidence of sulphur or micronutrient deficiencies. Phosphorus levels are low and nearly all profiles require some phosphorus. Since these soils sorb phosphorus fertiliser strongly, they require greater than replacement amounts of P fertilizer, where P is needed, to satisfy crop requirements.

Median soil test values for topsoils

Clay (%)	44.2
Organic C (%)	1.30
N mineralisation index	Moderate
pH (water)	5.10
CEC (me%)	7.93
Exch potassium (me%)	0.21
Exch calcium (me%)	3.73
Exch magnesium (me%)	2.12
Exch sodium (me%)	0.13
Exch sodium percentage (ESP)	1.64
Exch acidity (me%)	1.74
Acid saturation (%)	21.9
Sulphur (mg/kg)	18.0
BSES P (mg/kg)	17.0
P sorption	High
Zinc (mg/kg)	0.88
Copper (mg/kg)	1.10



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	5	110	80	30	100	0	0	0	0
Replant	5	130	80	30	100	0	0	0	0
Ratoon	0	130	40	30	100	0	0	0	0

Physical properties:

These soils are high in clay, well structured and have high organic matter content. They also have high water tables and poor drainage. Consequently profiles are usually wet, thus imposing limitations on both tillage and harvesting operations.

Tillage and water management:

They have a restricted moisture range for both tillage and trafficability and are often compacted due to harvesting operations occurring when soils are too wet. The presence of shrink-swell clays assists recovery from compaction. Soils have high field capacity but relatively low plant available moisture. They are difficult to drain and it is inadvisable to open up areas containing these soils unless an obvious drainage outlet exists. Laser levelling is essential for improving surface drainage and for reducing the incidence of ponding and inundation.

Environmental risk management:

Loss of nitrogen by denitrification is a major risk. Mounding of cane, application of nitrogen fertiliser to the mound surface and split fertiliser applications will help limit these losses.

Pale Brown Sandy Loam

Occurrence: These distinctive soils occur on colluvial fans along the footslopes of the Cardwell Range around South Gardiner Mountain in the south-west part of the Seymour. The high proportion of fine sand in these soils originates from the fine sandy acid volcanic parent material. It is a minor soil occupying less than 1% of the area under sugarcane.

Formation: These soils have formed on colluvial fans composed of weathered material derived from acid volcanic rocks. The dark organic topsoil and pale coloured subsoil have probably formed as a result of the wet conditions caused by continuous seepage from the adjacent hills.

Pale Brown Sandy Loams along the Cardwell Range

Pale Brown Sandy Loam soil profile

Field appearance: Profiles commonly have deep, weakly structured, dark brown, fine sandy loam topsoils abruptly overlying pale brown fine sandy loam subsoils. Subsoils are commonly mottled.

Similar soils:

Fine Grey Sand soils have paler coloured subsoils and paler topsoils with less organic matter and consequently greyer colours.

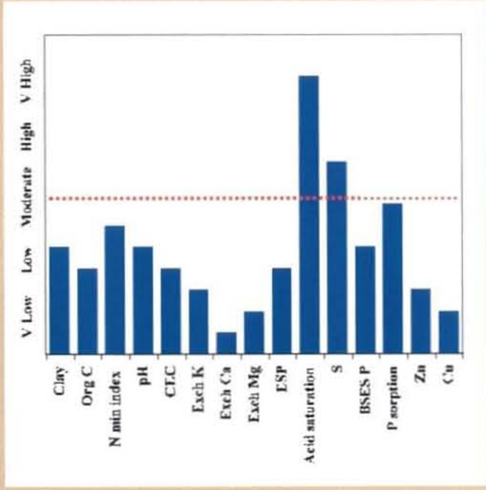
Fine Black Sand soils have blacker topsoils and paler coloured subsoils.

Grey Brown Loam soils have lighter coloured topsoils and a higher clay content.

Chemical properties:

These soils are reasonably well supplied with nitrogen and sulphur due to their moderate organic matter content but are deficient in most other nutrients due to a very low CEC and losses of nutrients through leaching. Topsoil pH averages 4.6 and acidic cations occupy more than 70% of total CEC. Exchangeable calcium, magnesium and potassium are deficient in nearly all profiles sampled. Copper and zinc are also deficient in most profiles. Most soils are well supplied with phosphorus but since these soils sorb phosphorus fertiliser moderately strongly, where P is needed, they require greater than replacement amounts of P fertiliser to satisfy crop requirements.

Median soil test values for topsoils	
Clay (%)	17.3
Organic C (%)	0.87
N mineralisation index	Moderately low
pH (water)	4.55
CEC (me%)	1.95
Exch potassium (me%)	0.11
Exch calcium (me%)	0.18
Exch magnesium (me%)	0.09
Exch sodium (me%)	0.05
Exch sodium percentage (ESP)	2.56
Exch acidity (me%)	1.52
Acid saturation (%)	77.9
Sulphur (mg/kg)	18.2
BSES P (mg/kg)	30.0
P sorption	Moderate
Zinc (mg/kg)	0.29
Copper (mg/kg)	0.08



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	120	60	20	120	0	125	10	10
Replant	2.5	140	60	20	120	0	125	10	10
Ratoon	0	140	30	0	120	0	0	0	0

Physical properties:

These fine sandy soils have relatively high plant available water due to their high organic matter content but are prone to leaching. Profiles often remain wet well into the dry season due to constant seepage of water from the surrounding hills.

Tillage and water management:

Despite their sandy texture these soils are often wet due to seepage. It is important that the surface horizons are given sufficient time to dry out prior to tillage or harvesting operations to avoid soil damage and compaction. Tillage should be kept to a minimum in order to conserve organic matter and the use of rotary hoes should be avoided. Springs and seeps can be drained using slotted underground pipes provided there is a suitable outfall.

Environmental risk management:

These soils are highly permeable and the risk of leaching is high. Split applications of fertiliser would be appropriate as would the growth of fallow crops for retaining nutrients during the wet season. There is a moderately high risk of denitrification, given the high organic matter content, particularly for late cut blocks.

Red Loam

Occurrence: These deep, red, well-drained soils occur extensively in Abergowrie and Stone River and less frequently in the Lannercost and Hawkins Creek. They occupy high river terraces and plains that are above flood levels.

Formation: These soils are formed on old river levees and terraces and have developed under conditions of good drainage. They are particularly well developed in Abergowrie.

Red Loam soils near the Abergowrie road

Red Loam soil profile

Field appearance: Profiles are well drained with a fairly shallow, dark brown, loam or sandy clay loam topsoil overlying a red or reddish brown to yellowish red clay loam subsoil. There is usually a clear change between topsoil and subsoil. In places soils are stony or gravelly at depth.

Similar soils:

Red Sands are usually redder in colour, with a much higher coarse sand and gravel content and occur on hillslopes.

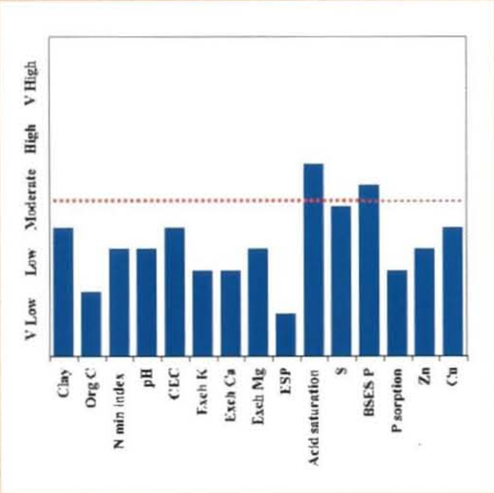
Clay Ridges occur on definite ridges and usually have a yellowish brown rather than a reddish brown subsoil.

Chemical properties:

Topsoils are low in organic matter and the whole profile is very acidic with a pH below 5. CEC is low and acidic cations commonly occupy over 50% of the CEC. Exchangeable potassium is deficient in about 70% of profiles sampled, calcium is deficient in about 30% and magnesium only occasionally. Sulphur is adequate in most profiles sampled. Copper levels are deficient in about 10% and zinc in 20% of profiles sampled. BSES phosphorus levels average over 50 mg/kg and only about 50% of profiles require phosphorus fertiliser.

Median soil test values for topsoils

Clay (%)	20.7
Organic C (%)	0.78
N mineralisation index	Low
pH (water)	4.80
CEC (me%)	3.09
Exch potassium (me%)	0.20
Exch calcium (me%)	0.89
Exch magnesium (me%)	0.34
Exch sodium (me%)	0.02
Exch sodium percentage (ESP)	0.65
Exch acidity (me%)	1.64
Acid saturation (%)	53.1
Sulphur (mg/kg)	11.0
BSES P (mg/kg)	41.2
P sorption	Low
Zinc (mg/kg)	0.53
Copper (mg/kg)	0.40



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	4	130	40	0	80	10	0	0	0
Replant	4	150	40	0	100	10	0	0	0
Ratoon	0	150	20	0	100	10	0	0	0

Physical properties:

These well drained soils have a moderately high moisture holding capacity and are reasonably easy to cultivate. They have few restrictions to downward root development.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter. Soil compaction can be a problem as these soils are favoured for harvesting in wet conditions and care needs to be taken in avoiding tillage and traffic when soils are wet. Intensive tillage is not normally required unless these soils are badly compacted. Laser levelling is unlikely to be necessary as soils are well drained and have a good natural slope.

Environmental risk management:

Trash blanketing is beneficial for moisture retention, increasing organic matter and CEC, and for protecting the soil against erosion. There is a risk of leaching particularly on the sandier versions of these soils. Split applications of fertiliser should be considered as well as growing fallow crops to protect the soil from erosion and to retain nutrients during the wet season.

Red Sand

Occurrence: These red coarse sandy soils occur in association with Grey Sand soils on fans of weathered granitic material along hill slopes around the edge of the Herbert sugarcane area. The Red Sands have formed on the well drained upper slopes of the fans whilst the Grey Sands occur on the more poorly drained lower slopes. It is a minor soil occupying around 2% of the area under sugarcane.

Formation: These soils have formed on well drained, coarse granitic deposits occurring on the upper slopes of colluvial fans. Seepage through the profile is responsible for the occurrence of iron and manganese concretions in the subsoil.

Red Sand landscape in Abergowrie

Red Sand soil profile

Field appearance: Profiles commonly have dark reddish brown coarse sandy loam topsoils overlying dark red, sandy clay loam subsoils. Iron and manganese concretions often occur in the subsoil and are commonly partially cemented together.

Similar soils:

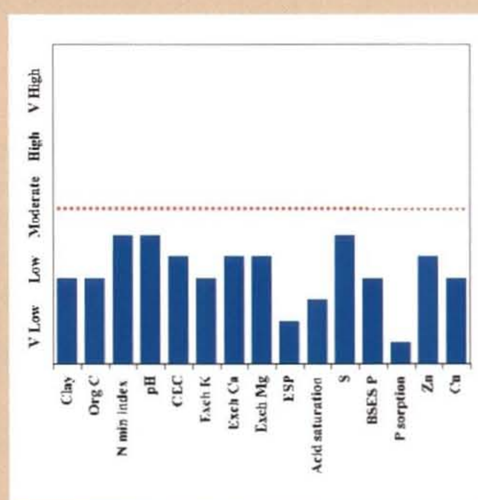
Grey Sand soils occur lower down on the fan slopes and have a similar texture but have much paler coloured profiles and poorer drainage.

Chemical properties:

These soils have low nutrient status due to low organic matter content, low CEC and losses of nutrients through leaching. CEC is very low and exchangeable nutrients commonly occur at low levels. Topsoil pH averages 5.3 and acidic cations occupy around 15% of total CEC. Exchangeable potassium is deficient in 80% of profiles sampled, calcium is deficient in 20% of profiles and magnesium in about 35% of profiles. Sulphur is deficient in about 35% of profiles sampled, copper is deficient in >60% profiles and zinc in about 30% of profiles sampled. Mean BSES phosphorus levels are low and 70% of sites sampled require phosphorus.

Median soil test values for topsoils

Clay (%)	15.6
Organic C (%)	0.82
N mineralisation index	Moderately low
pH (water)	5.37
CEC (me%)	2.18
Exch potassium (me%)	0.18
Exch calcium (me%)	1.32
Exch magnesium (me%)	0.35
Exch sodium (me%)	0.02
Exch sodium percentage (ESP)	0.92
Exch acidity (me%)	0.31
Acid saturation (%)	14.2
Sulphur (mg/kg)	8.2
BSES P (mg/kg)	22.5
P sorption	Very low
Zinc (mg/kg)	0.50
Copper (mg/kg)	0.19



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	130	40	10	100	15	0	10	0
Replant	2.5	150	40	10	100	15	0	10	0
Ratoon	0	150	20	0	100	15	0	0	0

Physical properties:

These coarse sandy soils have low plant available water capacity and are prone to leaching but are easy to cultivate at all moisture contents. However they are prone to compaction when moist.

Tillage and water management:

Tillage should be kept to a minimum in order to conserve moisture and organic matter and implements like rotary hoes do not need to be used. Good responses to supplementary irrigation can be expected.

Environmental risk management:

Trash blanketing is beneficial for conserving moisture, increasing soil organic matter and CEC and for protection against erosion. These soils are highly permeable and the main environmental risk is leaching. Split applications of fertiliser are appropriate. Also the growth of fallow crops helps protect the soil from erosion and retains nutrients during the wet season. Since these soils occur largely on sloping country, contour planting will help prevent erosion.

Ripple Alluvial

Occurrence: These soils are confined to the Seymour and Hawkins Creek areas and occur as a narrow band along the floodplains of Ripple and Arnot Creeks and the Seymour River. They are a minor soil occupying less than 1% of the area under sugarcane.

Formation: These are relatively recent soils which have formed on alluvial deposits derived largely from acid volcanic material. They have formed under well drained conditions and receive inputs of fresh alluvial material during floods.

Ripple Alluvial soils in Hawkins Creek

Ripple Alluvial soil profile

Field appearance: Profiles commonly have deep, friable, dark brown, loamy topsoils overlying uniform reddish brown clay loam subsoils. Topsoils have a high silt and fine sand content.

Similar soils:

River Bank soils have much more fine sand and less silt and clay.

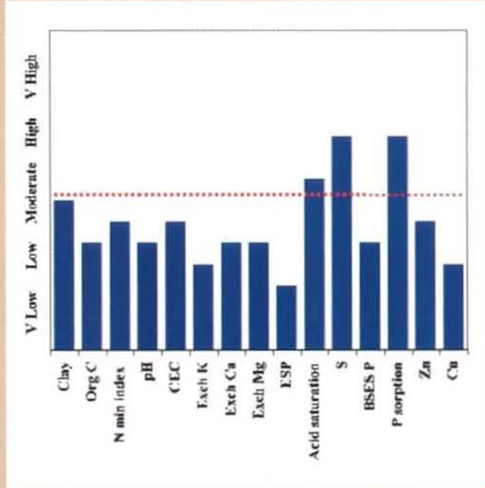
Red Loam soils have paler coloured topsoils due to less organic matter and have a lower clay content in the subsoil.

Chemical properties:

Topsoils are moderately low in organic matter content and CEC. Topsoil pH averages 4.9 and acidic cations occupy around 50% of total CEC. Exchangeable calcium is low and is deficient in 30% of profiles whilst magnesium is marginal and is deficient in 15% of profiles. Potassium is very low and is deficient in almost all profiles sampled. There is no evidence of sulphur deficiency. Copper is deficient in around 80% of profiles whereas zinc levels are reasonable. Most soils are well supplied with phosphorus but since these soils sorb phosphorus strongly, where P is needed, they require greater than replacement amounts of P fertiliser to satisfy crop requirements.

Median soil test values for topsoils

Clay (%)	26.6
Organic C (%)	1.04
N mineralisation index	Moderately low
pH (water)	4.91
CEC (me%)	3.43
Exch potassium (me%)	0.18
Exch calcium (me%)	1.21
Exch magnesium (me%)	0.41
Exch sodium (me%)	0.04
Exch sodium percentage (ESP)	1.17
Exch acidity (me%)	1.59
Acid saturation (%)	46.4
Sulphur (mg/kg)	20.6
BSES P (mg/kg)	30.0
P sorption	High
Zinc (mg/kg)	0.70
Copper (mg/kg)	0.16



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	4	120	80	30	100	0	0	10	0
Replant	4	140	80	30	100	0	0	10	0
Ratoon	0	140	40	0	100	0	0	0	0

Physical properties:

These freely draining, well structured soils have a moderately high moisture holding capacity and are reasonably easy to cultivate. They have few restrictions to downward root development but compact easily due to their high fine sand and silt content.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter. Soil compaction can be a problem as these soils are favoured for harvesting in wet conditions and care needs to be taken in avoiding tillage and traffic when soils are wet. Intensive tillage is not normally required unless these soils are badly compacted. Plant available water capacity is moderately high and supplementary irrigation is not considered necessary.

Environmental risk management:

There is a high environmental risk due to the outflow of nutrients and chemicals from these soils as they occur very close to rivers. Subsurface application of fertiliser is recommended particularly for late cut blocks to minimise nutrient runoff due to flooding. With the high flood risk on lower blocks it is recommended that planting and harvesting be completed as early as possible.

River Bank

Occurrence: This soil occurs on levee banks that have formed along major river channels. They are particularly widespread along the Herbert River and former courses of the Herbert such as Palm and Trebonne Creeks. They also occur along Stone River and major tributaries of the Herbert and Stone. They usually form in the highest parts of the floodplain landscape.

Formation: These soils have formed in recent sandy alluvial material on river banks and levees. They have formed over a sufficiently long time period to have developed a distinctive dark surface horizon which overlies a yellowish brown subsoil.

River Bank landscape at Hawkins Creek

River Bank soil profile

Field appearance: Profiles are sandy, well drained and have generally bright colours. They have a deep, dark coloured organic topsoil overlying a yellowish brown subsoil. Profiles are usually fine sandy loam in texture although some have a very sandy layer at about a metre depth.

Similar soils:

River Sand soils are sandier, have less profile development and a much shallower organic topsoil.

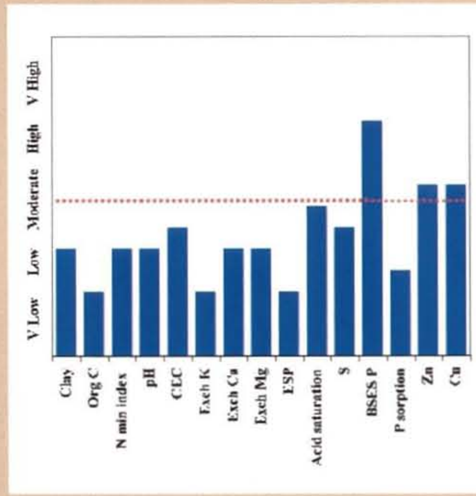
Terrace Silty Loam soils are not as sandy and have greyer colours in the subsoil, reflecting poorer drainage.

Chemical properties:

Despite their sandy texture these soils are moderately fertile due to their organic topsoils. Profiles have a moderately low CEC and are very acidic with acidic cations occupying around 40% of the CEC. Whilst exchangeable potassium is deficient in about 85% of samples, calcium and magnesium are deficient in only about 20%. Sulphur is deficient in about 30% of profiles. Copper and zinc levels are adequate in nearly all sites sampled. Median BSES phosphorus levels exceed 60 mg/kg and only 20% of sites require phosphorus.

Median soil test values for topsoils

Clay (%)	17.4
Organic C (%)	0.72
N mineralisation index	Low
pH (water)	4.77
CEC (me%)	3.05
Exch potassium (me%)	0.15
Exch calcium (me%)	1.15
Exch magnesium (me%)	0.44
Exch sodium (me%)	0.04
Exch sodium percentage (ESP)	1.31
Exch acidity (me%)	1.27
Acid saturation (%)	41.6
Sulphur (mg/kg)	8.8
BSES P (mg/kg)	60.8
P sorption	Low
Zinc (mg/kg)	1.21
Copper (mg/kg)	0.54



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	4	120	40	0	100	10	0	0	0
Replant	4	140	40	0	100	10	0	0	0
Ratoon	0	140	20	0	100	10	0	0	0

Physical properties:

These well drained soils are weakly structured with a high content of fine sand and a moderate water holding capacity. They are easy to cultivate at all moisture contents but are prone to leaching.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter. Implements like rotary hoes should not be used. Soil compaction can be a problem due to the high levels of fine sand and because these soils are favoured for harvesting in wet conditions. Laser levelling is not recommended as these soils usually occur in undulating areas and care needs to be taken to conserve the limited depth of topsoil. Good responses to supplementary irrigation occur in some years.

Environmental risk management:

Trash blanketing is beneficial for moisture retention, increasing organic matter and CEC, and for protecting the soil against erosion. There is a high risk from leaching as these soils are permeable and occur close to rivers. Split applications of fertiliser would be appropriate as would the growth of fallow crops for retaining nutrients during the wet season.

River Overflow

Occurrence: These deep, highly productive soils occur on active floodplains throughout the district. Some areas of river flats, where these soils occur, are covered with floodwater in both minor and major flood events.

Formation: These soils have formed from recent alluvium which has been deposited when rivers are in flood. Whilst texture is reasonably uniform there is a clear transition between topsoil and subsoil.

River Overflow soils near Abergowrie road

River Overflow soil profile

Field appearance: Profiles are well drained with deep, friable sandy to silty clay loam topsoils. Topsoils are characterised by high organic matter content and excellent structure. These overlie yellowish brown to strong brown silty clay loam subsoils.

Similar soils:

River Bank soils are sandier with a poorer structure.

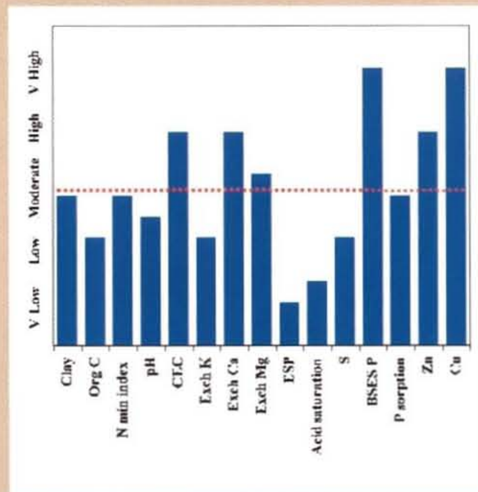
Terrace Silty Loam soils have a poorer structure and are not so well drained.

Chemical properties:

These are chemically very fertile soils. Topsoils have a moderate organic matter content and a moderately high CEC. Soil pH is around 5.1 and acidic cations occupy around 15% of the CEC. Whilst exchangeable potassium is low in about 80% of profiles sampled, calcium and magnesium are above critical levels in nearly all profiles. Sulphur is adequate in about 80% of profiles sampled. There is little evidence of micronutrient deficiency. Phosphorus levels are adequate in most profiles with BSES P levels averaging 69 mg/kg in the topsoil.

Median soil test values for topsoils

Clay (%)	26.3
Organic C (%)	1.16
N mineralisation index	Moderately low
pH (water)	5.07
CEC (me%)	7.55
Exch potassium (me%)	0.23
Exch calcium (me%)	4.72
Exch magnesium (me%)	1.50
Exch sodium (me%)	0.07
Exch sodium percentage (ESP)	0.93
Exch acidity (me%)	1.03
Acid saturation (%)	13.6
Sulphur (mg/kg)	8.0
BSES P (mg/kg)	69.1
P sorption	Moderate
Zinc (mg/kg)	2.27
Copper (mg/kg)	1.70



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	5	110	60	0	80	10	0	0	0
Replant	5	130	60	0	100	10	0	0	0
Ratoon	0	130	30	0	100	10	0	0	0

Physical properties:

These well drained soils have excellent physical properties. They are easy to cultivate with a good surface structure and have few restrictions to downward root development.

Tillage and water management:

There is little need for intensive tillage using a rotary hoe. However soil compaction can be an issue due to the high fine sand and silt content and because these soils are favoured for harvesting in wet conditions. Recovery from compaction, however, is usually good. Plant available water capacity is high and supplementary irrigation is not considered necessary.

Environmental risk management:

There is a high environmental risk due to the outflow of nutrients and chemicals from these soils as they occur very close to rivers. Subsurface application of fertiliser is recommended particularly for late cut blocks to minimise nutrient runoff due to flooding. With the high flood risk on lower blocks it is recommended that planting and harvesting be completed as early as possible.

River Sand

Occurrence: These young, sandy, very freely drained soils occur in association with River Bank soils along the banks of the Herbert and Stone Rivers. They have formed on recent flood deposits of river sand, mainly from the last three major flood events in 1927, 1967 and 1977. It is a minor soil occupying low terraces above the river.

Formation: These soils have been forming for less than a hundred years and have very little horizon development. Layers can be seen in the profile but these are due to different deposits of sandy alluvium.

River Sand soils in Hawkins Creek

River Sand soil profile

Field appearance: Profiles are very sandy in texture, have no structure and are extremely well drained. They have a shallow organic topsoil overlying layered sandy alluvial deposits. Some profiles overlie heavier textured material that represents a pre-existing soil which had developed before the sandy alluvium was deposited.

Similar soils:

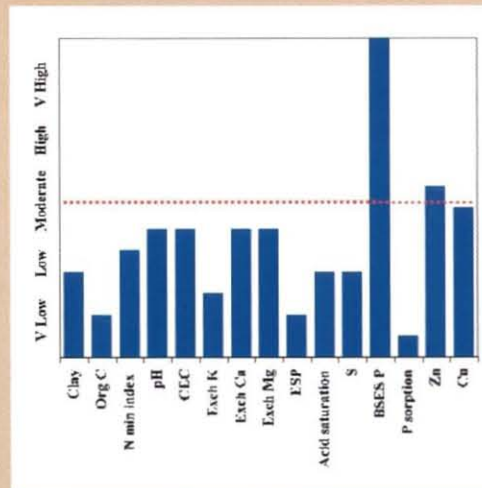
River Bank soils have more profile development with deeper, darker organic topsoils and more clay in the lower part of the profile.

Chemical properties:

Topsoils are shallow and usually low in organic matter. Profiles are moderately acidic with a surface pH range of 4.2 – 6.0. CEC is low and acidic cations commonly occupy around 20% of the CEC. Whilst exchangeable potassium is deficient in almost all profiles sampled, calcium and magnesium are deficient in only 1 or 2 profiles. Sulphur is deficient in about 80% of profiles sampled. Copper and zinc levels are low in about 10% of profiles sampled. Mean BSES phosphorus levels are extremely high and these soils do not require any phosphorus.

Median soil test values for topsoils

Clay (%)	12.8
Organic C (%)	0.46
N mineralisation index	Low
pH (water)	5.10
CEC (me%)	3.12
Exch potassium (me%)	0.15
Exch calcium (me%)	1.73
Exch magnesium (me%)	0.63
Exch sodium (me%)	0.03
Exch sodium percentage (ESP)	0.96
Exch acidity (me%)	0.58
Acid saturation (%)	18.6
Sulphur (mg/kg)	5.0
BSES P (mg/kg)	93.2
P sorption	Very low
Zinc (mg/kg)	1.06
Copper (mg/kg)	0.48



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	4	140	40	0	100	25	0	0	0
Replant	4	160	40	0	100	25	0	0	0
Ratoon	0	160	20	0	100	25	0	0	0

Physical properties:

These very sandy soils have a limited water holding capacity and are possibly the driest soils in the district. They are prone to leaching but are easy to cultivate at all moisture contents.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter. Implements like rotary hoes are not required as these soils do not set hard. Laser levelling is not recommended as these soils are naturally very well drained. As they occur in undulating areas care needs to be taken to conserve the limited amount of organic matter in the topsoil. Good responses to supplementary irrigation can be expected.

Environmental risk management:

Trash blanketing is essential for retaining moisture, increasing soil organic matter and CEC and for protecting the soil against erosion. There is a high environmental risk due to leaching as these soils are permeable and occur close to rivers. Care needs to be taken in using both fertilisers and chemicals. Split applications of fertiliser would be appropriate as would the growth of fallow crops for retaining nutrients during the wet season.

Sand Ridge

Occurrence: These soils occur as narrow, winding ridges along old prior stream channels. They are particularly common in Lannercost and Lannercost Extension but also occur in the Hawkins Creek and Stone River areas. Sandy areas elsewhere are broader and more complex and similar soils in these areas have been classified as Coarse Sandy Loams. It is a minor soil occupying around 2% of the area under sugarcane.

Formation: These soils have formed on very sandy channel infill deposits that occur in old prior stream channels. Towards the Herbert River these soils grade into Clay Ridge soils.

Sand Ridge soil in Lannercost Extension

Sand Ridge soil profile

Field appearance: These soils always occur on a pronounced ridge. Profiles are commonly well drained and have a dark brown sandy loam topsoil overlying pale brown or yellowish brown sandy loam or sandy clay loam subsoil.

Similar soils:

Clay Ridge soils also occur on ridges but have more silt and clay throughout the profile and stronger brown or reddish brown colours in the subsoil.

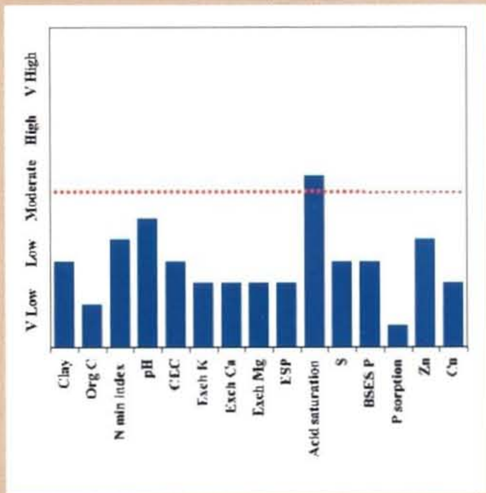
Coarse Sandy Loam soils have a similar texture but do not usually occur on such pronounced ridges and have a wider range of subsoil colours ranging from red to grey.

Chemical properties:

These soils have low nutrient status due to their low organic matter and CEC. Profiles have a very low CEC and all exchangeable nutrients occur at low levels. Exchangeable potassium is deficient in all profiles, calcium in >60% and magnesium in >70% of profiles. Acidic cations occupy more than 40% of total CEC. Sulphur deficiency occurs in 60% of profiles sampled. Copper is deficient in >60% profiles and zinc in about 20% of profiles sampled. Mean BSES phosphorus levels are low and almost all sites sampled require phosphorus.

Median soil test values for topsoils

Clay (%)	16.0
Organic C (%)	0.60
N mineralisation index	Low
pH (water)	5.04
CEC (me%)	1.56
Exch potassium (me%)	0.11
Exch calcium (me%)	0.55
Exch magnesium (me%)	0.18
Exch sodium (me%)	0.02
Exch sodium percentage (ESP)	1.28
Exch acidity (me%)	0.70
Acid saturation (%)	44.9
Sulphur (mg/kg)	5.2
BSES P (mg/kg)	22.0
P sorption	Very low
Zinc (mg/kg)	0.53
Copper (mg/kg)	0.13



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	140	40	10	120	15	75	10	10
Replant	2.5	160	40	10	120	15	75	10	10
Ratoon	0	160	20	10	120	15	0	0	0

Physical properties:

These well drained, very sandy soils have low water holding capacity and are prone to leaching but are easy to cultivate at all moisture contents.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter. Implements like rotary hoes should not be used. Laser levelling is not recommended as these soils have very shallow topsoils which if removed can severely reduce their productivity. Good responses to supplementary irrigation can be expected.

Environmental risk management:

Trash blanketing is essential for retaining moisture, increasing soil organic matter and CEC, and for protecting the soil against erosion. The main environmental risk is leaching and split applications of fertiliser should be considered as well as growing fallow crops to protect the soil from erosion and to retain nutrients during the wet season.

Sandy Clay

Occurrence: These soils occur in association with Sand Ridges or Coarse Sandy Loams and represent an intermediate soil type between the very sandy ridge crests and the heavier textured soils (usually silty clays) in the depressions. They occur on the broad shoulders of sandy ridges and are particularly common in the Lannercost and Mid Stone River areas. It is a minor soil occupying around 4% of the area under sugarcane.

Formation: These soils have formed on the edges of sandy infill deposits following prior streams derived from granitic materials and occur adjacent to heavier textured soils. Profiles have a substantial coarse sand content.

Sandy Clay soils in Lannercost

Sandy Clay soil profile

Field appearance: These soils commonly occur on the shoulder of sandy ridges. Profiles are pale in colour with a dark greyish brown, massive sandy loam topsoil overlying a yellowish brown or greyish brown mottled sandy clay or clay loam subsoil.

Similar soils:

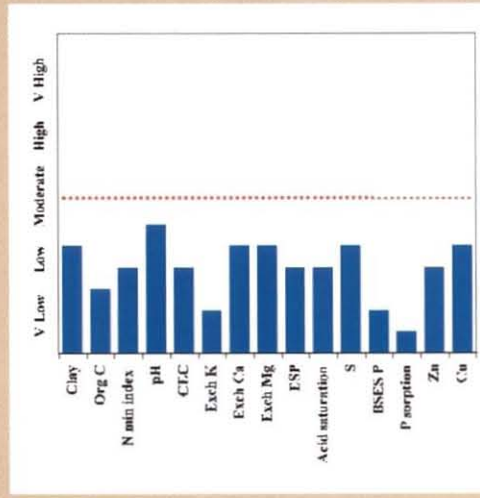
Grey Sand soils have similar pale greyish, mottled profiles but occur at the base of colluvial fans and have less clay in the subsoil.

Silty Clay soils have slightly darker colours, occur lower down in the landscape and have more clay throughout the profile.

Chemical properties:

These soils have low nutrient status due to their low organic matter content and low CEC. Exchangeable potassium is deficient in nearly all profiles, calcium in 20% and magnesium in 10% of profiles. Acidic cations occupy around 25% of total CEC. Sulphur deficiency occurs in >40% of profiles sampled. Micronutrient levels are marginal with copper and zinc deficient in around 25% of profiles sampled. Mean BSES phosphorus levels are low and almost all sites sampled require phosphorus. Around 15% of subsoils are sodic.

Median soil test values for topsoils	
Clay (%)	16.8
Organic C (%)	0.70
N mineralisation index	Low
pH (water)	5.30
CEC (me%)	1.97
Exch potassium (me%)	0.09
Exch calcium (me%)	1.02
Exch magnesium (me%)	0.36
Exch sodium (me%)	0.04
Exch sodium percentage (ESP)	2.03
Exch acidity (me%)	0.46
Acid saturation (%)	23.4
Sulphur (mg/kg)	6.9
BSES P (mg/kg)	12.0
P sorption	Very low
Zinc (mg/kg)	0.40
Copper (mg/kg)	0.26



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	2.5	130	40	10	100	15	0	0	0
Replant	2.5	150	40	10	100	15	0	0	0
Ratoon	0	150	20	10	100	15	0	0	0

Physical properties:

These imperfectly drained soils have seasonally high water tables and often remain wet due to seepage along the boundary between sandy ridges and heavier textured soils. They commonly have poorly structured, massive, hard setting topsoils.

Tillage and water management:

Their hard setting surface and vulnerability to compaction make a good tilth difficult to achieve although green cane trash blanketing has improved soil structure. Tillage should be kept to a minimum and rotary hoes should be used with care. Laser levelling is essential for improving surface drainage and slotted underground pipes are useful for draining springs and seeps.

Environmental risk management:

Trash blanketing is essential for retaining moisture, increasing soil organic matter and CEC and for protecting the soil against erosion. The main risks are leaching, denitrification and soil erosion. Split applications of fertiliser should be considered as well as growing fallow crops to protect the soil from erosion and to retain nutrients during the wet season.

Silty Clay

Occurrence: This major soil type, which occupies around 15% of the cane area, occurs throughout the Herbert River District in the lower part of the landscape. It occurs extensively in Hawkins Creek and Lannercost adjacent to Clay soils and Terrace Silty Loams and occupies an intermediate position between the two. In Abergowrie and Stone River areas Silty Clay soils occupy the lowest part of the landscape.

Formation: These soils have formed on heavy textured alluvium under conditions of poor drainage. Clay and Clay Loam soils occur at lower positions in the landscape and are higher in clay and organic matter.

Silty Clay soils at Hawkins Creek

Silty Clay soil profile

Field appearance: Profiles are poorly drained with powdery, hard setting, poorly structured greyish brown silty clay loam topsoils. These overlie pale coloured, mottled, grey silty clay to clay subsoils.

Similar soils:

Terrace Silty Loams are higher in the landscape and have better structure and drainage.

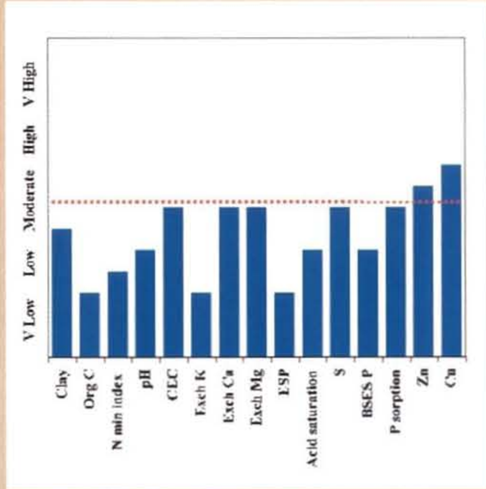
Clay and Clay Loam topsoils have more organic matter, darker colours, better structure and a higher clay content.

Chemical properties:

These soils have moderate fertility. Topsoils are low in organic matter and moderately low in CEC. Soil pH is around 5.0 and acidic cations occupy 25% of CEC. Whilst exchangeable potassium is low in about 90% of profiles sampled, calcium and magnesium are deficient in <5% profiles. Sulphur is adequate in almost all profiles sampled. There is little evidence of micronutrient deficiency. Median BSES P levels are 30 mg/kg in the topsoil and around 60% of profiles require some phosphorus. About 12% of these soils have sodic subsoils. These occur mainly in the drier parts of the district to the south of Ingham.

Median soil test values for topsoils

Clay (%)	23.5
Organic C (%)	0.75
N mineralisation index	Low
pH (water)	4.96
CEC (me%)	3.91
Exch potassium (me%)	0.14
Exch calcium (me%)	1.82
Exch magnesium (me%)	0.76
Exch sodium (me%)	0.07
Exch sodium percentage (ESP)	1.79
Exch acidity (me%)	1.12
Acid saturation (%)	28.6
Sulphur (mg/kg)	12.0
BSES P (mg/kg)	28.6
P sorption	Moderate
Zinc (mg/kg)	1.13
Copper (mg/kg)	0.79



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	4	130	60	20	100	5	0	0	0
Replant	4	150	60	20	100	5	0	0	0
Ratoon	0	150	30	0	100	5	0	0	0

Physical properties:

These poorly drained soils have seasonally high water tables. They are poorly structured and the high silt and fine sand content causes them to be prone to compaction, hard setting and also makes them susceptible to erosion.

Tillage and water management:

It is difficult to obtain a good tilth on these soils due to their vulnerability to compaction and hard setting. Controlled traffic would help to limit compaction and reduce lumpiness. The adoption of green cane trash blanketing has greatly improved soil structure, tilth and soil porosity. Soil ameliorants such as mill ash also improve friability and soil water holding capacity. They have a restricted moisture range for both tillage and trafficability and are often compacted due to harvesting operations occurring when soils are too wet. Laser levelling is essential for improving surface drainage and for reducing the incidence of waterlogging.

Environmental risk management:

Loss of nitrogen by denitrification is a constant risk. Strategies to reduce these losses include mounding of cane, application of nitrogen fertiliser to the surface of the mound and split application of fertiliser. Erosion can also be a problem as these soils are more dispersible than Clays and would benefit from applications of calcium based soil ameliorants.

Terrace Silty Loam

Occurrence: These soils occur widely on older terraces adjacent to the river levees along the main rivers and streams in the lower Herbert. They do not occur in Lannercost or Abergowrie. They usually occur in association with River Bank soils but occupy a slightly lower position in the floodplain landscape.

Formation: These soils have formed on alluvium adjacent to the active or recently active river levees, where silt and fine sand particles predominate. They occur in a variable deposition environment and some profiles have clay layers at depth. They are characterised by more profile development than the levee soils (River Bank).

Terrace Silty Loam soils in Hawkins Creek

Terrace Silty Loam soil profile

Field appearance: Profiles have deep, dark brown, well structured silty loam topsoils overlying greyish brown or yellowish brown clay loam subsoils. Many profiles have paler colours and mottling at depth due to seasonally high water tables or a perched water table on a clay layer.

Similar soils:

Clay Loam soils have higher organic matter and more clay throughout the profile.

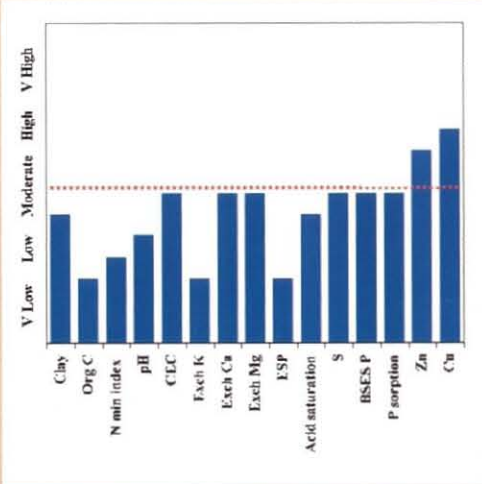
Silty Clay soils are more massive, lower in organic matter and have a higher clay content, particularly in the subsoil.

Chemical properties:

These soils have moderate fertility. Topsoils are moderately low in organic matter and CEC. Soils are very acid with a pH of around 4.8 and acidic cations occupy more than 30% of the CEC. Calcium and magnesium are deficient in less than 10% of samples whereas potassium is low in more than 80% of profiles sampled. There is no evidence of micronutrient deficiencies and sulphur is low in less than 10% of samples. Median BSES P levels are 41 mg/kg in the topsoil and around 50% of profiles require some phosphorus. A small number of profiles have high sodium levels in the subsoil.

Median soil test values for topsoils

Clay (%)	22.0
Organic C (%)	0.76
N mineralisation index	Low
pH (water)	4.82
CEC (me%)	4.44
Exch potassium (me%)	0.14
Exch calcium (me%)	1.87
Exch magnesium (me%)	0.81
Exch sodium (me%)	0.06
Exch sodium percentage (ESP)	1.35
Exch acidity (me%)	1.56
Acid saturation (%)	35.1
Sulphur (mg/kg)	12.0
BSES P (mg/kg)	40.6
P sorption	Moderate
Zinc (mg/kg)	1.59
Copper (mg/kg)	0.93



Nutrient management guidelines:

Crop situation	Lime (t/ha)	N (kg/ha)	P new land (kg/ha)	P old land (kg/ha)	K (kg/ha)	S (kg/ha)	Mg (kg/ha)	Cu (kg/ha)	Zn (kg/ha)
Fallow plant	4	130	60	20	100	0	0	0	0
Replant	4	150	60	20	100	0	0	0	0
Ratoon	0	150	30	0	100	0	0	0	0

Physical properties:

These are imperfectly or well drained soils with a seasonally high water table. They are much more permeable than the Silty Clays. They are moderately well structured and reasonably easy to cultivate, however they compact easily due to their high fine sand and silt content.

Tillage and water management:

Tillage should be kept to a minimum to conserve moisture and organic matter, and rotary hoes should only be used when soils are badly compacted. Care needs to be taken to avoid tillage and traffic when soils are moist or wet, as they are easily compacted. Whilst soil drainage is better than Silty Clays, laser levelling is beneficial for improving surface drainage.

Environmental risk management:

Soil erodibility is quite high due to the high fine sand and silt content, and trash blanketing is beneficial for protecting the soil against erosion. Intermittent waterlogging is common and losses of nitrogen by denitrification can be a problem with an early and heavy wet season.

CHAPTER 6

Tools for refining guidelines

The guidelines for managing nutrient inputs according to soil type (Chapter 5) should be refined by making use of some important tools such as soil testing, leaf analysis, juice analysis, and an integrated nutrient management package.

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.

Step 1. Sample collection

Collect soil samples according to the guidelines provided in Appendix 2.

Step 2. Sample analysis

Submit samples to a reputable laboratory for analysis.

Step 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 capable advisers such as extension officers.

Step 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 6.1, a critical value for a particular nutrient is that soil test value above which any further yield response to the applied nutrient is unlikely.

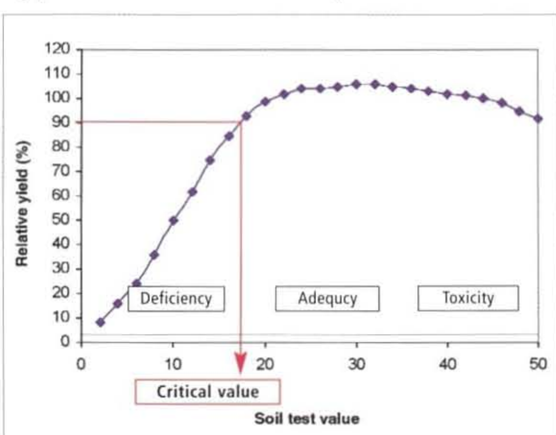


Figure 6.1. An example of a nutrient response curve for sugarcane.

Soil test results therefore indicate those nutrients which are present in adequate quantities (and are readily available to the crop), and those nutrients which are lacking (and need to be applied). As indicated in Chapter 4, 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 the 'Soil analysis interpretation guide for Herbert soils' (Appendix 4).

An example of a soil test report (Figure 6.2) 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 excess/toxic. These values are used to assess the amount of each nutrient required by the crop for optimum production.

Soil test report		
Trading Name: Bloggs & Bloggs	**Field Name:** Block 1	
Location: Herbert District	**Section of Field:** A	
Contact Name: Joe Bloggs	**GPS Latitude:**	**GPS Longitude:**
Work Phone:	**Sample type:**	**Depth: 0-20 cm**
Adviser:	**Lab Report Number:**	**Sampling Date:**
Phone:	**Crop:** Sugarcane	
	Stage: Plough-out/Replant	**Target Yield:** 120 tonnes/ha

		Low	<Optimum	Satisfactory	>Opt/ Norm	High	Excess/ Toxic
pH (1:5 water)	5.1	■					
Electrical Conductivity dS/m	0.02			■			
Organic C (%)	0.7	■					
Sulphate sulphur (MCP) mg/kg	12			■			
Phosphorus (BSES) mg/kg	25			■			
Potassium (Nitric) me%	1.52						
Potassium (Amm. Acetate) me%	0.14	■					
Calcium (Amm. Acetate) me%	1.11		■				
Magnesium (Amm.Acetate) me%	0.52				■		
Aluminium (KCl) me%	1.68					■	
Sodium (Amm. Acetate) me%	0.07	■					
Copper (DTPA) mg/kg	0.6			■			
Zinc (DTPA) mg/kg	0.4			■			
Zinc (HCl) mg/kg	0.7			■			
Manganese (DTPA) mg/kg	105					■	
Iron (DTPA) mg/kg	54				■		
Silicon (BSES) mg/kg	120				■		
Cation Exch Capacity me%	3.52		■				
Aluminium saturation %	47.9					■	
Sodium % of cations (ESP)	1.86	■					
Colour (Munsell)	Grey Brown						
Texture	Sandy Clay Loam						

Figure 6.2. Example of a soil test report from a commercial laboratory.

Appropriate fertiliser inputs for this soil test report are calculated using the guidelines in Appendix 4, as demonstrated below:

Nitrogen

N requirement is **150 kg N/ha** because the N mineralisation index is LOW due to an organic C (%) value of 0.7%. This requirement is appropriate for replant cane and ratoon cane after replant, but is modified according to the effect of fallow management or the use of ameliorants such as mill mud and/or mill ash. If, for example, the plant cane followed a grass/bare/poor legume fallow, the plant crop N requirement reduces to **130 kg N/ha**.

Phosphorus

P requirement for plant cane is **20 kg P/ha** because the block has been previously cropped to sugarcane (OLD LAND), the BSES P value is 25 mg/kg and the P sorption class is MODERATE (due to a texture described as sandy clay loam ie. a moderate clay content (24 – 36% clay) and an organic C (%) value of 0.7%). No P is required for the subsequent ratoon crops in this case. Since clay content is not normally reported in soil tests it is reasonable to use an approximate clay content determined from a determination of soil texture, as described in Appendix 1.

Potassium

K requirement is **100 kg K/ha** because the nitric K value is greater than 0.7 me%, the texture is described as sandy clay loam (24 – 36 % clay) and an exchangeable K value of 0.14 me%. 100 kg K/ha is needed for each ratoon crop.

Sulphur

S requirement is **10 kg S/ha** for the plant and all ratoon crops because the soil sulphur value is 12 mg/kg and the N mineralisation index is known to be LOW (as described above).

Magnesium

No Mg is required because the Mg soil test value is 0.52 me% which indicates relatively high reserves.

Copper and zinc

Although leaf analysis is the preferred means of determining micronutrient requirements (Appendix 4), the soil tests indicate that neither copper nor zinc are required as the soil tests are above the critical values.

Silicon

No silicon is required as the soil test value (120 mg/kg) is above the value (70 mg/kg) below which a response is likely.

Lime

Lime requirement is **4 t/ha** because the soil pH(water) value is below 5.5 and the cation exchange capacity is 3.52 me% (which is a medium CEC).

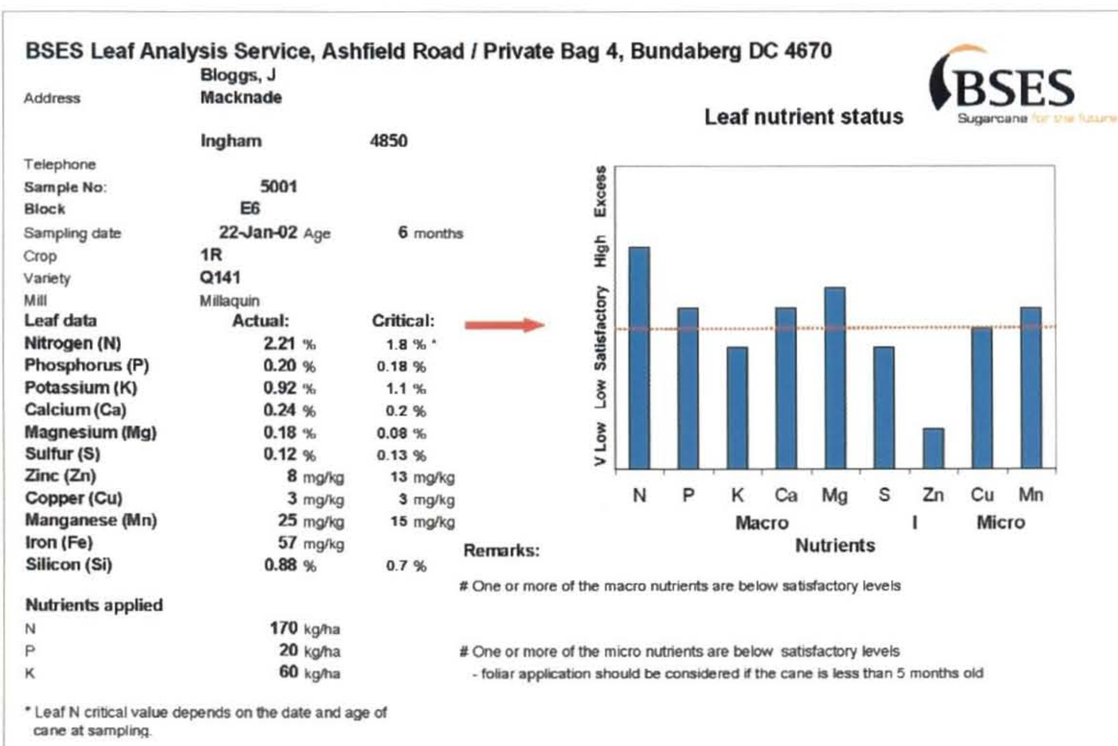
A summary of the nutrient requirement for the entire crop cycle (Plant crop and three successive ratoons) is as follows:

Crop	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Lime (t/ha) (prior to planting)
Replant cane	150	20	100	10	4
Ratoon crops	150	0	100	10	-

Leaf analysis

Leaf sampling offers an appropriate means of checking on the adequacy of fertiliser recommendations and nutrient inputs to a block of sugarcane, and 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). Leaf sampling instructions are supplied in Appendix 3.

An example of a leaf analysis report from the BSES Leaf Analysis Service is shown in Figure 6.3. Apart from showing the actual analysis data and appropriate critical values for the full range of nutrients the bar-graph representation of the results provides an easy to understand interpretation with the red dotted line indicating satisfactory levels. Statements below the bar-graph add to this interpretation.


BSES Leaf Analysis Service, Ashfield Road / Private Bag 4, Bundaberg DC 4670

	Bloggs, J	
Address	Macknade	
	Ingham	4850
Telephone		
Sample No:	5001	
Block	E6	
Sampling date	22-Jan-02 Age	6 months
Crop	1R	
Variety	Q141	
Mill	Millaquin	
Leaf data	**Actual:**	**Critical:**
Nitrogen (N)	2.21 %	1.8 % *
Phosphorus (P)	0.20 %	0.18 %
Potassium (K)	0.92 %	1.1 %
Calcium (Ca)	0.24 %	0.2 %
Magnesium (Mg)	0.18 %	0.08 %
Sulfur (S)	0.12 %	0.13 %
Zinc (Zn)	8 mg/kg	13 mg/kg
Copper (Cu)	3 mg/kg	3 mg/kg
Manganese (Mn)	25 mg/kg	15 mg/kg
Iron (Fe)	57 mg/kg	
Silicon (Si)	0.88 %	0.7 %
Nutrients applied		
N	170 kg/ha	
P	20 kg/ha	
K	60 kg/ha	

* Leaf N critical value depends on the date and age of cane at sampling.

Remarks:

One or more of the macro nutrients are below satisfactory levels

One or more of the micro nutrients are below satisfactory levels
- foliar application should be considered if the cane is less than 5 months old

Figure 6.3. Example of a leaf analysis report.

In the example on the previous page, the leaf analysis results are alerting Mr Bloggs to the following:

- The third leaf N value is high. This reflects the relatively high N fertiliser application rate (170 kg N /ha). Less N fertiliser should be applied next season.
- The third leaf P, Ca, Mg, Cu and Mn values are all satisfactory.
- The third leaf K value is low and reflects the relatively low K fertiliser rate (60 kg K /ha). Joe should consider applying additional K next season.
- The third leaf S value is slightly low. DAP (diammonium phosphate) which is currently used at planting does not contain sulphur. Superphosphate which was often used in the past contained substantial amounts of S. Joe should apply fertiliser mixtures that contain some sulphur in order to replace the S removed by the crop.
- The third leaf Zn value is very low. Had the cane been younger at the time of sampling, Joe could possibly have considered a foliar application of 1% zinc sulphate solution (300 litres/ha). Next season he should consider either applying zinc fertiliser (to the soil) or a foliar application of zinc sulphate when the cane is about 3 months old.

Juice analysis

Juice analysis has been proposed as a means of identifying nutrient imbalances in sugarcane. For instance, it has been reported that increased colour and amino N levels in cane juice are indicative of high N application rates. Unfortunately the absence of critical values for N and other nutrients has prevented this technique from being used for developing routine fertilizer recommendations.

Integrated nutrient management

Analytical results for a single soil or leaf sample are of limited value. Of much more benefit is the concept of integrated nutrient management which includes the use of a range of different activities for determining nutrient inputs to a particular cane block. In brief the integrated nutrient package consists of six steps:

1. Knowing which soils occur in each block of your farm. Soil maps are available for most farms through Herbert Cane Productivity Services apart from the Ingham Line area.
2. Understanding the properties of each soil and the nutrient processes likely to occur in each soil.
3. Regular soil testing (blocks should be sampled every crop cycle well before planting).
4. Developing a plan of fertiliser applications for each block covering a whole crop cycle (covering a plant crop and succeeding ratoons). This can be achieved using knowledge of the nutrient requirements of each soil and implementing soil/site specific fertiliser recommendations.

5. Using leaf analysis as a check on the adequacy of fertiliser recommendations (enabling modifications to the fertiliser plans).
6. Maintaining a good record keeping system which enables informed decisions to be made based on block histories and longer-term nutrient management strategies.

Implementation of this system on-farm will lead to best practice nutrient management and sustainable sugarcane production.

CHAPTER 7

Concluding remarks

Soils are complex physical, chemical and biological systems which store and release nutrients for crop growth and are not simply for holding up plants. 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 nutrient guidelines. This complexity is appreciated by cane growers in the Herbert River District who have an excellent understanding of the different soil types occurring on their farms and recognise that different management practices are appropriate for different soils. The information presented in this booklet is intended to reinforce this local soil knowledge and provide an easily understood system for soil and nutrient management that focuses much more than current systems on the chemical, physical and biological properties of different soils.

The proposed 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 building up high 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. It differs significantly from current approaches in the following ways:

- 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. Our N guidelines in particular are lower than current recommendations. This is particularly important given current concerns regarding elevated levels of nitrate in the waters of the Great Barrier Reef lagoon.
- 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 test somewhat differently for different soils.
- Our K guidelines are broadly similar to existing recommendations but take into account differences in soil texture. They are higher than current K usage and recognise the low exchangeable K levels in nearly all soils and the fact that we have not been replacing crop removal of K and have thus been exploiting soil K reserves.

We hope that this booklet will improve the local awareness and understanding of different soils and how they can be managed for sustainable sugarcane production. Whilst growers can use the management guidelines directly for their different soils, the booklet also explains the way 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 which we hope will encourage growers to make much greater use of these tools through the Herbert Cane Productivity Services and BSES soil and leaf analysis services.

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.


Forming the ball (bolus) of soil and pressing it into a ribbon

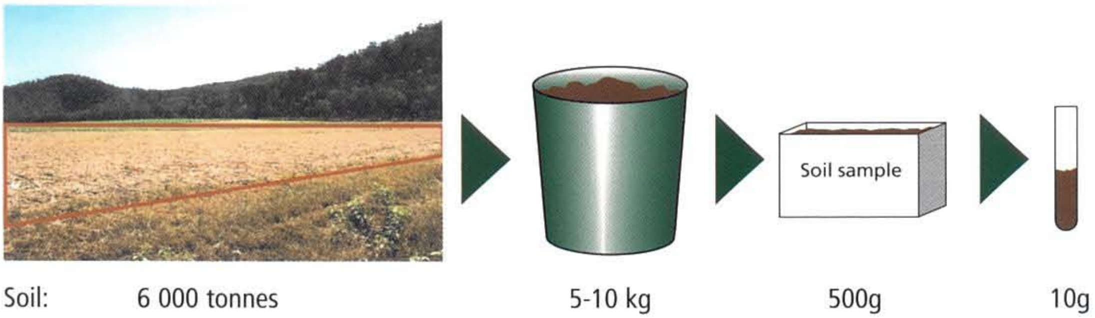
Simplified guide to determining soil texture.

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 and greasy feel, with coherence, but no obvious sandiness or 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 2

How to take a soil sample

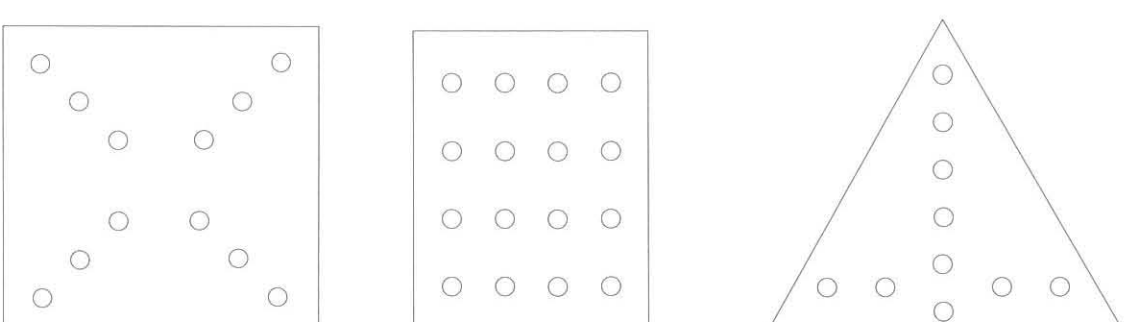
Soil tests in the laboratory are carried out on a 10 g sample which is taken from about 500 g of soil submitted to the laboratory. Usually this 500 g sample is a sub-sample of about 10 kg of soil which ideally should be sampled from a block of cane (average 2 hectare area) which contains about 6 000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



Some suggested sampling patterns within cane blocks of different shapes.

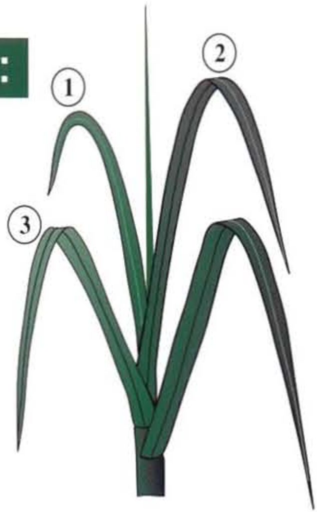
- Whilst there is some debate as to where soil samples should be taken in relation to the cane row or inter-row, we suggest that all samples be taken from the shoulder of the cane row, approximately mid way between the centre of the cane row and the centre of the inter-row. By following this rule you 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 remove pieces of stool.
- 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.
- 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. Assistance may be obtained from BSES, Herbert Cane Productivity Services or CSR Technical Field Department at Macknade.
- 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 otherwise zinc contamination could occur.

Appendix 3

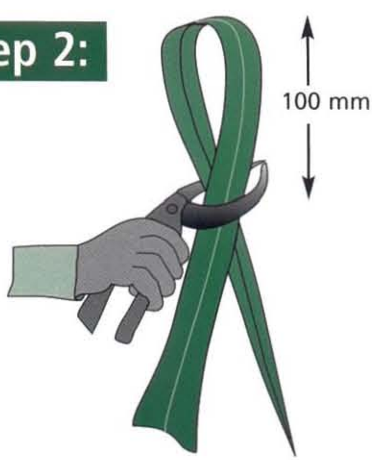
How to take a leaf sample

Step 1:

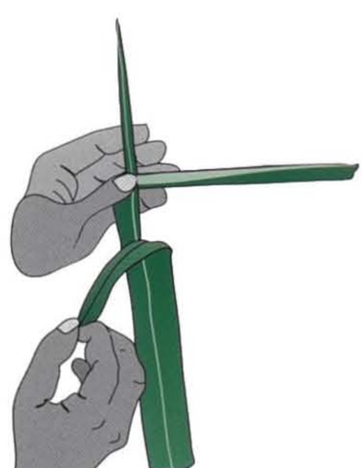


- Select leaves from stalks of average height.
- Sample the third leaf from the top of the stalk (as shown on the diagram). Counting from the top of the plant, the first leaf is the one that is more than half-unrolled. The third leaf usually corresponds to the top visible dewlap.
- Collect 30 - 40 leaves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

Step 2:



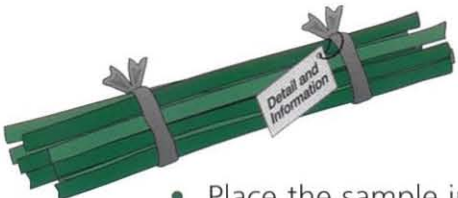
- Fold the leaves in half (top to base) and cut a 100-200mm length from these folded leaves (giving a total 200-300mm section of each leaf). Retain these middle 200-300mm sections of the leaf blades and discard the remaining top and bottom sections.



- Strip out & discard the midrib from each 200-300mm section.

Step 3:

- Bundle the leaf strips together and attach a completed BSES Leaf Analysis label (as shown opposite).



- 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:

  BSES Leaf Analysis Service
  Private Bag 4
  Bundaberg DC
  Qld 4670

NB 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). Sampling in the Burdekin can commence in October of each year.
- 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.

Leaf sampling allows you to:

- Check on the adequacy of fertiliser recommendations and the nutrients you have applied to your sugarcane.
- Adjust fertiliser rates if necessary next season (or in the current crop if the cane was young enough at the time of sampling).
- Identify possible nutrient problems associated with 'poor cane'.
- Monitor nutrient trends at the block, farm & regional levels

It is important that leaves are sampled correctly and that all the details requested on the BSES Leaf Analysis Service labels be supplied as accurately as possible. This will enable meaningful interpretation of the analysis results. An illustration of the leaf sample label is shown overleaf.

Labels and brown paper packets are available from BSES Experiment Stations and Extension Offices. If you would like to make use of this facility or get more information regarding leaf analysis, please contact you local Extension Officer or Dr Bernard Schroeder at BSES Bundaberg (4132 5200).

Dried samples should be submitted to your local extension officer. Alternatively you can post or dispatch them by courier to:

BSES Leaf Analysis Service,
Private Bag 4
Bundaberg DC
Qld 4670

An example of the BSES Leaf Analysis Service label.

BSES Leaf Analysis Service, P/Bag 4, Bundaberg DC Qld 4670	
SUGARCANE LEAF SAMPLE	
Grower's name:	
Farm identification:	
Address:	
Postal code:	**Tel number:**
Mill area:	**Sampling date:**
Block number:	**Details of fertiliser applied**
Crop: Plant / .... Ratoon	**Type:**
Variety:	**Rate: .... bags/acre .... kg/ha**
Age of cane at sampling: .... months*	

* calculated from the date of planting for plant or replant cane, the beginning of spring for winter-cut ratoons, and from harvest date for spring-cut ratoons.

Soil analysis interpretation guide for Herbert soils

This guide supplements the information presented in Chapter 6 and is intended to help those people who would like to interpret their own soil tests. The authors are developing a computer-based package that will calculate suggested nutrient inputs for a block after information from soil tests, fallow history and use of sugar mill by- products has been entered. This package is available from the authors.

NITROGEN GUIDELINES

N mineralisation index	Organic carbon (%)	Recommended N rate for ratoons and replant (kg/ha)
VL	<0.4	160
L	0.4-0.8	150
ML	0.8-1.2	140
M	1.2-1.6	130
MH	1.6-2.0	120
H	2.0-2.4	110
VH	>2.4	100

< denotes less than; > denotes greater than

Justification for replant and ratoon recommendations:

- Yield potential for Herbert District = 120 tonnes cane/hectare (yield potential = highest block yields averaged across the district's soils and over a number of seasons)
- Cane requires 1.4 kg N/tonne cane up to 100 t/ha and 1 kg N/tonne thereafter
- Thus to achieve potential yield on lowest organic matter soils we need a base application of N to ratoons of (1.4 x 100) + (1 x 20) = 160 kg N/hectare

Effect of fallow management on N mineralisation index and suggested N rates (kg/ha)

	VL	L	ML	M	MH	H	VH
Replant cane and ratoon after replant	160	150	140	130	120	110	100
Plant cane after grass/bare/poor legume fallow	140	130	120	110	100	90	80
Ratoon after grass/bare/poor legume fallow	160	150	140	130	120	110	100
Plant cane after good soybean/cowpea fallow	80	70	60	50	40	30	20
First ratoon after good soybean/cowpea fallow	110	100	90	80	70	60	50
Second ratoon after good soybean/cowpea fallow	160	150	140	130	120	110	100

Effect of mill by-products:

Mill mud (200 – 250 wet t/ha) - Subtract 100 kg N/ha from plant, 50 kg N/ha from 1st ratoon, 25 kg N/ha from 2nd ratoon

Mud/ash mixture (200 –250 wet t/ha) - Subtract 60 kg N/ha from plant, 30 kg N/ha from 1st ratoon, 15 kg N/ha from 2nd ratoon

Ash only – no change

PHOSPHORUS GUIDELINES

Old cane land

BSES P in soil test (mg/kg)	P sorption class	Suggested P rate (kg P / ha)	
>60	All	Nil P for at least 2 crop cycles	
40 – 60	All	Nil P for 1 crop cycle	
		Plant	**Ratoon**
20 – 40	Low	10	0
	Moderate	20	0
	High	30	0
10 – 20	Low	10	10
	Moderate	20	20
	High	30	30
<10	Low	20	20
	Moderate	40	30
	High	60	40

New land (first crop cycle)

		Plant	Ratoon
	Low	40	20
	Moderate	60	30
	High	80	40

P sorption classes

Organic carbon (%)	<24% clay	24-36% clay	>36% clay
<0.6	low	low	moderate
0.6 – 1.2	low	moderate	moderate
1.2 – 1.8	moderate	high	high
>1.8	high	high	high

< denotes less than; > denotes greater than

Effect of mill by-products:

Mill mud (200 – 250 wet t/ha) – Apply nil P for at least 2 crop cycles.

Mud/ash mixture (200 –250 wet t/ha) – Apply nil P for at least 2 crop cycles.

Ash only – Apply nil P for at least one crop cycle.

POTASSIUM GUIDELINES

K fertiliser guidelines (kg K / ha)

Soils with low K reserves (nitric K ≤ 0.7 me%)

Low clay soils (<24% clay)

Exch. K (me%)	<0.18	0.18 – 0.21	0.21 – 0.24	0.24 – 0.27	0.27 – 0.36	0.36 – 0.39	>0.39
Plant	120	100	80	60	40	0	0
Ratoon	120	120	120	100	100	100	0

Moderate clay soils (24 –36% clay)

Exch. K (me%)	<0.21	0.21 – 0.24	0.24 – 0.27	0.27 – 0.30	0.30 – 0.39	0.39 – 0.42	>0.42
Plant	120	100	80	60	40	0	0
Ratoon	120	120	120	100	100	100	0

High clay soils (>36% clay)

Exch. K (me%)	<0.24	0.24 – 0.27	0.27 – 0.30	0.30 – 0.33	0.33 – 0.42	0.42 – 0.45	>0.45
Plant	120	100	80	60	40	0	0
Ratoon	120	120	120	100	100	100	0

Soils with high K reserves (nitric K > 0.7 me%)

Low clay soils (<24% clay)

Exch. K (me%)	<0.18	0.18 – 0.21	0.21 – 0.24	0.24 – 0.33	0.33 – 0.36	0.36 – 0.39	>0.39
Plant	100	80	60	40	40	0	0
Ratoon	100	100	100	80	60	40	0

Moderate clay soils (24 –36% clay)

Exch. K (me%)	<0.21	0.21 – 0.24	0.24 – 0.27	0.27 – 0.33	0.33 – 0.39	0.39 – 0.42	>0.42
Plant	100	80	60	40	40	0	0
Ratoon	100	100	100	80	60	40	0

High clay soils (>36% clay)

Exch. K (me%)	<0.24	0.24 – 0.27	0.27 – 0.30	0.30 – 0.33	0.33 – 0.42	0.42 – 0.45	>0.45
Plant	100	80	60	40	40	0	0
Ratoon	100	100	100	80	60	40	0

< denotes less than; > denotes greater than

Effect of mill by-products:

Mill mud (200 – 250 wet t/ha) – Subtract 50 kg K/ha on first crop.

Mud/ash mixture (200 –250 wet t/ha) – Apply nil K on first 2 crops.

Ash only – Apply nil K for at least one crop cycle.

SULPHUR GUIDELINES

S fertiliser guidelines for plant and all ratoon crops (kg S/ha)

Sulphate S (mg/kg)	N min VL-L	N min ML-M	N min MH-H
<5	25	20	15
5 – 10	15	10	5
10 – 15	10	5	0
>15	0	0	0

< denotes less than; > denotes greater than

Effect of mill by-products:

Mill mud (200 – 250 wet t/ha) – Subtract 15 kg S/ha on first 3 crops.

Mud/ash mixture (200 –250 wet t/ha) – Subtract 15 kg S/ha on first 2 crops.

Ash only – Nil effect.

LIME GUIDELINES

Applications of pulverised lime (t/ha) for acid soils (pH_{water} <5.5) and for soils with low exchangeable Ca (<1.5me%)

Soils with low CEC (<3.0 me%)	2.5 t/ha lime
Soils with medium CEC (3-6 me%)	4 t/ha lime
Soils with high CEC (>6.0 me%)	5 t/ha lime

Effect of mill by-products:

Mill mud (200-250 wet t/ha) - Subtract 2.5 t/ha lime.

Mud/ash mixture (200-250 wet t/ha) - Subtract 2.5 t/ha lime.

Ash only - Subtract 2.5 t/ha lime.

MAGNESIUM GUIDELINES

Magnesium guidelines for plant crops (kg Mg/ha) with various soil exchangeable Mg levels

Soil test (me% Mg)	<0.05	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	>0.25
Mg application kg Mg/ha	150	125	100	75	50	0

< denotes less than; > denotes greater than

MICRO-NUTRIENT GUIDELINES

Leaf analysis is the preferred method of diagnosing whether micro-nutrient applications are required.

For copper and zinc using the DTPA soil test:

Copper: if soil test value less than 0.2 ppm - apply 10 kg Cu/ha once per crop cycle.

Zinc: if soil test value less than 0.3 ppm - apply 10 kg Zn/ha once per crop cycle.

For zinc using the BSES zinc test:

Zinc: if soil test value <0.6 ppm - apply 10 kg Zn/ha once per crop cycle.

SILICON GUIDELINES

Leaf analysis is the preferred method of diagnosing whether silicon applications are required. No deficiencies have been detected in the Herbert through leaf analysis.

There are two soil tests for silicon: $CaCl_2$ silicon and H_2SO_4 silicon. Using both soil tests together:

If $CaCl_2$ silicon is less than10 mg/kg and H_2SO_4 silicon is less than 70 mg/kg then a response to silicon is likely.

To rectify a silicon deficiency an application of 1.25 t/ha cement or 200-250 wet tonnes/ha of mill ash or mud/ash mixture is suggested.

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.

Bramley RGV and Wood AW (2000) 'Risk assessment of phosphorus (P) loss and guidelines for P use in lower Herbert soils'. Final Report, SRDC, Project CLW010.

Bruce RC (Ed.) (2000) 'Sustainable Nutrient Management in Sugarcane Production Short Course - Course Manual' (CRC for Sustainable Sugar Production, Townsville)

Bruce RC (Ed.) (2002) 'Managing Soils, Nutrients and the Environment for Sustainable Sugar Production - Course Manual' (CRC for Sustainable Sugar Production, Townsville)

Calcino DV (1994) 'Australian Sugarcane Nutritional Manual' (BSES/SRDC, Indooroopilly)

Hogarth DM and Allsopp PG (Eds) (2000) 'Manual of Canegrowing' (Bureau of Sugar Experiment Stations, Indooroopilly)

Schroeder BL, Moody PW and Wood AW (2003) 'Improved nutrient management in the Australian sugar industry'. Final Report, SRDC, Project BSS232.

White RE (1997) 'Principles and Practices of Soil Science'. 3rd Edition (Blackwell Science Ltd, Oxford)

Wilson PR and Baker DE (1990) 'Soils and agricultural land suitability of the wet tropical coast of north Queensland: Ingham area'. Queensland Department of Primary Industries Land Resource Bulletin QV 90001.

Wood AW, Noble AD and Bramley RGV (2002) 'Improving the environment for sugarcane growth through the amelioration of soil acidity'. Final Report, SRDC, Project CSR024.

Wood AW (2002) 'Inventory of Herbert soils for Sustainable Sugarcane Production'. Final Report, Natural Heritage Trust, Project 972077.

Wood AW and Stewart RL (1985) 'Nutrition and fertilising of sugarcane in the Herbert Valley'. CSR Ltd Technical Field Department, Macknade.

Wood AW, Schroeder BL, Stewart RL and Roth CH (2003) 'A reference booklet for cane growers on the nutrition and fertilising of sugarcane for different soil types'. Final Report, SRDC, Project CSR026.

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